The Victorian Naturalist

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Volume 122, part 1 comprises the Biodiversity Conference Special issue.
Volume 122, part 6 comprises the 125th year History Symposium Special Issue.

The Victorian Naturalist

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Biodiversity Conference Special Issue

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From the Editors

The papers published in this issue of *The Victorian Naturalist* were presented at a biodiversity conference held at University of Ballarat in June 2004. Dr Singarayer Florentine of the Centre for Environmental Management at the university has provided the following summary statement about that conference:

> On Thursday 10 June 2004, 190 delegates from twelve universities, state government agencies, catchment management authorities, community conservation groups, landcare groups, industry and environmental consultancies attended a conference entitled 'Biodiversity across the borders' at the Mt Helen Campus. The conference, organised by the Centre for Environmental Management (CEM), School of Science and Engineering, promoted the range of research into biodiversity issues being conducted by staff and students of the Centre as well as researchers based outside the university, working closely with staff of the Centre. Deputy Vice-Chancellor Professor Wayne Robinson welcomed delegates, and the keynote address was given by Professor Mark Burgmann of the School of Botany, University of Melbourne. Sixteen presentations followed, the majority by staff and post-graduate students of the Centre. The conference reinforced the central place that CEM now occupies in biodiversity research.

We are sure that readers will find much of interest in the papers from this conference.

Looking ahead to future issues of *The Victorian Naturalist* for the remainder of this year, we can promise readers further diversity in content. We have not been able to include all the papers offered from the Ballarat conference, so a couple have been held over for a later issue. The April issue will contain a range of subject matter, indicating some of the more interesting research undertaken recently. Similarly, the June issue will provide publication of new work in a variety of natural science areas.

This year holds the prospect of our publishing the proceedings of a couple of conferences. It is anticipated that the August issue will contain some of the papers that were delivered by speakers at the FNCV symposium 'Digging in the Bay', held on Sunday, 12 September 2004.

On the subject of FNCV symposia, readers will no doubt be aware that the Club will celebrate its 125th anniversary in May, with a two-day conference. This event will take place at Mueller Hall at the Royal Botanic Gardens, on the weekend of 28/29 May. Deatails of the conference and a registration form have been circulated with recent issues of *Field Nats News*. Copies of the registration form, and up-to-date details regarding the conference can be obtained also from the FNCV office. We are pleased to report that speakers at this important event will have the opportunity to publish their papers in *The Victorian Naturalist* later in the year. We are confident that in years to come this issue will be a highly valued number, in keeping with the importance of its subject matter.

The

Victorian Naturalist

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Editors: Anne Morton, Gary Presland, Maria Gibson

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Cover: Orchard Swallowtail *Papilio aegeus aegeus*. Photo by Wendy Clark. See page 21.

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Does size matter? Tree use by translocated Koalas

Flavia Santamaria [1,2], Marie R Keatley [3] and Rolf Schlagloth [4]

Abstract

Over-browsing of Manna Gum *Eucalyptus viminalis* and, in some instances, Swamp Gum *E. ovata* has occurred in areas where Koalas *Phascolarctos cinereus* have been translocated. A 26-month study of 30 radio-tracked translocated koalas examined tree use at three release forests in the Ballarat region. Tree species and tree diameter used by the koalas were recorded. Twenty tree species were used by the released koalas. Seven tree species were surveyed in the three forests. Diameter at Breast Height Over Bark (DBHOB) of trees surveyed was significantly different between forests and species and there was a significant interaction between species and forests ($p<0.001$, $F=3.48$). Koalas will use a wide variety of tree species if available and show a preference for larger trees. (*The Victorian Naturalist* **122** (1) 2005, 4-13).

Introduction

The Koala *Phascolarctos cinereus* is the largest arboreal marsupial living in Australia. Before the arrival of Europeans, its distribution encompassed the eastern and south-eastern lowland eucalypt forests of Australia, between Queensland and South Australia (Martin and Lee 1984; Phillips 1990). From the end of the 19th century through to the 1920s, following intensive hunting by white Australians, deforestation, wildfires and disease (Warneke 1978; Phillips 1990), many koala populations throughout Australia crashed. Around 1000 koalas survived in Victoria (Lewis 1934). Meanwhile, between 1880 and 1900, a few koalas were introduced from Corinella (mainland Victoria) to French Island in Western Port Bay (approximately 70 km south-east of Melbourne) (Lewis 1934, 1954).

The Koala's diet consists mostly, but not exclusively, of foliage from the genus *Eucalyptus* (Hindell *et al.* 1985). In Victoria, their highly preferred tree food species include Manna Gum *Eucalyptus viminalis* and Swamp Gum *E. ovata* (Hindell *et al.* 1985; Hindell and Lee 1987; Martin and Handasyde 1999) as well as River Red-gum *E. camaldulensis* and Southern Blue-gum *E. globulus* (Department of Sustainability and Environment (DSE) 2004). The population of koalas on French Island increased rapidly due to their inability to disperse from the island, the abundance of the optimal food tree species (*E. viminalis* and *E. ovata*), the absence of predators (Pratt 1937) as well as their *Chlamydia*-free status (Backhouse and Crouch 1990). By the 1920s, eucalypt defoliation had become a problem, and in 1923, a translocation program was begun to alleviate the pressure on the island's vegetation (Phillips 1990). Koalas were released into their former habitat on the Victorian mainland as well as onto other islands. Up to now, approximately 21 000 koalas have been translocated in Victoria (P. Menkhorst 2004 pers. comm. 30 April). Initial release sites were on other islands because these were considered safe havens (DSE 2004). These sites were mainly characterised by the presence of *E. viminalis* with little variety of other tree food species. This choice was made because it was believed that koalas would eat only a few eucalypt species. Over-browsing of *E. viminalis* and *E. ovata* has been occurring on islands and in isolated forested areas on the mainland (e.g. Framlingham Forest and Mount Eccles National Park). Past studies have indicated that koalas are more generalists than once suspected (Warneke 1978; Martin and Lee 1984; Phillips 1990) and would use a wide variety of tree species when available. Since the 1980s, the policy has been to avoid releases into isolated areas and into forests where *E. viminalis* is the prevalent species (DSE 2004).

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One of the aspects that has been poorly investigated in koala research is the size of the trees used by koalas. Past studies have acknowledged tree size as one of the meaningful aspects to take into account when considering the long-term survival of hollow-dependent arboreal mammals in Australia (Gibbons and Lindenmayer 2002; Wormington *et al.* 2003) and overseas (e.g. Fox Squirrel *Sciurus niger*) (Conner and Godbois 2002). Koalas have also been shown to have a preference for larger trees in a variety of forest types (Hindell *et al.* 1985; Hindell and Lee 1987; Melzer 1995 in Moore and Foley 2000; Phillips and Callaghan 2000; Santamaria 2002). One hypothesis is that a large trunk often supports a large crown (Niklas 1994), consequently more food availability (White 1994) and shelter (Hindell *et al.* 1985). Koalas' preference for larger trees has also been associated with their ability to climb (Hindell and Lee 1990).

A 26-month study was undertaken to investigate the outcome of koala translocation in three forests in the Ballarat area. Creswick, Enfield and Lal Lal Forests were selected because of the variety of tree food species available to koalas for fodder and/or shelter and the limited availability of *E. viminalis*. This paper will focus on one of the aspects of the research: tree species use by the translocated koalas with emphasis on tree size.

Methods

Koalas

Thirty koalas were relocated from French Island to three forests in the Ballarat region (Victoria). Twenty females (ten sub-adults and ten adults) and ten males (five sub-adults and five adults) were caught. Sub-adult koalas in this study were independent animals between one and three years of age, established by tooth wear (Martin 1981). The thirty koalas were released into the three forests on 21 October 1997 and radio-tracked for 26 months until December 1999. Koalas were radio-tracked and located during the day (between 6:00 am and 1:00 pm) They were tracked once a week for the first two months, then every two weeks for the following four months, and once a month for the last 20 months.

Site of origin

French Island is situated about 70 km south-east of Melbourne (in Western Port Bay, Victoria). Its area is approximately 17 410 ha; two thirds of the Island is National Park (proclaimed in 1997). Approximately 20% (about 220 ha) of the koala habitat on the island is scattered throughout the Park, the remainder is in remnant patches scattered across privately owned farmland (Parks Victoria 1998). Four indigenous species of eucalypts remain on the island: *E. viminalis*, *E. ovata*, Messmate Stringybark *E. obliqua* and Narrow-leaved Peppermint *E. radiata*. Koalas on the island show a strong preference for the first two species to the point that these are often defoliated (Martin 1985). Koalas have been consistently translocated from French Island by the Victorian Government since 1923 (DSE 2004) to avoid further defoliation of trees. Koalas studied during this research represented a small percentage of the koalas which were translocated from the island by the then Department of Natural Resources and Environment (now DSE) in 1997.

Release sites

The sites chosen to release the koalas were Creswick State Forest and Park (north-east of Ballarat), which is approximately 6985 ha including a softwood plantation (approximately 2850 ha) abutting the State Forest, Enfield State Forest and Park (south-west of Ballarat), which is about 9054 ha. A softwood plantation (approximately 54 ha) also abutting this State Forest; and Lal Lal State Forest (south-east of Ballarat) approximately 1550 ha.

Sites were chosen because of the scattered presence of *E. viminalis* and the presence of a variety of other eucalypt species (Table 1). The three forests chosen are classified as Open Forest (Land Conservation Council (LCC) 1980).

More detailed descriptions of the vegetation can be found in the Ecological Vegetation Classes (EVC) (Commonwealth and Victorian Regional Forest Agreement Steering Committee (CVRFASC) 1999). The vegetation at these sites has been classified under several EVCs. Vegetation types found at the release sites also occur in large areas throughout western Victoria.

Tree species listed in the descriptions might not be found in some sites within the release forests. Furthermore, species non-characteristic of this region, native and non-native introduced tree species, were recorded during this study.

Survey

The trees in which koalas were found were given a sequential number and tagged for future reference. When the same koala was found on a previously marked tree, the tree was counted only once. If a different koala was located in an already marked tree, the tree was counted again. Species and diameter at breast height over bark (DBHOB) of the trees occupied by koalas were recorded. *Eucalyptus obliqua* and Brown Stringy-bark *E. baxteri* were grouped together due to the difficulty of distinguishing the two species in the absence of accessible buds and fruits, and the similarity of their trunks often slightly burnt by the latest bushfire.

To test whether koalas were actively selecting trees according to species or size, the frequency and size class distribution of each species were estimated in each forest using Point-Quarter Sampling (Brower *et al.* 1998). Fourteen 200 m transects were randomly located through the areas used by the translocated koalas. From each point along the transects, the nearest tree in each quadrant (NW, NE, SE, SW) was selected for identification and measurement of DBHOB. During the survey, *E. obliqua* and *E. baxteri* were grouped together.

Statistical analyses

A two-way ANOVA was used to compare DBHOB of the surveyed trees and the trees used by the koalas amongst the three forests and amongst species (data were transformed to base 10 logarithms). A *G*-test (Fowler *et al.* 1998) was performed to compare the frequencies of the surveyed tree species and the frequencies of the species used by the translocated koalas in Creswick, as well as classes of DBHOB of trees surveyed and the trees used by the koalas in all three forests.

Results

Tree Species

Koalas were found in 20 tree species in all. In Lal Lal, koalas used 15 species in Creswick 16 and 20 in Enfield. Some of these were planted on private properties and/or plantations (e.g. Monterey Pine *Pinus radiata* and Blue Gum *E. globulus*) where koalas dispersed during the study period. Eight tree species were surveyed in Creswick (Fig. 1), eight in Enfield (Fig. 2) and 11 in Lal Lal (Fig. 3). Analysis between the frequencies of the surveyed tree species and the frequencies of the species used by the translocated koalas in Creswick showed that proportions were significantly different ($p<0.01$, $df=5$). The frequency of koalas using *E. viminalis* was higher than the surveyed frequency of this species (Fig.1). The frequencies of the surveyed *E. ovata* and the frequencies of usage of this species were similar. Stringybark species (*E. macrorhyncha*, *E. baxteri* and *E. obliqua*) were strongly avoided at this site. Statistical tests on the frequencies was not carried out on the Enfield data due to the great difference in the number of tree species surveyed and the species used by the koalas. Nevertheless, Fig. 2 indicates that the percentage of stringybarks (*E. obliqua* and *E. baxteri*) and *E. ovata* used by the koalas is higher than the percentage of the species surveyed in the forest. Although numbers are very low, the data also suggest that the percentage use of *E. viminalis* was higher than the percentage of the species surveyed. Analysis could not be performed on the Lal Lal data because the value of some frequencies was less than 5. Nevertheless, the data suggests that some species surveyed, such as *E. ovata* and *E. radiata*, have been preferred: other species such as Broad-leaved Peppermint *E. dives* have been used at a low frequency (Fig. 3). Use of *E. viminalis* appears to be similar to the frequency of this species in the area. The use of Sugar Gum *E. cladocalyx* was limited to an old (9 years of age) female that spent 45% of her time in a private property, moving amongst planted *E. cladocalyx*.

DBHOB

Analyses and box-plots on the diameter of trees surveyed in the three forests are shown in Table 2 and Fig. 4 respectively. DBHOB of trees surveyed was significantly different amongst forests ($p=0.047$, $F=3.73$) and species ($p=0.019$, $F=4.28$)

Table 1. Tree species as listed by the Land Conservation Council (1980) Victoria in the Creswick, Enfield and Lal Lal Forests.

Sites	Common overstorey species	Associated tree species	Common understorey species
Creswick	Messmate Stringybark *Eucalyptus obliqua* (Open Forest III)	Narrow-leaved Peppermint *E. radiata*, Candlebark *E. rubida*, Manna Gum *E. viminalis*, Broad-leaved Peppermint *E. dives*, Scent Bark *E. aromaphloia*, Swamp Gum *E. ovata*, Monterey Pine *Pinus radiata* (plantation)	Blackwood *Acacia melanoxylon*, Silver Common Cassinia *Cassinia aculeata*
Enfield	*E. obliqua*, Brown Stringybark *E. baxteri*, *E. ovata*, *E. rubida*, (Open Forest II)	*E. aromaphloia*, *E. radiata*, *E. dives*, Red Stringybark *E. macrorhyncha*, *P. radiata* (plantation)	*A. melanoxylon*, Late Black Wattle *A. mearnsii*.
Lal Lal	*E. obliqua* (Open Forest II)	*E. radiata*, *E. rubida*, *E. dives*, *E. aromaphloia*, *E. ovata*	*A. melanoxylon*, *A. dealbata*, *C. aculeata*.

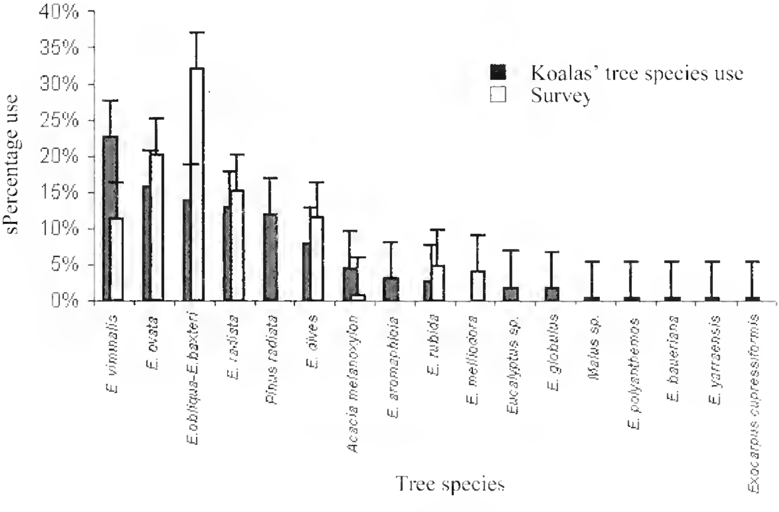

Fig. 1. Percentage of tree species used by the translocated koalas compared to percentage frequency of tree species in Creswick State Forest and Park. *Eucalyptus obliqua* and *E. baxteri* have been combined. Trees surveyed n=124; trees used by koalas n=247.

(Fig. 5). There was also a significant interaction amongst species and forests (p<0.001, F=3.48) indicating that the size of trees of each species could be influenced by the forest type and/or history.

Analyses and box-plot of the diameter of trees used by the koalas in the three forests is shown in Table 3 and Fig. 6, respectively. There was no significant difference in the size of trees used amongst the three forests, but there was a significant difference of DBHOB amongst the different species of trees used (p=0.001, F=7.34). This difference can be attributed to two species (Fig. 7), *E. viminalis* and *Acacia melanoxylon*. When these two species are not taken into account, the DBHOB of trees used by the released koalas is not significantly different across the species and the forests. It is also shown that there is no interaction between forests and species, indicating that the size of trees of different species chosen by the koalas does not vary between forests.

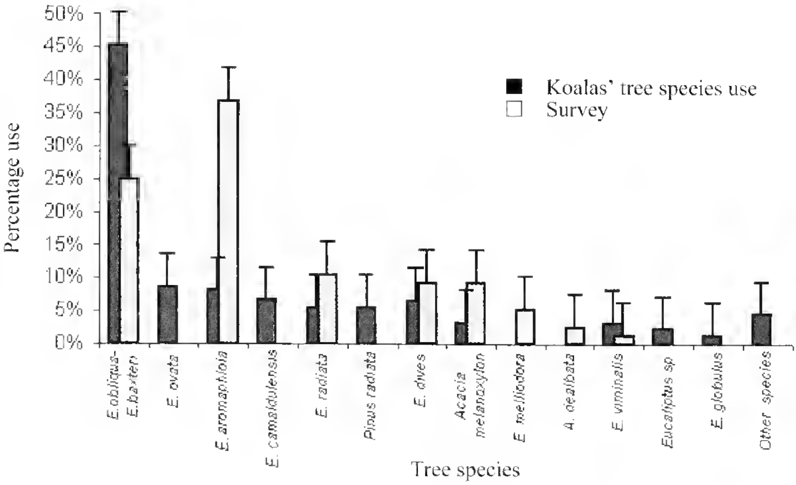

Fig. 2. Percentage of tree species used by the translocated koalas compared to percentage frequency of tree species in Enfield Forest. *Eucalyptus obliqua* and *E. baxteri* have been combined. Trees surveyed n=128; trees used by koalas n=256.

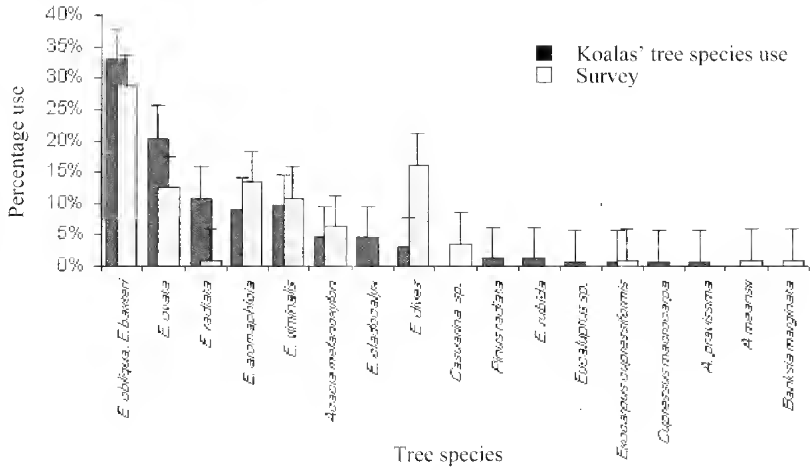

Fig. 3. Percentage of tree species used by the translocated koalas compared to percentage frequency of tree species in Lal Lal Forest. *Eucalyptus obliqua* and *E. baxteri* have been combined. Trees surveyed n=128; trees used by koalas n=194.

Creswick

Fig. 8 shows the frequencies of the DBHOB of trees surveyed and of trees koalas used in Creswick Forest. The last category includes trees with a DBHOB between 81 and 146 cm. Analysis performed on the frequencies showed that the proportions were statistically significantly different (p=0.01, df=7). Koalas mostly used trees with a DBHOB larger than the DBHOB commonly present in Creswick. Furthermore, trees with DBHOB between 31 and 40 cm were used slightly more often than trees with DBHOB between 21 and 30 cm.

Enfield

Fig. 9 displays the frequencies of the DBHOB of trees surveyed and of the trees in which koalas were found in Enfield. The

Table 2. Descriptive statistics on the diameter of trees surveyed in the three forests.

Forest	Number of trees	DBHOB range (cm)	mean	s.d	median
Creswick	112	10-134	44.3	24.0	40.0
Enfield	64	9- 63	36.6	14.6	23.0
Lal Lal	120	8-118	32.1	16.6	30.0

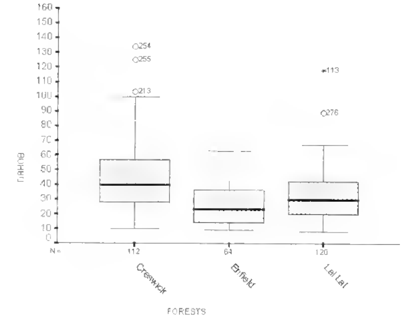

Fig. 4. Box-plot showing the median, quartiles, and extreme values of the DBHOB of all trees surveyed in the three forests. The box represents the interquartile range which contains the 50% of values. The whiskers are lines that extend from the box to the highest and lowest values, excluding outliers. The line across the box indicates the median. 'O' indicate the outliers.

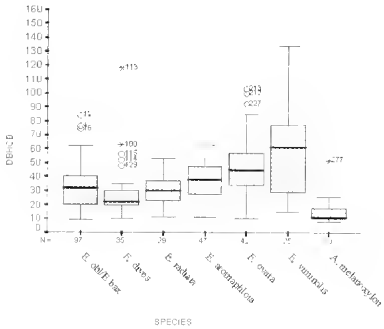

Fig.5. Boxplot showing the median, quartiles, and extreme values of the DBHOB of each species surveyed for the three forests combined. *Eucalyptus obliqua* and *E. baxteri* have been combined.

last category includes trees with a DBHOB between 61 and 200 cm. Koalas showed a marginal preference for trees with DBHOB class of 41-50 cm. Despite the wide range of DBHOB, the >61 category was also actively chosen given its low percentage availability at the site. However, trees with DBHOB classes of 21-30 cm and 31-40 cm were frequently chosen. The frequencies of the DBHOB of the trees surveyed and the DBHOB of the trees used by koalas were significantly different ($p<0.01$, $df=5$).

Lal Lal

Fig. 10 shows the frequencies of the DBHOB of trees surveyed and of trees in which koalas were found in Lal Lal. The last category includes trees with a DBHOB between 71 and 165 cm. There was a significant difference ($p<0.01$, $df=7$) between the frequencies of the diameters in the two groups. This is also evident from Fig. 10 where it appears that the trees in which koalas were most frequently found in Lal Lal had a DBHOB greater than the DBHOB of trees mostly available in the area. The DBHOB classes most commonly found in the forest were 11-20 cm and 21-30 cm, whereas the koalas were mostly found in trees with DBHOB between 31 and 50 cm.

Discussion

Species

Koalas were released into State Forests, but private properties and plantations, where they could find a wide variety of tree species both native and non-native to choose for food and/or shelter, could easily be accessed. The species used by the koalas were of a wider variety than the species surveyed in the forests. During this study, koalas were occasionally observed eating leaves of trees they were using. Most of the time, however, koalas were observed sitting in the trees in the morning. Some studies dealing with Queensland koalas (Melzer *et al.* 1995; Ellis *et al* 2002) have highlighted that often, but not always, daytime roosting is not a good indicator of diet. Previous studies on Victorian koalas (Robbins and Russell 1978; Hindell *et al.* 1985; Martin 1985; Hindell and Lee 1987, 1988), however, have shown that trees used during the day-

Table 3. Descriptive statistics on the diameter of trees used by the translocated koalas in the three forests.

Forest	Number of trees	DBHOB range (cm)	mean	s.d	Median
Creswick	182	12-146	51.48	27.7	45.0
Enfield	185	5-110	41.0	17.6	41.0
Lal Lal	165	7-165	45.8	23.2	44.0

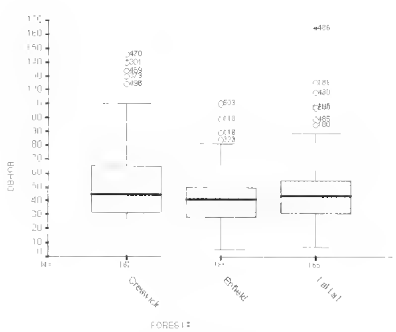

Fig. 6. Box-plot showing the median, quartiles, and extreme values of the DBHOB of all the trees used by the released koalas in the three forests.

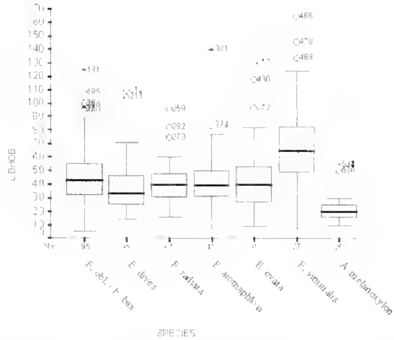

Fig. 7. Box-plot showing the median, quartiles, and extreme values of the DBHOB of each species used by released koalas. *Eucalyptus obliqua* and *E. baxteri* have been combined.

time are also used as fodder. It is important to underline, though, that none of those studies was dealing with translocated animals. The results of this study indicate that the translocated koalas utilised a wide range of tree species even though the frequencies of some of the chosen species in the forest were low. Nevertheless, when *E. viminalis* was present (e.g. Creswick Forest) this species appeared to be highly preferred.

DBHOB

This study strongly suggests that the choice of trees by koalas is not only driven by the presence of certain species but also by tree size. It is apparent from the results that koalas mostly preferred trees of the larger average diameter than those surveyed. The preference for larger trees was reflected at a species level where koalas used larger trees amongst species. At a forest level, koalas used a tree size class proportionally greater than what was commonly available in each area. Although the results indicate that the size of trees in the forests is a possible function of the forest types and the species, the tree size chosen by the koalas is not different between forests and/or species if *E. viminalis* (the largest species) and *A. melanoxylon* (the narrowest species) are not taken into account. *E. viminalis* is the species with larger tree sizes both surveyed and used by the koalas. This is probably due to the location in which larger *E. viminalis* are found. Trees in Creswick, Enfield and Lal Lal have been used for sawlog production and/or firewood. Trees with a DBHOB of 25 cm or larger are harvested for sawlogs and trees with a smaller diameter are considered residual round wood and chipped for paper or board products (Department of Natural Resources and Environment 1996a). The largest specimens are mostly found in gullies (Costermans 1994) where legal requirements prevent logging (Department of Natural Resource and Environment 1996b). Preliminary results of a survey using the Koala Habitat Atlas plot survey methodology (Phillips and Callaghan 2000) carried out in the Ballarat area by the Australian Koala Foundation (unpublished data) has indicated that the mean DBHOB of trees with koala scats present was 100.5 cm (nearly twice the mean diameter shown in this study) whilst trees without scats had a mean DBHOB of 50.2 cm. The survey was carried out mostly in unlogged areas. This could imply that, if given the opportunity, koalas would

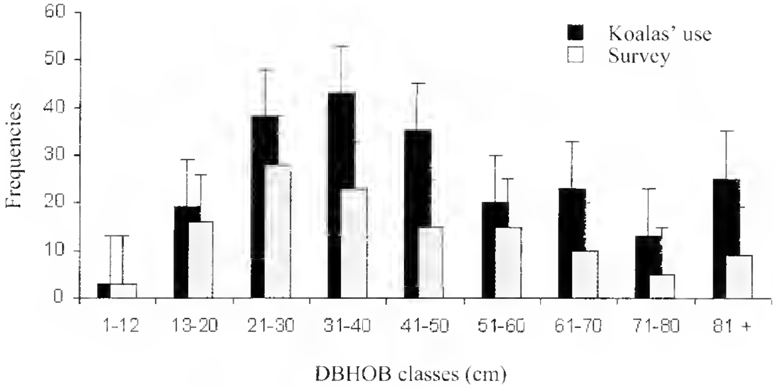

Fig. 8. Comparison of frequency distributions of DBHOB for trees in which koalas were sighted in Creswick Forest versus trees sampled along transects, all species combined.

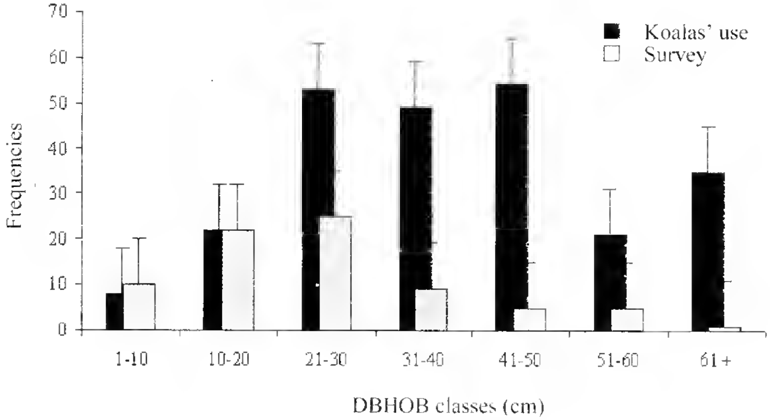

Fig. 9. Comparison of frequency distributions of DBHOB for trees in which koalas were sighted in Enfield Forest versus trees sampled along transects, all species combined.

select trees of larger size than they choose in logged forests.

Since a large trunk could mean a large crown (Niklas 1994) the selection for trees of bigger size can be linked to foliage abundance (White 1994). It appears that a link exists between adequate nutrition and successful progeny bearing (White 1994) as well as prevention of diseases (Lanyon and Sanson 1986 in White 1994). One reason for koalas' preference for larger trees is the greater access to nutrients in the soil by larger trees with larger root systems (Phillips and Callaghan 2000). However, in some mainland isolates and on islands in Victoria where koalas have been translocated, overpopulation occurs despite extensively defoliating *E. viminalis*. Koalas still display high reproductive success (DSE 2004). Over-browsing has been linked to the high palatability of the leaves caused by land management practices that enhance fertility and moisture in the soil (Jurskis and Turner 2002).

Preference for large trees for food, shelter and nesting in tree hollows has been documented for a wide variety of arboreal marsupials (Wormington *et al.* 2003). A study in New South Wales (Kavanagh and Webb 1998) has documented the negative

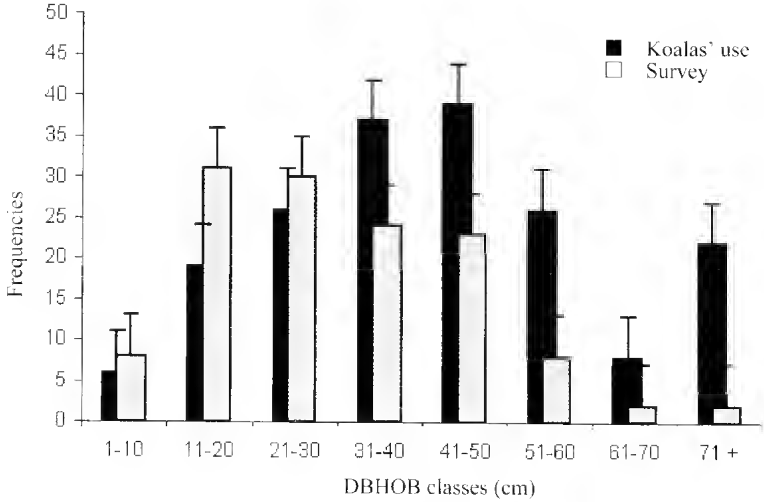

Fig. 10. Comparison of frequency distributions of DBHOB for trees in which koalas were sighted in Lal Lal Forest versus trees sampled along transects, all species combined.

impact of logging of large trees on the Greater Glider *Petauroides volans*, Sugar Glider *Petaurus breviceps* and Yellow-bellied Glider *Petaurus australis* and other species. It is possible that the removal of large trees for timber production or land development in Victoria, and more broadly in Australia, might have a future impact on the health and ultimately survival of the Koala as much as it has been shown to impact on the long term survival of hollow dependent fauna. Future studies should examine the relationship between tree size and koala density, health and survival.

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Some guidelines for the conservation of woodland insects in the Wimmera area

Fabian Douglas[1]

Abstract

Threatened woodland habitats in the Wimmera area of western Victoria have a vital role to play in maintaining insect biodiversity within the region. This work outlines some of the important ecological processes that insects perform and provides land management guidelines for the maintenance of viable insect populations in remnants of native vegetation. Some notes are also included on a selection of typical woodland and/or grassy woodland insects that occur in western Victoria. These include brief descriptions of the listed species and some basic information on their biology. (*The Victorian Naturalist* **122** (1) 2005, 13-20).

Introduction

The plant communities that comprise the various types of woodland and grassy woodland in the Wimmera area (of western Victoria) provide food and shelter for a wide variety of insects. Trees, understorey shrubs and forbs, perennial grasses, parasitic plants and fallen timber all have a vital role to play in maintaining the biodiversity of insect populations. A healthy insect population that is balanced and species rich ensures that pollination of native plants takes place, nutrients are recycled and that there is a reliable food supply for many vertebrate animals such as amphibians, reptiles, birds and small mammals (Crouch in prep.).

Unfortunately, since European settlement many woodland and grassy woodland insects have become restricted to remnant areas of natural habitat as a result of the widespread clearing of native vegetation for agriculture. Some species are now endangered and are only known to occur at

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one or two sites in the entire Wimmera area. Woodland remnants such as the Glenlee Flora Reserve (at 19 km NE of Nhill) and the Kiata Native Plants & Wildlife Reserve (on the south side of the Western Highway at Kiata) provide a valuable refuge for such species and the ecosystems to which they belong.

However, when the Wimmera is considered as a whole, it is apparent that such reserves are rare and that a number of woodland and grassy woodland habitat types are poorly represented in the major reserves within the region. For example, much of the Little Desert National Park is covered by heathland and mallee-heath habitats. For this reason, it is important that remnants of woodlands and grassy woodlands on private land are managed in such a way that their biodiversity is not seriously compromised and if possible protected under Trust for Nature (Victoria) covenants.

The dominant tree species throughout most of the woodland and/or grassy woodland habitats in the Wimmera are Black Box *Eucalyptus largiflorens*, Yellow Gum *E. leucoxylon* and River Red Gum *E. camaldulensis* (all Myrtaceae), Buloke *Allocasuarina luehmannii* (Casuarinaceae) and Slender Cypress Pine *Callitris gracilis* (Cupressaceae).

Notes on various species of woodland insects

The following is a small list of some woodland insects and the plants that are associated with various aspects of their life cycles. The common names that are used for the butterflies follow Braby (2000). However, when these differ from the older (but still often used) common names of these species, the older names in brackets follow the more recently used names in the heading for each species. With the exception of the widely accepted common names of Pale Sun-moth for *Synemon selene*, Golden Sun-moth for *S. plana* and Grey-furrowed Flower Beetle (or Grey-furrowed Rose Chafer) for *Trichaulax philipsii*, the other common names that are applied to the moths, beetles and cicadas in this work are, to the authors knowledge, proposed here for the first time.

Butterflies and Moths, Lepidoptera:
Small Grass-yellow Butterfly* Eurema smilax, *Pieridae.

The Small Grass-yellow is a small, bright yellow butterfly with a wingspan of about 3 cm. Although it is on the wing through the warmer months of the year it is usually seen during spring and autumn. The larvae of this butterfly feed on *Senna* species (Caesalpiniaceae) and probably utilise Desert Cassia *Senna nemophila* in the Wimmera area.

Spotted Jezebel Butterfly (Wood White)* Delias aganippe, *Pieridae

This spectacular butterfly has a wingspan of about 6 cm. It is boldly patterned in black and white with bright red and yellow markings on the underside of the hindwings. The protracted adult flight period of this species starts during August and concludes in May. Its gregarious larvae feed on a number of parasitic plants. Sweet Quandong *Santalum acuminatum* (Santalaceae) and Box Mistletoe *Amyema miquelii* and Buloke Mistletoe *Amyema linophyllum* (both Loranthaceae) seem to be the most commonly used larval food plants in the Wimmera area.

Fiery Copper Butterfly (Eltham Copper)* Paralucia pyrodiscus, *Lycaenidae.

The Fiery Copper is threatened in Victoria and has only one known population within the Wimmera area. It is a small metallic orange and blackish-brown butterfly with a wingspan of approximately 2.5 cm. As with many species in the family Lycaenidae, the larvae of this species have an obligate relationship with a particular genus of ants. During the day the larvae shelter in temporary nests of these ants and are probably protected from predators while feeding at night. In exchange for this the larvae secrete a sugary solution from a gland on the seventh abdominal segment that is eagerly consumed by the attendant ant.

The larval food plant of the Fiery Copper is Sweet Bursaria *Bursaria spinosa* (Pittosporaceae) and in western Victoria the attendant ant is *Notoncus ectatommoides*. At the Wimmera site this species has two generations annually with adults flying during late spring and early autumn.

Southern Purple Azure Butterfly (Genoveva Azure)* Ogyris genoveva, *Lycaenidae.

This colourful species exhibits sexual dimorphism to a remarkable degree with males being dark purple on the upperside of the wings while the females have metallic blue or bluish-green uppersides with broad black margins and a bean shaped white patch near the apex (tip) of each forewing. The wing expanse of this species is about 5 cm for males and 5.5 cm for females. Within the Wimmera area this species occurs near the Grampians where it is on the wing during December and January. The larvae of the Southern Purple Azure feed on Box Mistletoe growing on various *Eucalyptus* species and are attended by sugar ants in the *Camponotus consobrinus* species group.

Satin Azure Butterfly (Amaryllis Azure)* Ogyris amaryllis meridionalis, *Lycaenidae.

The Satin Azure is usually seen as it flies around its larval food plant, which in the Wimmera area is usually Buloke Mistletoe growing on mature Bulokes. It is a shining metallic blue butterfly with narrow black margins around the fore and hind wings and a wingspan of about 3.4 cm. Although a number of other Mistletoe species are utilized as larval food plants by this species in other regions, it seems that Buloke Mistletoe is favoured above all others throughout most of the Wimmera. Numerous small black ants, belonging to the *Iridomyrmex rufoniger* species group, usually attend the larvae of the Satin Azure.

In the Wimmera, the adult flight period for this species commences in September and concludes in April.

Varied Dusky-blue Butterfly (Western Dusky-blue)* Candalides hyacinthina simplexa, *Lycaenidae.

This species is a small butterfly with a wingspan of 2.5 cm. In the subspecies *simplexa* the upperside of the wings are deep metallic blue with the apical (outer) half of the forewings sooty black. Varied Dusky-blue larvae feed on Dodder Laurel *Cassytha* species (Lauraceae) with Coarse Dodder Laurel *Cassytha malantha* being the most frequently chosen species in the Wimmera area. Unusually for a member of the family Lycaenidae, the larvae of this butterfly appear to be only casually associated with ants.

This is another species that has a very long adult flight period with adults first appearing during August and persisting until April. As individual adults would only live for about a fortnight or less, it seems that there would be several generations of this species per year.

Six-spot Wood Moth* Endoxyla opposita, *Cossidae.

Although this species seems to be rare, it is probably widely distributed throughout the Wimmera area. However, it appears that its occurrence is restricted to areas of woodland that contain Bulokes as the dominant or co-dominant tree species. As the larvae of *Endoxyla* species are borers in the timber of living trees, the habitat preferences of the Six-spot Wood Moth indicate that its larvae may feed on the wood of Bulokes. The nocturnal adults of this species emerge from late December to the end of January. Males fly rapidly and both sexes are sometimes attracted to artificial light.

The Six-spot Wood moth is predominantly brownish-grey with a delicate, reticulated or net-like black pattern on the entire upper surface of the forewings, and also along the outer edges of the hindwings. The males have the remainder of the hindwings silky white, while in the females the hindwings are mainly light grey. Males have a wingspan of approximately 6.5 cm. The females are larger, with a wingspan of about 9 cm.

Unlike many of the other *Endoxyla* species, which have a black, horseshoe shaped marking on the thorax, this species has most of this characteristic 'horseshoe' marking reduced in such a way as to form a series of six black thoracic spots.

Pale Sun-moth* Synemon selene, *Castniidae.

This is a species of special interest, as it was originally discovered near Two Wells in South Australia where equal ratios of males and females were collected historically. However, when it was discovered in Victoria, it was noted that no males were present in the Victorian populations.

Following these initial discoveries, between the mid 1800s and early 1900s, the species was thought to have become extinct in both states as a result of habitat loss. It was then rediscovered in the Wimmera during 1991 by the late Frank Noelker and the author. Subsequent work that has been done on this species by the author (F. Douglas unpublished data) has shown that there are five distinct morphs or forms that occur in Victoria. This work has also demonstrated that all of these Victorian forms of the Pale Sun-moth are parthenogenetic. i. e. that they are capable of reproducing asexually.

As far as is known the parthenogenetic state of this species in Victoria is unique within the family Castniidae and is most unusual because the five forms must be genetically isolated from one another as they would be incapable of interbreeding. It is also noteworthy that all five of the Victorian forms of the Pale Sun-moth are now restricted to relatively small remnants of native grassland and grassy woodland. It seems that all of the forms are endangered with two of them being critically endangered. During the past few years the author has searched without success in the Two Wells area of South Australia for an extant population (with males) of the non-parthenogenetic form.

The Pale Sun-moth is diurnal and flies only when the sun is shining. A casual observer would easily mistake this species for a butterfly because it has clubbed antennae, a relatively slender body and bright coloration. The uppersides of the forewings are cryptically patterned in shades of fawn, brown and grey with small whitish markings. When the moth is resting, these camouflaged forewings are used to conceal the upperside of the brightly coloured hindwings, which are boldly marked with yellowish-orange and greyish-black. This species has a wingspan of about 4.5 cm. The larvae of the Pale Sun- moth live underground and it seems likely that they feed on the roots of wallaby grasses *Austrodanthonia* species (Poaceae). Adults of this species have a fairly brief flight period that starts during February and finishes in early March.

Golden Sun-moth* Synemon plana, *Castniidae

This species has a similar life history (and habitat requirements) to the Pale Sun-moth. It also has larvae that live underground and probably feed on the roots of wallaby grasses. However, the adults fly from late October to mid November in the Wimmera area and the species is not parthenogenetic. The sexes are very different in appearance, with the upperside of the males being dark brown with a series of delicate greyish-white patterns on the forewings. The females have similar coloured forewing uppersides to the males but there the similarity ends, as their hindwing uppersides are pure golden-yellow with a few small black spots towards the outer edge.

The females of this species are poor fliers and use their brightly coloured hindwings as a signal to attract a mate. The Golden Sun Moth could also be mistaken for a butterfly as it is day flying and in common with all other sun moths has strongly clubbed antennae. The wing expanse is about 3.5 cm for males and 3 cm for females. This species is now listed as *critically endangered* under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 and is listed as threatened under the Victorian *Flora and Fauna Guarantee Act* 1988. It occurs at a few sites in Victoria, three of which are in the Wimmera (near Nhill).

Silver-striped Swift Moth* Trictena atripalpis, *Hepialidae

Also known as the Bardi Grub Moth, this impressive nocturnal species appears during autumn, just before or during rain. With a wingspan of approximately 10 cm for males and 13 cm for females it is one of the largest insects to be found in the Wimmera area. The males are predominantly dark blackish-grey with two longitudinal silvery-white markings on the upperside of the forewings. These markings are surrounded by an intricate succession of wavy or curved pale grey lines that resemble the patterns of agate. The females are usually a paler shade of grey and have less distinct forewing markings. *Eucalyptus* species are the larval food plants of this species, with Yellow Gum and Red Gum being frequently utilised throughout the Wimmera. The larvae live in underground galleries where they feed on the roots of these trees and probably take several years to reach maturity. Pupation occurs in a deep, more or less vertical tunnel from which the large brownish-orange pupal shell is left protruding after the moth has emerged. It seems that the adult life-span of this species is very short (two or three days) as the adults have non functional mouth parts and do not feed. They are sustained for just long enough to find a mate and lay eggs, by fats that are accumulated in their bodies during the larval stage.

Beetles, Coleoptera:

Grey-furrowed Flower Beetle or Grey-furrowed Rose Chafer* Trichaulax philipsii, *Scarabaeidae

The Grey-furrowed Flower Beetle is a diurnal species that flies during summer and early autumn. It is easily recognised by the three deep grooves filled with short, stiff, silvery-grey hairs that run longitudinally down each elytron (wing cover). The remainder of the elytra are shiny black, which adds contrast to the hair-filled grooves. The head and legs are also black and the pronotum (exposed part of the thorax when viewed from above) is deep maroon. Both sexes are about 2.5 cm long.

It is likely that this species is an important pollinator of various summer flowering *Eucalyptus* species as the adults spend long periods of time feeding on nectar and pollen in the forest canopy. Generally, flower beetle larvae feed on damp, rotten timber or humus rich soil, in which they finally pupate inside an oval cocoon, constructed out of the surrounding material. However, despite careful searches, the author has not found the early stages of the Grey Furrowed Flower Beetle. This could be due to the possibility that this species breeds inside old, hollow, termite infested trees. This theory is supported by observations made on two separate occasions when an adult female was seen flying around and finally into the hollowed out branches of very old Yellow Gums.

Copper Stag Beetle* Lamprima varians, *Lucanidae

This diurnal beetle exhibits sexual dimorphism. Males are a metallic copper-bronze colour with enlarged mandibles that project anteriorly for 3 mm to 4 mm beyond the head. They are variable in size and can be from 1.5 cm to 2.5 cm long. The females are usually smaller than the males and measure about 1.5 cm to 1.9 cm long. Their mandibles are also shorter and usually project for about 1 mm (beyond the head). The metallic coloration of the females is spectacular and ranges from brilliant greenish-gold through shades of green to deep ultramarine blue and sometimes bluish-purple. The adults fly during November and December and during this time are usually seen resting on understorey shrubs such as Wallowa *Acacia calamifolia* (Mimosaceae) and Slender Hop Bush *Dodonaea viscosa* (Sapindaceae). They will also visit flowering shrubs such as Broom Baeckea *Baeckea behrii* (Myrtaceae).

The larvae of the Copper Stag beetle feed internally on the sap-wood of dead timber and pupate within the timber in capsule-shaped cavities known as pupal cells. Throughout the Wimmera, large fallen branches of Red Gum and Yellow Gum and stumps of Silver Banksia *Banksia marginata* and Desert Banksia *Banksia ornata* (both Proteaceae) are frequently chosen as larval food. In Victoria, the life cycle of this species usually takes three years to complete. Incredibly, after emerging from their pupae during late summer and autumn the adults do not break out of their pupal cells until the following flight season, approximately nine months later.

Purple and Yellow Jewel Beetle* Temognatha pascoei, *Buprestidae

So far as is known this is one of the rarest jewel beetles that occurs in Victoria. The records of this species from the Wimmera area that the author is aware of are as follows: (a) One elytron (wing cover) of a male, found by the author on private land near the Barrabool Flora and Fauna Reserve (at 7 km SSE. of Murtoa) on 19 January 1991. (b) One dead specimen found by K. V. Hateley in the Glenlee Flora Reserve during the 1940s. (c) Two female specimens collected by J. Hill in the Kewell area during the late 1800s or early 1900s. The only other Victorian record that the author was able to find is of one very old specimen in the insect collection of the Museum of Victoria. This specimen is a male that is simply labelled 'Mallee district, Victoria'.

This impressive species is one of the larger members of the family Buprestidae. The males measure about 3.5 cm with females a little larger at approximately 4 cm. The coloration of the two sexes is similar. The head and pronotum are metallic purple or coppery-purple, with a narrow creamy-yellow stripe along the sides of the pronotum. The elytra (wing covers) are creamy-yellow for the first (basal) two thirds of their length. The remaining (apical) third of the elytra are black with a purple or reddish-purple metallic sheen. This metallic section of the elytra is at the posterior end of the beetle when the elytra are closed. The adult flight period of the Purple and Yellow Jewel Beetle is probably during January and February. In Western Australia the adults have been found feeding on nectar from the blossom of *Eucalyptus* species (M. Hanlon 2002 pers. comm.). Therefore, it is possible that in the Wimmera area it may feed at the blossom of Black Box, Dumosa Mallee *E. dumosa* or Bull Mallee *E. behriana*.

Very little is known about the life history of this species. However, from what is known about the larval host plants of some of the other species in the genus *Temognatha*, it seems likely the larvae of the Purple and Yellow Jewel Beetle are borers in the timber of live Bulokes.

As jewel beetles in the genus *Temognatha* usually distribute their eggs widely, with only one or two eggs being laid on a particular larval host plant, it becomes apparent that they may require comparatively large areas of natural habitat for their survival. The small amount of available data on the Purple and Yellow Jewel Beetle would seem to indicate that it has become regionally endangered in Victoria as a result of habitat loss within the Wimmera area (due to the widespread clearing of Buloke woodlands for agriculture). The recent establishment of corridors of native vegetation along roadside verges and watercourses to connect existing remnants of Buloke woodland in the Wimmera should help to increase the population level of this species in Victoria.

Cicadas, Hemiptera:
Buloke Cicada* Cicadetta *sp. aff.* tigris, *Cicadidae

The author first discovered this distinctive species during 1997, at Wedding's Reserve near the north-west end of Lake Hindmarsh. Since then, twelve more small populations have been located in the Wimmera and southern Mallee areas. It now appears that this cicada has a restricted and patchy distribution within a rough triangle that runs from Staples' Bushland Reserve at 7.7 km SW of Rainbow to near Pimpinio and across to a site at 14 km NE of Nhill. Two of the known populations occur in the Glenlee Flora Reserve. The Buloke Cicada is a medium sized species with a wingspan of about 6 cm for males and 7 cm for females. It is black with light brown markings and has transparent wings, except for a conspicuous 'w' shaped, dark brown marking near the apex (tip) of each forewing.

The call of the male is most unusual and is a valuable aid to finding populations of the species. It is best described as a sharp 'chip chip chip chi-chi-chip, chip chip chip chi-chi-chip' etc. etc. This is continuously accompanied by a soft shivering sound that pulsates in time with the chipping call. The males usually call in unison for periods of half an hour or more, before falling silent for similar lengths of time. These bouts of calling occur more frequently during warm to hot weather conditions and can take place at any time from mid morning to about half an hour after sunset.

As its proposed common name implies, this cicada is associated with Bulokes. It has been found only in stands of these trees with occasional males calling from neighbouring eucalypts. To date, it has never been recorded in pure stands of any *Eucalyptus* species. In addition, several nymphal exuviae that probably belong to this species have been found on the trunks and lower branches of Bulokes. The adult flight period of the Buloke Cicada starts in late November and continues until early March.

Creaking Branch Cicada* Cicadetta spinosa, *Cicadidae

The presence of this wary cicada can be detected by its call, which resembles the creaking sound of two branches rubbing together in the wind. As each male cicada repeats this sound at approximately five-second intervals when calling, the noise can be virtually continuous (from mid morning to sunset) when population levels of this species are high.

The Creaking Branch Cicada is probably dependent on *Eucalyptus* species for its nymphal and adult food supply, as nymphal exuviae have been found under Yellow Gum and Black Box. In most cases the adults are also found in eucalypts and calling usually occurs in these trees as well. It is a widely distributed species in the Wimmera area and can be locally common in suitable woodland habitats. As with the preceding species, the adult flight period commences in late November and concludes during March.

The coloration of the Creaking Branch Cicada is predominantly black with brown or yellowish-brown markings on the thorax and abdomen. There is also a conspicuous pale yellow marking on the posterior end of the abdomen. The wings are transparent with yellow basal membranes on the forewings that are visible when they are spread open. The wing expanse of this species is about 5.5 cm for males and 6.5 cm for females.

Some guidelines for insect conservation in woodland habitats

Some guidelines for the long-term conservation of insects and other invertebrates in native woodland and grassy woodland habitats are as follows:

1.) Keep any form of soil disturbance or cultivation to as small an area as possible, i. e. during the harrowing of firebreaks or the construction of fences etc. Damage to the surface crust of the soil destroys native vegetation and the associated insect fauna. It also encourages introduced grasses and weeds to invade the disturbed area and become established.

2.) Avoid tree planting and soil disturbance in natural woodland glades. These open areas of native perennial grasses and forbs are the habitat of many insects, including the Pale Sun-moth and the Golden Sun-moth.

3. If feasible, expand the size of remnant areas of woodland by planting out adjacent degraded land with locally indigenous species of plants. Ideally, these should be raised from seed stocks that have been gathered from plants within or as near to the area in question as possible.

4. Protect the ecological integrity of remnant woodlands by controlling troublesome introduced weeds such as Horehound *Murrubium vulgare* and exotic pest animal species such as Rabbits *Oryctolagus cuniculus* and Foxes *Vulpes vulpes*.

5. Take care not to confuse (and destroy) native Sweet Bursaria with introduced African Boxthorn *Lycium ferocissimum*. Sweet Bursaria is the larval food plant of the Fiery Copper Butterfly and also provides nectar for a very wide variety of beneficial insects.

6. If native parasitic plants such as Dodder Laurels, Mistletoes or Quandongs are present, do not remove them to protect host trees. The larvae of several butterfly and moth species feed exclusively on the foliage and/or flower buds of parasitic plants.

7. Leave dead and fallen timber alone. It provides food and/or shelter for a vast array of native animals and is essential (as food) for many species of beetles and other invertebrates to complete their life cycles.

8. Do not plough firebreaks through remnant native vegetation on roadside verges. Doing this can destroy or seriously deplete local populations of native plants as well as the beneficial insects that directly or indirectly depend on them for their survival. Roadside verges are often the only places where some of the most threatened woodland habitat types remain in entire districts of largely cultivated farmland.

9. If it is deemed necessary to cool-burn a particular woodland remnant (for fuel reduction purposes), it is recommended that the entire area should not be burnt out at the same time. Any prescribed burning should be carried out on a rotational basis, in longer (preferably much longer) than annual cycles, so that some parts of the woodland area are left unburned for considerable periods of time. This practice ensures that there is always some suitable

habitat (i.e. food and shelter) available for wildlife, including insects.

10. Sheep grazing can sometimes be used as a valuable tool to maintain biodiversity in woodland habitats. In many cases a moderate grazing regime is necessary to prevent certain plant species from proliferating at the expense of others. For example, when open grassy woodlands are not grazed for long periods of time, grasses such as some of the taller spear grasses *Austrostipa* spp. tend to replace the shorter growing wallaby grasses. Eventually, an ecological process of this nature has a negative effect on the populations of certain endangered species of insects that feed on the wallaby grasses. However, as some native plant species are highly palatable to stock, it is recommended that grazing should be largely (or in some cases entirely) excluded from reasonably large sections of a given woodland remnant.

11. One of the most threatened types of habitat within the Wimmera area is woodland that is dominated by Bulokes. For this reason it is essential that such areas are carefully managed so as not to seriously compromise their ecological values. Although some of the insects that need Bulokes for their survival are still relatively common in the region, the gradual loss of mature trees over time will doubtless cause a widespread decline in their abundance in the future. To avert this situation, it is recommended that the regeneration of Bulokes should be actively encouraged, especially in areas that abut existing stands of mature trees.

12. It is imperative that efforts to conserve and restore indigenous woodlands and their associated wildlife are carried out on as large a scale as possible. Although the reasons for this are many, one of the most important is that a comparatively large area of habitat is likely to contain a greater spectrum of native plant and animal species. This in turn allows for more complete and frequent interactions between the species that are present and facilitates the balanced function of ecological processes.

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Author's note: Although the following references are not cited above, they contain the taxonomic names that have been used in this work. To the author's knowledge all of these taxonomic names are valid, as at 25 May 2004, except that Froggatt (1907) used the former generic name *Stigmodera* for the Purple & Yellow Jewel Beetle *Temognatha pascoei*. However, the current generic name of this sp. is correctly used for two other congeneric spp. in Hangay and German (2000).

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Biodiversity and status of butterflies in the Ballarat Region, Victoria

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Abstract
The butterfly fauna of the Ballarat region is not well known, reflecting a lack of comprehensive surveys. This paper firstly characterises the Ballarat region and documents butterfly species found locally. Forty-five species from five families and 31 genera are now known for the region, including one introduced species. Management issues include habitat fragmentation and degradation. Some species are insufficiently known in the region to permit the development of management strategies. (*The Victorian Naturalist* **122** (1) 2005, 21-34).

Introduction

The butterfly fauna of the Ballarat region is poorly documented. Before 1995, just 11 species had been recorded on the Victorian Butterfly Database for the grid squares that include Ballarat and environs: 143°45'00" E, 37°35'00" S and 143°55'00" E, 37°35'00" S. Surprisingly, the list excluded several abundant species. This paper records species found in the vicinity of Ballarat, with some notes on the broader region, extending as far as Ararat, Castlemaine and Lismore. It documents the status of each, their flight season and habitat use within the region. Database records are supplemented by records from transects made from 1991 to 1994, subsequent casual observations by the author, unpublished observations by naturalists, and literature records, including notes on regional species from the Ballarat *Courier*. Common and scientific names of butterflies follow the usage in Braby (2000).

Characteristics of the Ballarat region

The Ballarat region is depicted in Fig. 1. Ballarat (population 86 000) lies 100 km west of Melbourne, Victoria, at altitudes of 400-500 m ASL. Ballarat is extensively urbanised, but has many areas of remnant vegetation within its outer suburbs. The urban/rural fringe of Ballarat is a dynamic environment that is strongly influenced by human activities. Prior to European settlement, the volcanic plains near Ballarat bore grasslands and grassy woodlands. These have been greatly diminished and fragmented by the combined impacts of grazing, cropping and urbanisation. However, there are still substantial remnants of mixed-eucalypt open-forest on nutrient-poor Ordovician soils, as well as plantations of Monterey Pine *Pinus radiata* and eucalypts.

Grasslands on volcanic soils are dominated by Common Tussock-grass *Poa labillardieri* or Kangaroo Grass *Themeda triandra*. Grassy woodlands on volcanic soils have an overstorey of Manna Gum *Eucalyptus viminalis* and Messmate *E. obliqua*. Mts Warrenheip and Buninyong, volcanic peaks of about 740 m to the east and south-east of Ballarat, retain their original dominant vegetation (*E. viminalis*/*E. obliqua*/*P. labillardieri*).

Many open-forests in the region (Fig. 1) are still regenerating after widespread clearance and soil disturbance during the gold rush and/or subsequent logging. Mixed-eucalypt open-forests on Ordovician soils typically include Messmate, Scent-bark *E. aromaphloia*, Narrow-leaf Peppermint *E. radiata* and Blackwood *Acacia melanoxylon*, with a diverse understorey of shrubby legumes (including many peas, family Fabaceae), forbs such as Wattle Mat-rush *Lomandra filiformis* and Grey Tussock-grass *Poa sieberiana*. In damper gullies, Manna Gum, Swamp Gum *E. ovata* and Yarra Gum *E. yarraensis* commonly form the canopy. The understorey includes Sweet Bursaria *Bursaria spinosa*, Slender Tussock-grass *P. tenera*, Soft Tussock-grass *P. morrisii*, Weeping Grass *Microlaena stipoides* and various sedges.

Butterfly fauna of the Ballarat region

Forty-five butterfly species from five families and 31 genera are now known,

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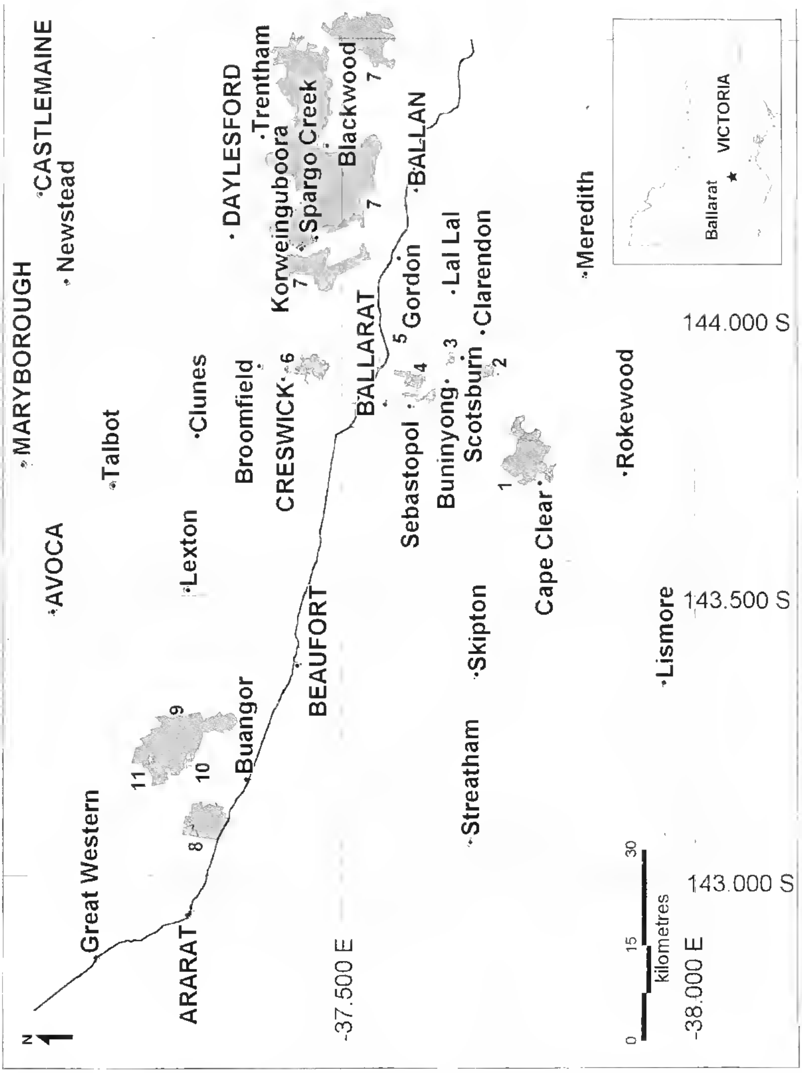

Fig. 1. The Ballarat Region, Victoria. Larger cities and towns are shown in capitals. Some Ballarat suburbs (Canadian, Delacombe, Mt. Clear, Mt. Helen, Mt. Pleasant and Wendouree) are not indicated. Key: 1 = Enfield State Park, 2 = Garibaldi State Forest, 3 = Mt Buninyong, 4 = Canadian bushland/plantations, 5 = Mt Warrenheip, 6 = Ballarat-Creswick Regional Park, 7 = Wombat State Forest, 8 = Langi Ghiran State Park, 9 = Mt Cole State Forest, 10 = Mt Cole, 11 = Ben Nevis. Map: M O'Keefe.

including the introduced Cabbage White *Pieris rapae* (Table 1). The most diverse families in the region are Nymphalidae and Lycaenidae, with 13 species each. Twenty-five species forage for nectar in urban parks and gardens, including 14 species that also breed there, outside vegetation remnants. Five of these make significant use of exotic vegetation as larval food plants and nectar sources. Most butterfly species occupy either forest understorey or open situations, including grasslands, pasture and gardens. Few species are associated with tree canopies.

Potential occurrences in the region

It is acknowledged that the small number of knowledgeable observers in the region is unlikely to have recorded all local species. Indeed, it is hoped that the publication of this paper will stimulate interest in the region's butterflies and increase the number of informed and interested lepidopterists. Cryptic and high-flying species, and those noted in Table 1 as localised and uncommon, are likely to be under-recorded. Further populations of some species will probably be discovered in suitable sites, particularly if intact habitat and larval foodplants are still widespread. This is likely to be the case with species dependent on *Oxalis* and *Gahnia*, for example. Species dependent on introduced *Citrus* and related genera are either uncommon for unknown reasons (e.g. Dainty Swallowtail *Papilio anactus*) or still in the process of extending into the area (e.g. Orchard Swallowtail *P. aegeus aegeus*). Citrus trees, with the exception of Lemons and Cumquats, are not widely grown near Ballarat because of the cold climate. Localised and uncommon species that hilltop (listed in Table 1) may be more effectively sought on the summits of prominent local hills and mountains. A number of species not recorded to date are likely to occur in the region. Some of these are known to hilltop. Table 2 lists some possible candidates.

The species listed in Table 2 may have escaped detection because they are localised and sedentary, rare, or fly high in the canopy. Others inhabit less well searched montane and damp, moist habitats that are more distant from Ballarat. Table 2 suggests that the most productive areas in which to search for further species in the region are hilltopping sites, damp montane forests and damp understoreys with *Gahnia* sedges. Promising localities to search for damp forest species include wetter parts of the Wombat State Forest (Trentham and Daylesford-Korweinguboora-Spargo Creek areas), Enfield State Forest and the Mt Cole/Ben Nevis region. The four lycaenids that require drier forests, woodlands and heathlands are all hilltopping species with associations between their larvae and ants. They may be most effectively detected on prominent hill summits near suitable plant communities that have relatively intact understoreys. Systematic searching during summer for the two possible vagrants (see Table 2) is unwarranted because of the low probability of encountering them.

Hilltopping

Hilltopping is a form of serial polygyny in which males attempt to attract females to their territory (lek) by displays. Butterflies assemble at prominent features on the landscape, the males seeking mates and courting. The hilltopping behaviour of species may differ according to available vegetation and in the location on the hilltop, height above the ground, time of day and time of year. After mating, females disperse to suitable habitats containing larval foodplants, where they lay their eggs (Common and Waterhouse 1981).

Males of some species tend to set up perching territories on the summits. Perching hilltoppers are capable of rapid flight. They may dart up quickly to investigate passing insects and then court potential mates or pursue rivals (F Douglas 2004 pers. comm. 10 June). They include smaller understorey species such as skippers (ochres *Trapezites* spp., Bright Shield-skipper *Signeta flammeata*), as well as lycaenids (e.g. some azures *Ogyris* spp., Rayed Blue *Candalides heathi heathi*). Larger hilltopping species may be camouflaged at rest (e.g. *Vanessa* spp., Marbled Xenicas *Geitoneura klugii klugii* and browns *Heteronympha* spp.). Butterflies such as the Tailed Emperor *Polyura sempronius* and some *Geitoneura* species have perching sites but also intermittently patrol a larger area (F Douglas 2004 pers. comm. 10 June).

Males of broader-winged species, adapted for gliding, are able to patrol suitable areas searching for females in an energy-efficient manner. They may do so over longer periods during the day than the perchers. These include swallowtails *Papilio* spp., the Forest Brown *Argynnina cyrila* and the Imperial Jezebel *Delias harpalyce*. Cabbage Whites tend to be quite mobile, ascending and patrolling mountains, but are not considered hilltoppers (Wainer and Yen 2000).

Mt Buninyong and Mt Warrenheip are significant for hilltopping butterflies, particularly those that are uncommon or widely dispersed or localised, such as the ochres *Trapezites* spp. and swallowtails *Papilio* spp. Wasps, hoverflies, and probably other insects, may also hilltop at these sites. Large numbers of dragonflies hawk for these hilltopping insects in the canopy at the summits. Both mountains have been proclaimed as scenic reserves. The Land Conservation Council, Victoria (1981) recommended that their management should aim to protect the relatively undisturbed native vegetation. This should also assist in conserving the local insect communities.

Table 1. Flight seasons and status of butterflies in the Ballarat Region. Status: H = historic record (pre-1990) only, current status unknown; R = rare; UC = uncommon; MC = moderately common; C = common; VC = very common; loc = localised; v = vagrant with few recorded local sightings; F = visit to feed on nectar (urban areas); BF = breed and feed on nectar (urban areas); nb = not breeding; ✓ = species recorded as hilltopping; x = species not hilltopping; Pe = territorial perching; Pa = patrolling behaviour; nb = species not breeding in the Ballarat region; Flight seasons: * = the flight season for the Ballarat region; # = flight season for Victoria recorded in Braby (2000); e = found early in the month; l = late in the month. Flight seasons are not provided for species in the Ballarat region for which insufficient information is available. Information for Ballarat flight seasons in Table 1 is summarised from field data collected by the author, Neil Hives, Fabian Douglas, David Crosby and Roger Thomas; also these references: Anderson and Spry (1893), Braby (2000), Thomas (1990a, 1990b, 1991, 1992a, 1992b, 1992c, 1993a, 1993b, 1993c, 1994, 1995, 1997a, 1997b, 1998).

Species in urban areas (Excludes species found in or near urban vegetation remnants)		**Status**	**Breed/ Feed**	**Hill-top? Perch/ patrol?**	**Flight season of adults** J	A	S	O	N	D	J	F	M	A	M	J
Family Hesperiidae (Skippers, Awls, Grass-darts)																
Heath Ochre	*Trapezites phigalia phigalia*	MC loc	F?	✓Pe			#	*#	*#	*#	#					
Montane Ochre	*Trapezites phigalioides phigalioides*	H loc		✓Pe				#	#	#*	#*	#				
Yellow Ochre	*Trapezites lutea lutea*	H loc		xPe				#	*#	*#	#	#	#			
Splendid Ochre	*Trapezites symmomus soma*	H loc		xPa/Pe						*	*#	*#	*#	*#		
Barred Skipper	*Dispar compacta*	MC	BF	✓Pa							*#	*#	*#	*#		
Bright Shield-skipper	*Signeta flammeata*	MC	F	✓Pe						#	*#	*#	*#	*#		
Varied Sedge-skipper	*Hesperilla donnysa patmos*	UC loc	F	xPe					*#	*#	*#	*#	*#			
White-banded Grass-dart	*Taractrocera papyria papyria*	C	BF	x? Pe					#	*#	*#	*#	*#	#*	#	
Green Grass-dart	*Ocybadistes walkeri sothis*	R loc	BF	x			#	#	*#	*#	*#	*?#	*?#	*?#	#	#
Family Papilionidae (Swallowtails)																
Dainty Swallowtail	*Papilio anactus*	UC	BF	✓Pa				* l	*#	*#	*#	*#	*#	#	#	
Orchard Swallowtail	*Papilio aegeus aegeus*	UC	BF	x				#	#	#	#	#	#	#		
Chequered Swallowtail	*Papilio demoleus sthenelus*	UC	nb?	✓Pa, nb	#	#	#	* l#	*#	*#	*#	*#	*#	#	#	#
Family Pieridae (Whites and Yellows)																
White Migrant	*Catopsilia pyranthe crokera*	R v	Fnb	x?, nb	#	*v#	#	#	#	#	#	#	#	#	#	#
Small Grass-yellow	*Eurema smilax*	R/UC	Fnb	x?, nb	#	#	#	*#	*#	#	#	#	*#	#	#	#
Narrow-winged Pearl-white	*Elodina padusa*	H v	nb	N/A					#	#	#		*v#	*v		
Caper White	*Belenois java teutonia*	MC/VC	Fnb	N/A	#	#	#	*#	*#	*#	*#	#	#	#	#	#
Imperial Jezebel	*Delias harpalyce*	UC/MC	BF	✓Pa	#	#	#	*#	*#	*#	#	*?#	*?#	*?#	#	#
Spotted Jezebel	*Delias aganippe*	UC/MC	F	xPa		#	#	*#	*#	*#	*#	*#	*#	*#	#	
Cabbage White	*Pieris rapae*	VC	BF	xPa	#	* l#	*#	*#	*#	*#	*#	*#	*#	*#	* e#	#

Species and status in urban areas		Status	Breed/ Feed	Hill-top? Perch/ patrol?	Flight season of adults J	A	S	O	N	D	J	F	M	A	M	J
Family Nymphalidae (Danaids, Browns, Nymphs)																
Silver Xenica	*Oreixenica lathoniella herceus*	C loc		xPc						*	*	*#	*#	*#	#	
Forest Brown	*Argynnina cyrila*	UC/MC	F	✓Pa		#	#	*#	*#	*?#	#					
Ringed Xenica	*Geitoneura acantha*	UC loc		xPa					*	*#	*#	*#	*#	*#	#	
Marbled Xenica	*Geitoneura klugii klugii*	C loc		✓Pc						*#	*#	*#	*#	*c?#		
Common Brown	*Heteronympha merope merope*	C	F	✓Pe			#	#	*l#	*#	*#	*#	*#	*#	*c#	
Shouldered Brown	*Heteronympha penelope sterope*	C	F	✓Pe							*#	*#	*#	*#		
Varied Sword-grass Brown	*Tisiphone abeona albifascia*	UC loc		✓Pa			#	#	* v#	*#	*#	*?#	*?#	#		
Tailed Emperor	*Polyura sempronius*	v		✓Pe					#	#	*v#	*v#	#	#	#	
Meadow Argus	*Junonia villida calybe*	MC	BF	xPc			#	#	*#	*#	*#	*#	*#	*#		
Yellow Admiral	*Vanessa itea*	MC	BF	✓Pc	#	* l#	*#	*#	*#	*#	*#	*#	*#	*#	#	#
Australian Painted Lady	*Vanessa kershawi*	C	BF	✓Pc/Pa		* l#	*#	*#	*#	*#	*#	*#	*#	*#	#	
Lesser Wanderer	*Danaus chrysippus petilia*	R v	BF	x				*#	*#	*#	*#	*#	*#	#		
Monarch	*Danaus plexippus plexippus*	R/UCv	BF	x	#	#	#	#	*#	*#	*#	*#	*#	*#	* e#	#
Family Lycaenidae (Blues, Azures, Hairstreaks, Coppers)																
Grassland Copper	*Lucia limbaria*	R/UC loc		x		#	#	#	#	#	#	#	#	#	#	
Bright Copper	*Paralucia aurifer*	R loc		x			#	#	* l#	*#	*#	*#	*e#			
Dark-purple Azure	*Ogyris abrota*	R loc		x				#	#	#	*#	#	#	#		
Satin Azure	*Ogyris amaryllis meridionalis*	H		x				#	#	*#	#	#	#	#		
Imperial Hairstreak	*Jalmenus evagoras evagoras*	UC loc	F	x					#	*#	*#	*#	*#	*c#		
Amethyst Hairstreak	*Jalmenus icilius*	H loc		x				#l	#	*#	#	#	#	#		
Silky Hairstreak	*Pseudalmenus chlorinda zephyrus*	R loc		x		#	#	*#	*#	*#	#					
Varied Dusky-blue	*Candalides hyacintha hyacintha*	H		✓Pc				#	#	#	#					
Rayed Blue	*Candalides heathi heathi*	R loc		x, nb?		#	#	#	#	#	#	#	#	#		
Two-spotted Line-blue	*Nacaduba biocellata biocellata*	UC/MC loc	F	x		#	#	#	*#	*#	*#	#	#	#	#	
Saltbush Blue	*Theclinestes serpentata*	H		x, nb		#	#	#	#	#	#	#	#	#	#	
Long-tailed Pea-blue	*Lampides boeticus*	UC/MC	BF	x	#	#	*#	*#	*#	*#	*#	*#	*#	*#	#	#
Common Grass-blue	*Zizina labradus labradus*	VC	BF	x	#	#	*#	*#	*#	*#	*#	*#	*#	*#	*c#	#

Historic Records

Eight species are known only from historic records (Table 1) and their current status in the region is unclear. One of these, the Narrow-winged Pearl-white *Elodina padusa*, is a rare vagrant that does not breed in the region. Two other species have larval foodplants that are not plentiful in the region. The larvae of the Varied Dusky-blue *Candalides hyacintha hyacintha* feed on the hemiparasitic dodder-laurels *Cassytha* spp. (Lauraceae), which are uncommon close to Ballarat. The Saltbush Blue *Theclinestes serpentata* is facultatively myrmecophilous. Its larvae feed on various chenopods (Chenopodiaceae). (Few chenopods are abundant locally, except for an introduced annual, Fat Hen *Chenopodium album*). The other three species are ochres *Trapezites* spp., discussed under 'Use of Urban Areas'. The Amethyst Hairstreak *Jalmenus icilius* has been recorded once (December 1982) at Kalimna Park, Castlemaine, in association with Wire-leaf Mistletoe *Amyema preissii* (Loranthaceae) growing on wattles (DF Crosby 2004 pers. comm.). The Amethyst Hairstreak is possibly a rare resident of northern areas. Other historic records are discussed under 'Vagrants' and 'Management Issues'.

Seasonal Changes in the Butterfly Community

Some early season butterflies (Yellow Admiral *Vanessa itea*, Australian Painted Lady *V. kershawi* and Cabbage White) arrive from late August, on days with northerly winds. These are later supplemented by locally emerging adults. Several other species are known only as uncommon vagrants or migrants. Most uncommon migrants, such as the Small Grass-yellow *Eurema smilax*, arrive in October and November in association with greater, but highly variable, numbers of the Caper White *Belenois java teutonia*. In some years during the mid-late 1980s there were sufficient Caper Whites appearing suddenly in spring to prompt media attention. Numbers of migrant species have been very low since the mid-1990s, possibly because a lengthy drought produced an extended series of poor breeding seasons in their area of origin. Prevailing winds can also influence the number of migrants arriving in an area, but this possibility has not been investigated. Smaller numbers of migrants appear in late summer and autumn.

Butterfly abundance and diversity increase through spring and summer. Late summer-autumn butterflies include four skippers and two nymphalids (Shouldered Brown *Heteronympha penelope sterope* and Silver Xenica *Oreixenica lathoniella herceus*), which tend to breed in gullies, forest understoreys, clearings and forest margins. All but the last species venture outside forested areas to forage for nectar. Dense forests and pine plantations are occupied only during the warmest months, mostly by female Common Browns *Heteronympha merope merope*. Butterfly numbers and diversity eventually decline as nights become cooler in April.

Influence of the Cool Climate

The Ballarat region has a cool climate because of its altitude and inland location. Nights and winters are colder than those of Melbourne because temperatures are not moderated by the ocean. As a result, many butterflies in the Ballarat region have shorter flight seasons than those in Melbourne or Victoria generally. Species such as the Imperial Hairstreak *Jalmenus evagoras evagoras* may have fewer generations per year than elsewhere because of the shorter warm season. Early season species either disperse into the region from warmer areas to the north or emerge later than lowland individuals. Few late-season species survive past April. Apparently no butterflies overwinter as adults: none is seen after the onset of cold weather and frosts in early May, even on occasional sunny winter days.

Adults of three species require cool, moist and sheltered conditions: Splendid Ochre *Trapezites symmomus soma*, Silver Xenica and Ringed Xenica *Geitoneura acantha* (Braby 2000). In the Ballarat region, they often dwell in sheltered gullies where their larval foodplants are less desiccated. Silver Xenicas are also found in the cooler and moister conditions of the summits of Mts Buninyong and Warrenheip. The Ringed Xenica is known from sheltered gullies (e.g. around the Union Jack Creek bridge, Buninyong) but

Table 2. Potential occurences in the Ballarat Region. This table is compiled from suggestions supplied by Fabian Douglas. Notes on larval food plants, adult flight periods for Victoria, behaviour (e.g. hilltopping) and habitat preferences are based on Braby (2000). Distributions of plants in the Ballarat region follow Gullan (2002).

Species	Larval foodplant	Flight period (Vic.), likely status. Local occurrence of foodplants
Montane Sedge-skipper *Oreisplanus perornata*	Saw-sedges *Gahnia*, including Red-fruited Saw-sedge *G. sieberiana* and Thatch Saw-sedge *G. radula* (Cyperaceae)	October – April. Possible resident. Populations are localised. *G. sieberiana* grows in state forests to the SW, S and E of Ballarat, including Canadian State Forest. *G. radula* is also widespread, particularly to the N, E and S of Ballarat, often in drier forests than those inhabited by *G. sieberiana*.
Spotted Sedge-skipper *Hesperilla ornata ornata*	Saw-sedges *Gahnia* and tassel-sedges *Carex* (Cyperaceae)	October – April. Possible resident. Populations are localised. A hill topping species that both perches and patrols in the afternoons. Both sedge genera are widespread in damp habitats.
Heath Sand-skipper *Antipodia (Hesperilla) chaostola chares*	Saw-sedges *Gahnia* (Cyperaceae)	October – December. Possible resident.Populations are rare and localised, often in moist heathlands or sparse eucalypt forest. *G. radula* and *G. sieberiana* both grow in the region (as above).
Lemon Migrant *Catopsilia pomona pomona*	Cassias *Senna* (Caesalpinaceae)	Summer. Possible vagrant. Tropical species, occasionally irrupting to scattered Victorian localities. Cassias are not local native plants. Both exotic and native cassias are cultivated occasionally.
Yellow Albatross *Appias paulina ega*	Yellow Tulip *Drypetes deplanchei* (Euphorbiaceae) and possibly Dog Caper *Capparis canescens* (Capparidaceae)	Summer. Possible vagrant. Occasionally disperses during summer to eastern and central Victoria. Neither foodplant occurs locally.
Striped Xenica *Oreixenica kershawi kershawi*	Grasses, including tussock-grasses *Poa* and Forest Wire-grass *Tetrarrhena juncea* (Poaceae)	December – April. Possible resident of montane forests. May occur in the Mt. Cole/BenNevis region. *Poa* spp. are widespread. *T. juncea* grows in wetter forest understoreys S and E of Ballarat and (NW) in the mountainous area noted.
Spotted Brown *Heteronympha paradelpha*	Soft grasses, e.g. Weeping Grass *Microlaena stipoides*, Slender Tussock-grass *Poa tenera*.	January – April. Possible resident. Known from Mt. Buangor and Macedon. Mountains and foothills. Found in shady moist forests. A patrolling species with an erratic flight close to the ground. Larval foodplants are common forest understorey species.
Solander's Brown *Heteronympha solandri*	Native grasses, including tussock-grasses *Poa* spp. (e.g. Common Tussock-grass *P. labillardieri*), Forest Wire-grass *Tetrarrhena juncea*	December – April. Possible resident. Found in montane forests and woodlands, including Mt. Cole and Mt. Buangor, usually above 500-600 m. Inhabits cool moist habitats. Powerful erratic flight within a few metres of the ground. *Poa* spp. and *T. juncea* are common in suitable habitats.
Bright-eyed Brown *Heteronympha cordace cordace*	Tall Sedge *Carex appressa* (Cyperaceae)	November - March. Possible resident of wetlands or damp sites, e.g. swampy areas and near creeks. Recorded at Mt. Buangor (Braby 2000) and Mt. Cole (DF Crosby 2004 pers. comm.). Slow meandering flight close to the ground. Tall Sedge is widespread in suitable damp habitats in the region.

Species	Larval foodplant	Flight period (Vic.), likely status. Local occurrence of foodplants
Moonlight Jewel *Hypochrysops delicia delicia* (*H. d. delos*)	Wattles, especially Late Black Wattle *Acacia mearnsii* and Blackwood *A. melanoxylon*, but also Early Black Wattle *A. decurrens* and Silver Wattle *A. dealbata* (Mimosaceae)	November - March. Possible resident. A hilltopping species that flies rapidly at tree top level in the afternoon, usually late. Localised breeding colonies. Found in drier eucalypt forests and woodlands on the slopes and foothills. The Moonlight Jewel has an obligate relationship with *Crematogaster* ants. *A. decurrens* is widely planted, while the other species listed are common native species in forests of the Ballarat area.
Fiery Jewel *Hypochrysops ignita ignita*	Many species of wattles, especially Golden Wattle *Acacia pycnantha* and Early Black Wattle *A. decurrens* (Mimosaceae), also Daphne Heath *Brachyloma* (Epacridaceae), hopbushes *Dodonaea* (Sapindaceae), pomaderris *Pomaderris* (Rhamnaceae), some eucalypts *Eucalyptus* (Myrtaceae).	December – early March. Possible resident. Sparse in temperate areas. The Fiery Jewel has an obligate association with *Papyrius* ants. Hilltopping species, usually seen early and mid-afternoon. A locally common species in drier eucalypt woodlands, open-wood lands and heathlands. Many of the foodplants occur locally. (Refer to Gullan 2002.)
Broad-margined Azure *Ogyris olane ocela*	Mistletoes, especially Drooping Mistletoe *Amyema pendula* and Box Mistletoe *A. miquelii*. (Loranthaceae)	September - May. Possible resident. Some larvae are attended by ants of several genera. A hilltopping species, flying at treetop level from late morning to late afternoon. Found in drier eucalypt open-forests and woodlands. Both mistletoes occur in the region, the former being the more common.
Fringed Heath-blue *Neolucia agricola agricola*	Flower buds and flowers of some members of the pea family (Fabaceae), including Aotus *Aotus*, bossiaeas *Bossiaea*, bitter-peas *Daviesia*, parrot-peas *Dillwynia*, Eutaxia *Eutaxia* and bush-peas *Pultenaea*.	September – February? Possible resident. A hilltopping species that flies rapidly close to the ground. Larvae are sometimes attended by *Iridomyrmex* ants. Found in heathlands or the heathy understorey of woodlands. Shrubby and herbaceous species of Fabaceae are common understorey plants in local forests, in particular *Bossiaea*, *Daviesia*, *Dillwynia* and *Pultenaea*.

not from the mountains. Crosby (1998) described the Ringed Xenica as non-alpine at Mt Buffalo because it frequented shady damp areas around the base of the mountain but not higher altitudes. The three species emerge earlier than lowland adults, probably facilitated by Ballarat's cooler summer. There are insufficient local records of the Splendid Ochre to comment on its distribution near Ballarat. It is likely to be uncommon because its larval foodplant, Spiny-headed Mat-rush *Lomandra longifolia*, is not abundant close to Ballarat. A recent trend towards landscaping with this plant may provide more opportunities for this and other species. Splendid Ochres fly from December to April, Silver Xenicas from late December until April, while Ringed Xenicas fly from November to April.

Use of Urban Areas

Most of the common urban butterflies are not sedentary and feed on nectar from garden plants and weeds. Some lay eggs on weeds and cultivated plants, including grasses, legumes, plantains, nettles and daisies. In some cases, there is a correlation between watering and butterfly abundance: in the early 1990s, Common Grass-blues *Zizina labradus labradus* were more abundant in gardens with watered lawns than those left dry. Current restrictions preventing the watering of lawns in Ballarat have diminished the numbers of this species.

Long-flowering exotic plants with taproots, such as Smooth Catsear *Hypochoeris glabra* and Hairy Hawkbit *Leontodon saxatilis*, continue to produce nectar and attract butterflies through late summer and autumn when few native plants (apart from

Sweet Bursaria and Messmate) are flowering in habitat remnants. The two exotics mentioned often penetrate remnant understoreys.

Butterflies breeding in urban areas include amongst their larval foodplants introduced species that are cultivated or associated with disturbance. Grass-feeding larvae of the White-banded Grass-dart *Taractrocera papyria papyria* and Green Grass-dart *Ocybadistes walkeri sothis* include exotic grasses in their diet and appear to benefit from luxuriant grass in urban areas. Australian Painted Ladies are more common in gardens (especially cottage gardens) and pastures than in remnants with native daisies. Ongoing summer watering of nectar and foodplants, enabling them to remain turgid, may permit this and other multivoltine garden species to continue producing rapidly developing further generations over summer. The Meadow Argus *Junonia villida calybe* was found to be associated with disturbed sites and exotic plantains *Plantago* spp. rather than the native Varied Plantain *P. varia*. The larvae are also often found on centaury *Centaurium* spp. (Gentianaceae), common pink-flowered weeds represented by three species in the region. Centauries are able to grow in disturbed and bushland situations too dry for plantains. Yellow Admirals show a preference for laying eggs on exotic annual stinging nettles (Small Nettle *Urtica urens*) rather than on the perennial native Scrub Nettles *U. incisa*, as demonstrated by choice experiments (Harris 1993). The former is a weed of damp rich soils, including well-manured pastures, volcanic soils, stockyards at Delacombe and gardens in urban Ballarat, while the latter grows in riparian vegetation (e.g. below Lal Lal falls). The Lesser Wanderer *Danaus chrysippus petilia* and Monarch *D. plexippus plexippus* are able to breed in the region only because butterfly fanciers cultivate (frost-tender) Swan Plants *Asclepias* spp. in more protected locations to attract them.

Suburbs lacking remnants (e.g. Wendouree) tend to have less rich butterfly communities. However, even quite small vegetation remnants in urban areas contain rich butterfly communities, provided the understorey is largely intact. Dense shade is inimical to understorey plants and is avoided by most butterflies except at the height of summer. Sunny glades in open-forest seem to promote species richness, as demonstrated by the experimental creation of a glade in the University of Ballarat Regional Arboretum, Mt Helen, although they also increase butterfly observability. Particularly rich remnants include those along track margins in the Canadian State Forest, Webbs Hill Rd, Buninyong, Wombat State Forest and Tinworth Avenue, Mt Clear. Remnants with retained older trees (e.g. in Peady St Reserve, Mt Pleasant, University of Ballarat Regional Arboretum, Mt Helen, Union Jack Creek reserve and Webbs Hill Rd, Buninyong) may contain the locally uncommon Dark Purple Azure *Ogyris abrota* and the Silky Hairstreak *Pseudalmenus chlorinda zephyrus* and Imperial Hairstreak *Jalmenus evagoras*. All three require bark or wood crevices for at least one of the following activities: egg deposition, larval sheltering and pupation.

Cabbage Whites undergo several generations during their long flight season, becoming very abundant by autumn. They are especially common around canola crops and stands of cruciferous weeds such as *Brassica*, *Raphanus*, *Rorippa* and *Capsella*, but also frequent gardens with cruciferous vegetables or weeds.

Some species do not use urban areas (Table 1), and are confined to the vicinity of native vegetation remnants. These include:

- Those whose larvae largely or exclusively eat local native plants (most skippers except the grass-darts, Chequered Swallowtail *Papilio demoleus sthenelus*, Silver Xenica, Ringed Xenica, Forest Brown, lycaenids except the Long-tailed Pea-blue *Lampides boeticus* and Common Grass-blue);
- Those whose larvae feed on moist grasses or mat-rushes in sheltered sites over the warmer months (as described below);
- Those using leaf litter for larval shelters or pupation sites (ochres and other skippers);
- Those relying on adult camouflage against leaf litter (some nymphalids);
- Sedentary and localised species (designated 'loc' in Table 1; mainly hesperiids);

- Those having obligate relationships with ants. Many lycaenids have these relationships. The exceptions are either non-myrmecophiles (*Candalides* spp.) or facultative myrmecophiles (Long-tailed Pea-blue, Common Grass-blue);
- Forest understorey species (ochres *Trapezites* spp.; xenicas *Oreixenica*, *Geitoneura* spp.) that are sedentary and form localised colonies do not use urban areas except in the immediate vicinity of bushland remnants. The three ochres (Montane Ochre *Trapezites phigalioides phigalioides*, Yellow Ochre *T. lutea lutea* and Splendid Ochre *T. symmomus soma*) all form localised colonies and depend on leaf litter or tussock bases as larval shelters and pupation sites. The larvae feed on mat-rushes. The ochres may be locally rare or extinct because of habitat loss or understorey disturbance. The Yellow Ochre is discussed further under 'Management Issues'. Montane Ochres may be present but mistaken for the moderately common Heath Ochre *T. phigalia phigalia*. *Geitoneura* adults depend on camouflage against a background of leaf litter. Two of the xenicas, Ringed Xenica and Silver Xenica, have grass-feeding larvae and require moist sheltered conditions where grasses do not desiccate severely over summer.

Vagrants

Five vagrant species are listed in Table 1. The Monarch or Wanderer *Danaus plexippus plexippus* is recorded from gardens in Lismore, Avoca, Creswick, Broomfield and Ballarat. (Thomas 1992a, 1993a, 1993b, 1997a) although doubtless it travels widely and appears elsewhere. The same applies to the Lesser Wanderer, which is recorded from Creswick (Thomas 1997b) as well as Ballarat (University of Ballarat campus, Mt Helen). Both wanderers occur sporadically in small numbers and are not seen every year. The larvae of both feed on Swan Plants or Milkweeds, usually the South African species *Asclepias pubescens* and *A. fruticosa* (Asclepidaceae). The latter, though somewhat frost-tender, is sometimes available in local nurseries. Both wanderers apparently breed occasionally in the region.

The Tailed Emperor was first recorded in the Ballarat region during February/March 2001. A dead gravid female was discovered in the Rainforest Garden at the University of Ballarat, Mt Helen, near planted specimens of two larval foodplants, Flame Tree *Brachychiton acerifolium* and Kurrajong *B. populneus* (Sterculiaceae). The species is known to disperse widely and occasional records are noted from Victoria (Braby 2000). The Tailed Emperor has a wide range of larval foodplants, mostly legumes, but also kurrajongs and other rainforest trees (Braby 2000). The female may have dispersed from a small colony that was discovered in Castlemaine in 1993 and persisted for at least four years. Several members of the Castlemaine Field Naturalists' Club reported Tailed Emperors in Castlemaine in 2001 (R Thomas 2001 pers. comm. 10 March). Butterflies in that population favoured Silver Wattle *A. dealbata* and Cootamundra Wattle *A baileyana* (Mimosaceae) as larval foodplants (R Thomas 2001 pers. comm. 10 March, quoting Gary Sobey, proprietor of 'Skydancers' butterfly farm in Castlemaine). Mr Sobey is also aware of unpublished sightings of the species in Stawell, Maldon and Bendigo. Males have been observed hilltopping at Mt Piper, Broadford, and Mt Paps, Mansfield (D. Britton 2004 pers. comm.).

Management Issues

Sands and New (2002) evaluated the conservation status of Australian butterflies, considered the threatening processes involved and proposed an action plan to address these processes. None of the species recorded for the Ballarat region is listed as a threatened taxon in Victoria, although subspecies of three are listed for other states.

The Yellow Ochre has previously been noted in Beaufort, Mt Clear and Buninyong (Thomas 1990b). This species has a very brief flight period at any one site, is effectively camouflaged at rest, and thus is easily overlooked. It does survive in lightly grazed habitats, and may even benefit from having grass cover removed from around the larval foodplant (Wattle Mat-rush). Thomas (1992a) records a sighting of the Yellow Ochre from Creswick late in the nineteenth century. It was also observed in the 1980s at the Buninyong cemetery (1981), the Canadian gully near Hocking Avenue, Mt Clear (1980), Beaufort (1981), 3.5 km east of Beaufort (1981) and on a roadside on a hill behind Castlemaine East High School (1987) (DF Crosby 2004 pers. comm.). In addition, hilltopping Yellow Ochres were observed in territorial disputes with Montane Ochres on a hill south of Chewton, near Castlemaine, on the Dingo Farm turnoff (DF Crosby 2004 pers. comm.). The fate of most of these populations is unknown. However, the Yellow Ochre may have been eliminated from the Buninyong cemetery during the 1990s because of an expansion of gravesite/ mown lawn areas, as well as more intensive mowing and extensive tidying operations by the Friends group. This needs to be verified. Mowing has significantly altered the structure and composition of the remnant grassland, which is dominated by Kangaroo Grass. The larval foodplant and nectar sources such as riceflowers *Pimelea* spp. and native daisies are now confined to relatively small areas at the periphery of the site and are kept low by mowing. Scarcely any native grassland survives outside the cemetery. Other small cemeteries with remnant grasslands that include Wattle Mat-rush (e.g. at Clarendon) would be worth searching for this and other species dependent on the groundcover flora. Cemeteries in towns not subjected to large population increases are likely to have better preserved grassland flora and fauna.

The Green Grass-dart has recently been seen in urban gardens in Ararat (2000, 2001, 2004), Mt Clear (2002) and Mt Helen (2004) between November and January, although it probably flies until about April. In each instance, only one individual was seen foraging for nectar. It appears that this species has established in small numbers in both Ararat and Ballarat. The grass-eating larvae are known to disperse in instant turf and may have originated in Sydney (Braby 2000), although they also appear to have separately extended their range, spreading along the Murray valley and into the Victorian Mallee and Wimmera as early as the mid-1980s (F Douglas 2004 pers. comm.). However, the Ballarat climate is cooler and wetter than that of these areas. The Green Grass-dart tends to form small, localised colonies, often where the White-banded Grass-dart is also found. Its caterpillars require broad-bladed grasses that remain green over summer (F Douglas 2004 pers. comm.). Suburban gardens, with Panic Veldt-grass *Ehrharta erecta*, bromes *Bromus* spp. and various lawn grasses, are close to local sightings. Sites with suitable grasses may be more restricted in occurrence beyond urban areas, but might include gullies, riparian vegetation and stands of Kangaroo Grass.

The Chequered Swallowtail is a widely distributed and abundant migrant, but seldom reaches southern Victoria (Braby 2000). Its larvae feed on scurf-peas or Psoraleas *Cullen* spp. (Fabaceae). Small numbers of Chequered Swallowtails were discovered during the early 1990s, patrolling stands of Mountain Psoralea *C. adscendens* on the summit of Mt Warrenheip. They may breed there regularly or more likely re-establish at intervals via migrants. Similar but smaller stands at the summit of Mt Buninyong are not known to be used. Before the early 1990s, Mountain Psoralea was not known to be suitable for Chequered Swallowtail larvae. Plants grown from seeds obtained at the Mt Warrenheip site were supplied to Melbourne Zoo's Butterfly Department. The curator reported that Chequered Swallowtails in the Butterfly House laid eggs on the plants. The larvae completed all instar stages and successfully pupated (N Dowsett 1993 pers. comm. 22 June).

Chequered Swallowtails are at risk from the establishment of communications towers at the summit of Mt Warrenheip. A commercial FM transmitter erected in the 1990s largely eliminated the biggest patch of Mountain Psoralea at the site. Although Mt Warrenheip is a scenic reserve, it is sparingly managed. The absence of fire has caused tussocks of Common Tussock-grass to close over, severely restricting the intertussock spaces required by Mountain Psoralea and other forbs. (The species regenerated well from the soil seed bank following a small fire started by lightning in the mid-1990s.) Forget-me-not *Myosotis sylvatica* is invading intertussock spaces in damper parts of the summit, but prefers damper and more shaded habitats than Mountain Psoralea.

Weed invasion of habitat remnants is common, particularly in volcanic soils and the richer, damper soil of gullies. Dry ridges and slopes are often comparatively weed-free. Many gullies are heavily infested with blackberries *Rubus* spp. These outcompete larval foodplants such as Slender Tussock-grass, Soft Tussock-grass, Weeping Grass, Hairy Rice-grass *Tetrarrhena distichophylla*, Forest Wire Grass *T. juncea* and wallaby-grasses *Austrodanthonia* spp. Many browns and skippers are disadvantaged by weedy gullies, especially those requiring summer shelter and moisture or larval foodplants (e.g. sedges and grasses) that do not desiccate over summer and early autumn. The Varied Sword-grass Brown *Tisiphone abeona albifascia* provides an example. In this region it is known from a vagrant in Mt Helen and two localised populations, one near Mt Buangor and the other, discovered in 2004, 2 km SW of Spargo Creek (pers. obs.). Both colonies are associated with drainage lines and wet gullies containing Red-fruited Saw-sedge *G. sieberiana*, the principal larval foodplant. Other potentially suitable habitats exist within several kilometres of both sites, although their size and quality vary. There is circumstantial evidence to suggest that the butterfly is capable of at least short-range dispersal, perhaps also occurring as a vagrant over larger distances (F Douglas 2004 pers. comm.). Consequently, the butterfly could discover and use surrounding patches of the sedge. Some gullies appear too dry to support many sedges. Other, damper gullies with richer soils, often near farmland, may be overgrown with blackberries. Red-fruited Saw-sedge has been almost eliminated over the past decade in two gullies near Spargo Creek as blackberries proliferated. This has permanently diminished opportunities for local colonisation of the most suitable sites by Sword-grass Browns, perhaps jeopardising the local metapopulation. The species may eventually be confined to smaller patches of foodplants in suboptimal sites.

The Grassland Copper *Lucia limbaria* was noted in pastures above the Woady Yaloak River to the west of Cape Clear (Thomas, 1992c), near the south-western edge of the Enfield State Forest. It was seen with Common Grass Blues in early March 1992, but was difficult to observe because of windy conditions. The species was also recorded in March from near Newstead (Thomas, 1993b). The number of individuals seen is not recorded. As suggested by the common name, this species is found in open pastures and grassy plains. Its caterpillars feed on prostrate native wood-sorrels, the Shady Wood-sorrel *Oxalis exilis* and Grassland Wood-sorrel *O. perennans* (Oxalidaceae), previously listed under the exotic species Yellow Wood-sorrel *O. corniculata* (Braby 2000). These wood-sorrels are found widely in the region, even in somewhat disturbed grassy habitats and pastures. However, the butterfly tends to form small and often transient colonies (Douglas and Braby 1992) that may be widely separated. They may thus take a lot of effort to find. The larvae feed at night and have an obligate relationship with small black ants (*Iridomyrmex* species, *gracilis* group or *rufoniger* group) (subfamily Dolichoderinae) (Braby 2000). The ants tend them by day in galleries in the soil beneath the foodplant. They pupate in these galleries.

Populations of the Grassland Copper tend to be temporary and sporadic, although they may persist even in degraded or disturbed areas provided the ant and foodplants remain (Braby 2000). Given the fragmented and degraded state of many grasslands in the region, these two sightings should be followed up. Observations are needed to determine whether the populations are still extant or if new ones have formed. The size of any that currently exist should be estimated. Management issues should be identified and addressed.

The Bright Copper *Paralucia aurifer* is recorded from only one location, along roadside verges of Webbs Hill Rd, Buninyong, on the margin of the Garibaldi Forest. There are two generations annually, a smaller one in November-December and a larger one in late January-March. A small black ant, *Anonychomyrma* sp. (*nitidiceps* group) (subfamily Dolichoderinae) attends the Bright Copper (Braby 2000). Ant colonies and Bright Coppers are invariably associated with stunted shrubs of Sweet Bursaria in drier and more sunlit locations. Foraging adults rarely travel more than 20 m from the colony, limiting their access to scattered Sweet Bursaria stands. This reduces the likelihood of new colonisations or recolonisation of stands with the appropriate ants. The Webbs Hill Rd population may be at risk from roadside grading, road widening, slashing or tilling for fire prevention or the spraying of woody weeds. Some locals mistakenly believe that Sweet Bursaria is a weed because it is a spiny shrub. It may be sprayed in any case because the roadside stands are interspersed with Gorse *Ulex europaeus* and Blackberry.

The forest-dwelling Silky Hairstreak is considered rare in Victoria (Braby 2000) and the species has undergone a serious decline in Tasmania (Couchman and Couchman 1977). It frequents wattles, including Blackwood, Late Black Wattle *A. mearnsii* and Silver Wattle and pupates under the bark of nearby trees (Common and Waterhouse 1981). The Silky Hairstreak is associated with the Forest Black Cocktail Ant *Anonychomyrma biconvexa* (formerly *Iridomyrmex foetans*, subfamily Dolichoderinae) that forms colonies in tree trunk heartwood or the ground layer. Understorey clearing (Prince 1988) and other processes (New 1990) may disadvantage both ant and butterfly. Small, localised populations of the Silky Hairstreak have been found to the south-east of Ballarat. Adults were first seen in the region between 1996 and 1998, on the margin of the Garibaldi Forest at Webbs Hill Rd, Buninyong, and at the University of Ballarat Regional Arboretum (pers. obs.). Three pupae were located at the summit of Mt Buninyong in February 1998. They were found under the loose bark of a Manna Gum growing beside a large Blackwood. These pupae were reared, with adults emerging in spring (F Douglas 1999 pers. comm.). Prior to this, the species was known in Western Victoria only from the Grampians and sites east of Gisborne (Common and Waterhouse 1981). However, Braby (2000) gives some additional localities for this species in the Ballarat region, including Mt Buangor State Park, Trentham Falls, the Wallace-Gordon district, Korweinguboora and Bullarto South.

The Amethyst Hairstreak is recorded in the region only from adults and pupae collected in December 1982, 3.5 km east of Beaufort at a bend in the Langi Kal Kal Road (DF Crosby 2004 pers. comm.). They were closely associated with a roadside stand of Late Black Wattle, now felled for unknown reasons. Although roadside verges can preserve some local native plants and their fauna, they are not necessarily secure from a variety of damaging processes.

Drier understoreys in many Ballarat remnants bear dense stands of exotic shrubby peas (brooms *Cytisus* and *Genista*, Furze or Gorse). These can exclude most other understorey plants and contribute long-lived seeds to the seed bank. As some consolation, the Long-tailed Pea-blue uses them as larval foodplants. Ironically, butterflies are attracted to the nectar, pollinating shrubs that are stifling the understorey. Remnants adjacent to pine plantations (e.g. Tinworth Avenue, Mt Clear and parts of Canadian State Forest) are colonised by pine seedlings. In the absence of fire, these mature to provide dense shade and more seeds. By degrees, the understorey is obliterated by shading. Volunteering pine seedlings must be removed from high quality butterfly habitat or the understorey should be burnt at intervals, before young pines cast substantial shade or litter and prior to their setting seed.

In summary, management for native butterflies in the region is primarily a matter of habitat management. Habitat degradation, fragmentation and loss occur as a result of agriculture and urban development, weed invasion, infrastructure works and detrimental activities on roadsides and other public land. Some species in the region are too poorly documented to permit the development of management strategies.

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Donald Bruce Foreman
1945-2004

Although not an FNCV member, Don Foreman had a connection with the Club through his position on the Australian Natural History Medallion General Committee, as a representative of the Toowoomba Field Naturalists Club. Don also influenced many Club members with an interest in botany through his work at the Royal Botanic Gardens Melbourne from 1984-1997, initially as Botanist and later Collections Manager. Born in Trangie, NSW, and educated at the University of New England, Don initially worked as a forest botanist in Papua New Guinea and then as a lecturer in the Botany Department at UNE.

At RBG Melbourne Don carried out taxonomic studies on Proteaceae and Monimiaceae, and was the author of a publication on Victorian *Isopogon* and *Petrophile* in *The Victorian Naturalist.* In addition, Don co-edited the introductory volume of *Flora of Victoria* (which remains a very valuable resource on a variety of facets of Victoria's flora) and was editor of *Muelleria*, journal of the National Herbarium of Victoria. Don introduced a computer database system of information on the herbarium specimens, laying valuable groundwork for the current Australian Virtual Herbarium project, which will see data on all Australian plant specimens in the Herbarium database and available over the internet. Don later worked in Canberra on the *Flora of Australia,* then in a gardening business, and not long before his death was Botanist in Residence at the Geelong Botanic Gardens (the first botanist at these Gardens in its 152 year history). Don was widely respected for his knowledge, patience and willingness to help others.

A detailed obituary for Don by Neville Walsh appeared in *Australian Systematic Botany Society Newsletter* 199, which also contains an appreciation by Barry Conn of Don's time in Papua New Guinea.

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Feasibility study for the use of small format large-scale aerial photography for vegetation condition assessment in north-west Victoria

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Abstract
Vegetation condition assessments are increasingly being undertaken across Victoria but have largely focused on field techniques. This study compared field techniques with small format large-scale aerial photography for vegetation condition assessment of semi-arid woodland in the Murray-Sunset National Park (north-west Victoria). Aerial photograph interpretation was undertaken using on-screen digitising, and supervised and unsupervised classifications, to determine cover of individual trees, tree condition, identification of tree species, and percentage cover of the tree canopy, bare ground and ground cover. Accuracy assessments were performed for each variable and relative costs for field survey and aerial photography interpretation were calculated. Costs were similar for field survey and aerial photography. Percentage cover of the tree canopy was reliably determined from aerial photography analysis (R^2 = 0.91 on screen digitising, R^2 = 0.78 supervised classification). However, percentage cover of bare ground, ground cover and tree condition were not reliably assessed from aerial photography. (*The Victorian Naturalist* **122** (1) 2005, 35-46).

Introduction

Vegetation condition assessment is increasingly being used as a tool for monitoring vegetation that has been subject to disturbance. The National Framework for the Management and Monitoring of Australia's Native Vegetation (DNRE 2002) has highlighted vegetation condition assessment as an essential component of native vegetation management. Condition assessments have been used since the early 1900s for monitoring rangelands (Dyksterhuis 1949), and are increasingly being developed as an assessment tool in Victoria to assess impact of disturbances, particularly grazing within National Parks (e.g. Miller *et al.* 1998; Gibson *et al.* 1999; Westbrooke *et al.* 2001; Gowans and Westbrooke 2002; Leversha and Gowans 2003).

Smith (1989) provides a useful definition of condition for rangelands, which is applicable to other vegetation types and land uses, stating:

> [Condition] is not a characteristic … which can be measured directly. Attributes such as plant cover or density, standing crop, soil texture, can be measured or estimated in the field. Trend in these parameters over time can be measured. Range condition, however, is an interpretation of these data in light of what is assumed to be possible or desirable. The selection or weighting of attributes chosen for measurement reflects the values and objectives of the person or agency making the evaluation.

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The definition suggests the condition of vegetation is influenced and defined by the goals and ideals of the assessor and may be described in good or poor condition dependent on their views. Therefore, it is possible that vegetation may be in good condition for one goal, but poor condition for another. For example, vegetation may be in good condition for stock grazing, but poor condition for habitat of a threatened species. This has implications for design of condition assessments, which must relate to management goals and identified issues for a site.

Field survey has long been the traditional method for condition assessment; however, remotely sensed data are increasingly being used for vegetation condition monitoring. The first aerial photographs were taken in 1885 from a hot-air balloon in France (Mikhail and Bethel 2001) and by 1913, aerial photographs began to be used for mapping purposes (Wolf and Dewitt 2000). Aerial photography was used extensively for topographic mapping between the first and second World Wars, and rapid advancements since have led aerial photography to become indispensable as a tool for vegetation mapping and monitoring (Wolf and Dewitt 2000).

Progress in aerial photography has led to the development of standardised cameras and techniques; however, there is substantial additional cost involved in the use of this specialised equipment (Warner *et al.* 1996). Small format aerial photography

(SFAP) provides a low-cost alternative to standard aerial photography. The format size of the camera refers to the dimensions of the film or charge-coupled device (CCD) (Warner *et al.* 1996). A metric aerial survey camera uses a 230 mm square format, whereas SFAP utilises standard cameras with smaller formats (e.g. the common 35 mm), with the main advantages being cost and flexibility (Warner *et al.* 1996; Rowe *et al.* 1999; Abd-Elrahman *et al.* 2001). Small format cameras are considerably cheaper to purchase than metric cameras, and are also lighter and cheaper to mount within single engine light aircraft which are commonly employed for this type of imagery (Rowe *et al.* 1999). SFAP allows for flexible image acquisition. The camera can either be hand-held for oblique photography, or mounted in the undercarriage for vertical photographs. The date of imagery acquisition can be chosen, leading to greater flexibility with weather conditions (Warner *et al.* 1996; Rowe *et al.* 1999). Colour and colour infrared photography are also easily obtainable with SFAP (Warner *et al.* 1996).

The main limitations of SFAP occur through the use of standard cameras without lens calibration, or film flattening devices, leading to potential for image distortion (Warner *et al.* 1996). In addition, positional accuracy may be low in relation to the high resolution of these images (Abd-Elrahman *et al.* 2001). Despite these limitations, SFAP has been used for a number of vegetation mapping projects, and has been adopted for monitoring purposes in the forestry industry (Warner 1994; McCormick 1999; Rowe *et al.* 1999; Abd-Elrahman *et al.* 2001).

Techniques for monitoring forestry and rangeland productivity have been widely published (Smith and Woodgate 1985; Tickle *et al.* 1998; Taube 1999; Wallace and Thomas 1999; Hyyppa *et al.* 2000; Pickup *et al.* 2000). However, few studies have utilised aerial photography for vegetation condition assessment in conservation reserves (e.g. Wallace and Furby 1994; McCormick 1999; Callister 2004).

The objectives of this research were to:

(i) investigate suitable techniques and parameters for remotely sensed condition assessment using SFAP; and

(ii) compare costs and outcomes of SFAP assessment with on-ground assessment of vegetation condition assessment.

Methods

Study area

The study was undertaken within Belah *Casuarina pauper* ex L.A.S. Johnson and Pine-Buloke *Callitris gracilis* subsp. *murrayensis* (J. Garden) K.D. Hill – *Allocasuarina luehmannii* (R.T. Baker) L.A.S. Johnson woodlands in the Murray-Sunset National Park. Vegetation and the study area are described in Gowans *et al.* (in press).

The earliest available aerial photographs for the study area were taken in 1941, with further images recorded in most decades through to the 1980s. However, spatial coverage is incomplete, temporal coverage is variable, most photographs are in black and white, and resolution is variable between years. Therefore, it was necessary to obtain more recent, targeted aerial photography.

Aerial photograph acquisition

Aerial photographs were taken of Belah and Pine-Buloke woodlands at locations across the Murray-Sunset National Park. Aerial photography was taken on 28 May 2001 using a Nikon D1 digital camera mounted in the belly of a high wing Cessna 182RG aircraft. The camera was remotely controlled and slaved to a Nikon motor drive to enable photographs to be taken by the pilot in flight. The Nikon D1 is a 2.7 megapixel digital camera with a 23.7 x 15.6 mm, 12 bit RGB CCD (red green blue charge coupled device) delivering 2000 x 1312 pixel images. The lens used was a Nikkon 14 mm F2.8 with a 78 degree angle of view.

The camera was rigid mounted to a camera mount installed on the co-pilot's seat rails enabling in-flight pan and tilt camera adjustments. The camera was then positioned over the aircraft's camera hatch providing a vertical view of the landscape below. A retractable undercarriage provided the opportunity for an uninterrupted view of the ground below as well as providing greater stability for the photographic platform when retracted.

A cloud-free day was chosen for the photography, however, by midday some cloud cover appeared, resulting in cloud shadows on some photographs. A ground speed of 100 knots (185 km/hr) was planned for the flight; however, due to upper wind and drift this speed was not always achieved.

Height was determined from the aircraft's altimeter, which was calibrated using pressure (area QNH) determined by Flight Service in Melbourne with an estimated error of plus or minus 45 m.

Optimal photograph scale for condition assessment was determined using photographs taken from three heights: 1000 feet (approx. 300 m, minimum safe flying height) above ground level; 2000 feet (approx 600 m) and 4000 feet (approx 1200 m) above ground level. Images were saved as Joint Photographic Expert Group (JPEG) files which give good compression with minimal geometric or visual degradation (Lammi and Sarjakoski 1995). Aerial photograph pixel size, the on-ground dimensions covered by each photograph and scale are presented in Table 1.

An eight channel Garmin 12 XL Global Positioning System (GPS) unit was carried within the aircraft. An aerial attached to the inside of the rear window ensured satellite coverage throughout the flight. The time was recorded as the digital photograph was taken, and this was related to the time of GPS points recorded continuously on the GPS track function. Many more sophisticated systems of linking GPS to cameras exist, however this low-tech solution provided low cost photograph acquisition.

Aerial photographs were located on-ground using the GPS waypoints, and scale was calculated using on-ground measurements. Eight photographs were selected from two target areas to investigate methods for aerial photograph analysis. Photographs chosen covered areas in a range of conditions, as determined by earlier field-based condition assessment (Gowans *et al.* in press).

Three techniques were investigated to perform these analyses: on-screen digitising, unsupervised classification, and supervised classification. The main variables assessed using aerial photograph interpretation and the field parameters used for accuracy assessment are listed in Table 2.

On-screen digitising

On-screen digitising was selected as one of the simplest methods for analysis of unpaired (non-stereoscopic) digital photographs. An auto balance procedure was performed in Microsoft Photo Editor to adjust the brightness and contrast of each image to produce an optimal display. Measures of individual tree cover were determined in a Geographical Information Systems (GIS) by on-screen digitising, by approximating tree canopies with ellipses. Tree condition and identification of tree species were also visually assessed using on-screen digitising.

Unsupervised classification

To enable classifications using IDRISI32 (Clark Labs 2002), the aerial photographs were first separated into three colour bands; red, blue and green. An unsupervised classification procedure was used to determine percentage cover of tree canopy cover, bare ground, shadow and ground cover (including cryptogams, litter and dried annual ground cover). An ISOCLUST procedure was applied in IDRISI32 (Clark Labs) where a seeding process is performed using a colour composite image to locate initial clusters. Pixels are then assigned to the nearest cluster mean using a maximum likelihood procedure. The mean of each class is then updated and pixels are reassigned. This is repeated until no further significant change in classes or pixel assignment occurs (Eastman 2001). Fourteen clusters were created and grouped into classes representing tree canopy cover, bare ground, shadow, and ground cover (including cryptogams, litter and dried annual ground cover) by visual inspection of the image.

Supervised classification

Supervised classification techniques were trialled using a maximum likelihood classifier. Training areas were defined for tree canopy cover, bare ground, shadow, and ground cover (including cryptogams, litter and dried annual ground cover). The area of individual shrubs was too small to enable training areas specifically for shrub species.

A maximum likelihood procedure was used to classify the image, using spectral

Table 1. Dimensions of aerial photographs showing scale, on ground dimensions and pixel size.

Height above sea level (m)	Scale	Dimensions (m)	Pixel size (cm)
300	1:1130	275 x 415	20
600	1:2390	645 x 980	50
1200	1:5730	1320 x 2005	100

Table 2. Parameters derived from small format aerial photography, and the field data used for accuracy assessment. *Method for field assessment described in Gowans *et al.*

SFAP Parameter	Method of analysis	Field data used for accuracy assessment
Foliage cover of individual trees	On screen digitising	For 47 trees on three large scale photos tree condition was recorded, and canopy width was measured at two perpendicular cross sections using a measuring tape. Canopy area was calculated using the mean of the two canopy widths.
Tree condition (individual trees)	On screen digitising	Measured on a five point scale.*
Identification of tree species	On screen digitising	62 trees occurring within the smallest scale maps (300 m ASL) were identified to species level in the field.
Percentage cover tree canopy	Supervised classification	Visual estimate of projected foliage cover by one observer.*
Percentage cover bare ground	Supervised classification	Visual estimate of bare ground by one observer.*
Percentage cover ground cover	Supervised classification	Visual estimate of cryptogamic cover, cover of litter plus cover of projected foliage cover of native and introduced species in the ground stratum.
Percentage cover shadow	Supervised classification	N/A

signatures calculated from the training areas. In this procedure, pixels are assigned to a class based on probability contours from the training areas (Gibson and Power 2000). The default of equal class membership prior probabilities was used due to a lack of information on the likely extent of each cover class within the image.

Parameter selection

Correlations of parameters assessed in the field survey (including measures used to determine condition and other raw data collected) were performed to investigate relationships with the quadrat condition indices. Coefficients of determination were calculated to determine how much of the variance in the field vegetation condition scores was explained by each parameter. This was used to assist in determining appropriate parameters to analyse with aerial photography. Preliminary analysis suggested that some parameters violated the assumptions of normality and homoscedasticity, and so Spearman's Rank Order Correlations were performed.

Accuracy assessment

Following completion of the aerial photograph analysis, sites covered by the photographs were located on the ground to provide comparative data against which to measure aerial photograph interpretation results. Field data at these sites were collected using the methodology for field condition assessment (Gowans *et al.* in press) or as outlined in Table 2. A plot size of 50 m x 50 m was used to investigate vegetation condition within the aerial photographs.

Regression equations were calculated to determine the relationship between field-based measures and aerial photograph interpretation. Accuracy assessment of tree condition and tree species identification were analysed using error matrices, and Kappa values were calculated to indicate if the extent of agreement between the two data sets was greater than that expected by chance. A Kappa value of one indicates a perfect agreement, with all observations falling on the diagonals of the error matrix, and a value of zero indicates agreement no better than chance (Agresti 1990).

Data cost and availability

To determine the cost of obtaining SFAP, two aerial photography contractors were contacted and asked to provide a quote for performing 100 aerial photos within the study area. This was compared to the costs of undertaking a field-based assessment.

Results

Eight aerial photographs were selected from two target areas and measures of individual trees, and percentage cover parameters were investigated using digitising and classifications. This information was used to test the accuracy of measures as presented below.

Parameter selection

Correlations of each variable with the quadrat condition indices indicated that percentage cover of trees, percentage cover of bare ground, and tall shrub species richness were most strongly correlated with the quadrat condition indices (Table 10). Coefficients of determination showed that percentage cover of tree layer accounts for almost 50% of the variability in the quadrat condition indices (Table 10).

Individual tree parameters

Table 3 suggests aerial photograph measures of individual tree canopies using on-screen digitising were a reliable measure when compared with field based measures. Tree condition, however, was not reliably detected from on-screen digitising of large-scale aerial photographs, with an overall accuracy of 44.7% and Kappa of 0.12 (Table 4).

Table 3. Relationship between tree canopy areas calculated from SFAP at 300 m ASL and field measurements of tree canopy.

Parameter	Tree canopy area
Regression equation	$y = 1.06x - 5.9$
R^2	0.87
P	<0.001
N	47

Some differences in colour, form and shadow outline were observed between different tree species, enabling differentiation of species using on-screen digitising of aerial photographs taken at 300m ASL. Overall accuracy calculated from the error matrix was 73% with a Kappa of 0.59 (Table 5).

Percentage cover parameters

Comparisons of SFAP analysis of canopy cover within a 50 m x 50 m quadrat, with field-based estimates of tree layer cover showed good relationships between digitised canopy measures, and supervised classifications of canopy cover for all scales of aerial photographs (Table 6). Regressions confirmed a strong relationship between field canopy cover estimates and supervised classifications and digitising techniques, but no relationship between bare ground and ground cover (Table 7).

Costs of SFAP and field survey techniques

Table 8 shows the approximate costs for acquiring and analysing 100 aerial photographs to produce an interpolated map of vegetation condition within a large study area such as the Murray-Sunset National Park. Within the Murray-Sunset National Park (6363 km^2), 100 photographs at the largest scale would cover 11.5 km^2 or 1.8% of the Murray-Sunset National Park. If positional accuracy is important, then ortho rectified imagery can be purchased, although at significantly higher cost. A quote for orthorectified imagery from a local supplier suggested costs of approximately $520 per km^2 (Lourens, UW [Qasco] 2002 pers. comm. 4 February).

Table 9 indicates approximate costs of performing a field-based condition assessment at a remote site such as the Murray-Sunset National Park. Costs are based upon the study outlined previously (Gowans *et al.* in press) and assume per-

Table 4. Error matrix of tree condition estimated from SFAP compared with ground measures.

SFAP tree condition scores	Field survey tree condition scores 1	2	3	4	Total
1	1	-	-	-	1
2	3	10	6	2	21
3	1	9	10	4	24
4	-	1	-	-	1
Total	5	20	16	6	47

Table 5. Error matrix of tree species identified from SFAP, compared with field identification.

(*Myoporum platycarpum* subsp. *platycarpum*, *Casuarina pauper*, *Callitris gracilis* subsp. *murrayensis*, *Alectryon oleifolius* subsp. *canescens*).

Aerial photo identification	Field identification *Myoporum*	*Casuarina*	*Callitris*	*Alectryon*
Myoporum	7	-	5	2
Casuarina	-	4	1	-
Callitris	-	-	12	2
Alectryon	3	-	4	22

Table 6. Comparison of canopy cover calculated using on-screen digitising and classifications with field estimates of canopy cover and total perennial cover.

Height ASL	Photo ID	Field estimate %	Digitised %	Supervised classification	Unsupervised classification
300	1	2	2	2.8	2.3
300	2	2	4	4.9	21.0
300	3	5	7	8.0	9.0
600	4	35	29	48.1	30.2
600	5	5	4	6.9	11.9
1200	6	2	8	23.9	25.8
1200	7	5	8	16.3	28.8
1200	8	10	6	19.4	9.4

Table 7. Relationship between photographic calculation and field estimates of condition parameters.

Parameter and analysis	Regression equation	R^2	P
Canopy cover			
Supervised classification	y=0.66x-2.49	0.78	0.01
Unsupervised classification	-	0.19	0.28
Digitising	y=1.24x-2.33	0.91	0.00
Bare ground			
Supervised classification	-	0.07	0.53
Unsupervised classification	-	0.001	0.96
Ground cover			
Supervised classification	-	0.07	0.51
Unsupervised classification	-	0.19	0.29

forming 100 randomly located quadrats across an area the size of the Murray-Sunset National Park (6363 km^2). With 100 quadrats of 0.1 ha each, approximately 0.02% of the semi-arid woodlands in the Murray-Sunset National Park would be sampled. It is difficult to estimate the number of samples that would ideally be required due to the large number of factors that affect the required sample size. Factors including the heterogeneity of the site or surface variation, distribution of the sampling (random or systematic) may all influence the required sample size (Haining 1993).

Discussion

Results suggest that whilst many of the aerial photograph measures appear to be reliable, condition assessment by aerial

Table 8. Costs for obtaining and analysing aerial photographs to determine vegetation condition.

Task / Item	Resources	Units	Total Cost
Aerial Photography Acquisition			
	Flying time	5 hours	$ 2500.00
	Photo prints	100 photos	$ 3000.00
Sub-total			**$ 5500.00**
Ground Truthing			
Field survey	2 botanists	5 days	
Travel	travel	2000 km	
Meals/accom		4 nights	
Data entry			
Sub-total			**$ 8400.00**
Imagery Analysis			
SFAP interpretation	1 scientist	15 days	
Accuracy assessment	1 scientist	5 days	
Sub-total			**$ 13 600.00**
Total cost			***$ 27 500.00***

Table 9. Costs to undertake a field based condition assessment of approximately 100 random points across an area of 6000 km^2.

Task / Item	Resources	Units	Total Cost ($)
Field Survey			
Field Survey	2 botanists	14 days	
Travel	travel	3000 km	
Meals/accom		13 nights	
Sub-total			**20 000.00**
Data Analysis			
Plant ID, data entry and analysis	1 botanist	12 days	
Sub-total			**5 600.00**
Total cost			***25 600.00***

photography is unlikely to result in any cost savings over a field-based study. This appears to be largely due to the costs for ground-truthing results of the aerial photograph interpretation. The number of days required for SFAP interpretation will depend upon the methods chosen, and it is possible that these costs could be reduced by using a simple method such as a dot grid, where a count of cover types falling under the dot is made. Up to 30–40 photos a day can be analysed by a skilled analyst using this method (Norton-Griffiths 1988), which may significantly reduce aerial photograph interpretation time and costs.

Field survey, particularly in remote areas, is costly due the amount of time required and travel costs, so therefore only a small proportion of the study area can be directly assessed. Some studies have recommended sampling rates of 2% (Bird *et al.* 2000), which would be expected to result in greatly increased costs in a remote area such as the Murray-Sunset National Park. It is expected that the costs of aerial photography would be relatively less under a more intensive survey effort, as the ground truthing element would remain constant. Repeat studies may also be more economical due to the limited need for ground truthing.

Potential aerial photograph parameters

The breadth of previous studies using aerial photography analysis suggests that many vegetation parameters could be measured with the use of large-scale, SFAP (e.g. Warner *et al.* 1996; McCormick 1999;

Table 10. Spearman's correlation and co-efficient of determination of parameters with quadrat condition indices. * = significant at the 0.05 level; ** = significant at the 0.01 level.

	%cover trees	%cover tall shrubs	%cover small shrubs	%cover ground layer	%cover exotic ground layer	%cover cryptogams	%cover litter	%cover bare ground	No. tree age classes	tree condition	tree richness	tall shrub richness	small shrub richness	regenerating shr[illegible]
%cover trees	1													
%cover tall shrubs	0.387**	1												
%cover small shrubs	0.369**	0.436**	1											
%cover ground layer	-0.402**	-0.202**	-0.146	1										
%cover exotic ground layer	-0.404**	-0.227*	-0.092	0.893**	1									
%cover cryptogams	0.415**	0.408**	0.316**	-0.314**	-0.345**	1								
%cover litter	0.354**	0.316**	0.109	-0.228**	-0.221**	0.234**	1							
%cover bare ground	-0.560**	-0.572**	-0.378**	0.335**	0.377**	-0.444**	-0.297**	1						
No. tree age classes	0.407**	0.184**	0.150	-0.091	-0.131	0.169*	0.026	-0.330**	1					
tree condition	0.304**	0.161*	-0.113	-0.237**	-0.303**	0.190**	0.086	-0.441**	0.270**	1				
tree richness	0.328**	0.120	-0.105	-0.252**	-0.351**	0.097	0.099	-0.364**	0.028	0.198**	1			
tall shrub richness	0.471**	0.791**	0.336**	-0.269**	-0.330**	0.442**	0.464**	-0.540**	0.216**	0.227**	0.191**	1		
small shrub richness	0.425**	0.259**	0.139	-0.352**	-0.413**	0.217**	0.243**	-0.410**	0.143*	0.213**	0.383**	0.345**	1	
regenerating shrubs	0.368**	0.447**	0.185**	-0.421**	-0.451**	0.326**	0.117	-0.465**	0.180*	0.252**	0.401**	0.460**	0.479**	1
Quadrat condition index	**0.705****	**0.545****	**0.391****	**-0.452****	**-0.549****	**0.476****	**0.247****	**-0.656****	**0.558****	**0.572****	**0.343****	**0.609****	**0.532****	**0.598****
Coefficient of determination	0.497	0.297	0.153	0.204	0.301	0.227	0.061	0.430	0.311	0.327	0.118	0.371	0.283	0.358

Cameron *et al.* 2000; Fensham and Fairfax 2002). Potential parameters for aerial photograph condition assessment examined in this study were tree species, tree canopy cover, cover of perennial vegetation, and cover of bare ground. Whilst tree condition was not successfully determined using on-screen digitising (overall accuracy 44.7), previous studies have shown that measures of tree condition can be accurately obtained using colour-infrared film and stereoscope (Margules & Partners Pty Ltd *et al.* 1990). It is possible that the number of different tree species present confounded the analysis of tree condition. It is first necessary to correctly identify the tree species, before it can be determined if the canopy is in the expected shape for the species. It is likely that obtaining stereoscopic pairs may aid in more accurately determining tree condition.

Determining tree species richness by accurate identification of tree species was relatively successful, with on-screen identification of tree species resulting in an overall accuracy of 72.6%. It is likely that this could also be improved by using stereoscopic viewing of image pairs, as has been used in a number of other studies reporting higher accuracy in species identification (Hall and Aldred 1992; McCormick 1999). However, this would result in higher costs of image acquisition due to the need for overlapping images and an increase in analysis time. Alternatively, development of an aerial photograph key may also aid tree species identification.

Many studies have shown that vegetation cover calculated from aerial photography is a good approximation of vegetation cover on the ground (Tueller *et al.* 1988; Knapp *et al.* 1990; Soule and Knapp 1999; Fensham 2002). Percentage cover calculations of tree canopy from SFAP provided some of the most accurate data in this study. Similarly, percentage cover calculations from large-scale aerial photography has been shown to correlate well with on ground measures in other arid environments (Tueller *et al.* 1988; Knapp *et al.* 1990). Tueller *et al.* (1988) also found that species identification and density counts provided less reliable information than cover estimates.

Lack of regeneration has been identified as a major threat to semi-arid woodlands in north-west Victoria (Cheal 1993; Westbrooke 1998; Sandell *et al.* 2002). Therefore, determining presence or absence of tree regeneration would be a useful assessment tool. Unfortunately, no tree seedlings were present on any aerial photograph, and so seedling detection accuracy was unable to be investigated. However, previous studies suggest that regeneration of tree species can be detected using aerial photography. In a study on forest regeneration within Mixed Boreal Forest in Canada, regeneration in cutover forestry sites was examined using 1:10 000 aerial photograph stereo pairs (Hall and Aldred 1992). Seedlings measured ranged in height from 0 to 201 cm, and as expected, greater ability to detect larger seedlings was observed. No seedlings under 15 cm were able to be detected; however, the overall seedling percent detectability for cutover sites was 62% (Hall and Aldred 1992). Identification of tree seedlings was performed in another study of regeneration of forestry areas in Virginia, using large-scale aerial photography and colour film (Smith *et al.* 1986). Loblolly Pine *Pinus taeda* seedlings (mean height 44–66 cm) were not able to be accurately detected at a scale of 1:890, but were accurately detected (overall accuracy 72–75%) at a scale of 1:297.

These previous studies suggest that it may be possible to identify tree seedlings on aerial photographs of semi-arid woodland in north-west Victoria, provided the images of the seedlings were not obscured by other vegetation such as other tree canopies, tall grasses or shrubs. Using the current set-up, aerial photos would have to be flown at between 100 to 150 m above ground level to detect seedlings. This is likely to be border-line for safe minimum flying heights, and to minimise image blurring, a high shutter speed would be required.

In producing a condition index from aerial photography, compared with field survey techniques, the number of parameters identified from aerial photos would probably be reduced due to the time required to analyse many different features from aerial photography. The choice of aerial photograph scale, film types and techniques for analysis should be determined according to the parameters to be measured. For example, whilst broader scale photographs provide a cheaper coverage of large areas, the types of variables that can be calculated from broad-scale photographs is limited.

Further research is required to determine optimal sampling regimes for interpolation models if maps are to be produced from aerial photography analysis within large areas such as the Murray-Sunset National Park.

Much variation in the quadrat condition indices is explained by the percentage cover of trees within the quadrat. The coefficient of determination shows that percentage tree cover explains almost 50% of the variation in the quadrat condition indices. Therefore it is expected that remote assessment methods that can accurately determine percentage tree cover will be strongly correlated to the quadrat condition indices. It is likely that the addition of more explanatory factors will increase the relationship between the quadrat condition indices and a condition assessment based on aerial photography.

Advantages of small format aerial photography

The main advantage of aerial photography over other remote data sources is the detail of potential measures. Aerial photography at an appropriate scale can be used to provide objective measures of many of the parameters used in field surveys of vegetation. The use of aerial photography can reduce travel costs whilst enabling a larger sample to be surveyed with all photos captured within a short period. If simple measures are used, such as dot-grid estimate of cover, set-up costs can be less than those required for other remote data sources, and staff training may be minimal (Tueller *et al.* 1988).

Limitations with small format aerial photography

One of the main limitations with aerial photography with a study area of the size of the Murray-Sunset National Park is the need for interpolation of data for map production. Even at the smallest scale used, more than 2400 photographs would be required to cover the study area of 6330 km^2. The cost of obtaining orthorectified or colour-infrared imagery also quickly becomes prohibitive within this large study area.

Whilst there are many methods for achieving high positional accuracy with SFAP, the challenge is to find a method that does not greatly increase the associated costs. Factors impacting on the positional accuracy of SFAP include synchronisation between the different components (digital camera and GPS), accuracy of navigational equipment and altitude sensors, mounting platform stability, lens distortion, and weather conditions (Abd-Elrahman *et al.* 2001). The limited positional accuracy of SFAP may be problematic in a location such as remote semi-arid woodland with few identifying ground features. However, with the use of an appropriate sampling method, positional accuracy may not be highly important in determining the vegetation condition of an area such as the Murray-Sunset National Park, provided the samples are located within the correct vegetation community.

Some parameters that formed an important part of the field-based condition assessment, such as regeneration of trees and understorey species and species richness, were not able to be reliably assessed using SFAP. Field survey also enabled assessment of some of the potential impacts upon vegetation condition such as observation of grazing animals, scats and browse damage on plants. New threats could also be discovered during field survey, for example, observation of a new pest species. These threats are unlikely to be detected using aerial photography until considerable change to the vegetation has taken place.

Limitations of the study

It must be emphasised that this was a feasibility study only. There are a number of limitations with the analyses, particularly the number of samples performed at each photograph height above ground level. Further research is required to determine a complete method for aerial photography condition assessment, and to fully test the accuracy of parameters. In addition, a more objective measure for field-based percentage cover measures should be used in future comparisons with aerial photography.

Condition mapping from aerial photography

To complete a map of vegetation condition from aerial photography interpretation, interpolation-modelling procedures similar to those applied in the field-based assessment (Gowans *et al.* in press) could be applied. The accuracy of the interpolation model is dependent upon many factors including the heterogeneity of landscapes and disturbances, sampling regime and number of samples taken (Haining 1993). The reliability of interpolation models reduces with greater distance between adjacent quadrats and without further accuracy assessment the reliability of the model is unknown.

As aerial photograph measures of vegetation condition do not provide the same level of detail as field-based measures, it would be expected that interpolation models based on aerial photography would not exceed the accuracy of field assessment models.

Conclusions

SFAP provides an alternative to field-based methods of vegetation condition assessment. Whilst SFAP is unlikely to provide significant cost savings over field-based methods, greater flexibility in image acquisition and access are provided. Aerial photograph condition assessment is likely to be of most use in remote areas inaccessible by road, where field-based methods are less feasible. Further research is required to refine methods for aerial photography. However, initial investigation suggests that tree species identification and tree canopy cover measures provide potential for determining vegetation condition in Belah and Pine-Buloke woodlands. Strong correlations between tree canopy cover and other vegetation condition parameters used in field survey suggest that tree canopy cover measures may describe much of the variability in vegetation condition.

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Fire and hollow formation in Box-Ironbark eucalypts of the Warby Range State Park

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Abstract

Hollows are an important, but rare, resource for several vertebrate species in the Box-Ironbark forests of central Victoria, yet there is limited knowledge of the hollow formation process within these forests. This study assessed the external features of trees from burnt and unburnt areas of forest to determine the influence of fire on hollow formation in Box-Ironbark eucalypts. Significantly greater proportions of trees in burnt areas had scars than trees in unburnt areas ($p = 0.05$). Within burnt areas, Red Stringybark *Eucalyptus macrorhyncha* trees were more likely to contain scars, as were trees of smaller diameter. Fire had less influence on the number of small, medium, large and very large dead branches/branch stubs than tree diameter. Similarly, tree size rather than fire was a major determinant in the occurrence of hollows. There was no difference in the number of epicormic knobs between trees in burnt and unburnt areas, which may indicate that the fire was not particularly intense and therefore did not influence hollow formation as much as more intense fires would have. The greater number of scars in burnt trees might eventually lead to differences in hollow numbers between burnt and unburnt trees; however, the most common type of dead wood source within trees was dead branches/branch stubs, which did not differ significantly between trees in burnt and unburnt areas but was influenced most by tree size. (*The Victorian Naturalist* 122 (1) 2005, 47-56).

Introduction

The use of semi-enclosed cavities, or hollows, in live and dead standing trees by arboreal vertebrates and birds is common on most continents. In Australia, it is estimated that approximately 15% of all terrestrial vertebrates use hollows (Gibbons and Lindenmayer 2002). At least 100 of the rare, threatened or near-threatened vertebrate species on state or commonwealth endangered lists utilise hollows (Gibbons and Lindenmayer 2002). The lack of hollow-bearing trees within Victoria is of such concern that their removal is considered a threatening process under the Victorian *Flora and Fauna Guarantee Act* (1988). Over the past twenty years, studies into hollows in both standing and fallen (logs) eucalypts of several different species have shown a positive correlation between tree age and the proportion of trees containing hollows, number of hollows per tree and/or hollow size (Mackowski 1984; Mackowski 1987; Newton-John 1992; Lindenmayer *et al.* 1993; Rose 1993; Taylor and Haseler 1993; Bennett *et al.* 1994; Williams and Faunt 1997; Ross 1999; Soderquist 1999; Wormington and Lamb 1999; Lindenmayer *et al.* 2000). Since tree size increases with age it is the big, old trees within our forests that are valued highest as hollow resources. Within wood-production areas trees are often routinely felled before reaching hollow-bearing size, restricting and inhibiting hollow recruitment and limiting the survival prospects of hollow-using fauna in many forest types around Australia.

Since European settlement of central Victoria, vast tracts of Box-Ironbark Forests (BIBF) have been cleared. Today, only 15 – 20% of these forests remain (ECC 1997) and show considerable changes in structural composition. Large trees within wood production areas are rare, with most trees less than 40 cm in diameter (Soderquist 1999). Prior to European settlement the BIBF comprised open stands (approximately 5 trees/ha) of trees estimated to be 75 – 90 cm in diameter at breast height (dbh) (Newman 1961). Hollows suitable for use by vertebrates are more likely to occur in trees at least 60 cm in diameter, yet trees this size or larger currently account for only 6% of the stems within these forests (Soderquist 1999). Even if all wood production were to end immediately it would still take many decades for most trees to form hollows

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since the average diameter growth rate of Box-Ironbark eucalypts is approximately 2.5 mm/year (Lloyd and Lau 1986). Knowledge of the hollow formation process is lacking for eucalypts in this forest type (Soderquist 1999) and is required to ensure the most appropriate retention strategies are implemented to support healthy populations of hollow-dependent fauna.

The process of hollow formation in eucalypts occurs through decay and consumption of non-living heartwood at the centre of trees by fungal and termite species (Wilkes 1982; Mackowski 1984; Wilkes 1985). These organisms penetrate into the heartwood region via scars caused by fire or wind and/or dead branches and branch stubs (Wilkes 1982; Wilkes 1985). Actual excavation of wood tissue by fungi is negligible (Mackowski 1984), but in some instances termite consumption and excavation occurs, or is accelerated, only where fungal decay of wood tissue has occurred (French 1978; Ruyooka and Edwards 1980; Perry *et al.* 1985). Heartwood is the area most susceptible to fungi and termites because it has no active defence mechanism to repel them. Instead, heartwood must rely on the anti-fungal and anti-termitic chemicals (extractives) deposited when first formed to deter these organisms (Rudman and Da Costa 1958; Raven *et al.* 1992). A radial gradient of susceptibility to fungal and termite attack occurs within heartwood with the innermost heartwood (oldest tissue) usually being more susceptible than the outer heartwood (younger tissue) (Rudman 1964; Da Costa and Osborne 1967; Rudman and Gay 1967; Ruyooka and Edwards 1980; Ruyooka and Griffin 1980; Ruyooka and Groves 1980; Wilkes 1985; Wilkes 1985). This is due to the progressive breakdown of these chemicals over time (Rudman 1964; Rudman 1965) resulting in lesser amounts of resistant chemicals occurring in the oldest tissue (Hillis 1971). Thus the heartwood of eucalypts becomes susceptible to attack only when sufficient time has elapsed, which varies between species (Rudman 1964; Hillis 1971).

Previous fire damage in the form of scars is positively associated with either the presence of hollows or decay organisms in standing trees and logs (McCaw 1983; Perry *et al.* 1985; Taylor and Hascler 1993; Williams and Faunt 1997; Whitford 2002). A scar involves the partial death (i.e. death to one side or portion of the stem) of the vascular cambium. The damage caused by fire may influence the likelihood of hollow formation in several ways. Wilkes (1985) found that fungi entered eucalypts via scars, while enclosed (included) scars caused by fire are susceptible to termite attack (McCaw 1983). Basal fire scars were correlated with the occurrence of snag-tops in giant sequoia trees of North America (Rundel 1962). This creation of extensive areas of dead wood in the crown may increase the chance of decay-causing fungi entering a tree. The creation of epicormic growth following fires is a common response of many eucalypt species. Potential infection by decay organisms can occur when epicormic branches are shed from the main stem and the knob from which they grow is occluded (Jacobs 1955). The association of fire with the presence of hollows and its ability to reduce the average age of den trees used by the Common Ringtail and Common Brushtail Possums in Western Australian eucalypts (Inions *et al.* 1989) implies that fire has potential use as a management tool, a concept supported by Rose (1993) and Williams and Faunt (1997). However, the extent to which fire influences the hollow formation process and the precise manner of its influence is unknown.

The aims of this study were to (i) determine the influence of fire on hollow formation by comparing the number of hollows and features that predispose hollow formation between burnt and unburnt trees (ii) determine the influence of other factors such as tree size and tree health and (iii) identify some of the hollow-forming termite species within these forests. Knowledge gained from this study will guide future research and contribute to the formation of appropriate strategies for managing hollows in these forests and, thus, animals that utilise these hollows.

Materials and Methods

Study site

The area chosen for this study site was located within the Killawarra Forest (formerly Killawarra State Forest) of the Warby Range State Park, 13 km north-west of Wangaratta, Victoria (146°14'44" E, 36°14'05" S) (Fig. 1). The site contained an area of forest burnt by wildfire in 1990. The area immediately surrounding the fire boundary within the Killawarra Forest according to historical records had not previously been burnt. The fire started at the southern extent of the boundary and progressed north. The fire was intense at times but according to records was of low intensity upon reaching the Killawarra Forest. (Fig. 1).

Study design

A total of 159 standing eucalypts (130 Mugga Ironbark *E. sideroxylon* and 29 Red Stringybark *E. macrorhyncha*) were randomly sampled along four 90 m transects using the point-quarter technique at 10 m intervals. Two transects were in the burnt area and two in the unburnt area. Burnt areas were identified using historical maps. Transects in this area were run through patches that contained visual evidence of previous fire. Areas containing relatively denser stands of young *Acacia* saplings and the occurrence of charcoal on stumps and logs were used as indicators. Unburnt areas of similar tree composition, tree size distribution, slope and orientation to burnt areas were chosen.

Tree assessment

The type and number of hollows, dead branches/branch stubs, scars and epicormic knobs were visually assessed for each tree. All provide areas for fungi to access eucalypt heartwood (Jacobs 1955; Wilkes 1982; Wilkes 1985). The scale used for assessing crown senescence is shown in Fig. 2. All features were recorded by ground-based assessment, and their position noted as from the base (up to 1 m from base of tree), the bole (the area along the main stem from 1 m above the base to crown break) and the crown (area above crown break) (Fig. 3). Visual estimates of the size of branches on trees were regularly tested by measurement of visually similar sized branches on the ground. In addition, the presence of previous termite activity based on the presence of mud galleries was recorded.

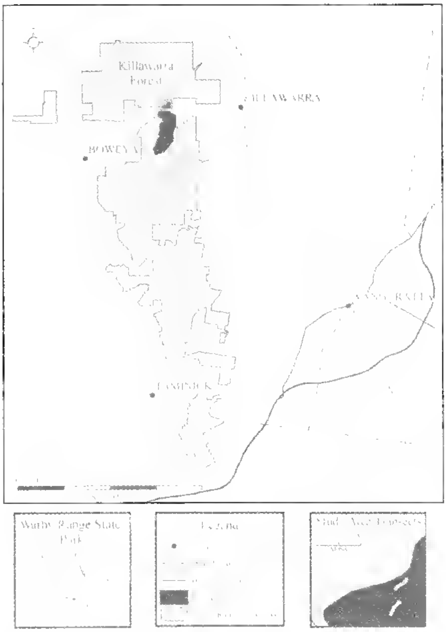

Fig. 1. Location of Warby Range State Park and boundary of 1990 fire.

Statistical Analysis

All data were analysed for normality. Continuous data that was normally distributed was analysed using a One-way ANOVA. Continuous data that was not normally distributed was analysed using the Kruskal-Wallis rank sum test. Categorical data that was not normally distributed and contained at least 5-counts/category were analysed using Pearson's chi-square test with Yate's continuity correction. For data that contained <5-counts/category Fisher's exact test was used.

Data were analysed using the statistical package S-Plus 2000 Professional Release 2 (MathSoft Incorporated 1988–1999). Where presented, standard error is equal to $\pm$ 1.

Results

Sampled trees

The mean dbh of *E. sideroxylon* trees was 31.4 cm (n = 130) and for *E. macrorhyncha* 17.6 cm (n = 29). Only 4% of the total trees were $\geq$ 60 cm dbh, while nearly 80% of the trees were < 40 cm dbh (Fig. 4). Only one *E. macrorhyncha* tree

Table 1. Tree attributes measured.

Feature	**Description**
Area	The location of the tree as being in either the 1990 fire area (burnt) or non-fire area (unburnt)
Tree species	Identification based on leaves, bark and fruits
Diameter at breast height	Diameter of tree measured at a height of 1.3 m
Hollows	The number of hollow entrances in three different size classes. A hollow is defined as a hole ≥ 2 cm wide (at its narrowest point) and ≥ 10 cm deep (Woodward 1993; Soderquist 1999). Small = 2.0 cm – 4.9 cm wide Medium = 5.0 cm – 9.9 cm wide Large = 10.0 cm – 19.9 cm wide
Scars	The number of scars (areas of exposed dead wood) in three different size classes; small, medium and large. Scars were noted to be caused by either injury or, where obvious, areas of exposed old stumps not yet occluded by regrowth (coppicing) stems. Small = ≤50 sq. cm Medium = >50 sq. cm – ≤1000 sq. cm Large = >1000 sq. cm
Dead branches/branch stubs	The number of non-living branches and/or branch stubs in four size classes (diameter (cm)). Diameter was estimated at the base of each branch. Small – ≤5 cm Medium = >5 cm – ≤10 cm Large = > 10 cm – ≤20 cm Very large = >20 cm
Epicormic knobs	The number of epicormic knobs in three size classes (length at widest point (cm)) Small = ≤10 cm Medium = >10 cm – ≤30 cm Large = >30 cm
Crown senescence	Eight qualitative classes based on crown and stem characteristics (Fig 2.)

was >40 cm dbh (Fig. 4). The mean dbh for trees sampled in burnt areas was 27.4 cm (n = 80) and 30.2 cm for trees in unburnt areas (n = 79).

The mean crown senescence for all trees was 2.4 (Whitford 2002). No significant differences were found for crown senescence (p = 0.32 Kruskal-Wallis rank sum test) between burnt trees (mean = 2.3) and unburnt trees (mean = 2.5). No significant differences were found between tree species either (p = 0.21 Kruskal-Wallis rank sum test), with the mean crown senescence for *E. sideroxylon* and *E. macrorhyncha* 2.3 and 3.0 respectively, thus, neither fire nor tree species influenced tree health.

Hollows

Only three trees (2% of all trees) had hollows, containing a total of five hollows (0.03 hollows/tree). Four hollows were small in size and one large. Two of the hollow-bearing trees were >60 cm in diameter representing 33% of all trees >60 cm diameter. The third tree was 46 cm diameter representing 4% of all trees in the 40 – 60 cm diameter class (Fig. 4). All hollow-bearing trees were *E. sideroxylon* and occurred in burnt areas (Fig. 4). Comparison of the proportion of trees with hollows in burnt and unburnt areas was not significant (p = 0.25 Fishers exact test). All hollows occurred within the crown of trees and were at least 10 m from the ground. The mean crown senescence rating for hollow-bearing trees was 4.7 (SE = 1.3) and 2.4 (SE = 0.1) for non-hollow- bearing trees. This was not a significant difference (p = 0.06 Kruskal-Wallis rank sum test). The mean diameter of hollow-bearing trees was significantly greater than that of non-hollow-bearing trees (p = 0.01 Kruskal-Wallis rank sum test) (Fig. 4) in burnt areas.

Scarring

A significantly greater proportion of trees in burnt areas contained scars in comparison with trees in unburnt areas (p = <0.00 Pearson's chi-sqnare test with Yate's continuity correction) (Fig.5). Nearly half (46%) of the stems within burnt areas had at least one scar while only 10% of unburnt stems contained scars (Fig. 5). All

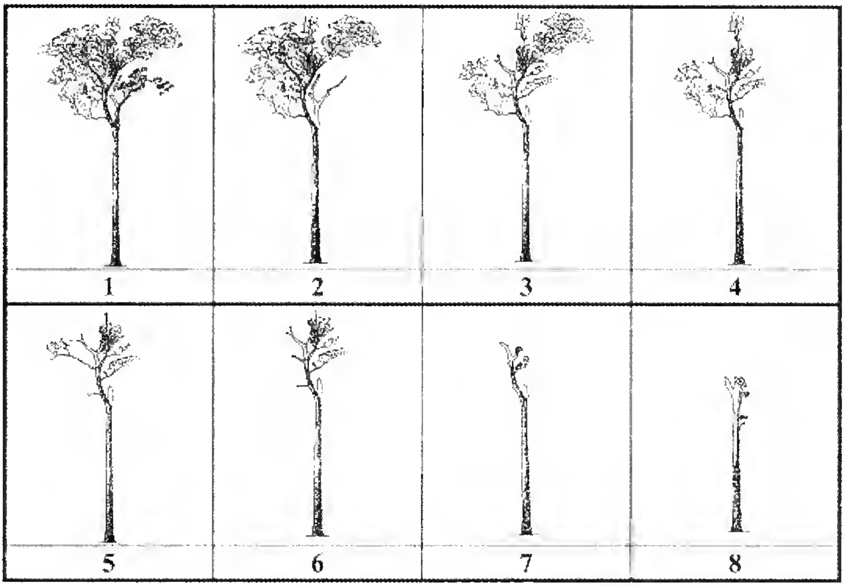

Fig. 2. The pictorial scale used to assess Crown Senescence. Taken from Whitford (2002)

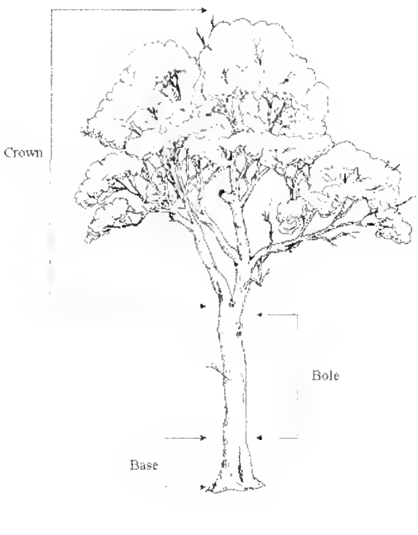

Fig. 3. Areas sampled on tree (Base (up to 1 m), Bole and Crown). Drawing: G Ambrose.

scars within the burnt area were consistent with injuries caused by fire, while all scars recorded in unburnt areas were at the base of trees and a result of exposed parts of old stumps not yet included by coppice regrowth stem. Potential entry points for decay-causing fungi provided by scars were therefore greater in trees from burnt areas.

Within burnt areas scarred trees were significantly smaller than unscarred trees (One-way ANOVA: p = <0.00; SE = 1.13) (Fig. 6). The mean dbh for scarred trees was 25.3 (SE = 2.2) cm while unscarred trees had a mean diameter nearly 10 cm greater (34.2; SE = 2.5) (Fig. 6), suggesting that smaller trees are more susceptible to fire damage than larger trees. There were no significant differences between scarred and unscarred trees in unburnt areas (p = 0.06 Kruskal-Wallis rank sum test) (Fig. 6).

Greater proportions of *E. macrorhyncha* stems in burnt areas had scars than *E. sideroxylon* (p = 0.00 Fisher's exact test) (Fig. 7). Nearly three times as many *E. macrorhyncha* stems had at least one scar compared to *E. sideroxylon* which suggest that *E. macrorhyncha* is more sensitive to fire (Fig. 7). No significant differences were found for unburnt areas (p = 0.15 Fisher's exact test) (Fig. 7).

The majority of scars in trees from burnt areas occurred in the crown (72%) and

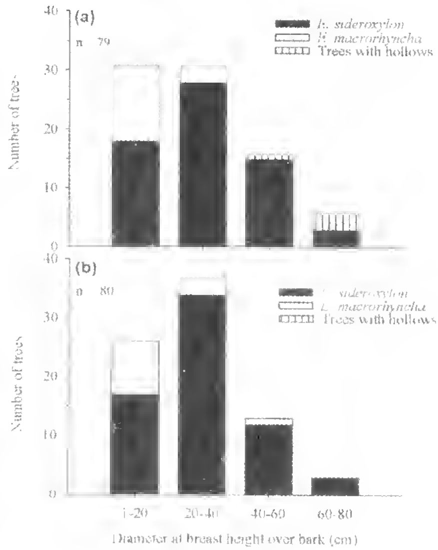

Fig. 4. The diameter class distribution of *Eucalyptus sideroxylon* and *Eucalyptus macrorhyncha* trees and trees with hollows in (a) burnt and (b) unburnt areas of the Warby Range State Park.

over half (56%) were small (Fig. 8). Overall, the least number of scars occurred at the base (12.5%), but this contained the greatest proportion of large scars. No large scars occurred along the bole while in the crown large scars accounted for only 10% of all scars. In trees from unburnt areas all scars occurred at the base (Fig. 8).

The Influence of Fire and Tree Size on Dead branches/Branch stubs

Trees from burnt areas had a significantly greater number of small dead branches/branch stubs per tree than trees from unburnt areas (p = 0.02 Kruskal-Wallis rank sum test) (Table 2). No significant differences ($p \leq 0.05$ Kruskal-Wallis rank sum test) were found for medium, large or very large trees (Table 2) indicating that smaller branches are more sensitive to fire.

Tree size influenced the amount of dead branches/branch stubs within a tree with significant difference found between size classes for all four branch sizes ($p \leq 0.05$ Kruskal-Wallis rank sum test) (Table 2). As expected, large trees (60–80 cm dbh) contained the greatest number of small, large and very large branches. Very small trees (1–20 cm dbhob) did not contain any large or very large branches (Table 2).

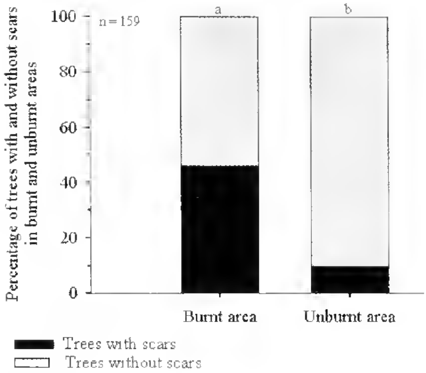

Fig. 5. The percentage of trees from burnt and unburnt areas with at least one scar (areas of exposed dead sapwood) of any size. Means with the same letters are not significantly different (lsd p = 0.05).

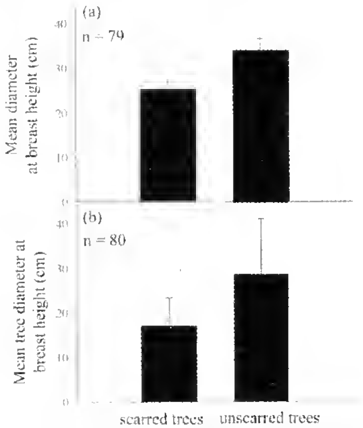

Fig. 6. The mean diameter at breast height of scarred and unscarred trees in (a) burnt and (b) unburnt areas of the Warby Range State Park.

Fire and Tree Species' Association with Termite Activity

No trees sampled contained active galleries. However, 5% of all trees showed external evidence of previous termite activity. The mean diameter of trees with termite activity was 19.6 cm (SE = 2.3). All evidence of previous activity was found within base scars. There was no significant difference in the proportion of

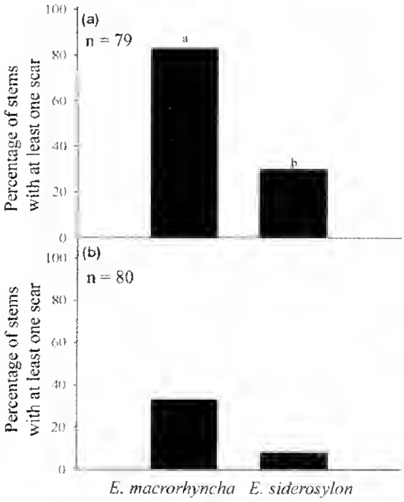

Fig. 7. The proportion of *Eucalyptus macrorhyncha* and *Eucalyptus sideroxylon* stems with at least one scar from (a) burnt and (b) unburnt areas of the Warby Range State Park. Means with the same letters are not significantly different (lsd $p = 0.05$)

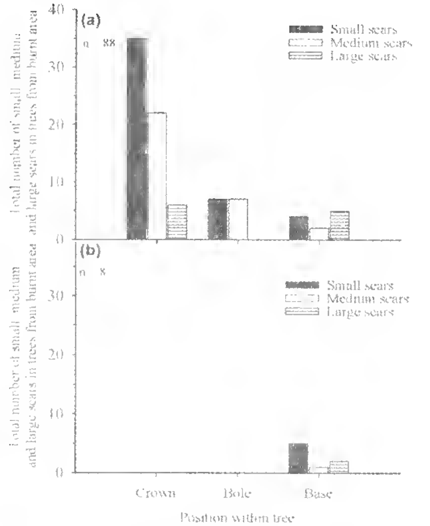

Fig. 8. The frequency distribution of small (1-50 sq. cm), medium (50-1000 sq. cm) and large (> 1000 sq.cm) scars in the crown, along the bole and at the base of trees in (a) burnt and (b) unburnt areas of the Warby Range State Park.

trees from burnt areas (8%) with previous termite activity compared with trees from unburnt areas (4%) (Fisher's exact test: $p = 0.33$). However, there were differences associated with tree species with significantly greater proportions of *E. macrorhyncha* showing visible signs of termite activity compared to *E. sideroxylon* ($p = <0.00$ Fisher's exact test) (Fig. 9). This difference may be related to the susceptibility of *E. macrorhyncha* to fire damage. No significant differences were found between species in unburnt areas.

Discussion

The lack of hollows observed within this study area suggests that hollows are lacking within the Killawarra Forest and also limits any assertions about the importance of different factors influencing the hollow formation process. However, for eucalypts in BIBF, greater proportions of larger trees are hollow-bearing than smaller trees (Soderquist 1999). Our results would appear to support this claim since the only hollow-bearing trees observed were considerably larger than non-hollow bearing trees (Fig. 4). Soderquist (1999) has also shown that <1% of very small trees (<20 cm dbh) are likely to contain hollows while for small trees (20 – 40 cm dbh) only 4% are likely to contain hollows. For this study most trees were either very small or small in size (Fig. 4). The absence of large trees found in this study best explains the lack of visible hollows.

Fire did not appear to influence the occurrence of externally visible hollows in the Warby Range State Park, but this may be because 14 years was not long enough for visible differences to become apparent. The absence of visible hollows in this study makes determining the influence of this fire on hollow formation difficult. The only other study in Australia that has looked at the influence of fire on hollow formation was Inions *et al.* (1989) who showed that a high intensity fire could increase the rate of hollow formation in Jarrah *E. marginata* and Marri *Corymbia. calophylla*. Several studies have shown that the presence of previous fire damage in the form of scars is positively associated with either the presence of hollows or decay organisms in standing trees and logs (McCaw 1983; Perry *et al.* 1985; Taylor and Haseler 1993; Williams and Faunt 1997; Whitford 2002) indicating that fire

Table 2. The mean number of small, medium, large and very large dead branches/branch stubs in trees from burnt and unburnt areas and trees from four different diameter size classes. [a] Significant at $p = 0.05$ for Kruskal-Wallis rank sum test. [b] Diameter size class based on dbh (cm). Both unburnt and burnt trees were grouped except for small branches where only unburnt trees were analysed. [c] Size was determined by the diameter of dead branch/branch stub at base.

Attribute	Dead Branch/Branch Stub Size[c]			
	Small	**Medium**	**Large**	**Very Large**
Burnt	8.3	2.6	0.6	0.1
Unburnt	6.9	2.6	0.3	0.1
p-value	*0.02* [a]	*0.43*	*0.32*	*0.73*
Diameter class[b]				
1 – 20	3.9	0.5	0.0	0.0
20 – 40	7.4	2.5	0.3	0.1
40 – 60	13.8	6.3	1.1	0.0
60 – 80	15.1	6.2	3.5	1.2
p-value	*<0.00* [a]	*<0.00* [a]	*<0.00* [a]	*<0.00*

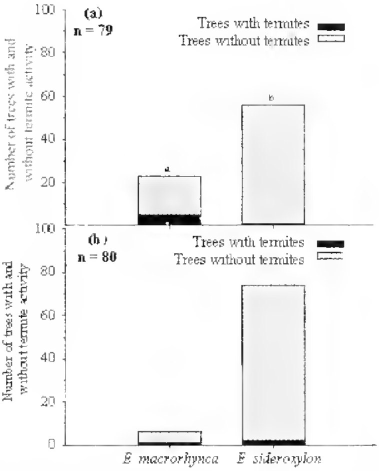

Fig. 9. The number of *Eucalyptus macrorhyncha* and *Eucalyptus sideroxylon* trees in (a) burnt and (b) unburnt areas with evidence of previous termite activity. Means with the same letters are not significantly different (lsd $p = 0.05$)

could influence the hollow formation process since greater numbers of scars were found in burnt trees. The findings from this study indicate that termite activity was only associated with base scars so fire appears to influence termite activity only if it creates scarring close to the ground. It would appear that the greater susceptibility of *E. macrorhyncha* to fire has resulted in an increase in termite activity through the availability of scars, which may lead to increased hollow numbers compared to *E. sideroxylon* in the future. No difference in the number of epicormic knobs was found between burnt and unburnt trees, indicating that the intensity of this particular fire was low. This lack of intensity may have reduced the influence of fire on the hollow formation process.

Burnt trees contained a greater number of scars than unburnt trees and therefore may allow greater chance of fungal decay occurring within a tree. However, dead branches and branch stubs also provide a conduit via which fungi access heartwood (Wilkes 1985). For this study the number of dead branches was significantly greater than the number of scars in trees from both burnt and unburnt areas, suggesting fire's ability to influence fungal access may be negligible since tree size appeared to be a greater determinant of dead branches/branch stubs numbers. Fire's influence on hollow formation in this study may be further undermined since the majority of scars recorded in burnt trees were small in size (Fig. 8). Since small scars will take less time to occlude they are less likely to provide access for fungi. The successional peak of some saproxylic fungi in Fennoscadian forests can take up to eight years (Lindhe, Asenblad *et al.* 2004). The surface area provided by a scar will most likely influence its potential as an infection conduit also.

Fire-burnt trees contained a greater number of small dead branches than unburnt trees but no differences occurred in the number of medium, large or very large branches. Positive correlations between diameter and bark thickness have been established by McArthur (1968) and Vines (1968) who also showed that thicker bark results in greater protection from the heat effects of fire. Our results are consistent with their findings. Although fire increased the number of small dead branches in trees, its ability to influence hollow formation in this case may be minimal since larger branches are more likely to persist and penetrate further into the main stem of trees (Jacobs 1955) providing greater potential for fungal and termite infection. Marks (1986) found for *E. regnans* that the probability of defects occurring in the main stem increased rapidly once branch diameter exceeded 10 mm. The presence of branch stubs and/or dead branches have previously been used to measure the hollow forming potential of eucalypts (Wormington and Lamb 1999). They defined a branch stub or dead branch >5 cm diameter as a pre-disposing hollow formation feature.

Tree size was shown to be a significant factor in the number of dead branches in trees and appears to be more influential in providing entry sources for fungi. Dead branches are shed from a tree through the formation of what Jacobs (1955) describes as a 'brittle zone' that forms at the base of the branch. The brittle zone does not form in areas of heartwood, so branches containing heartwood are less likely to break off cleanly and a branch stub often remains (Jacobs 1955; Marks *et al.* 1986). A branch stub containing heartwood takes longer to eject than branches containing no heartwood (Marks *et al.* 1986).The heartwood to sapwood ratio increases with branch size, therefore larger branches are less likely to break cleanly and may persist for considerable time.

Most hollows appear when areas of excavated heartwood are exposed, and most commonly occurs through branch breakage caused by wind or when dead branches are shed from the tree (Mackowski 1984). Gibbons (2000) found that, with the exception of hollow openings created by scars or fissures, the size of a hollow was a reflection of the size of the previously shed branch. If we consider the potential maximum size of hollow openings based on branch diameter then it is clear from this study that large trees are more likely to provide hollow openings of all sizes (Table 2). A similar result was found by Gibbons (2000). Even if fire were able to initiate and accelerate the hollow formation process there is no potential for large and very large hollow openings, based on branch diameter, to appear in very small trees and only slight potential in small trees.

In conclusion, the absence of large trees within this study site best explains the lack of visible hollows and raises concerns about the potential shortage of suitable habitat for hollow dependent fauna within this forest. Fourteen years after fire, trees in burnt areas have not significantly produced any more visible hollows than trees in unburnt areas. However, fire has resulted in greater scarring within the crown, which may influence the level of fungal decay within burnt trees, and ultimately hollows. Tree size and species influenced the likelihood of scarring caused by fire. While termite activity was associated with base scars, the number of base scars was not influenced by fire in this study. Fire has been shown again possibly to influence the hollow formation process, yet results from this study are inconclusive. Further studies in areas of forest exposed to fire of greater intensity may give a clearer indication of fire's ability to influence the hollow formation process.

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Relationship between perennial species richness and distance from water in Belah *Casuarina pauper* woodland

ME Westbrooke[1]

Abstract

Two hundred and fifteen *Casuarina pauper* woodland sites from pastoral leases and conservation reserves in NSW, SA and Victoria were assessed to determine community structure and floristics. Perennial species occurring were recorded, together with evidence of grazing, length of grazing history, time since reservation and distance from water, to investigate factors influencing species within the community. There was a clear relationship between perennial species richness and distance from water ($r = 0.7378$). Total grazing pressure including impact of sheep, rabbits, macropods and goats is difficult to determine for the present and is at best speculative for the past. Stocking rates, where available, are at a paddock level and grazing pressure may vary considerably across the paddock. Available water has a strong influence on grazing pressure. The distance from the nearest permanent or semi-permanent water was determined as the best surrogate measure of long-term grazing pressure. (*The Victorian Naturalist* **122** (1) 2005, 57-62)

Introduction

Belah *Casuarina pauper* woodland occurs from south-western Queensland through inland New South Wales, north-west Victoria and South Australia to Western Australia on a wide variety of soils. Data from stands in Mallee Cliffs National Park (Morcom and Westbrooke 1990) and the Scotia country (Westbrooke *et al.* 1998), which have had a history of low grazing pressure, suggest the community may be characterised by a far richer understorey than currently seen in most sites (Fig. 1). Because of its low fodder value *C. pauper* has been cleared by ring-barking or chaining over large areas to promote pasture growth (Cunningham *et al.*1981). Much Belah woodland in southern NSW and the Victorian Mallee has been cleared for cropping. Most of the remainder has been grazed by domestic stock, rabbits and elevated populations of kangaroos for up to 150 years (Fig. 2).

Methods

Two hundred and fifteen quadrats within *C. pauper* woodland on pastoral leases (n=183) and conservation reserves (n=32) in NSW, SA and Victoria were assessed to determine community structure and floristics. A limitation in comparative studies of vegetation in the arid zone is that the herbaceous vegetation responds rapidly to rainfall and certain species respond to rainfall only in particular seasons. The composition of the annual or short-lived perennial species in the ground layer is largely determined by the amount and seasonal distribution of rainfall. In drought years this layer of vegetation may be missing (Fox 1991). The sampling in this study was carried out over several seasons during which erratic rainfall led to high variation in the occurrence of ephemeral species. To enable valid comparisons between sites, only perennial species were included in most analyses. Each 50m x 50m (0.25ha) quadrat was selected as a homogeneous stand of vegetation, obvious ecotones being avoided. All perennial species occurring at each site were recorded. Current stocking level was determined from state government records and/or estimates of dung and vegetation damage. Level of grazing by rabbits was estimated based on presence/absence of warrens and estimates of dung and scratchings. These were combined with observations of macropod scats to give an estimate of total grazing. Length of grazing history and time since reservation were determined. All factors were assigned ordinal classes or values as follows:

(1) Current stocking rate from records and ground assessment

(SHEEP)
- 0 = unstocked
- 1 = light stocking
- 2 = moderate stocking, fresh dung
- 3 = high stocking rate, abundant fresh dung
- 4 = apparent overgrazing (based on vegetation damage)

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Fig. 1. Belah woodland in good condition: Yarrara Flora and Fauna Reserve.

Fig. 2. Belah woodland with degraded understorey.

(2) Rabbit grazing

(RAB) 0 = nil, no evidence of rabbits
1 = light, limited old dung
2 = moderate, frequent fresh dung and scratching
3 = heavy, abundant dung and scratching
4 = very high, adjacent active warren

(3) Overall grazing level based on visual evidence of stock, rabbits and macropods

(ALLGRAZ) 0 = nil
1 = light
2 = moderate
3 = high
4 = very high

(4) Period of grazing, based on years from first lease or licence to cessation or present (TIME)

$$\text{TIME} = \frac{\text{Time - minimum}}{\text{Range}}$$

(5) Time since reservation. Factor based on years since stock were removed (RES)

$$\text{RES} = \frac{\text{Time since res} - \text{minimum time since res}}{\text{Range of reservation period in sample}}$$

(6) Distance from water (DIS)

DIS = Distance in km to nearest permanent or semi-permanent water.

The distance to the nearest permanent or semi-permanent water source for stock was determined from on-ground observation, reference to maps and analysis of a Landsat TM (23 February 1993) image obtained following very high rainfall in 1992-93. Following this rainfall event all ground tanks, whether or not they were maintained, were holding water.

Species richness of quadrats was related to land use, perceived past and present grazing levels and distance from water. Stepwise multiple regression was used to give an understanding of the site variables most important in determining species richness.

Results

Seventy-five perennial trees, shrubs, climbers and woody parasites were recorded from the 215 study sites. These represent 22 families, with the highest representation from the Chenopodiaceae (26), Myoporaceae (8) and Mimosaceae (8). The species frequency in all study sites is given in Table 1.

Correlation coefficients for the relationship between perennial species richness and the six habitat variables for all quadrats, pastoral quadrats and conservation quadrats are given in Table 2.

Species richness increased with distance from water (Fig. 3) and time since reservation but decreased with increased rabbit grazing. Grouping of sites according to their distance from water clearly showed this relationship (Table 3). Comparison of the species frequency of individual species at sites close to (n=69) and distant from water (n=53) indicates those species that decline under the impact of grazing (Table 4).

Discussion

The impact of grazing on the rangelands of the study area was noted in the last century Dixon (1892), for example, commented that continuous stocking had destroyed the bushy vegetation and perennial grasses. He reported that numerous palatable chenopods and other species including *Myoporum* were disappearing to be replaced by inedible shrubs. Of the lower Murray region Dixon (1892: 202) comments:

> *... it does not appear probable that these extensive tracts can again be covered with their original flora which is unequalled in the world for abundance and variety of the very best fodder plants.*

The idea that sites a long distance from water may be important refuges for plant species in the rangelands is not new. Ratcliffe (1938: 213-4) during a study of the impact of rabbit grazing in South Australia observed:

> *Once I was shown a little corner a long way from the nearest water which had managed to survive in something like its virgin state. It was a sight for sore eyes, and a very useful indication of the extent of the changes which had taken place since the white man settled the land. There was actually grass about and the foliage of the shrubs grew down to the very ground; and I saw little bushes here which had practically vanished from the landscape.*

Species richness of quadrats was related to a number of factors which related to past grazing pressure. These included: period of stock grazing, grazing pressure based on evidence recorded from the site, stocking rate based on known grazing records and on ground observation, estimated rabbit grazing, distance from perma-

Table 1. Frequency of occurrence of perennial species in all study sites. * denotes exotic species. [1]Number of quadrats in which species occurred. [2]Percentage occurrence

Species	No.[1]	%[2]	Species	No.[1]	%[2]
Acacia aneura	2	0.9	*Grevillea huegelii*	26	11.4
Acacia burkittii	16	7.0	*Hakea leucoptera*	30	13.2
Acacia colletioides	84	36.9	*Hakea tephrosperma*	11	4.8
Acacia loderi	14	6.1	*Leichhardtia australis*	21	9.2
Acacia melvillei	8	3.5	*Lycium australe*	22	9.6
Acacia nyssophylla	1	0.4	**Lycium ferocissimum*	1	0.4
Acacia oswaldii	46	20.6	*Lysiana exocarpi* ssp. *exocarpi*	3	1.3
Acacia sclerophylla	2	0.9	Maireana appressa	5	2.2
Alectryon oleifolius ssp. *canescens*	146	64.0	*Maireana brevifolia*	21	9.2
Amyema linophyllum ssp. *orientale*	9	3.9	Maireana georgei	21	9.2
Amyema miraculosum ssp. *boorman*	45	19.7	*Maireana pentatropis*	69	30.3
Amyema quandang var. *quandang*	1	0.4	*Maireana pyramidata*	41	18.0
Atriplex stipitata	50	21.9	*Maireana radiata*	6	2.6
Atriplex vesicaria	47	20.7	*Maireana sedifolia*	62	27.2
Beyeria opaca	3	1.3	*Maireana trichoptera*	11	4.8
Callitris glaucophylla	24	10.5	*Maireana triptera*	15	6.6
Callitris gracilis	9	3.9	*Maireana turbinata*	6	2.6
Casuarina pauper	113	49.6	*Myoporum platycarpum*	152	66.7
Chenopodium curvispicatum	92	40.4	*Nitraria billardierei*	22	9.6
Chenopodium desertorum	79	34.6	*Olearia muelleri*	47	20.6
Chenopodium nitrariaceum	2	0.9	*Olearia pimeleoides*	78	34.2
Cratystylis conocephala	1	0.4	*Pimelea microcephala* . ssp. *microcephala*	21	9.0
Dodonaea viscosa ssp. *ang.*	89	39.0	*Pittosporum phylliraeoides*	18	7.9
Einadia nutans	31	13.6	*Rhagodia spinescens*	6	2.6
Enchylaena tomentosa var. *tomentosa*	165	72.4	*Rhagodia ulicina*	2	0.9
			Santalum acuminatum	22	9.6
Eremophila deserti	17	7.0	*Scaevola spinescens*	17	7.5
Eremophila glabra	55	24.1	*Sclerolaena bicornis*	2	1.0
Eremophila longifolia	17	7.5	*Sclerolaena diacantha*	34	14.9
Eremophila maculata var. *maculata*	1	0.4	*Sclerolaena divaricata*	4	1.8
Eremophila oppositifolia			*Sclerolaena obliquicuspis*	13	49.6
ssp. *oppositifolia*	28	12.3	*Sclerolaena patenticuspis*	77	33.8
Eremophila scoparia	12	5.3	*Senna artemisioides* ssp. *coriacea*	80	35.0
Eremophila sturtii	77	33.8	*Senna artemisioides* ssp. *filifolia*	57	25.0
Eriochiton sclerolaenoides	10	4.4	*Senna artemisioides* ssp. *petiolaris*	58	25.4
Eucalyptus gracilis	7	3.1	*Templetonia egena*	46	20.2
Exocarpos aphyllus	86	37.7	*Triodia scariosa*	2	1.0
Exocarpos sparteus	1	0.4	*Westringia rigida*	10	4.4
Geijera parviflora	26	11.4	*Zygophyllum aurantiacum*	22	9.6

nent or semi-permanent water and, if reserved, time since reservation. The visible manifestations of stock grazing were the result of up to 150 years of impact, and current stocking rates may, therefore, be a poor indicator of grazing damage. Even if current grazing pressure is a contributing factor, it is total grazing pressure which is most important. Current impacts of rabbits, macropods and goats are difficult to determine and past impacts are at best speculative. Stocking rates where available are at a paddock level but the grazing pressure may vary considerably across the paddock (Pickup 1994). Available water is a strong influence on grazing pressure. Several workers have discussed the impact of distance from water on vegetation and its relationship to grazing pressure (Osborn *et al.* 1932; Barker and Lange 1969). In this study, distance of the quadrat from the nearest permanent or semi permanent-water was determined as the best surrogate measure of long term grazing pressure.

In contrast to the high positive correlation between species richness and distance from water found in this study, a low correlation was found in a study of eight sites in arid Australia (Landsberg *et al.* 1996). Those assessments, however, were based on only six points ranging between 0.5 and 9km from water. Friedel (1997) found

Table 2. Correlation coefficients for the relationship between species richness and the six habitat variables for all quadrats, for pastoral quadrats and for conservation quadrats. *, P = <0.05; **, P = <0.01

Variable	All Quadrats	Pastoral quadrats	Conservation quadrats
Distance from water (DIS)	0.7378 **	0.7774 **	0.6691 **
Grazing level (ALLGRAZ)	0.6318 **	0.6007 **	0.4871 **
Stocking rate (SHEEP)	0.5792 **	0.6476 **	not relevant
Rabbit abundance (RAB)	0.6928 **	0.6177 **	0.6903 **
Period of grazing (TIME)	0.3233 **	0.1985 *	0.3864 *
Time since reservation (RES)	0.2892 **	not relevant	0.4182 **

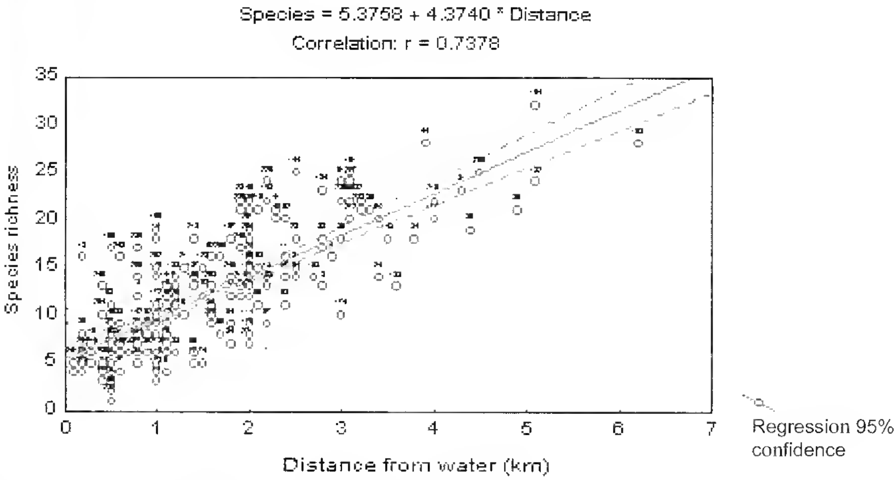

Fig. 3. Correlation between distance from water and perennial species richness, all sites.

fewer species at heavily grazed sites but no consistent trend of increasing species richness with distance from water, but her study differed from the present one in that it was based on herbaceous species recorded from small quadrats. The herbaceous layer shows high seasonal fluctuations and these may obscure the effects of grazing (Austin *et al.* 1981; O'Connor and Roux 1995).

Conclusion

Increased grazing pressure from stock, rabbits and increased macropod populations have had a significant impact on community structure of arid woodlands in south east Australia. Whilst past and present grazing levels are difficult to quantify, these data indicate that distance from water is a useful surrogate measure. This also supports the view that, in conservation reserves created in areas previously used for pastoralism, an essential measure for vegetation recovery is the closure of watering points.

Table 3. Mean perennial species richness of quadrats in relation to distance from water.

Distance from water (km)	Species richness
>2 (n=53)	18.8 (10-22)
1-2 (n=93)	11.4 (5-18)
<1 (n=69)	6.5 (1-16)

Acknowledgements

I would like to thank the many pastoralists for their hospitality, provision of access to sites and sharing of knowledge. Also Richard Bath, Robert Scriven of the Department of Conservation and Land Management, NSW; Joanne Gorman of the National Parks and Wildlife Service, NSW and Mate Osborne of the SA National Parks and Wildlife Service for freely giving advice and assistance. Thanks are also due to Sue Hadden, Miranda Kerr and John Miller, Centre for Environmental Management, University of Ballarat for assistance and companionship during fieldwork and Dr Bob Parsons for his enthusiasm and support.

Table 4. Perennial species frequency for quadrats distant (>2km) and close (<1km) to water.

Species	% >2km	% <1km	Species	% >2km	% <1km
Acacia burkittii	15	5	*Maireana pentatropis*	53	12
Acacia colletioides	62	20	*Maireana pyramidata*	15	18
Acacia oswaldii	38	14	*Maireana radiata*	2	6
Acacia sclerophylla	2	0	*Maireana sedifolia*	47	5
Atriplex stipitata	42	11	*Maireana trichoptera*	17	0
Atriplex vesicaria	26	15	*Maireana triptera*	11	2
Beyeria opaca	6	0	*Maireana turbinata*	8	0
Chenopodium curvispicatum	70	15	*Nitraria billardierii*	13	9
Chenopodium desertorum	66	11	*Olearia muelleri*	45	5
Chenopodium nitrariacenm	2	0	*Olearia pimeleoides*	64	15
Cratystylis conocephala	2	0	*Pimelea microcephala*	17	5
Dodonaea viscosa ssp. *ang.*	64	15	*Pittosporum phylliraeoides*	17	3
Einadia nutans	21	5	*Rhagodia spinescens*	6	5
Enchylaena tomentosa	83	56	*Rhagodia ulicina*	2	0
Eremophila deserti	13	3	*Santalum acuminatum*	23	5
Eremophila glabra	49	8	*Scaevola spinescens*	21	3
Eremophila oppositifolia	21	3	*Sclerolaena diacantha*	30	10
Eremophila scoparia	13	2	*Sclerolaena divaricata*	6	0
Eremophila sturtii	47	18	*Sclerolaena obliquicuspis*	49	47
Eriochiton sclerolaenoides	8	2	*Sclerolaena patenticuspis*	49	22
Exocarpos aphyllus	64	18	*Senna artemisioides ssp. fil.*	47	11
Grevillea huegelii	25	5	*Senna artemisioides ssp. pet.*	43	11
Leichhardtia australis	21	3	*Senna artemisioides ssp. x cor.*	47	11
Lycium australe	17	5	*Templetonia egena*	47	5
Maireana appressa	4	0	*Westringia rigida*	9	0
Maireana brevifolia	6	12	*Zygophyllum aurantiacum*	23	2
Maireana georgei	19	3			

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Kookaburra: King of the Bush

by Sarah Legge

Publisher: *CSIRO Publishing, Collingwood, Vic, 2004. 117 pp, paperback, illus. ISBN 0643090630. RRP $34.95*

Kookaburras, with their relatively large size and loud voices, are among the most easily recognisable Australian birds. They feature so prominently in our culture that it would seem reasonable to expect details of their lives and habits to be well known. Until recently, however, there have been many gaps in our knowledge, as well as a number of misconceptions about kookaburras' appearance and behaviour. Now this entertaining, informative and very readable book substantially adds to our understanding of these remarkable birds.

Most of the book is based on the author's PhD research on Laughing Kookaburras, but all four kookaburra species, two of which live only in New Guinea, are included. There are nine chapters: The culture of kookaburras, Taxonomy and distribution, Appearance and habits, Social and mating system, Breeding, The helping system, Life in the nest, Mortality, and Conservation and management. References for each chapter are located at the end of the book. The text is illustrated with photographs (black and white and colour), maps, tables and diagrams, along with the author's delightful monochrome drawings of the birds. There is no index.

Each chapter is filled with interesting information, starting with Aboriginal legends and popular jingles, and proceeding to specific details, such as how kookaburras' eyes focus on prey items and how their social organisation works. As stated in the preface, 'The end point of these ever-more [sic] microscopic enquiries is a thorough description of what happens in the nest, and it makes for front-page tabloid material: intense rivalry for resources, murder of relatives, and Machiavellian tactics by parents to control the violent tendencies of their young.'

In some places the text is marred by clumsy expression, e.g. 'Like the shape of the brain, the olfactory bulbs are similar in size to the raptors.'(page 42); '…how each bird in a cooperative group is related to each other…'(page 50); and '…chicks aged 6, 7 and 8 days old' (page 66). Also, references to studies by Bill Buttemer (pages 34, 38), Reyer & Schmidl (page 45), and Mike Baker (page 45) have been omitted; Chapter 3 begins by confusing size with weight; and T (for 'telencephalon') should have been included in the caption for Figure 3.2 (page 41).

This book makes a significant contribution to our knowledge of Laughing Kookaburras, and provides a fascinating insight into the complexities of their lives. It should be useful to amateur and professional ornithologists, upper secondary level and undergraduate students, and anyone interested in natural history. It will surely inspire further investigation of kookaburra and other wildlife mysteries that are still waiting to be solved.

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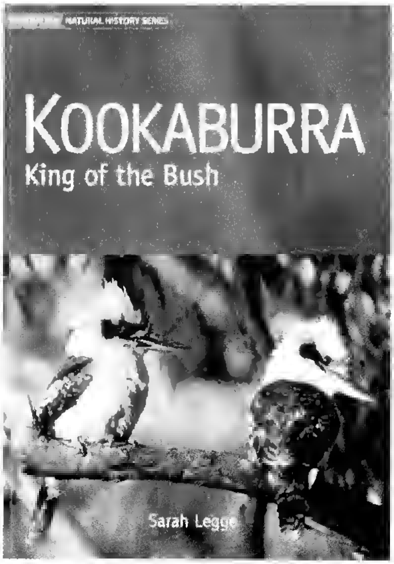

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The Victorian Naturalist

Volume 122 (2) **April 2005**

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From the Editors

As promised in our Editorial of the previous issue, this issue of *The Victorian Naturalist* contains the results of recent research undertaken in a range of subject areas. Within these pages is discussion of work on birds, fish, plants, reptiles, and mammals. The geographic focus of the interesting work reported here is similarly wide - from the western shore of Port Phillip Bay to the Murray-Sunset National Park in the State's northwest, and including a couple of areas more-or-less in between.

The paper by Gowans, Callister, Westbrooke and Gibson is one of two that look at aspects of the vegetaion in the Murray-Sunset National Park. It is one of the papers delivered at the Biodiversity Symposium at Ballarat, which was not included in the previous issue.

This issue also includes the most recent additions to the bibliography on *Banksia*, compiled by Tony Cavanagh. The previous four parts of the bibliography have appeared in *The Victorian Naturalist* in 1989, 1994, 1997, and 2000, and this part extends the list to more than 530 entries. As well as providing an up-to-date list of references on this important topic, this bibliography indicates the shifts in area of research on Banksia, that occur from time to time.

The Editors regularly receive books offered for review in the pages of *The Victorian Naturalist*. This issue contains four such reviews of volumes we feel will be of interest to many readers. It seems that publishing in natural history and related subjects is currently vibrant and readers can look forward to more reviews of published work in a range of fields relevant to the purview of the Field Naturalists Club of Victoria..

Thankyou to Ken Bell for the Index to Volume 121, 2004 which is published in this issue.

***

We take this opportunity to remind members of the FNCV, and other readers of *The Victorian Naturalist*, of the Club's forthcoming symposium in celebration of its 125th anniversary. This two-day event will take place at Mueller Hall at the Royal Botanic Gardens, on the weekend of 28/29 May. Details of the conference and a registration form have been circulated with recent issues of *Field Nats News* and can be obtained from the FNCV office. Those readers who are unable to attend will be pleased to know that many of the papers delivered at the Symposium will be published in *The Victorian Naturalist* later in the year.

Erratum

In the most recent issue of *The Victorian Naturalist* (vol. 122, no. 1) an unfortunate mistake was made in the caption for the cover photograph. The illustration showed a Dainty Swallowtail *Papilio anactus*, which was erroneously labelled as 'Orchard Swallowtail *Papilio aegeus aegeus*'. The Editors regret the mistake, and apologise if any readers were inadvertantly misled. We also thank Dr Michael Braby for pointing out the error to us.

Cover: Photograph of *Banksia* (species not known), by Wendy Clark. See article on p. 102

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Victorian Naturalist

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Distribution of foraging waterbirds throughout the Lake Borrie ponds at the Western Treatment Plant, Victoria (Australia)

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Abstract

Lake Borrie at the Western Treatment Plant (WTP) is widely regarded as an important site for waterbirds, and it forms part of a Ramsar Wetland of International Importance. The lake comprises two independent series of waste-stabilisation ponds. The distribution of foraging waterbirds throughout the two systems was studied. Overall, Lake Borrie was used by many species of waterbirds with different foraging methods. Birds that fed in the water were found in highest densities on the aerobic ponds, which occur towards the end of each series. Musk Ducks *Biziura lobata* were in highest densities in the deepest of these aerobic ponds. Some waterbirds, such as ibis species, fed on the dense grass meadows of the embankments of the anaerobic ponds. Paradise Pond, a shallow wetland to the north of Lake Borrie that receives overflow from one of the Lake Borrie ponds, supported higher numbers of waders than any of the Lake Borrie ponds. In 2005, Lake Borrie will be supplied with treated effluent rather than raw sewage, as is currently the case. Such a change has the potential to affect benthic and planktonic food-webs, which could, in turn, influence foraging waterbird use of the ponds. The data presented here will provide a useful reference point for detecting any such changes in the future. (*The Victorian Naturalist* **122** (2) 2005, 68-78)

Introduction

The Western Treatment Plant (WTP) is a large sewage treatment facility that receives about 52% of the Greater City of Melbourne's sewage (about 500 ML day^{-1}) (Melbourne Water *et al.* 2000). It is listed as a wetland of international importance in acknowledgement of the internationally significant numbers of waterfowl and shorebirds found there (Ramsar Convention Bureau 1984). Within the WTP, a site known as Lake Borrie is considered to be of particular importance to waterbirds (Elliget 1980; Ramsar Convention Bureau 1984; Lane and Peake 1990). Lake Borrie is made up of two independent series of waste-stabilisation ponds (WSP). Unlike most series of WSP at the WTP, the Lake Borrie ponds vary greatly in size, are irregular in shape and differ in depth. One pond, Pond 9, is unique in that it contains a large stand of dead trees (mostly *Melaleuca lanceolata*). The physical, chemical and biological properties of ponds in a sewage treatment series are largely dependent on the position of the pond in the series. Ponds at the start of a series tend to be anaerobic, those in the middle, facultative (i.e. aerobic upper layer and anaerobic lower layer), and those toward the end, aerobic. Waterbird use of WSP has been well documented (Dornbush and Anderson 1964; Uhler 1964; Dodge and Low 1972; Willson 1975; Swanson 1977; Maxson 1981; Piest and Sowls 1985), but only few studies have investigated the distribution of waterbirds throughout ponds representing various stages of treatment (Hamilton *et al.* 2005).

At present, Lake Borrie is supplied with pre-settled raw sewage. But this will not always be the case. More stringent discharge standards relating to the quality of effluent that is discharged from the WTP into Port Phillip Bay will be enforced. In order to meet these demands, two new activated sludge treatment plants (ASP) have been commissioned. From 2005 onwards, Lake Borrie will be supplied with the effluent from one of these plants. This effluent would be expected to be of greatly different quality from pre-settled raw sewage. In particular, the concentration of biologically available carbon is likely to be much lower in the ASP effluent, and it is not known what effect such a change will have on the food-webs in the Lake Borrie ponds

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(Hamilton *et al.* 2003). If the food-webs are altered drastically, then this may affect the use of the ponds by foraging waterbirds (Hamilton *et al.* 2002). It is possible that the distribution of waterbirds throughout the ponds will change. The primary objective of this paper is to provide data that can be used as a reference point for detecting such changes. We also briefly describe the use of a shallow pond, Paradise Pond, adjacent to Lake Borrie North.

Materials and methods

Study site

The WTP occupies 10 851 ha and is located 35 km west of Melbourne on the shores of Port Phillip Bay (Fig. 1). The Lake Borrie North and South systems are two major series of waste-stabilisation ponds at the WTP (Fig. 2). They are independent: there is no exchange of sewage between them. Both have about the same total capacity, 48.2% and 51.8% of the total capacity of Lake Borrie for North and South respectively. They receive influent from a common supply carrier and they usually receive roughly equal levels of flow. The two systems also cover about the same total surface area; the North and South accounting for 49.4% and 50.6% of Lake Borrie respectively (Elliget 1980).

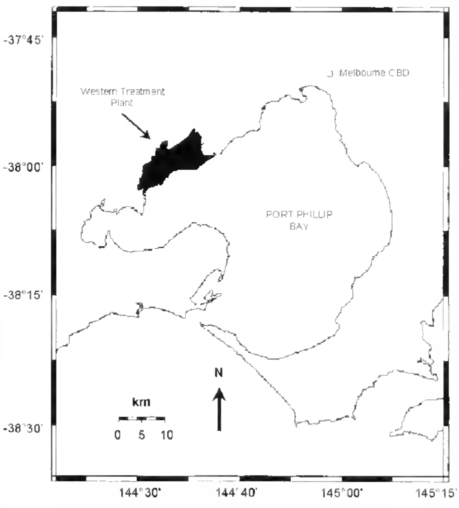

Fig. 1. Map showing the location of the Western Treatment Plant.

At the northern-most point of Pond 9 some of the effluent from the pond flows through a drain to form a pool of shallow water on the other side of the road. This pool is colloquially known as Paradise Pond (Fig. 2). Paradise Pond is not formally considered to be a part of the Lake Borrie North lagoon, but it can effectively be seen as an extension of Pond 9.

The direction of sewage flow through the Lake Borrie systems is marked in Fig. 2. The estimated mean depth of each pond is presented in Tables 1 and 2. These estimates were calculated from the ratio of maximum volumetric capacity to surface area (data obtained from MMBW Map L–76). The ponds that are considered to be anaerobic (according to Melbourne Water map L-76) are also denoted in Tables 1 and 2. Most of the remaining ponds are aerobic, but Ponds 8 and 23 in the North and South systems respectively can change in oxygenation status from anaerobic, to facultative, to aerobic (A Dunn pers. comm.).

The boundary of the Paradise Pond area has been estimated roughly here. It should be acknowledged that in summer it sometimes receives minor additional input from overland-flow treated effluent (T Gulovsen pers. comm.). Similarly, it should be recognised that in summer Pond 28 receives, at its southern end, a relatively minor addition of overland-flow treated effluent, and in the first week of May and in October some grass-filtered effluent enters here as well.

Sampling protocol

All 30 of the Lake Borrie Ponds plus Paradise Pond were surveyed at approximately monthly intervals from 1 August 1998 to 27 June 1999. It took about two hours to survey all of the ponds, and sampling was timed so that the mid-point roughly coincided with mid-afternoon (i.e. half way between true midday and sunset). Different species of waterbirds spend different amounts of time feeding at different times during the day, and thus it was impossible to choose a sampling time when all species were expected to be feeding near peak levels. The mid-afternoon sampling time was chosen for two reasons. First, most waterfowl species would be expected to be spending a relatively high

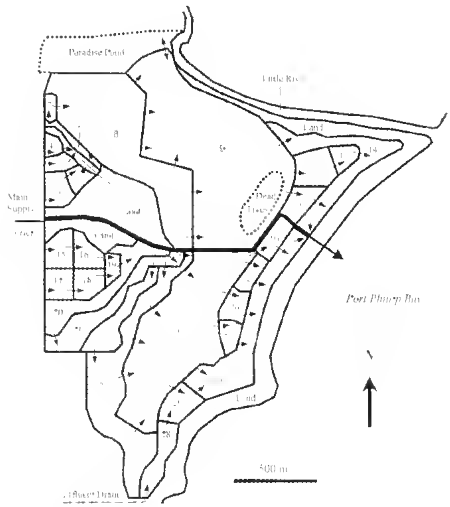

Fig. 2. Map of the Lake Borrie North and South systems.

proportion of their time feeding at this time of day (Hamilton *et al.* 2002). Second, the length of time it took to survey all the ponds (about two hours) precluded a sampling protocol centred on sunrise or sunset.

Ponds were sampled in the same order on each date. Due to logistical constraints, mainly time and track access, it was not possible to randomise the order of sampling. The ponds at the start of the system were sampled first, and sampling then progressed down Lake Borrie, with no distinction being made between the North and South systems. Paradise Pond was sampled immediately after the Lake Borrie surveys had been completed. Most ponds were surveyed from the car using a Leica® Televid 77 telescope (20–60 x zoom magnification) mounted to the window with a Bushnell® car window clamp. Because of both its large size and the presence of the dead trees, Pond 9 was surveyed using the approach described by Hepworth and Hamilton (2001), which basically involved dividing the pond into five sections. Several ponds (2, 5, 6 and 15–18) could only be reached by foot, and they were surveyed using binoculars (Carton® 10 x 50). The total number of individuals of each species at each pond was recorded. Birds in flight were not recorded, as they could not be inferred to be using any particular pond. For diving species, the fact that some birds could be under water needed to be taken into account. Hardheads *Aythya australis* and Hoary-headed Grebes *Poliocephalus poliocephalus* were surveyed using the methodology described in Hamilton and Taylor (2004) and Hamilton *et al.* (2004), respectively. For Blue-billed Ducks *Oxyura australis* and Musk Ducks, which have been reported to have maximum dive times of 30 and 60 seconds respectively (Frith 1982), each field of view was maintained for at least this long so that all birds could be counted.

Feeding and resource use assumptions

Time constraints did not permit a detailed survey of the birds' activities, as was done by Hamilton *et al.* (2002) for waterfowl at Pond 9, and feeding frequency data at one particular time of day would have been of little value. However, qualitative observations were made at each pond to determine if a species fed at the pond at all. Any species seen feeding at Lake Borrie was simply defined as a 'foraging species' for the purposes of this study. Furthermore, there were no ponds where any of these foraging species were only seen roosting; some individuals of each species, at each pond, were seen feeding. Species that were never seen feeding at Lake Borrie, i.e. Australian Pelicans and all cormorant species, were excluded from the analysis.

Birds using any of the resources were included in the analysis. Thus, it was assumed that birds that were seen using a resource where they were unlikely to feed, such as Pink-eared Ducks *Malacorhynchus membranaceus* on a log, would have been resting between feeding bouts at that particular pond. This assumption is not likely to be true always, as some individuals may have roosted at different ponds from those which they fed on. But for the waterfowl species studied at Pond 9 over the same period (Hamilton *et al.* 2002), there was minimal diurnal variation in abundance over the day, which implies that there were not substantial movements to or from this pond throughout the day.

Data analysis

The distribution of waterbirds on the various ponds was considered separately for the North and South systems. Data were pooled across all dates, and the density of birds at each pond was simply reported as a percentage of the sum of densities from all ponds in the series. By reporting data as percentage densities rather than percentage abundances, implications about the habitat quality could be made. Some species were found exclusively on the embankment, and for these abundance was corrected for the length of the pond perimeter rather than surface area (i.e. density for birds using pond). This was important because large ponds have a lower perimeter to surface area ratio than small ponds. Representing the embankment as a one-dimensional measure is not ideal, but the area of the embankment for each pond was not known. Nevertheless, the width of the embankment was very similar for all ponds, as it is effectively a vehicular track. Thus, perimeter length was probably a reasonable measure of relative availability of embankment habitat. Species that were only represented on less than five dates are denoted (Tables 1 and 2), and the total number of birds, which was very low for some species, is reported. These parameters are important when interpreting the relative abundances across the ponds.

Since Paradise Pond is not formally considered to be part of the North system—and because its physical characteristics are distinctly different from the Lake Borrie ponds—it was considered separately. The number of individuals of each species seen at Paradise Pond on each of the twelve sampling dates is presented in Table 3. The surface area of Paradise Pond is unknown, and hence the data could not be presented as densities. As with the study of the Lake Borrie Ponds, species that were not seen feeding at Paradise pond were not included.

Results

Lake Borrie North

All the aerobic ponds (9–14) supported substantially higher percentage densities of total waterbirds than the anaerobic ponds (1–7) (Table 1). Pond 8, which varies in oxygenation status, also supported relatively low densities of waterbirds. With the exception of the Pacific Black Duck *Anas superciliosa*, all species were completely absent from the water of the anaerobic ponds throughout the study; all other species were seen feeding on the embankments. Whilst Pacific Black Ducks were seen on the water, they were only seen feeding on the grasses on the embankment. Thus, no species was seen feeding in the water on the anaerobic ponds. Black Swans *Cygnus atratus*, Australian White Ibises *Threskiornis molucca*, Purple Swamphens *Porphyrio porphyrio*, and Masked Lapwings *Vanellus miles* were also seen feeding on the embankments of these ponds (Table 1).

Pond 9 appeared to provide the most useful habitat for foraging waterbirds in general, supporting the highest relative density (30% of the North System); most waterfowl species were found in high percentage densities on this pond. The most notable exception was Musk Duck, which was reported almost exclusively on Pond 14. Australasian Shoveler *Anas rhynchotis*, Australian Shelduck *Tadorna tadornoides*, Chestnut Teal *Anas castanea*, and Pink-eared Duck demonstrated a strong preference for Pond 9 (90%, 77%, 72%, and 100% respectively). Black Swans were found in similar densities across all the aerobic ponds, and Hardheads were found in greatest densities across three of them—Ponds 9, 11, and 13. Hoary-headed Grebes were observed in greatest densities on Ponds 13 and 14 (26% and 31%), although reasonably high percentage densities (10–19%) were also reported for the other aerobic ponds. Eurasian Coots *Fulica atra* were found in the highest densities at Pond 12 (78%). Neither Hoary-headed Grebes nor Eurasian Coots were seen on the anaerobic ponds on any occasion. Grey Teal *Anas gracilis* was the only species that was observed to use Pond 8 to an appreciable degree (55%). Purple Swamphens were most frequently seen feeding on the grassy embankments of the anaerobic ponds (Table 1). There were insufficient data available to adequately describe the distribution of the other waterbird species (Table 1).

Lake Borrie South

Like the Lake Borrie North system, the anaerobic ponds in the South system were used substantially less frequently than the aerobic ponds by most waterbirds (Table 2), and species were only ever seen feeding on embankments of these ponds, never

Table 1. The percentage densities of foraging waterbirds on the Lake Borrie North ponds (i.e. percentage of individuals of a species, standardised for the area of the pond, or, in the case of species that were only seen on the pond embankments or wading at the edge of any pond['], the length of its perimeter). Total waterbird percentage densities are based on pond area. The number of species observed has not been adjusted for pond area. *Species that were observed on less than 5 of the 12 sampling dates, [']species never seen feeding on open water of that particular pond, only on embankment, *n* = total number of birds counted across all dates, [a]anaerobic ponds (according to Melbourne Water map L-76).

pond no.	1[a]	2[a]	3[a]	4[a]	5[a]	6[a]	7[a]	8	9	11	12	13	14	*n*
depth (m)	0.38	0.60	0.62	0.46	0.54	0.45	0.60	1.25	0.85	1.22	1.28	1.13	1.22	
Hoary-headed Grebe								0.4	13.7	10.1	18.9	26.0	30.9	*8624*
Black Swan	0.4[']			0.3[']				1.0	15.4	18.6	22.5	15.4	26.2	*4411*
Australian Shelduck								7.8	76.8	10.4	0.4	1.7	2.9	*3913*
Pacific Black Duck	23.9[']							7.9	8.4	23.8	9.6		26.4	*198*
Grey Teal								54.5	35.2	1.2			9.1	*1118*
Chestnut Teal								0.5	72.3	0.8	3.8	5.8	16.7	*9165*
Australasian Shoveler								0.2	89.8				10.0	*1753*
Pink-eared Duck									100.0					*4229*
Hardhead								2.9	32.4	21.5		37.7	5.5	*119*
Freckled Duck*									100.0					*2*
Blue-billed Duck*									17.7				82.3	*9*
Musk Duck									0.1			10.4	89.5	*124*
Purple Swamphen[']	24.3		18.4	37.2	1.4	2.0	15.4		0.9				0.4	*86*
Eurasian Coot								0.1	9.6		78.4		11.9	*612*
White-faced Heron['] *				98.5					1.5					*4*
Australian White Ibis[']	9.2	3.3	16.7	70.1					0.8					*24*
Straw-necked Ibis['] *			100.0											*1*
Sharp-tailed Sandpiper['] *							98.4		1.6					*2*
Masked Lapwing['] *	22.5			77.5										*5*
Black-winged Stilt['] *				88.0					12.0					*39*
Red-necked Avocet['] *									100.0					*30*
Silver Gull*								69.9	30.1					*2*
All waterbirds	**1.2**	**<0.1**	**0.8**	**2.5**	**<0.1**	**0.1**	**0.5**	**2.0**	**29.9**	**9.0**	**16.3**	**15.0**	**22.5**	***34819***
Total no. species	**5**	**1**	**3**	**6**	**1**	**1**	**2**	**10**	**20**	**7**	**6**	**6**	**12**	***22***

on the water. But the Australian Shelduck and Grey Teal, which did not use the anaerobic ponds in the North system, did use them in the South system. Both species were often seen grazing on the dense meadows of grass around the first few ponds in the series (Table 2). Australian Shelduck densities were highest at Pond 24, where these birds fed in the water. Pacific Black Ducks were seen feeding on grasses on the embankments of some of the anaerobic ponds, but they were found in greatest densities on the aerobic ponds—particularly Pond 28—where they fed in the water. Black Swans, whilst found in highest densities on the aerobic ponds, were also seen feeding on the embankments of the anaerobic ponds (Table 2). Chestnut Teal were almost exclusively found on the aerobic ponds, particularly 25, 26, and 30. Australasian Shovelers, Blue-billed Ducks, Eurasian Coots, Hoary-headed Grebes, Musk Ducks and Pink-eared Ducks were entirely absent from the anaerobic ponds. The highest densities of Australasian Shovelers were at Ponds 10 and 24. Blue-billed Ducks were reported only on Pond 24, although they were seen only on three dates. Eurasian Coots were present on all the aerobic ponds, but they were found in highest densities on Pond 29. Hoary-headed Grebes also used all the aerobic ponds. They were observed in highest densities on Pond 30. Musk Duck relative densities were substantially higher on Pond 30 (85% of the South System) than for any other pond. Pink-eared Ducks were found almost exclusively on Pond 24, although they were seen only on three dates, and any conclusions about their distribution need to be treated with caution.

Australian White Ibises were frequently seen feeding on the embankments of the anaerobic ponds, particularly Ponds 15 and 22. Similarly, Purple Swamphens were often seen feeding on the embankments of the anaerobic ponds, especially Pond 16. The distribution of all other species can be seen in Table 2, but their numbers were generally low, and they were all observed on less than five dates.

Paradise Pond

The waterbird community at Paradise Pond was characterised by the presence of many wader species, five of which—Common Greenshank *Tringa nebularia*, Curlew Sandpiper *Calidris ferruginea*, Double-banded Plover *Charadrius bicinctus*, Red-capped Plover *Charadrius ruficapillus*, and Red-necked Stint *Calidris ruficollis*—were not reported at either of the Lake Borrie systems during the study. In addition, another two species, the Glossy Ibis *Plegadis falcinellus* and Sharp-tailed Sandpiper *Calidris acuminata*, were found in greater numbers over the entire study at Paradise Pond (20 and 1845 respectively) than at the two Lake Borrie systems combined (one and two respectively). All these species fed by wading in the shallow water of Paradise Pond. Also, since this study, around 40 Banded Stilts *Cladorhynchus leucocephalus* were observed feeding at the site in a mixed flock with Black-winged Stilts *Himantopos himantopus* (AJH pers. obs. September 2001).

Masked Lapwings, Black Swans, Australian White Ibises, Straw-necked Ibises, Australian Shelducks and Australian Wood Ducks all fed on the embankment. Silver Gulls *Larus novaehollandiae* were seen feeding in the water.

Most duck species were seen feeding at Paradise Pond (Table 3), the exceptions being the two diving species—Blue-billed Duck and Hardhead. Another diving bird, Hoary-headed Grebe was only rarely sighted at Paradise Pond (three birds over entire study), and Eurasian Coots were not seen at all.

Discussion

In general, the distribution of waterbirds throughout the Lake Borrie ponds in this study was similar to that observed by Elliget (1980) over twenty years ago. For the North and South systems, both studies found that the anaerobic ponds were rarely used by any species of waterbirds. The only feeding habitat these ponds appeared to offer was the embankment. In both studies, Purple Swamphens, Pacific Black Ducks, Australian Shelducks and Black Swans were seen grazing on the grass surrounding these ponds. These grass meadows were dominated by *Paspalum* sp. (Elliget 1980; AJH pers. obs.). In the present study White-faced Herons *Egretta novaehollandiae* were observed stalking in

Table 2. The percentage densities of foraging waterbirds on the Lake Borrie South ponds. Presentation as for Table 1.

pond no.	**15**[a]	**16**[a]	**17**[a]	**18**[a]	**19**[a]	**20**[a]	**21**[a]	**22**[a]	**23**	**24**	**25**	**26**	**27**	**10**	**28**	**29**	**30**	***n***
depth (m)	0.66	0.69	0.72	0.84	0.81	1.50	0.99	1.68	0.88	0.98	1.21	1.52	1.34	1.28	1.06	1.12	1.31	
Hoary-headed Grebe									2.2	16.2	10.3	10.1	7.7	16.8	6.2	7.0	23.6	*9959*
Black Swan	3.0[$]	0.2[$]	1.5[$]	5.2[$]			0.1		3.7	7.8	9.3	9.0	16.7	19.7	7.3	10.5	6.1	*3324*
Australian Shelduck	25.5[$]	6.4[$]	5.0[$]	0.4[$]	2.5[$]	0.5[$]			5.7	31.2			1.0	13.0		2.7	6.2	*1766*
Pacific Black Duck		0.4[$]				0.2[$]	4.0[$]	13.7[$]	2.5	0.5	1.2	13.5	14.3	1.6	44.0	1.1	3.0	*373*
Grey Teal	64.9[$]	11.4[$]							5.2	5.5	5.8	4.7		1.0			1.4	*266*
Chestnut Teal							0.1	0.9	4.5	1.4	20.7	39.0	3.7	5.1	3.6	2.5	18.3	*927*
Australasian Shoveler									0.3	38.5		8.0	3.4	49.9				*1935*
Pink-eared Duck*										94.5				3.3			2.2	*1613*
Hardhead*										6.2	93.8							*36*
Blue-billed Duck*										100.0								*413*
Musk Duck										0.2	10.9	2.0				2.2	84.6	*262*
Purple Swamphen'	11.0	58.7	17.7	7.0		2.6		2.5	0.1	0.3								*187*
Eurasian Coot									5.3	8.6	4.0	7.4	10.9	8.3	1.1	49.0	5.3	*477*
White-faced Heron'*													100.0					*1*
Glossy Ibis'*	100.0																	*1*
Australian White Ibis'	39.0	5.3	2.5		14.1	1.8	1.4	32.7	0.8						2.5			*45*
Straw-necked Ibis'*	9.5			12.1	20.7		6.2	48.0	3.5									*11*
Masked Lapwing'*	41.6						54.2			4.2								*13*
Black-winged Stilt'*		100.0																*4*
Silver Gull*															80.4		19.6	*6*
All waterbirds	**4.0**	**2.4**	**1.1**	**1.4**	**0.3**	**0.1**	**0.3**	**1.1**	**2.8**	**14.8**	**8.7**	**10.7**	**8.6**	**15.5**	**6.8**	**7.1**	**14.2**	***21619***
Total no. species	**8**	**7**	**4**	**4**	**3**	**4**	**6**	**5**	**11**	**14**	**8**	**8**	**8**	**9**	**7**	**7**	**11**	***20***

the grass, and both ibis species were seen feeding in this soft ground. In contrast, the embankments of the aerobic ponds were generally much steeper, thus less moist, and more compacted by vehicular traffic, and they did not support lush growth of grass as did the anaerobic ponds. These characteristics probably explain why birds were rarely seen feeding on these embankments.

Even though the embankments of the aerobic ponds were not well used, the ponds themselves were clearly the most utilised ponds in the North and South systems in both the present study and that of Elliget (1980)[1]. It is likely that the aerobic ponds supported a higher abundance food, but samples were not taken to confirm this. A study on several other series of ponds at the WTP found that populations of planktonic and benthic invertebrates were more abundant in aerobic ponds than anaerobic ponds (Hamilton *et al.* 2005).

It could be argued that waterbirds chose ponds based on their size. But this seems unlikely for most species, since in both the North and South systems several relatively small ponds (e.g. 10, 12, 13 and 26) supported substantially higher densities of total waterbirds, and of most species, than much larger ponds within the respective systems (e.g. 8, 11 and 23). Pond 10 is one of the smallest ponds in the South system, yet it supported the highest density of total

[1] Elliget (1980) presented data as abundance, but we have recalculated her data as percentage density. These recalculated data will be referred to henceforth.

Table 3. Numbers of waterbirds seen at Paradise Pond on twelve dates.

	1/8/ 1998	29/8/ 1998	27/9/ 1998	24/10/ 1998	28/11/ 1998	28/12/ 1998	24/1/ 1999	21/2/ 1999	28/3/ 1999	25/4/ 1999	29/5/ 1999	27/6/ 1999	*total*
Australian Pelican		1											*1*
Hoary-headed Grebe						1				2			*3*
Black Swan	3		7	4	10	1	9	323	437	33	136	18	*981*
Australian Shelduck	1	1	15	222	267	97	230	151	20	5	1	3	*1013*
Pacific Black Duck					1	1	22	2	5	12	7	4	*54*
Grey Teal	118	168			5	10	215	87	210	139	104	113	*1169*
Chestnut Teal	3	22		7	73	16	36	69		25	60	3	*314*
Australasian Shoveler	13	2	2		18		84			11		69	*199*
Pink-eared Duck							1	294	176	363	10		*844*
Australian Wood Duck						11							*11*
Purple Swamphen				1					5	1	25		*32*
White-faced Heron	1												*1*
Glossy Ibis		12	8										*20*
Australian White Ibis								3	3	3	1		*10*
Straw-necked Ibis								40		1			*41*
Common Greenshank					2								*2*
Sharp-tailed Sandpiper			1500	175	160		10						*1845*
Red-necked Stint			225										*225*
Curlew Sandpiper			500		30			13					*543*
Masked Lapwing		2	3							18			*23*
Double-banded Plover		2											*2*
Red-capped Plover		2			3								*5*
Black-winged Stilt	1	15	4		20		12	1	1	23		50	*127*
Red-necked Avocet	53	1	98		40	22				21	35	24	*294*
Silver Gull		2					52				50	5	*109*
Total waterbirds	**193**	**230**	**2362**	**409**	**629**	**159**	**671**	**983**	**857**	**657**	**429**	**289**	**7868**
No. species	**8**	**12**	**10**	**5**	**12**	**8**	**10**	**10**	**8**	**14**	**10**	**9**	**25**

waterbirds. Nevertheless, Pink-eared Ducks were observed exclusively on the two largest ponds in Lake Borrie, Ponds 9 and 24 (mainly Pond 9), and Australian Shelducks were also found in highest densities on these two ponds. Elliget (1980) found similar distributions for both of these species.

Australian Shelducks did not form distinct feeding or resting flocks as did Pink-eared Ducks. Ponds 9 and 24, with respective mean depths of only 85 cm and 98 cm, are much shallower than all the other aerobic ponds (Tables 1 and 2), and this may partially explain why Australian Shelducks, at least, used these two ponds almost exclusively. Based on measurements provided by Frith (1982), an average-sized Shelduck would probably be able to reach down to about 60 cm by up-ending. Even though the depth data represent only an estimated average depth, this tends to suggest that the other aerobic ponds were too deep for this species to reach the bottom. Personal observation (AJH) of Pond 9 from a boat suggests that whilst parts of this large pond would also be too deep for this species to reach the bottom, other parts were only around 30–40 cm deep. Even if Australian Shelducks were able to reach the bottom of many parts of some of the other ponds, they may have been able to do so only by up-ending but not dipping (i.e. submerging head simply by bending at neck, keeping body horizontal with the water's surface). Dipping accounted for 37% of the foraging in Pond 9 (Hamilton *et al.* 2002), and it is likely that it is a more energetically efficient means of feeding than up-ending, and as such it would be the preferred method.

The diet of Australian Shelducks at Lake Borrie is not known. This species is generally considered to be able to feed on both animal and vegetable matter (Frith 1982). Filamentous benthic algae may form a major component of its diet. If so, it is possible that the shallower depths of Ponds 9 and 24, where this species was found in high densities, favoured the development of benthic algal communities. But Black Swans, which have been seen feeding on filamentous algae at Pond 9 (Hamilton *et al.* 2002), and which are generally considered to be entirely herbivorous (Frith 1982), were found in highest densities in several of the deeper ponds. Therefore, it may be that the accessibility to the bottom is a more likely explanation of the Australian Shelduck's preference for the shallowest ponds. Selection of the most suitable pond for foraging may be of particular importance to Australian Shelducks, as these birds were moulting and thus flightless during much of their stay at Lake Borrie (Hamilton and Taylor 2002).

The availability of trees for roosting may have increased the attractiveness of Pond 9 to Chestnut Teal, and possibly to other species (e.g. Australian Shelduck, Australasian Shoveler and Pink-eared Duck). Chestnut Teal would not have been able to reach the bottom of many parts of Pond 9, although they were commonly seen up-ending and dipping around the dead trees where sediment may have accumulated, leading to shallower water.

In both the present study and that of Elliget (1980) Pacific Black Ducks did not demonstrate a preference for the shallowest aerobic ponds. Several aerobic ponds of various depths and sizes supported the majority of the birds in both systems. However, unlike the other large up-ending/dipping duck, Australian Shelduck, Pacific Black Ducks were most frequently seen feeding at the edge of the ponds, where the water was presumably shallower. Another up-ending/dipping species, Grey Teal, was sighted in greatest densities on Ponds 8 and 9. The percentage of total density was slightly higher for Pond 8 than for Pond 9 (Table 1). But this probably does not reflect the preferred feeding habitat of the species, as the abundance for Pond 8 was inflated by a large flock present there on one date only. Most of the birds in this flock were not feeding.

Unlike the up-ending species that might have been unable to feed in the deeper ponds, some diving species may have preferred deeper water. In both this study and that of Elliget (1980), Musk Ducks were found almost exclusively in the deepest two ponds of the North (Pond 14) and South (Pond 30) systems. These two ponds are substantially deeper than any of the other Lake Borrie ponds (Tables 1 and 2). The remaining birds were roughly evenly distributed amongst the next few deepest ponds in each system. Frith (1982) believed that the preferred habitat of this species was deep, permanent water, although he did not say how deep.

Factors other than water depth may explain pond choice by Musk Ducks. The fact that densities were highest in the last pond of each system may mean that they preferred to forage in 'clearer' water. Being at the end of a series, these ponds would be expected to have less suspended sediment, although there are no data available to support this, and it is not known if Musk Ducks locate their prey and navigate by sight or touch (Frith 1982). It is possible that the benefits of decreased turbidity may have been negated by increased depth, which would also reduce visibility. The possibility that there were higher concentrations of invertebrate prey items in these ponds should also not be discounted as a possible factor explaining the higher densities of Musk Ducks in these ponds.

Even though Hoary-headed Grebe densities were highest in Ponds 14 and 30, the preference for these ponds was not as marked as that for the Musk Duck, and Hoary-headed Grebes were found in relatively high densities in all the aerobic ponds. The reason for this pattern is not clear. It is possible that the deeper ponds were the preferred foraging habitat for Hoary-headed Grebes, but that intra-specific competition in this very abundant species forced some birds to forage on the less profitable ponds. In contrast to the findings of this study, Elliget (1980) found that several of the smaller aerobic ponds supported the highest densities of this species, and that there was no preference for the deeper ponds.

For the species discussed above, the distribution of those for which the choice of pond is likely to be largely dependent on food resources, rather than physical characteristics such as depth, may change after the two systems receive treated effluent in 2005. Studies on the potential food resources would need to be conducted to address this.

Paradise Pond was identified as an important site for several wader species. The shallow water made wading possible, unlike the Lake Borrie Ponds where even the edges were usually unsuitable for wading. Conversely, Paradise Pond was presumably too shallow for diving waterbirds. It is important to acknowledge that Paradise Pond receives most of its water from Pond 9. Therefore, it is effectively part of the Lake Borrie system, and consequently susceptible to impacts resulting from changes to Lake Borrie influent quality. The area is also one of the few shallow freshwater sites available to wading birds in the WTP. Large numbers of several wader species have been reported to feed along the shoreline of the WTP (Lane and Peake 1990), and it may be that Paradise Pond offers a useful alternative feeding area for these species. Paradise Pond is well used by waders and thus needs to be managed with prudence.

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Observations of the nationally threatened freshwater fish, Murray Hardyhead *Craterocephalus fluviatilis* McCulloch 1913, in three Victorian salt lakes

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Abstract
Five self-sustaining populations of the nationally threatened fish Murray Hardyhead *Craterocephalus fluviatilis* are known to exist in Victoria, all of which are located in saline lakes in the north-central and north-west of the state. A survey was undertaken in February 2002 to determine the status of three of these populations, found in Lake Elizabeth, Round Lake and Woorinen North Lake. In Lake Elizabeth and Woorinen North Lake an abundance of fish encompassing a broad range of size classes were collected, indicating that these populations were in good health. A high percentage of the fish from these two lakes were also found to be in spawning condition. The population of *C. fluviatilis* from Round Lake was found to be in poor health, being both less abundant and displaying a restricted size class. This appears to be primarily due to deteriorating water quality, declining water level and subsequent reduction of aquatic vegetation which *C. fluviatilis* use as habitat. (*The Victorian Naturalist* **122** (2) 2005, 78-84).

Introduction

Increases in salinity levels are a major threat to freshwater biodiversity throughout Australia (Hart *et al.* 1991; Clunie *et al.* 2002). As the most regulated system in Australia, the Murray-Darling Basin (MDB) has been particularly impacted, with land clearing and flow regulation contributing to increases in salinity across vast areas (Hart *et al.* 1991; Clunie *et al.* 2002).

Murray Hardyhead *Craterocephalus fluviatilis* McCulloch 1913, is one fish species inhabiting the MDB which is potentially threatened by increasing salinity. The Murray Hardyhead is a mobile schooling species that is usually associated with shallow sand or silt flats, but can also be found within deep and well-vegetated habitat (Ebner *et al.* 2003). Some observations of the species have been made in riverine environments; however, more conspicuous, large, self-sustaining populations persist primarily in ephemeral saline depressions (Ebner *et al.* 2003). Murray Hardyhead are often found amongst submerged aquatic vegetation, upon which adhesive eggs are laid (Llewellyn 1979, Ivantsoff and Crowley 1996). This vegetation is of great importance as it provides cover from predators, and can act as a foraging ground for prey items (Lyon *et al.* 2002).

Although historically believed to be common throughout South Australia, southern New South Wales and northern Victoria, the range of Murray Hardyhead has declined drastically (Morris *et al.* 2000;

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Ebner *et al.* 2003). At present, the only known populations in Victoria are located in isolated floodplain lakes associated with the Murray River in north-central and north-western Victoria (Ebner *et al.* 2003). Recent surveys have confirmed Murray Hardyhead present in the following Victorian waterbodies: Round Lake, Golf Course Lake (now extinct due to low water and high salinity levels), Lake Elizabeth, Woorinen North Lake, Cardross Lakes and Lake Hawthorn (McGuckin 1999; Raadik and Fairbrother 1999; Hardie 2000). Apart from increases in salinity, other reasons for the decline in range of Murray Hardyhead could include altered flow regimes, farming practices, the effects of introduced predatory fish (in particular Gambusia *Gambusia holbrooki*), river regulation and loss of connectivity of rivers to floodplain lakes (Ebner *et al.* 2003, Lyon *et al.* 2002).

Over the past 50 years there has been some confusion over the identification of *Craterocephalus* species (Crowley and Ivantsoff 1990). Murray Hardyhead have often been confused with three other species of the same genus: Lake Eyre Hardyhead *C. eyresii* Steindacher 1883; the recently described Darling River Hardyhead *C. amniculus* (Crowley & Ivanstoff 1990), and the Unspecked Hardyhead *C. stercusmuscarum fulvus* (Ivanstoff *et al.* 1987) which was previously considered to be *C. fluviatilis* due to similarities in their morphology. The Lake Eyre Hardyhead is restricted to the Lake Eyre Drainage Basin (Allen *et al.* 2002). The Darling River Hardyhead appears to be found only in the upper tributaries of the Darling River system, and is most easily distinguished from other hardyheads by a relatively large number of transverse scales (up to 17). The Unspecked Hardyhead is ubiquitous, being found throughout a large portion of the MDB, extending into Queensland, and many early Murray Hardyhead records may have been attributed to this species. The feature which most easily distinguishes the Unspecked Hardyhead from the Murray Hardyhead is the number of transverse scales (7-8 scales on unspecked hardyhead, 10-12 scales on Murray Hardyhead) (T Raadik pers. comm.).

Craterocephalus fluviatilis has recently been listed as *Vulnerable* under the Environment Protection and Biodiversity Act 1999 and *Endangered* under the International Union for the Conservation of Nature (IUCN) Red List 2004 (Wager 1996). The limited distribution and abundance of *C. fluviatilis* in Victoria, and Australia, means that the known remnant populations are of great significance in terms of the survival of the species.

The aim of this study was to investigate the abundance and size distribution of the three populations of *C. fluviatilis* found in the Kerang Lakes complex (of the five known Victorian populations) to obtain an indication of population status.

Methods

The three lakes were sampled between 25 and 27 February 2002, with 9 seine pulls undertaken within each lake. Seine netting was undertaken using a 26 m long, 1.5 m deep fine mesh (8 mm) seine net. Seine shots did not overlap with each other within any site. A minimum of 50 randomly chosen Murray Hardyhead sampled from each lake were weighed (to the nearest 0.1 g) and measured (fork length in mm). The remaining individuals were counted and a total weight taken to ensure the representativeness of the sub-sample. Spawning condition was measured by lightly pressing on the underside of those fish that were weighed and measured. If eggs or milt were excreted by light touch, the fish was deemed to be ripe (i.e. in spawning condition).

Water temperature (°C), electrical conductivity (electrical conductivity units, measured as µs/cm at 25°C , and abbreviated as EC), dissolved oxygen (mg/L) and pH were all recorded using a TPS 90FL Microprocessor Field Analyser. Turbidity was measured using a Hach 2100P Turbidimeter.

Study Area

All sampling sites are within the Murray-Darling Basin. The three lakes chosen for this study (Fig. 1) are located in the Kerang Lakes district. The Kerang Lakes are located in north-central Victoria, and consist of over 170 wetlands, of which 50 are considered major waterbodies (Lugg *et*

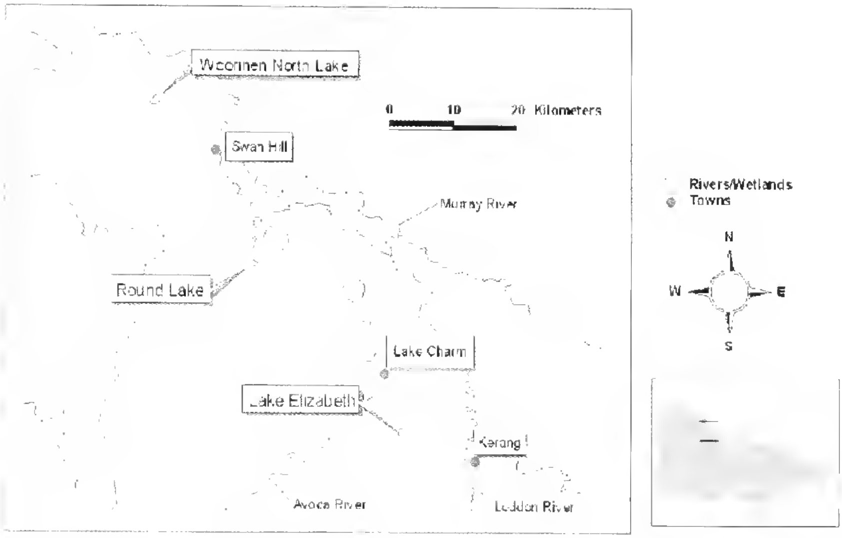

Fig. 1. Location of Study Sites (Kerang/Swan Hill Area: +143° 43′ 00″, -35° 30′ 00″)

al. 1989). More than half of the 35 native fish species found within the MDB have been recorded in the Kerang Lakes area (Anderson 1991).

Although the Kerang area is recognised for its high conservation values, up to 72 % of the region is affected by high salt levels (McGuckin 1991), and no natural wetlands in the area are considered as pristine (Anderson 1991). The Kerang Lakes have naturally high salinity levels, and these have been exacerbated by intensive agriculture. Lugg *et al.* (1989) described how an increase in salinity is often accompanied by a decrease in diversity of aquatic invertebrates. This is also true for fish species, as most adult MDB fish (apart from Murray Hardyhead) cannot tolerate salinities above 15 000 EC for long periods of time (Anderson 1991; Clunie *et al.* 2002).

Elizabeth and Round lakes were surveyed as part of an ongoing monitoring regime undertaken by the Department of Sustainability and Environment. Woorinen North Lake was surveyed as part of a project commissioned by Goulburn Murray Water (GMW). Lake Elizabeth (53 000 EC) is a 94 ha saline lake with a maximum depth of 4.0 m and an average depth of 3.0 m, and Round Lake (44 000 EC) is a 40 ha saline lake with a maximum depth of 2.5 m and an average depth of 1.8 m. Woorinen North Lake (28 000 EC) is a 57 ha saline lake with a maximum depth of 3.0 m and an average depth of 1.5 m. All three lakes contain beds of the aquatic macrophyte *Ruppia* spp.

Results

Lake Elizabeth

A total of 509 Murray Hardyhead was captured from Lake Elizabeth (average of 57 individuals per seine shot). Of these, 83 were weighed (average weight ± 1 standard deviation (S.D.): 1.2 g ± 1.7 g) and measured (average length ± 1 S.D: 34.0 mm ±19.8 mm) independently, and another 426 fish were weighed together (average weight 2.2 g). The size range of these fish showed a bimodal distribution, indicating two distinct year classes (Figure 2a). Of the 37 fish measured that were over 35 mm (the size under which few fish were in spawning condition) 73% contained eggs or milt (i.e. were ripe). The smallest ripe male was 28 mm and the smallest ripe female measured 43 mm. Table 1 shows water quality data from Lake Elizabeth. One Gambusia was also captured from the lake.

Round Lake

A total of 106 fish was sampled from Round Lake (average of 12 individuals per seine shot), of which 53 fish were weighed (average weight ± 1 SD: 1.7 g ± 0.9 g) and

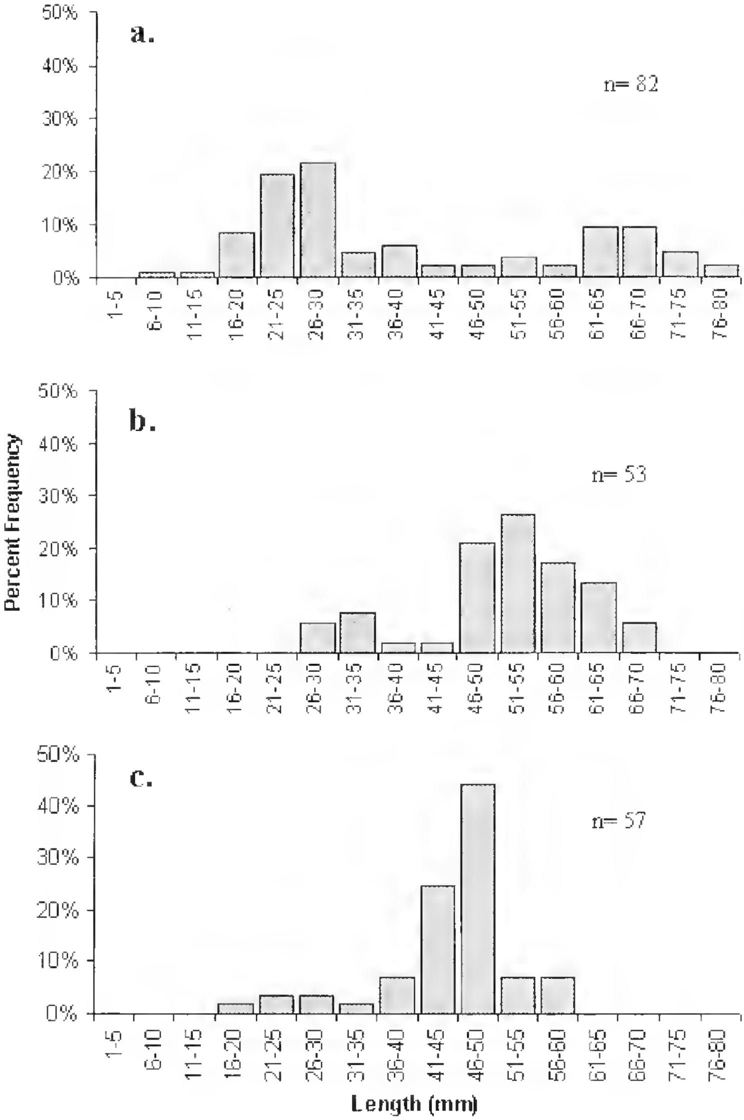

Fig. 2. Size range of *Craterocephalus fluviatilis* captured from (a) Lake Elizabeth, (b) Round Lake and (c) Woorinen North Lake

measured (average length ± 1 SD: 51.9 mm ± 10.3 mm) independently, and another 53 fish were weighed together (average weight 1.8 g). Two year classes were observed, however these were not as distinct as those found in Lake Elizabeth. The size range of these fish is shown in Figure 2b. Of the 49 fish measured that were over 35 mm, 71% were ripe. The smallest ripe male was 37 mm and the smallest ripe female was 52 mm. Table 1 shows water quality data from Round Lake.

Table 1. Water quality parameters and number of *C. fluviatilis* sampled from each Lake.

Parameter	Elizabeth	Round	Woorinen North
Temperature (°C)	26.3	25.9	24.4
Turbidity (NTU)	33.4	62.2	8.1
Conductivity (μS/cm)	53200	43833	28033
pH	8.71	8.58	9.04
Dissolved Oxygen (mg/L)	7.11	4.60	8.24
Number of individuals	509	106	373

Woorinen North Lake

A total of 373 Murray Hardyhead was captured from Woorinen North Lake (average of 41 individuals per seine shot), of which 57 were weighed (average weight ± 1 SD: 1.1 g ± 0.6 g) and measured (average length ± 1 SD: 44.2 mm ± 9.8 mm) independently and the other 316 weighed together (average weight 1.0 g). The size range of these fish is shown in Figure 2c, and indicates one strong year class of fish between 40 and 50 mm. No other strong year classes were noted. Of the 52 fish measured that were over 35 mm, 88% were ripe. The smallest recorded ripe male was 34 mm and the smallest recorded ripe female was 41 mm. Table 1 shows water quality data from Woorinen North Lake.

Discussion

Each of the populations of Murray Hardyhead surveyed has a unique set of values and threats that need to be considered in their management. One threat that is common among all three lakes is that of decrease of water caused primarily by increased water-use efficiency. Historically, lakes in this area have received a relatively constant water supply from irrigation run-off (Lugg *et al.* 1989). Increased water-use efficiency threatens this important source of water. In areas prone to salinisation, lower lake levels can impact on fish species in two distinct ways. Firstly, as water levels drop, the corresponding concentration of salt increases. Secondly, lowering water levels can expose areas of important aquatic vegetation to drying, subsequently making this habitat unavailable to fishes. Murray Hardyhead use this aquatic vegetation, primarily *Ruppia* spp.. (or *Potamogeton* spp.) as habitat and foraging areas.

Although this source of water was not available prior to European settlement, connectivity between the lakes during times of flood would have ensured that populations could be re-seeded even if lakes dried during summer months. Therefore, in recent times with reduced connectivity, the lakes with relatively good quality macrophyte populations are very important for the long-term survival of the fish populations.

Lake Elizabeth

Abundant beds of the aquatic macrophyte *Ruppia* spp. provided habitat for a variety of size classes of *C. fluviatilis* found in Lake Elizabeth. Fish captured in this lake were of a larger size range than those captured in the other two lakes (Figure.2). The reasons for this are unclear, however Hardie (2000), who also noted this phenomenon, suggested that there may be genetic differences between the three populations due to their isolation from each other.

Lake Elizabeth receives the majority of its water from irrigation run-off. A major threat to the Murray Hardyhead in Lake Elizabeth is an interaction between the lake and its underlying groundwater. As the lake level falls, pressure on a saline aquifer under the lake is decreased (MacCumber 2002). This allows the saline water from the aquifer to enter lake. A lower lake level also means that the salt already present within the lake becomes more concentrated. The highest recorded salinity level at which Murray Hardyhead have been found is 67 500 EC (McGuckin 1999). It is important that any management regimes formulated for this lake take into account it's already high levels of salinity (approximately 50 000 EC). These levels are likely to be close to the upper tolerance level of *C. fluviatilis* and further increases in salinity may be detrimental to this population, particularly as little is known of the impacts on spawning and tolerances of eggs and larvae.

Round Lake

Round Lake contained the least fish abundances within the most restricted size classes. At the time of survey, the water level of Round Lake was low, and much of the fringing aquatic vegetation was either dead or dying, leaving large mats of decomposing material around the edge of the lake. Many thousands of waterbirds inhabiting the lake also provided a potentially large source of nutrient input. No fish under 25 mm were found in this lake, indicating that successful recruitment may not have taken place for at least one year. However, the two year classes which were present indicate that conditions required for successful recruitment were available for at least two years previous.

Woorinen North Lake

Woorinen North Lake has a thick and healthy layer of a submerged macrophyte *Ruppia spp.*, which provides cover and foraging habitat for Murray Hardyhead. Prior to 2003, the lake received water via irrigation run-off from the Torrumbarry channel system. However, a pipeline project (part of a water-saving program by Goulburn Murray Water) has rendered the channel system obsolete, with the lake now relying on inputs directly from piped water. Lyon *et al.* (2002) proposed a series of control measures to protect the Murray Hardyhead population, including implementing a minimum lake water level and a maximum salinity level. Salinity in Woorinen North Lake increased from an average of approximately 20 000 EC in early 2001, to 30 000 EC in late 2001 (Lyon *et al.* 2002). It is likely that this sharp increase in salinity is responsible for the disappearance of bony bream (*Nematalosa erebi*) and flat-head gudgeon (*Philypnodon grandiceps*) from the lake (both species were found in a survey by Hardie (2000), but not by Lyon *et al.* (2002)), and is most likely responsible for the lack of young age cohorts recorded in this survey. Further work is required to determine the effects of increases in salinity to eggs and larvae on the different populations of *C. fluviatilis*.

A similar scenario to that of Woorinen North Lake has developed in the Lake Cardross system where irrigation efficiency improvements have resulted in less water movement through these lakes that have been traditionally operated as a disposal basin. These lakes support a large population of Murray Hardyhead and have therefore required an allocation of environmental water from the Murray River to maintain levels of both water and salinity (Ryan *et al.* 2003).

Individuals of *C. fluviatilis* within the three lakes were generally captured in or around aquatic habitat. The availability of this habitat is strongly associated with lake levels. The Round Lake population, which had the lowest abundance and most restricted size class of fish, also had the least available habitat due to low water levels. Further research is needed to determine the actual interactions between *Ruppia* spp. and *C. fluviatilis*, as observations made during this study suggest that this habitat is important. It should also be noted that increases in salinity levels, which are also strongly correlated with lake level, can also have a substantial effect on *C. fluviatilis* populations in these lakes. For example, Hardie (2000) did not record Murray Hardyhead in Golf Course Lake in April 2000, which previously contained a population in April 1999 (McGuckin 1999). Hardie (2000) attributed this to high salinity levels (88 650 EC).

Given the continual decline of Murray Hardyhead over the last two decades (Lugg *et al.* 1989; McGuckin 1999; Ryan *et al.* 2003, Hardie 2000; Lyon *et al.* 2002), the remaining known populations are of great significance. With threats from increased water use efficiency, introduced species, rising salinity and loss of connectivity, it is important that the few remaining populations of *C. fluviatilis* are managed to ensure the long-term survival of the species.

Note

Further surveys of the three lakes described in this study were undertaken just prior to this article going to print. Murray Hardyhead were collected from both Round Lake and Woorinen North Lake, however no fish were detected in Lake Elizabeth. More surveys will be undertaken over the next 12 months to confirm the status of this population. An investigation into possible causes of the decline of *C. fluviatilis* in Lake Elizabeth is currently being undertaken.

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One Hundred and Twenty Five Years Ago

FIELD NATURALISTS' CLUB OF VICTORIA

On the 17th of May, at an adjourned meeting held at the Melbourne Athenaeum, was inaugurated the above society, the success of which, we are pleased to note, as a gratifying fact. The following genetlemen were elected office-bearers for the current year:– President, Professor McCoy; Vice-Presidents, Dr. Lucas and the Rev. J. J. Halley; Treasurer, E. Howitt; Secretary, D. Best; Committee, J. G. Luehmann, C. French, J. R. Y. Goldstein, J. Wing, W. T. Kendall, and F. A. Leith.

The fortnightly field-days of the Club have been of an enjoyable character, many members having been very successful in their captures and collections. The monthly meetings have been well attended, and a large amount of interest has been evinced in the proceedings, the general conversaziones at the close of each meeting having enlisted marked enthusiasm. The members' list is being augmented each month, and the Club is becoming a very strong and influential one.

From *Southern Science Record* **1**, p. 11-12, December 1880

Vegetation condition assessment of the semi-arid woodlands of Murray-Sunset National Park, Victoria

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Abstract

The semi-arid woodlands in Victoria's north-west have been modified by the removal of overstorey species and long-term elevated grazing pressure. Despite a reduction in grazing pressure in the Murray-Sunset National Park since it was proclaimed in 1991, there has been concern regarding limited perennial species regeneration. To provide a foundation for future monitoring of vegetation condition change within these woodlands, floristic and structural data were recorded from 115 quadrats across the Park within the Belah and Pine-Buloke woodlands in 2000. For each quadrat, six parameters were scored relative to benchmark values and a condition index was calculated for each quadrat and community. A condition map was generated from the quadrat condition indices using an interpolation technique. The overall condition indices for both Belah and Pine-Buloke woodland were consistently lower in the Park (0.37 and 0.41 respectively) than for the reference sites (0.75 and 0.79 respectively). Woodlands in the Park were typified by low native perennial species richness and low cover and regeneration of native shrubs. Trees were generally healthy although the number of tree age classes present was typically low. This study provides a snapshot assessment of vegetation condition within the Park, and will assist in examining changes in vegetation condition over time. (*The Victorian Naturalist* **122** (2), 2005, 85-93).

Introduction

Murray-Sunset National Park is the largest continuous expanse of public land in Victoria's north-west, encompassing an area of 633 000 hectares (NRE 1996) (Fig. 1). The Park was proclaimed in 1991 following recommendations from the Land Conservation Council (LCC 1989) and incorporated Pink Lakes State Park (50 700 hectares) which was first reserved in 1979 (NRE 1996).

The Park protects semi-arid vegetation growing on dunefields, plains and floodplains (NRE 1996). Mallee vegetation dominated by eucalypts occupy large areas of the Park on dunes while patches of Belah *Casuarina pauper* F Muell ex LAS. Johnson, Slender Cypress Pine *Callitris gracilis* subsp. *murrayensis* (J Garden) KD Hill and Buloke *Allocasuarina luehmannii* (RT Baker) LAS Johnson woodlands are scattered throughout (LCC 1987; NRE 1996). Salt-tolerant shrubs and grasses grow on the low-lying dry lakebed areas around the Raak Plain and Pink Lakes (NRE 1996). On Lindsay Island, where the Park extends to the Murray River, the floodplain supports woodlands of River Red Gum *Eucalyptus camaldulensis* Dehnh and Black Box *Eucalyptus largiflorens* F Muell (LCC 1987; NRE 1996).

The semi-arid woodlands in Murray-Sunset National Park have been modified by the activities of the early pastoral settlers (LCC 1987). Prior to the proclamation of the Park, it was 'uncommitted' public land and large areas were subject to licensed stock grazing (LCC 1987). Along with grasslands, the Belah and Pine-Buloke woodlands were particularly seen to be favourable for agriculture as they tend to grow on soils of relatively high fertility (LCC 1987; NRE 1996). Timber harvesting, clearing, thinning and grazing are some of the practices that have led to the modification of these woodlands (LCC 1987; NRE 1996). The development of earth tanks and troughs throughout Victoria's north-west by the early pastoralists not only provided stock with water but also rabbits and kangaroos, therefore exposing the semi-arid vegetation to artificially high grazing pressures (LCC 1987). In areas which have been subjected to stock grazing, the woodlands have suffered most with a dramatic decline in their structure, cover and floristic diversity (Westbrooke *et al.* 1988; LCC 1989; Cheal 1993; NRE 1996; Westbrooke 1998). By

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Fig. 1. Location of Murray-Sunset National Park in Victoria.

1996, after further recommendations from the Land Conservation Council, licensed stock grazing had ceased within the Park (Sandell *et al.* 2002).

Many burial grounds, middens and scar trees provide evidence of a long history of aboriginal occupation in the Murray-Sunset National Park (Ross 1981) however, little is known of aboriginal impact on the vegetation of the area (Morris 1942; Massola 1966; Tindale 1974).

Some of the threats to the long-term survival of these woodlands are that only small remnant stands remain, the overstorey trees are senescent, and there has been limited regeneration of native perennial species since the removal of stock grazing (Westbrooke *et al.* 1988; LCC 1989; NRE 1996; Westbrooke 1998; Sandell *et al.* 2002). Threatening processes affecting the recovery of semi-arid woodlands currently include grazing by both native (kangaroos) and introduced (rabbits and feral goats) herbivores, and competition from weeds (Cheal *et al.* 1992; NRE 1996). In addition, even though prolonged periods of low rainfall are natural features of Victoria's north-west, and most vegetation is well adapted to such conditions, recovery of these woodlands can be prevented by the combined affects of insufficient water and artificially high grazing pressure (LCC 1987). Chesterfield and Parsons (1985) expressed concern for the future of *Casuarina pauper* given widespread regeneration failure following an exceptionally high rainfall period in the mid 1970s. Westbrooke *et al.* (1988) found that localised regeneration of Sugarwood *Myoporum platycarpum* RBr occurred following this rainfall period in areas where rabbit populations and stocking levels were low. Sandell (2002) investigated the implications of the rabbit haemorrhagic disease (RHD) for the short-term recovery of semi-arid woodlands in the Murray-Sunset National Park and found that the removal of stock grazing was more important for the persistence of regrowth of *A. luehmannii* than the subsequent reduction in rabbit abundance. It is anticipated that a reduction in total grazing pressure, combined with adequate rainfall, may lead to the recovery in the condition of these woodlands (Sandell *et al.* 2002). Another threat to the long-term conservation of the woodlands is fire. Although the woodlands typically do not support sufficient fuel to carry a fire, under extreme conditions, fire may damage or destroy mature trees and eliminate seedlings (LCC 1987).

The phasing out of stock grazing, management of kangaroo and feral goat populations, and the reduction in rabbit abundance as a result of RHD together with the progressive closure of artificial waters throughout Murray-Sunset National Park provides an opportunity to maintain grazing pressure at low levels (Sandell *et al.* 2002; Sandell 2002). This study was undertaken to provide an understanding of the condition of the semi-arid woodlands occurring on the dunefields and plains within Murray-Sunset National Park. As this study is envisaged as the foundation for long-term monitoring, it was important to adopt an approach that will detect changes in condition for these woodlands. This study was based on a vegetation condition assessment conducted at Wyperfeld National Park by Miller *et al.* (1998).

Methods

The methods used in this study are based on the vegetation condition assessment described in Parks Victoria (1998), and the methods applied at Wyperfeld National Park (Miller *et al.* 1998) and are detailed below.

Study area

The study area was the Murray-Sunset National Park in north-west Victoria (141°30'S, -34°44'E) (Fig. 1). The median annual rainfall in the study area ranges from 344 mm at Ouyen in the south-east, to 257 mm at Lindsay Point in the north-west (Clewett *et al.* 2003).

Sampling strategy

The semi-arid woodlands occurring on the dunefields and plains within Murray-Sunset National Park were assessed in November and December 2000. Areas extending from the Murray River supporting woodlands associated with the floodplain (e.g. *Eucalyptus camaldulensis* and *E. largiflorens*) were not included in this study. The semi-arid woodlands assessed cover some 63 862 hectares (10%) of the Park and comprise five vegetation communities (LCC 1987; NRE 1999) (Table 1). The vegetation communities originate from floristic vegetation mapping of public land as part of the Mallee Area Review coordinated by the Land Conservation Council (LCC 1987; NRE 1999).

The broad scale (1: 100 000) mapping (LCC 1987; NRE 1999) on which this study is based fails to clearly distinguish some of the semi-arid vegetation communities and places much of the woodland in either the mosaic unit or in units which may well be anthropogenic grasslands (LCC 1987; Westbrooke 1998). Areas mapped as Belah Woodland and Pine-Buloke Woodland were those that have largely retained a high density of the dominant overstorey tree species (NRE 1999). The mosaic of Savannah Woodland, Savannah Mallee and Grassland contains scattered remnants of the overstorey species of Belah or Pine-Buloke Woodland and is likely to be a variant of these two communities (LCC 1987; Westbrooke 1998). The original composition and structure of Gypseous Plain Grassland and Sandplain Grassland can only be inferred and may represent modified examples of either Belah Woodland or Pine-Buloke Woodland (LCC 1987). Notwithstanding this, all quadrats were in patches supporting overstorey trees of Belah or Pine-Buloke woodland. It is difficult to provide a detailed comparison of the condition of Gypseous Plain Grassland and Sandplain Grassland as they are assumed to be highly modified examples of either Belah or Pine-Buloke Woodland (LCC 1987; Westbrooke 1998). In this study, these vegetation communities along with the mosaic community have been regarded as highly modified examples of either Belah Woodland or

Table 1. Semi-arid woodlands within Murray-Sunset National Park. *Description and conservation status information derived from LCC (1987).

Vegetation community and Description*	Area of Park (ha)	Conservation status*
Belah Woodland - Dominated by Belah *Casuarina pauper*. Diverse small and tall shrub layer and a ground layer consisting of herbs, sub-shrubs and perennial grasses.	1 274	Substantially threatened due to small size of the remnant stands.
Pine-Buloke Woodland - Dominated by Buloke *Allocasuarina luehmannii* and/or Slender Cypress Pine *Callitris gracilis* subsp. *murrayensis*. Understorey typically dominated by perennial grasses and herbs.	4 006	Most threatened vegetation community in the Mallee
Gypseous Plain Grassland - Overstorey of scattered Sugarwood *Myoporum platycarpum*. Understorey of native and introduced annuals.	5 438	Original community is extinct in the State although modified remnants occur in limited localities.
Sandplain Grassland - Occasional scattered woodland trees. Dominated by perennial grasses and native annual herbs.	2 414	One of the most threatened communities due to suitability for stock grazing.
Savannah Woodland / Savannah Mallee / Grassland Mosaic - Dominated by Slender Cypress Pine *Callitris gracilis* subsp. *murrayensis*, Cattle Bush *Alectryon oleifolius* subsp. *canescens* ST Reynolds, Grey Mallee *Eucalyptus socialis* F. Muell ex Miq. or Yorrell *Eucalyptus gracilis* F Muell.	50 730	Remnants of other communities.

Pine-Buloke Woodland. All quadrats were described as either Belah Woodland or Pine-Buloke Woodland based on their location in the landscape and/or dominant overstorey species present. The Belah Woodland is predominantly located in the north-west area of the Park whilst Pine-Buloke Woodland is mainly located in the south-east.

A total of 115, 1 000 m² quadrats (50 m x 20 m) were sampled in Belah Woodland and Pine-Buloke Woodland across Murray-Sunset National Park (Table 2). Quadrat size was based on recommendations from NRE (1995) and Parks Victoria (1998). Quadrats within the Park were located using a stratified random procedure, with stratification according to vegetation community. Six quadrats were also subjectively located in neighbouring reserves, considered representative of either Belah or Pine-Buloke woodland with minimal historical disturbances and low grazing pressure and sampled as reference sites. These sites included Mallanbool Flora and Fauna Reserve, bushland around Walpeup Research Station, bushland along the Walpeup – Patchewollock road, Patchewollock Racecourse Flora Reserve, and a Railway Reserve near Dattuck.

Data recorded

Some of the data recorded were used specifically for the assessment of vegetation condition while other data provided a basis for long-term monitoring. All woody perennial vascular flora present in the quadrat were recorded, identified to species with nomenclature following Walsh and Entwisle (1994; 1996; 1999), categorised according to life forms as identified in the Flora Information System (NRE 2000), and given a cover/abundance value (i.e. modified form of Braun-Blanquet scale as cited in Kershaw and Looney (1985). Only dominant native and introduced herbaceous species in the ground layer were recorded, as unpredictable fluctuations following rainfall are problematic for comparative studies in semi-arid areas (Pickup 1996). A visual estimate of the typical height and projected foliage cover of both native and introduced species in each stratum was recorded. The presence of seedlings and/or juveniles for all shrub species was recorded. The stem diameter over bark (recorded from 1.3 m above the ground) was measured for each individual tree within the quadrat and used to judge the number of different age classes (cohorts) present in the tree layer. The number of cohorts present is assumed to reflect eposodic regeneration events. A visual assessment of tree health was recorded for each individual tree present on a five-point scale (0 = dead; 1 = less than 25% of tree mass alive; 2 = Irregular crown, many dead branches projecting from the canopy; 3 = Well formed crown but dead branches projecting from the canopy; and 4 = Healthy, well formed crown, no dead branches within the canopy) and visual estimates of the total percentage cover of litter, bare ground, cryptogams and logs were also recorded.

To assist future re-location of quadrats, each corner tree was marked with an aluminium tag. The orientation of the quadrat and the bearing of the marked corner of the quadrat were recorded. A photograph was taken from ten metres outside the quadrat on the long axis at each site to provide a record of the appearance of the site (Photographs were taken to provide a record of the appearance of the site and were not intended to provide permanent monitoring points). The date, recorders names, a unique quadrat identification number, Australian Map Grid (AMG) co-ordinates, description of site location and observed vegetation community were recorded.

Vegetation condition parameters and condition indices

From the data recorded, six parameters were used to assess vegetation condition across the Park:

1. Native perennial species richness – total number of native perennial plant species recorded from the quadrat.
2. Native shrub cover – projected foliage cover of native species in the shrub layers (combined tall and small shrub layers) recorded from the quadrat.
3. Regeneration of native shrub species – proportion of shrub species present in the quadrat showing regeneration (i.e. any number of seedlings or juveniles

Table 2. Sampling effort in each vegetation community within Murray-Sunset National Park.

Vegetation community	Area of Park (ha)	Area of Park (ha)	Quadrats (%)	Quadrats (%)
Belah woodland	~ 56 547	89	77	67
Pine-Buloke woodland	~ 7 315	11	38	33
Total	63 862	100	115	100

present regardless of the level of regeneration).

4. Tree age classes – the stem diameter was assessed for each individual tree within the quadrat and the number of different cohorts present in the tree layer determined.
5. Tree condition – assessed for each individual tree within the quadrat and assigned a score from zero to four.
6. Strata intactness – Intactness was measured on a presence or absence basis based independently on cover and species richness of perennial native species under the following guidelines derived from reference quadrats:

- Tree strata intact if two or more individual trees present (number of species not relevant), condition greater than two and a stem diameter greater than 10 cm.
- Tall shrub layer intact if cover is greater than 5% and species richness greater than two.
- Small shrub layer intact if cover is greater than 10% and species richness greater than five.
- Ground layer intact if annual native species cover greater than 10%.

For each quadrat, each parameter value was compared to benchmark values of either Belah or Pine-Buloke woodland sourced from either the reference sites or expert opinion. Each parameter value within each quadrat was divided by the benchmark value resulting in a score from zero to one. For example, if a quadrat located within Belah Woodland supported 10 native perennial plant species, and the benchmark value for that community was 20 species, the score for native perennial species richness would be 0.5. If a parameter value was greater than the benchmark value, the parameter received a score of one. For example, if a quadrat located within Belah Woodland supported 22 native perennial plant species, and the benchmark value for that community was 20 species, the score for native perennial species richness would be 1.1 but truncated to a maximum score of 1.0.

A condition index for each quadrat was calculated using all the parameter scores, where all parameters were weighted equally in the calculation. The parameter scores within each quadrat were summed, then divided by the total number of parameters assessed (i.e. six), resulting in a score from zero to one.

A condition index for each woodland community was calculated using all the quadrat condition indices for the community. The quadrat condition indices for each community was summed then divided by the total number of quadrats assessed for that community resulting in a score from zero to one. For example, the summed quadrat condition indices were divided by 77 for Belah Woodland and 38 for Pine-Buloke Woodland.

Vegetation condition mapping

In order to produce a map showing the variation in vegetation condition within all Belah and Pine-Buloke woodland across the Park a condition surface was calculated from the 115 quadrat condition indices. The condition surface was created using the inverse distance weighted interpolation algorithm of the INTERPOL module within the Idrisi32 raster geographic information system (GIS) program. The inverse distance weighted algorithm is one of the most commonly used techniques for interpolation of scatter points (Johnston 1998). The method is based on the assumption that the surface should be influenced most by nearby points and less by more distant points. The resulting surface is a weighted average of the condition indices from the sampled quadrats, and the weight assigned to each quadrat condition index diminishes as the distance from the interpolation point to the quadrat increases. The inverse distance weighted algorithm predicted the condition index for every 20 m x 20 m pixel throughout the semi-arid woodlands.

Results

Vegetation communities sampled

Overall, 90% of quadrats sampled for the Gypseous Plain Grassland, Sandplain Grassland and Savannah Woodland / Savannah Mallee / Grassland Mosaic vegetation communities supported one or more overstorey species (dominant or associated) typical of either Belah or Pine-Buloke woodland (i.e. *C. pauper*, *Callitris gracilis* subsp. *murrayensis*, *A. leuhmannii* or Umbrella Wattle *Acacia oswaldii* F Muell., Cattle Bush *Alectryon oleifolius* subsp. *canescens*, Berrigan *Eremophila longifolia* (RBr) F Muell., Needlewood *Hakea* species and Sugarwood *Myoporum platycarpum*).

Vegetation condition parameter scores and condition indices

The mean vegetation condition parameter scores obtained for Belah and Pine-Buloke woodland are shown in Figs. 2 and 3. These indicate how each of the parameters influenced the vegetation community condition indices. All parameters measured in the Park for both Belah and Pine-Buloke woodland were consistently lower than those measured in the reference sites. For both Belah and Pine-Buloke woodland, native perennial species richness, native shrub cover, regeneration of native shrub species and strata intactness had mean scores less than 0.5 (Figs. 3 and 4). Tree age classes and tree condition for both Belah and Pine-Buloke woodland had mean scores greater than 0.5.

Fig. 4 shows the vegetation community condition indices derived for Belah and Pine-Buloke woodland within the Park and for the reference sites. The condition indices for both the Belah and Pine-Buloke woodland within the Park were lower than those for the reference sites. Similar vegetation community condition indices were obtained for Belah (0.37) and Pine-Buloke (0.41) woodland within the Park. The indices indicate on a scale of zero to one where the vegetation condition of each community sits relative to one comprising all the benchmark values for each of the parameters assessed (i.e. potential 'expected' condition in terms of those particular parameters). The parameters that influenced the low condition indices for Belah woodland are shown in Fig. 2 and in Fig. 3 for Pine-Buloke woodland, these were

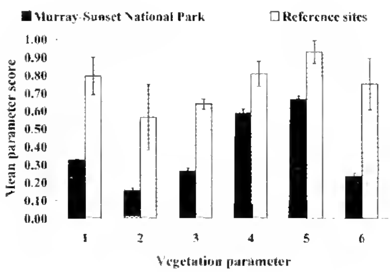

Fig. 2. Mean (± SE) vegetation parameter scores for Belah woodland within Murray-Sunset National Park and reference sites. 1. native perennial species richness, 2. native shrub cover, 3. regeneration of native shrub species, 4. tree age classes, 5. tree condition, 6. strata intactness.

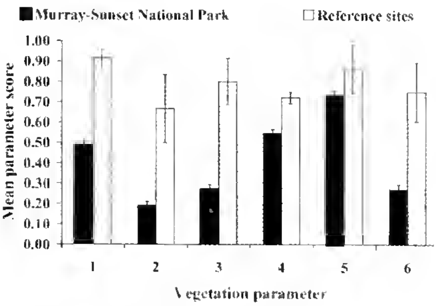

Fig. 3. Mean (± SE) vegetation parameter scores for Pine-Buloke woodland within Murray-Sunset National Park and reference sites. 1. native perennial species richness, 2. native shrub cover, 3. regeneration of native shrub species, 4. tree age classes, 5. tree condition, 6. strata intactness.

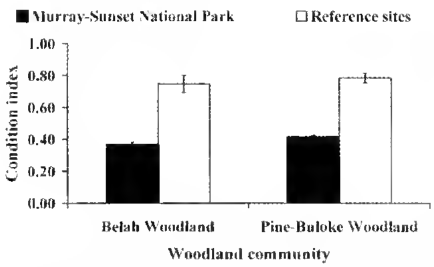

Fig. 4. Mean (± SE) vegetation community condition indices for Belah and Pine-Buloke woodland.

native perennial species richness, native shrub cover, regeneration of native shrub species and strata intactness.

Vegetation condition mapping

A condition surface was interpolated for the Belah and Pine-Buloke woodlands using the condition indices calculated from the 115 quadrat across the Park. A copy of the resultant map can be obtained by request from the primary author. The condition surface shows that vegetation condition across the Park is mostly ranged between 0.14 and 0.49 with scattered patches ranging between 0.50 and 0.69. Only one area in the north-central part of the Park shows vegetation condition in the higher range, between 0.70 and 1.00.

Discussion

Vegetation condition parameters and condition indices

All vegetation parameters measured contributed equally to the scoring. No attempt was made to weight particular parameters to reflect either their importance to vegetation condition or their sensitivity to grazing pressure. Both the Belah and Pine-Buloke woodlands in the Park were typified by low perennial species richness, and low cover and regeneration of shrub species. Tree condition was generally healthy in both vegetation communities although the number of tree age classes present was typically low.

The vegetation community condition indices derived for both the Belah and Pine-Buloke woodlands in Murray-Sunset National Park are low compared to the reference sites. This outcome may be attributed to a number of factors. The effects of pastoral influences prior to the proclamation of the Park such as timber harvesting, clearing, thinning and grazing have been well documented (LCC 1987; Westbrooke 1988; Westbrooke 1998; NRE 1996). Also, since the proclamation of Murray-Sunset National Park, there has been little opportunity for recovery to occur due to insufficient rainfall events to provide suitable conditions for recruitment of perennial species. In addition, whilst grazing pressure has been reduced in the Park, this remains a threat to regeneration of woodland species (NRE 1996; Westbrooke 1998; Sandell *et a*l. 2002; Sandell 2002).

Vegetation condition mapping

The condition map shows broad trends in vegetation condition in Belah and Pine-Buloke woodland across the Park. The map was influenced by individual quadrat condition indices and predicted condition of areas between the quadrats sampled using an interpolation technique. Further analysis is required to determine the accuracy of the condition map, although it is likely that areas closer to quadrat sites give the most accurate representation of the vegetation condition. The vegetation in the north-western area of the Park had condition indices mostly below 0.50 while vegetation in the north-central area had condition indices mostly above 0.70. Vegetation in other areas of the Park had (condition indices mostly less than 0.7. The area in the north-west of the Park, extending from the Murray River, was a licensed grazing area which has a long history of utilisation by early pastoralists (LCC 1987). Historical maps produced by the LCC (1987) show that the area in the north-central part of the Park where quadrats exhibited condition close to that of the reference sites, was also under a grazing licence prior to proclamation of the Park. However, this area may have escaped pressures associated with this land use as most of the northern extent of this patch had been cleared for agriculture and is mostly surrounded by Mallee vegetation. Alternatively, this patch may have been located at a distance from the nearest permanent watering point (i.e. earth tank or trough) that discouraged grazing animals to venture into this area. The area of the Park that has been reserved since 1979 (forming Pink Lakes State Park) supported vegetation with condition indices mostly in the mid range between 0.50 to 0.70. The extent of change since reservation is unknown, as no baseline data is available, however, this is one of the larger patches supporting vegetation with these mid range condition indices across the Park. The majority of woodland vegetation that was grazed until 1991 was found to have relatively low condition indices. It is difficult to speculate whether this is due to recovery of woodlands in the former Pink Lakes State Park, or other differences in past management. This does however suggest that vegetation recovery will be a relatively slow process.

Benchmarks

Determination of vegetation condition is commonly reliant on a benchmark or reference site against which to compare sites and define long-term goals. Where benchmarks involve on-ground sites, there are a number of potential problems. Natural disturbance such as fire may affect the validity of the reference site, however, exclusion of disturbances may equally affect the site. Regardless of management, ecosystems will continue to change over time leading to a change in both the reference and the compared site (Landres 1990).

To help overcome these problems, a combination of expert opinion and reference site values were used in this study. The presence of examples of Belah woodland within the north-central area of the Park showing condition indices similar to the reference sites indicates that some areas in the park are still capable of supporting higher condition vegetation as defined by the reference sites and expert opinion.

Potential for vegetation condition improvement

Sandell *et al.* (2002) found that there has been limited recovery of vegetation since the establishment of the Park in 1991. The most prolific overstorey recovery found in both the Sandell *et al.* (2002) study and this study is that of *A. oleifolius* subsp. *canescens*, although this is all of sucker origin and is limited in distribution. It is suggested by Sandell *et al.* (2002) that much of this regrowth is a result of reduced grazing pressure. Regeneration of *C. pauper* and Needlewood *Hakea* species has been more limited within the Park . For *M. platycarpum* and *C. gracilis* subsp. *murrayensis*, both obligate seed regenerators, there is some evidence of recent regeneration in scattered localities in the Park. Minor improvements in vegetation condition in these localities can possibly be attributed to the progressive closure of artificial waters throughout the Park, the removal of stock by 1996, management of feral goat and kangaroo populations and the reduction in rabbit abundance as a result of rabbit haemorrhagic disease (RHD). Sandell (2002) found that the removal of stock grazing from the Park was important for the persistence of regrowth of *A. luehmannii*. Sandell *et al.* (2002) also detected an increase in the shrub component of the understorey of these woodland communities with some chenopod species that were only recorded at 10% of sites at the beginning of the study in 1991 increasing to 50% of sites in 1997.

Limitations

As one of the objectives of this study was to provide for long-term monitoring in which major changes can be identified, the floristic assessment was based on woody perennial species only. A limitation to comparative studies of vegetation in semi-arid areas is that the herbaceous vegetation responds rapidly to rainfall and certain species respond to rainfall in particular seasons (Pickup 1996). The amount and seasonal distribution of rainfall largely determines the composition of the annual or herbaceous perennial species in the ground layer. In drought years this layer of vegetation may be missing (Fox 1991).

Future monitoring

In the review of Vegetation Monitoring in the Mallee Parks of Victoria, Hodgkinson and Baker (2000) endorsed the methods used for a vegetation condition assessment by Miller *et al.* (1998) at Wyperfeld National Park subject to improved repeatability. As it was an objective of this study to adopt an approach that provides for a sound basis for future assessments so that changes in condition can be detected, it is believed that the data recorded, coupled with the permanent marking (GPS coordinates and aluminium tagging) and photographing of all quadrat locations will ensure that future assessments will give reliable information on change in vegetation condition. Hodgkinson and Baker (2000) found that the vegetation parameters assessed will be suitable for tracking change.

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A survey of the vertebrate fauna of the Black Range, near Stawell

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Abstract

A survey of the vertebrate fauna on seven private properties in and adjacent to the Black Range, south of the township of Stawell in western Victoria, was carried out over a two year period between April, 2000 and March, 2002. A total of one hundred and fifty-three vertebrate species were recorded during the survey. These included twenty-eight mammals, one hundred and four birds, fifteen reptiles and six amphibians. A number of notable woodland species were recorded suggesting that the habitat contained in these areas of the Black Range may be important wildlife refuges in western Victoria. (*The Victorian Naturalist* **122** (2) 2005, 94-102)

Introduction

The Black Range is located approximately five kilometres south of the township of Stawell in western Victoria and covers an area of approximately 40 square kilometres. Much of the range is privately owned and has been subjected to over-grazing, weed and rabbit infestation, erosion and other adverse activities.

The survey was carried out on a voluntary basis by members of the Fauna Survey Group (FSG) of the Field Naturalists Club of Victoria, for the Black Range Landcare Group. Data collected during the survey were to aid formulation of a management plan for the range. The work was carried out at nine sites on seven private properties, all of which have been subjected to extensive revegetation, weed removal, rabbit eradication and habitat enhancement works. None of the private properties adjoin each other. The areas surveyed represent approximately ten percent of the Black Range. Two areas of Crown Land in the range are managed by Parks Victoria, however, difficulty of access meant that intensive fauna survey work was not undertaken in these areas.

Topography and Vegetation

The Black Range is made up of ancient decomposed granite outcrops, with shallow loams on the ridges and deep granite sands in the valleys. There are numerous underground springs, which develop dark peaty soils at the surface. The range features massive granite tors and numerous exposed slabs and boulders. The topography is hilly, with steep ridges, deep valleys and the highest point above sea level is approximately 480 metres.

The Black Range contains seven vegetation communities:

Granite Hills Woodland, dominated by Scent-bark *Eucalyptus aromaphloia*, occasional Yellow Box *Eucalyptus melliodora*, with a mid-storey of Black Wattle *Acacia mearnsii*, and a ground cover of various species of Wallaby Grasses *Austrodanthonia* spp., Spear Grasses *Austrostipa* spp., and Kangaroo Grass *Themeda triandra*.

Granite Hills Herb-rich Woodland, a community similar to Granite Hills Woodland, but with a more diverse ground flora containing numerous herbaceous species, notably Common Raspwort *Gonocarpus tetragynus*, Tall Raspwort *Gonocarpus elatus*, Blue Pincushion *Brunonia australis* and Inland Creamy Candles *Stackhousia* sp.

Granite Outcrop Complex, dominated by Scent-bark, with occasional Yellow Box and Long-leaf Box *Eucalyptus goniocalyx* and a mid-storey dominated by Black Wattle, Lightwood *Acacia implexa*, Silver Banksia *Banksia marginata* and Sweet Bursaria *Bursaria spinosa*. Ground cover included Soft Spear-grass *Austrostipa mollis*, Rough Spear-grass *Austrostipa scabra*, Weeping Grass *Microlaena stipoides*, Wallaby Grasses *Austrodanthonia* spp., and large patches of Austral Bracken *Pteridium esculentum*.

Valley Grassy Forest, which occurs in narrow strips along the various creeks running out of the range, is dominated by River

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Red Gum *Eucalyptus camaldulensis*, Scent-bark, Yellow Box, with occasional Blackwood *Acacia melanoxylon* and Black Wattle in the mid-storey. Ground cover is dominated by Wallaby Grasses, Weeping Grass, Austral Bracken and Hedge Wattle *Acacia paradoxa*.

Wimmera Grassy Woodland, dominated by River Red Gum with virtually no mid-storey. There are occasional thickets of Prickly Tea-tree *Leptospermum continentale* with a diverse ground flora of native grasses, herbs and orchids. Winter-wet swamps occur in several low areas, with a rich ground flora dominated by *Austrodanthonia semiannularis*, *Pentapogon quadrifidus*, *Villarsia reniformis*, *Triglochin striata* and *Goodenia humilis*.

Heathy Woodland, dominated by Yellow Gum *Eucalyptus leucoxylon*, Yellow Box and Scent-bark, with occasional Slaty Sheoke *Allocasuarina muelleriana*, Beaked Hakea *Hakea rostrata* and Black Wattle. The ground flora is dominated by a large variety of heathy shrubs including Heath Tea-tree *Leptospermum myrsinoides*, Upright Guinea Flower *Hibbertia riparia*, Cranberry Heath *Astroloma humifusum*, Common Flat-pea *Platylobium obtusangulum*, Horny Cone-bush *Isopogon ceratophyllus* and Black Rapier Sedge *Lepidosperma carphoides*.

Red Stringybark Grassy (Heathy) Woodland, dominated by Red Stringybark *Eucalyptus macrorhyncha*, with occasional Messmate *Eucalyptus obliqua*, Red Box *Eucalyptus polyanthemos* subsp. *vestita* and Yellow Box. There is a very sparse mid-storey and a ground flora dominated by numerous heathy shrubs, herbs, orchids and native grasses.

Methods

Survey methods included Elliott trapping (Type A), cage trapping (Wiretainers Standard Bandicoot Traps), pitfall trapping (lines of 10, 20 litre plastic buckets, with 30cm high drift fence over 60 metres), bat trapping (Faunatech harp traps), stag-watching (watching arboreal mammals emerge from hollow trees), spotlighting, frog survey by triangulation (a method of locating calling male frogs), rock, log and tin turning, bird spotting, owl pellet analysis, artificial nest-boxes and general observation. A tape of frog calls (Littlejohn 1987) was used to assist in the identification of calling frogs.

The area was visited on ten occasions during the two year period and 2849 trap-nights were completed. These consisted of 1487 Elliott, 641 cage, 687 pitfall and 34 harp trap-nights. Sixty spotlight hours were completed and stagwatching involved twelve stags. Triangulation for frog location was carried out for approximately ten hours. Five artificial nest-boxes were erected on one of the properties (Table 1).

Results

One hundred and fifty-three vertebrate species were recorded during the survey. These included twenty-eight species of mammals (Table 2), of which sixteen were placentals, eleven marsupials and one monotreme. Twenty-one of the mammal species were native and seven were introduced. The Brush-tailed Phascogale *Phascogale tapoatafa*, which is classified as lower risk (near threatened) in Victoria, was recorded on one occasion only in Wimmera Grassy Woodland. Several species that were rare in this part of western Victoria (Atlas of Victorian Wildlife, Department of Sustainability and Environment) were also recorded. These included the Southern Brown Bandicoot *Isoodon obesulus*, Feathertail Glider *Acrobates pygmaeus* and the Eastern False Pipistrelle *Falsistrellus tasmaniensis*. Most captures of the Southern Brown Bandicoot took place in an area of Wimmera Grassy Woodland infested with Gorse *Ulex europaeus*, on the south-eastern slopes of the range. The Feathertail Glider was recorded from Granite Hills Woodland, where one specimen only was found alive on the ground. The Eastern False Pipistrelle was recorded in an area of Wimmera Grassy Woodland, where one specimen only was captured.

The Swamp Rat *Rattus lutreolus* was recorded from one site only, in a gully amongst a large patch of Prickly Tea-tree in Wimmera Grassy Woodland on the south-eastern slopes of the range. The Yellow-footed Antechinus *Antechinus*

Table 1. Survey methods and effort completed for each vegetation community. E = Elliott trap-nights; C = cage trap-nights; P = pit-nights; B = bat trap-nights; N = nest-boxes; Sp = spotlight hours; St = number of stags watched; T = triangulation, number of hours.

Vegetation Community	E	C	P	B	N	Sp	St	T
Granite Hills Woodland	661	307	182	8	5	24	8	
Granite Hills Herb-rich Woodland	173	116						
Granite Outcrop Complex	334	38	140					
Valley Grassy Forest	96	18	50	11		20	4	6
Wimmera Grassy Woodland	223	162	265	15				4
Heathy Woodland			50					
Red Stringybark Grassy (Heathy) Woodland						16		
Total effort	1487	641	687	34	5	60	12	10

Table 2. List of mammals and total number recorded during survey. E = estimated number; * = introduced species.

Common Name	Scientific Name	Number
Short-beaked Echidna	*Tachyglossus aculeatus*	9
Brush-tailed Phascogale	*Phascogale tapoatafa*	1
Yellow-footed Antechinus	*Antechinus flavipes*	39
Fat-tailed Dunnart	*Sminthopsis crassicaudata*	1
Southern Brown Bandicoot	*Isoodon obesulus*	16
Common Brushtail Possum	*Trichosurus vulpecula*	55
Feathertail Glider	*Acrobates pygmaeus*	1
Sugar Glider	*Petaurus breviceps*	10
Common Ringtail Possum	*Pseudocheirus peregrinus*	3
Eastern Grey Kangaroo	*Macropus giganteus*	180E
Red-necked Wallaby	*Macropus rufogriseus*	3
Black Wallaby	*Wallabia bicolor*	21
White-striped Freetail Bat	*Tadarida australis*	1
Gould's Wattled Bat	*Chalinolobus gouldii*	1
Chocolate Wattled Bat	*Chalinolobus morio*	5
Large Forest Bat	*Vespadelus darlingtoni*	4
Southern Forest Bat	*Vespadelus regulus*	1
Little Forest Bat	*Vespadelus vulturnus*	41
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	1
Lesser long-eared Bat	*Nyctophilus geoffroyi*	28
House Mouse*	*Mus musculus*	15
Swamp Rat	*Rattus lutreolus*	5
Black Rat *	*Rattus rattus*	6
Red Fox*	*Vulpes vulpes*	2
House Cat (Feral)*	*Felis catus*	1
European Rabbit*	*Oryctolagus cuniculus*	7
Brown Hare*	*Lepus capensis*	4
Goat (Feral)*	*Capra hircus*	10E

flavipes, (Fig.1) was recorded from Granite Hills Woodland, Granite Outcrop Complex and Granite Hills herb-rich Woodland. The Fat-tailed Dunnart *Sminthopsis crassicaudata* was recorded in Wimmera Grassy Woodland, where one specimen only was found under a small section of log. The Sugar Glider *Petaurus breviceps* was recorded in small numbers from Granite Hills Woodland, Granite Outcrop Complex and Valley Grassy Forest. The Black Wallaby *Wallabia bicolor* and Eastern Grey Kangaroo *Macropus giganteus* were recorded from all parts of the range, however, the Red-necked Wallaby *Macropus rufogriseus* was seen on only three occasions in Granite Hills Woodland.

Fifteen reptiles were recorded (Table 3), which included two species of gecko, one monitor, two dragons, seven skinks and three elapid snakes. The Sand Goanna *Varanus gouldii*, (Fig. 2) was found in Granite Hills Woodland only, where the deep sandy soils of this vegetation commu-

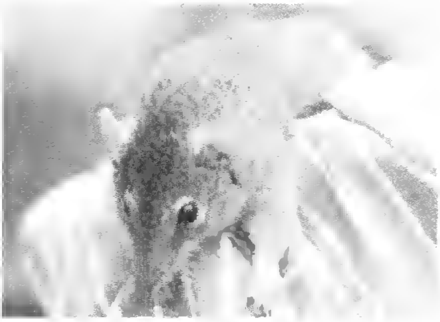

Fig. 1. Yellow-footed Antechinus *Antechinus flavipes*. Photo: Maryrose Morgan.

nity may best suit the construction of burrows. The Large Striped Skink *Ctenotus robustus*, (Fig.3) was found in Granite Hills Woodland, Granite Outcrop Complex and Heathy Woodland. The Eastern Three-lined Skink *Bassiana duperreyi*, a common skink throughout much of Victoria (Cogger 2000), was found on two occasions only, both in Wimmera Grassy Woodland. The Garden Skink *Lampropholis guichenoti*, Stumpy-tail Lizard *Tiliqua rugosa*, Bougainville's Skink *Lerista bougainvillii*, Boulenger's Skink *Morethia boulengeri*, Marbled Gecko *Christinus marmoratus* and Thick-tailed Gecko *Underwoodisaurus milii*, were all found in all parts of the range. The Little Whip Snake *Parasuta flagellum* was found under rocks and discarded tin in Granite Hills Woodland and Granite Outcrop Complex. The Tree Dragon *Amphibolurus muricatus* and Eastern Bearded Dragon *Pogona barbata* were recorded in Granite Hills Woodland.

Six species of amphibians were recorded (Table 4), including one species of tree frog and five southern frogs. The Common Froglet *Crinia signifera*, Southern Bullfrog

Table 3. List of reptiles and total number recorded during survey.

Common Name	Scientific Name	Number
Marbled Gecko	*Christinus marmoratus*	40
Thick-tailed Gecko	*Underwoodisaurus milii*	6
Tree Dragon	*Amphibolurus muricatus*	4
Eastern Bearded Dragon	*Pogona barbata*	3
Sand Goanna	*Varanus gouldii*	2
Eastern Three-lined Skink	*Bassiana duperreyi*	2
Large Striped Skink	*Ctenotus robustus*	29
Garden Skink	*Lampropholis guichenoti*	57
Bougainville's Skink	*Lerista bougainvillii*	10
Boulenger's Skink	*Morethia boulengeri*	11
Common Blue-tongued Lizard	*Tiliqua scincoides*	3
Stumpy-tail Lizard	*Tiliqua rugosa*	38
Little Whip Snake	*Parasuta flagellum*	9
Red-bellied Black Snake	*Pseudechis porphyriacus*	5
Eastern Brown Snake	*Pseudonaja textilis*	6

Fig. 2. Sand Goanna *Varanu gouldii*. Photo: Sally Bewsher.

Fig. 3. Large Striped Skink *Ctenotus robustus*. Photo: Sally Bewsher.

Limnodynastes dumerilii and Southern Brown Tree Frog *Litoria ewingii* were found on numerous occasions in all parts of the range. However, the Plains Froglet *Ranidella parinsignifera* was found only in Wimmera Grassy Woodland and the Common Spadefoot Toad *Neobatrachus sudelli* was detected only in Granite Hills Woodland. Bibron's Toadlet *Pseudophryne bibronii* was detected in Granite Hills Woodland and Valley Grassy Forest.

One hundred and four bird species were recorded (Table 5), of which one hundred and one were native species and three were introduced. Ten species were recorded as breeding in the area during the survey. Amongst the birds was the Powerful Owl *Ninox strenua*, which is classified as endangered in Victoria. This species was recorded at four sites within the range, including one site where an adult bird was found roosting in a small plantation of *Pinus radiata*. All the owls regurgitate pellets containing indigestible remains (Simpson and Day 1989) and nine such pellets were collected from this roost site. Analysis showed them to contain the bones of several juvenile Common Brushtail Possums and one bird, possibly a species of Currawong *Strepera* sp. Several woodland birds, whose range and/or populations have decreased over recent years (Barrett *et al.* 2003) were also recorded. These included the Speckled Warbler *Sericornis sagittatus*, Hooded Robin *Melanodryas cucullata*, Red-capped Robin *Petroica goodenovii*, White-winged Triller *Lalage tricolor*, Crested Shrike-tit *Falcunculus frontatus*, Scarlet Robin *Petroica multicolour*, Jacky Winter *Microeca leucophaea*, White-fronted Chat *Ephthianura albifrons* and Brown Treecreeper *Climacteris picumnus* .

Common and scientific names are those currently recognised by the Atlas of Victorian Wildlife, Department of Sustainability and Environment.

Discussion

This survey significantly increased the number of vertebrate species known to inhabit the Black Range. Prior to the survey, records for only ten species of birds, eighteen mammals, eleven reptiles and two amphibians were available for this area (Atlas of Victorian Wildlife, Department of Sustainability and Environment).

Records for the presence of the Koala *Phascolarctos cinereus*, in 1990 exist (Atlas of Victorian Wildlife), however, the only evidence found during this survey was skeletal remains, estimated to be about two years old. The last sighting of this species in the Black Range by members of the Landcare Group was in December 1998 (N Marriott, pers. comm.).

The Southern Brown Bandicoot has been encountered in low numbers by members of the Landcare Group at various times

Table 4. List of amphibians and total number recorded during survey. E = estimated number.

Common Names	Scientific Names	Number
Southern Bullfrog	*Limnodynastes dumerilii*	35E
Common Spadefoot Toad	*Neobatrachus sudelli*	5
Bibron's Toadlet	*Pseudophryne bibronii*	9
Plains Froglet	*Ranidella parinsignifera*	10
Common Froglet	*Crinia signifera*	230E
Southern Brown Tree Frog	*Litoria ewingii*	11

Table 5. List of birds and total numbers recorded during survey. E = estimated number; B = breeding confirmed; * = introduced species.

Common Name	Scientific Name	Number
Hoary-headed Grebe, B	*Poliocephalus poliocephalus*	5
Australasian Grebe	*Tachybaptus novaehollandiae*	6
Little Pied Cormorant	*Phalacrocorax melanoleucos*	1
Pacific (White-necked) Heron	*Ardea pacifica*	1
White-faced Heron	*Ardea novaehollandiae*	2
Australasian Shelduck, B	*Tadorna tadornoides*	35
Pacific Black Duck	*Anas superciliosa*	30E
Grey Teal	*Anas gibberifrons*	4
Maned (Wood) Duck	*Chenonetta jubatta*	50E
Whistling Kite	*Milvus sphenurus*	2
Brown Goshawk	*Accipiter fasciatus*	2
Wedge-tailed Eagle	*Aquila audax*	5
Little Eagle	*Hieraaetus morphnoides*	2
Australian Hobby	*Falco longipennis*	1
Brown Falcon	*Falco berigora*	8
Painted Button-quail	*Turnix varia*	2
Masked Lapwing	*Vanellus miles*	15
Black-fronted Plover	*Elseyornis melanops*	2
Peaceful Dove	*Geopelia placida*	40E
Common Bronzewing	*Phaps chalcoptera*	16
Crested Pigeon	*Geophaps lophotes*	4
Yellow-tailed Black Cockatoo	*Calyptorhynchus funereus*	100E
Galah	*Cacatua roseicapilla*	16
Long-billed Corella	*Cacatua tenuirostris*	60E
Sulphur-crested Cockatoo	*Cacatua galerita*	12
Rainbow Lorikeet	*Trichoglossus haematodus*	2
Musk Lorikeet	*Glossopsitta concinna*	4
Purple-crowned Lorikeet, B	*Glossopsitta porphyrocephala*	20E
Little Lorikeet	*Glossopsitta pusilla*	2
Crimson Rosella	*Platycercus elegans*	30E
Eastern Rosella	*Platycercus eximius*	12
Red-rumped Parrot	*Psephotus haematonotus*	30E
Pallid Cuckoo	*Cuculus pallidus*	2
Fan-tailed Cuckoo	*Cuculus flabelliformis*	4
Black-eared Cuckoo	*Chrysococcyx osculans*	2
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*	2
Powerful Owl	*Ninox strenua*	4
Southern Boobook	*Ninox novaeseelandiae*	3
Tawny Frogmouth	*Podargus strigoides*	2
Australian Owlet-nightjar	*Aegotheles cristatus*	4
Laughing Kookaburra	*Dacelo novaeguineae*	20E
Sacred Kingfisher	*Halcyon sancta*	2
Rainbow Bee-eater	*Merops ornatus*	6
Welcome Swallow	*Hirundo rustica*	32
Tree Martin	*Hirundo nigricans*	6
Richard's Pipit	*Anthus novaeseelandiae*	4
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	5
White-bellied Cuckoo-shrike	*Coracina papuensis*	5
White-winged Triller	*Lalage tricolor*	3

Table 5. cont'd.

Common Name	Scientific Name	Number
White's (Bassian) Thrush	*Zoothera dauma*	1
Blackbird*	*Turdus merula*	1
Scarlet Robin	*Petroica multicolour*	10
Red-capped Robin	*Petroica goodenovii*	2
Hooded Robin	*Melanodryas cucullate*	3
Eastern Yellow Robin	*Eopsaltria australis*	3
Jacky Winter	*Microeca leucophaea*	9
Crested Shrike-tit	*Falcunculus frontatus*	3
Golden Whistler	*Pachycephala pectoralis*	3
Rufous Whistler	*Pachycephala rufiventris*	14
Grey Shrike-thrush	*Colluricincla harmonica*	7
Restless Flycatcher	*Myiagra inquieta*	4
Grey Fantail	*Rhipidura fuliginosa*	1
Willie Wagtail	*Rhipidura leucophrys*	30E
White-browed Babbler	*Pomatostomus superciliosus*	40E
Rufous Songlark	*Cinclorhamphus mathewsi*	14
Superb Fairywren	*Malurus cyaneus*	50E
Speckled Warbler	*Sericornis sagittatus*	10
Brown Thornbill	*Acanthiza pusilla*	10
Buff-rumped Thornbill	*Acanthiza reguloides*	6
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	36
Southern Whiteface	*Aphelocephala leucopsis*	4
Varied Sitella	*Daphoenositta chrysoptera*	2
White-throated Treecreeper	*Cormobates leucophaea*	8
Brown Treecreeper	*Climacteris picumnus*	7
Red Wattlebird	*Anthochaera carunculate*	18
Little Wattlebird	*Anthochaera lunulata*	2
Noisy Miner	*Manorina melanocephala*	1
Yellow-faced Honeyeater	*Lichenostomus chrysops*	5
Yellow-tufted Honeyeater, B	*Lichenostomus melanops*	16
Fuscous Honeyeater	*Lichenostomus fuscus*	4
White-plumed Honeyeater	*Lichenostomus penicillatus*	50E
Black-chinned Honeyeater	*Melithreptus gularis*	1
Brown-headed Honeyeater	*Melithreptus brevirostris*	3
White-naped Honeyeater	*Melithreptus lunatus*	12
New Holland Honeyeater	*Phylidonyris novaehollandiae*	30E
Eastern Spinebill	*Acanthorhynchus tenuirostris*	15
White-fronted Chat	*Ephthianura albifrons*	6
Mistletoebird, B	*Dicaeum hirundinaceum*	5
Spotted Pardalote, B	*Pardalotus punctatus*	7
Striated Pardalote, B	*Pardalotus striatus*	8
Silvereye	*Zosterops lateralis*	6
European Goldfinch*	*Carduelis carduelis*	6
House Sparrow*	*Passer domesticus*	12
Red-browed Firetail, B	*Neochmia temporalis*	100E
Diamond Firetail	*Stagonopleura guttata*	4
Olive-backed Oriele	*Oriolus sagittatus*	3
White-winged Chough, B	*Corcorax melanorhamphos*	20
Australian Magpie-lark	*Grallina cyanoleuca*	2
Dusky Woodswallow	*Artamus cyanopterus*	9
Australian Magpie, B	*Gymnorhina tibicen*	50E
Pied Currawong	*Strepera graculina*	1
Grey Currawong	*Strepera versicolor*	6
Australian Raven	*Corvus coronoides*	17
Little Raven	*Corvus mellori*	2

over the last twenty years in various parts of the range (A Davis *et al.* pers.comm.). Despite this, very little evidence of the presence of the species was found over most of the range during this survey. However, grassy areas around the largest patch of Gorse in Wimmera Grassy Woodland on the south-eastern edge of the range, contained large numbers of the typical conical feed holes produced by the Southern Brown Bandicoot. Capture rates for this species are normally low (Menkhorst 1995), however, the trapping rate around the largest patch of Gorse was particularly high (14 captures out of 162 cage trap-nights). Whilst Gorse is a major environmental weed in various parts of southern Australia. it never the less has the ability to provide thick, prickly cover down to ground level. In the Black Range Southern Brown Bandicoots use areas infested with Gorse to seek protection from predators such as the Red Fox. Anecdotal evidence from local landholders suggests that the species also uses rabbit burrows, thick garden beds near houses and fallen hollow logs for shelter from predators.

The capture of the Eastern False Pipistrelle during this survey in an area of River Red Gums in Wimmera Grassy Woodland was unexpected. This species is normally found in wetter, tall forests (Menkhorst 2001). The species has since been recorded in larger numbers in similar habitat on the basalt plains near Buangor in western Victoria (Homan 2004).

Records for the Feathertail Glider are low in woodland areas of western Victoria (Atlas of Victorian Wildlife). The very small size of the species makes it difficult to detect using spotlights and previous surveys by the FSG in woodland areas have found only very small numbers of the species (Myers and Dashper 1999).

Records for the endangered Powerful Owl are also low in woodland areas of western Victoria (Atlas of Victorian Wildlife). Over much of the range of this species in Victoria the Common Ringtail Possum is an important item of prey (Menkhorst 1995). However, this possum species was only recorded from one site during this survey within the Black Range, whilst the Common Brushtail Possum was found to be common and widespread throughout the range and surrounding areas. The results of analysis of Powerful Owl pellets collected during this survey indicate that juvenile Common Brushtail Possums and roosting birds are a major item of prey for this species in this area.

Habitat enhancement works on the properties on which the FSG worked have been beneficial to several species. The protection of old-growth eucalypts, with numerous hollows close to the ground and the practice of leaving hollow limbs where they fall, has produced ideal habitat for the Yellow-footed Antechinus. The loss of this sort of habitat throughout woodland areas of Victoria is of particular concern for the long-term survival of this species (Menkhorst 1995). Properties on the south-western and south-eastern slopes of the Black Range may contain some of the best privately owned habitat for this species in Victoria.

The retention of fallen logs and limbs has also provided enhanced habitat for the Brown Treecreeper and the cessation of grazing, along with revegetation works has benefited other woodland birds. Most sightings of the Speckled Warbler took place in areas of Austral Bracken within Granite Outcrop Complex, which had been previously grazed. Whilst improved habitat may be beneficial to woodland birds, all the woodland species detected during the survey were recorded in low numbers. Local bird enthusiasts have reported a steady decline in the population of small woodland birds over the last fifty years in this area (J Pickford pers.comm.).

The use of nest-boxes during this survey made up only a small part of the survey effort. Despite this, five nest-boxes placed in an area of Granite Hills Woodland, which was devoid of natural hollows, produced one record of the Sugar Glider, within three months of the boxes being erected. Spotlighting in this area had failed to detect the species. Myers and Dashper (1999) found that Sugar Gliders often used nest-boxes in areas that are almost totally devoid of hollow-bearing trees.

Prior to the formation of the Black Range Landcare Group in 1986, the Black Range was severely infested with rabbits and introduced weeds and many parts of the range were suffering from severe erosion. Since then extensive rehabilitation works have been carried out by members of the Landcare Group. The results of this fauna survey show that these efforts have been extremely beneficial to native vertebrate fauna in the Black Range, by producing a range of enhanced habitats which support an interesting variety of species.

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The biology, ecology and horticultural potential of *Banksia* L.f.: A bibliography of recent literature

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Abstract

In this fifth bibliography of recent literature on *Banksia*, a further 94 items are added to the list. There appears to have been a wane in interest in general pollination studies but an increase in research on chemical control of *Phytophthora*. A new section has been added to the bibliography, to include papers on this subject. (*The Victorian Naturalist* **122** (2) 2005, 102-107)

This is the fifth bibliography of *Banksia* I have prepared since 1989 (Cavanagh 1989, 1994, 1997, 2000) and brings the number of references on this important topic to more than 530. The bibliography mainly lists papers published in journals between 1999 and 2003, although books, theses and special reports also are included. Because of its importance to the taxonomy of *Banksia*, the bibliography also includes reference to the revision of *Banksia* by Alex George in 1999 (George 1999).

Interest in general pollination studies appears to have waned since 2000 although the role of animal pollinators and the feeding and foraging behaviour of birds and animals still attract considerable attention. Ecological studies remain one of the major areas of interest with the role of fire and the continuing devastating effect of *Phytophthora cinnamomi* (dieback) being the subject of ongoing research. The latter was the subject of an international conference in Albany in 2001. One consequence of this research is increasing interest in chemical control of *Phytophthora*, especially by the use of the fungicide phosphite. Papers on this are included in a separate section. Studies of the utilisation of water and nutrients are also included

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separately this year. Some work continues on the rare and endangered species but this still tends to focus on the better-known species; translocation of endangered species is suggested in some publications as one possibility of improving their survivial. There were relatively few papers on applied horticulture, despite the ongoing interest in banksias as cut flowers, although several studies on seed storage have direct relevance to the horticultural industry.

The bibliography is arranged alphabetically by author under the following categories:-

Books on Banksia, Systematics and Paleobotany, Reproductive Biology: *Pollination – General, Pollination – Birds and Mammals, Floral Damage and Flower/Seed Consumption, Seed Development and Canopy Storage.* **Ecology:** *General Studies, Nutrient and Water Studies, Role of Fire, Role of* Phytophthora *and other Diseases and Pests – Broad Studies, Role of* Phytophthora *and other Diseases and Pests – Chemical Control of* Phytophthora, *Rare and Endangered.* **Horticulture:** *General Studies, Propagation, Cultivation and Chemical Studies.*

Numbering begins at 434 and follows on from the 2000 survey (Cavanagh 2000). The listing of species in Appendix 1 follows the *Australian Plant Name Index* (APNI) which is largely based on the work of George (1996a, 1996b and 1999) and Thiele and Ladiges (1996) and the acceptance of names by various Herbaria, but it is recognised that other interpretations are possible. Each taxon is indexed to relevant papers in the bibliography.

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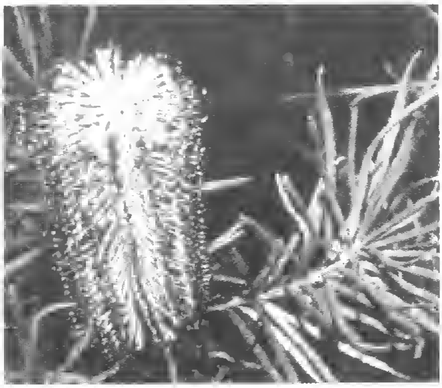

Banksia spinulosa. Photo by Wendy Clark.

Appendix

Listing of all *Banksia* species as given in the *Australian Plant Names Index* (APNI) which is largely based on the work of George (1996a, 1996b and 1999) and Thiele and Ladiges (1996), as well as names accepted by Australian Herbaria. Species are indexed to relevant papers.

Banksia aculeata A.S. George
Banksia aemula R. Br. 445
Banksia aquilonia (A.S. George) A.S. George 437
Banksia ashbyi E.G. Baker 525, 526, 527
Banksia attenuata R. Br. 452, 455, 481, 483, 511
Banksia audax C. Gardner
Banksia baueri R. Br. 491
Banksia baxteri R. Br. 452, 491, 500c
Banksia benthamiana C. Gardner
Banksia blechnifolia F. Muell.
Banksia brevidentata (A.S. George) K. Thiele
Banksia brownii Baxter ex R. Br. 507, 508
Banksia burdettii E.G. Baker
Banksia caleyi R.Br.
Banksia candolleana Meissner
Banksia canei J.H. Willis
Banksia chamaephyton A.S. George
Banksia coccinea R. Br. 442, 493, 519, 521
Banksia conferta A.S. George subsp. *conferta*
Banksia cuneata A.S. George 458, 459, 514
Banksia dentata L.f.
Banksia dolichostyla (A.S. George) K.Thiele
Banksia dryandroides Baxter ex Sweet
Banksia elderiana F. Muell. & Tate
Banksia elegans Meissner
Banksia epica A.S. George
Banksia ericifolia L.f. subsp. *ericifolia* G 442, 448, 456, 473, 474, 489, 528
Banksia ericifolia L.f. subsp. *macrantha** A.S. George 457
Banksia gardneri A.S. George var. *gardneri*
Banksia goodii R.Br. 513, 515
Banksia grandis Willd. 471, 472a, 477, 486, 496, 497, 500a, 500b, 509, 510, 524
Banksia grossa A.S. George
Banksia hiemalis (A.S. George) K. Thiele
Banksia hookeriana Meissner 462, 483, 509, 516, 517, 519
Banksia ilicifolia R. Br. 460, 481
Banksia incana A.S. George
Banksia integrifolia L.f. subsp. *compar* (R. Br.) K. Thiele 437
Banksia integrifolia L.f. subsp. *integrifolia* 435, 437, 446, 448, 463, 465, 478, 492, 504
Banksia integrifolia L.f. subsp. *monticola* K. Thiele 437
Banksia laevigata Meissner subsp. *fuscolutea* A.S. George
Banksia laevigata Meissner subsp. *laevigata*
Banksia lanata A.S. George
Banksia laricina C. Gardner
Banksia lemanniana Meissner
Banksia leptophylla A.S. George var. *leptophylla*
Banksia leptophylla A.S. George var. *melletica* A.S. George
Banksia lindleyana Meissner
Banksia littoralis R. Br.
Banksia lullfitzii C. Gardner
Banksia marginata Cav. 456, 466, 490, 503
Banksia media R. Br. 453
Banksia meisneri Lehm. subsp. *ascendens* A.S. George
Banksia meisneri Lehm. subsp. *meisneri*
Banksia menziesii R.Br. 518, 519, 521, 523
Banksia micrantha A.S. George
Banksia nutans R.Br. var. *cernuella* A.S. George
Banksia nutans R.Br. var. *nutans* 454, 491
Banksia oblongifolia Cav. 456, 489
Banksia occidentalis R.Br. 477
Banksia oligantha A.S. George
Banksia oreophila A.S. George
Banksia ornata F. Muell. ex Meissner 487
Banksia paludosa R.Br. subsp. *paludosa*
Banksia paludosa R.Br. subsp. *astrolux* A.S. George
Banksia penicillata (A.S. George) K. Thiele 512
Banksia petiolaris F. Muell.
Banksia pilostylis C. Gardner
Banksia plagiocarpa A.S. George
Banksia praemorsa Andrews
Banksia prionotes Lindley 462, 472, 475, 476, 477, 480, 483
Banksia pulchella R.Br.
Banksia quercifolia R.Br.
Banksia repens Labill.
Banksia robur Cav.
Banksia saxicola A.S. George 435, 436
Banksia scabrella A.S. George
Banksia sceptrum Meissner
Banksia seminuda (A.S. George) B.Rye
Banksia serrata L.f. 518
Banksia solandri R.Br.
Banksia speciosa R.Br. 499, 529
Banksia sphaerocarpa R.Br. var. *caesia* A.S. George
Banksia sphaerocarpa R.Br. var. *sphaerocarpa*
Banksia spinulosa Smith var. *collina* (R.Br.) A.S. George
Banksia spinulosa Smith var. *cunninghamii*** (Sieber ex Reichenbach) A.S. George 479
Banksia spinulosa Smith var. *neoanglica* A.S. George
Banksia spinulosa Smith var. *spinulosa* 456
Banksia telmatiaea A.S. George
Banksia tricuspis Meissner
Banksia verticillata R.Br.
Banksia victoriae Meissner
Banksia violaceae C. Gardner

* = Not listed in APNI
** = Considered by some to be a separate species, *B. cunninghamii* Sieber ex Rchb

Damage by the Feral Goat *Capra hircus* to Mallee in Murray-Sunset National Park

David Cheal[1]

Abstract

This paper describes the apparent browsing damage caused by the Feral Goat *Capra hircus* in Loamy Sands Mallee along the dune crest and upper slopes of Mt Crozier. Data are from a single, representative quadrat, but provide an indication of the quantitative impact of browsing in mallee. Broom Baeckea *Babingtonia behrii* has been almost eliminated from mallee shrublands at Mt Crozier and Scrub Pine *Callitris verrucosa* is threatened with local extinction. (*The Victorian Naturalist* **122** (2), 2005, 108-111)

Introduction

Feral goats are widespread in the Mallee parks of north-western Victoria (Anonymous 1996). In spite of the lack of documented evidence of their impacts in national parks and other reserves in the region, they are recognised elsewhere as a major threat to the maintenance of functioning vegetation communities (Chesterfield and Parsons 1985; Coates *et al.* 2002; Lange and Purdie 1976; Pickard 1976; Wilson *et al.* 1976). The Management Plan for the (Victorian) Mallee Parks (Anonymous 1996) declares that '*Goats appear to prefer grasses and herbage to woody shrubs*', although other authors have highlighted their preference for shrub browse (Chesterfield and Parsons 1985; Graetz and Wilson 1979; Wilson *et al.* 1976). Whatever their diet, they are considered a major threat to the integrity of the Mallee parks, and management strategies have been devised and recommended for their control (Anonymous 1996; Anonymous 1999).

Due to the local landscape variability, Mt Crozier was selected as a field study site for the Mallee Ecology Course (a training course managed by the Mallee Catchment Management Authority) where one of the issues investigated was the apparent browsing damage in Loamy Sands Mallee along the dune crest and upper slopes.

Mt Crozier is a prominent, deep siliceous sand dune in the central east of Murray Sunset National Park (at 54H WG637378, on the Sunset 1:100 000 mapsheet No. 7228). It is stabilized by Loamy Sands Mallee, *sensu* White *et al.* (2003) dominated by Yellow Mallee *Eucalyptus incrassata*, Narrow-leaf Mallee *Eucalyptus leptophylla* and Grey Mallee *Eucalyptus socialis*. There is an open shrub layer including Scrub Pine *Callitris verrucosa*, Small Cooba *Acacia ligulata*, Pale Turpentine Bush *Beyeria lechenaultii* and Broom Baeckea *Babingtonia behrii* above a rich flora of perennial and annual herbs typical of deep siliceous sands. Surrounding vegetation communities include Woorinen Sands Mallee on the dune slack and Woorinen Mallee Woodland and degraded Semi-arid Parilla Woodland on nearby landscapes lacking an aeolian sand overlay.

Fig. 1. Broom Baeckea *Babingtonia behrii* at Mt Crozier. Foliage below 175 cm is heavily browsed, above 175 cm is unbrowsed.

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Methods

A quadrat (0.15 ha, i.e. 30 m x 50 m, with the quadrat's long axis parallel with the dune crest) was laid out immediately north of the dune crest. The quadrat boundaries were selected so as to include a representative sample of Loamy Sands Mallee. The data were collected on 12 November 2003.

The most common shrubs growing in the quadrat were identified, counted, measured (height, minimum height to unbrowsed foliage) and browsing impact assessed on a 3-point scale (i.e. 'dead', 'browsed' and 'no evidence of browsing').

Vascular plant nomenclature follows Walsh and Entwisle (1994; 1996; 1999).

Results

A browse-line was obvious and unambiguous for Broom Baeckea and Scrub Pine (Figs. 1-3). It was less obvious for Small Cooba (Fig. 4) where the measured 'browse line' was an indication of the lowest extent of the canopy (i.e. the foliage closest to the ground). Eighty-nine per cent of the 'browsed' individuals of *A. ligulata* had unbrowsed foliage extending above the 'browse line' for that shrub (i.e. 89% were tall enough to have some foliage beyond reach of the browsers). The maximum browse line observed for *A. ligulata* was at 2.5 m, mean 111 cm (standard error – 128 cm).

Fig. 2. Scrub Pine *Callitris verrucosa* at Mt Crozier. Foliage below 180 cm is heavily browsed, above 180 cm is unbrowsed.

For Scrub Pine, 4.5% of the browsed individuals had unbrowsed foliage extending above the browse line. The maximum browse line for Scrub Pine was at 2.0 m, mean 187 cm (standard error – 44 cm).

Individuals of palatable species that had not lignified before being browsed (i.e. had no woody stems) may have been completely removed by browsing, leaving no evidence. Hence, data for palatable species (notably Broom Baeckea and Scrub Pine) are likely to be an under-estimate of original density and proportions browsed or dead. The data for shrub densities and grazing impact are presented in Table 1.

Of the seven species measured at Mt Crozier, four were not obviously affected by goat browsing, *viz*. Pale Turpentine Bush, Yellow Mallee, Narrow-leaf Mallee and Grey Mallee. There was no evidence that foliage from any of these species had been taken (Table 1), even though it may have been readily accessible (e.g. maximum height for Pale Turpentine Bush was 1.0 m).

The impact on Broom Baeckea was devastating – 98% death (Table 1). This was attributed to browsing as plants that die from other causes, such as drought, are not usually clipped at 2-3 mm diameter stems. The impact on Scrub Pine was similarly severe, but with only 10% death to date (Table 1). Nevertheless, all accessible foliage of Scrub Pine had been browsed (removed).

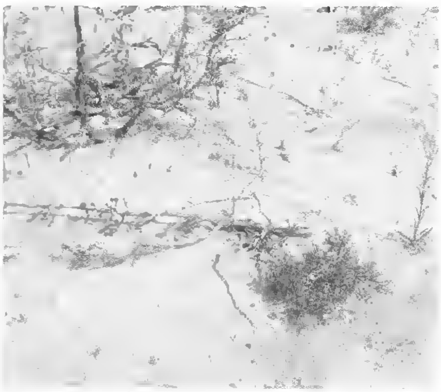

Fig. 3. Heavily browsed Scrub Pine *Callitris verrucosa* at Mt Crozier.

Table 1. Browsing damage in Mallee. d = dead, b = browsed.

Species	Density (ha^{-1})	Mean Height (cm) (std. error)	Max. Height (m)	% dead	% live, browsed	% live, no browse line
Acacia ligulata Small Cooba	187	230 (428)	4.0	4	89	7
Babingtonia behrii Broom Baeckea	287	107 (24)	1.8	98	2	0
Beyeria lechenaultii Pale Turpentine Bush	47	59 (79)	1.0	0	0	100
Callitris verrucosa Scrub Pine	760	120 (727)-d 88 (117)-b	7.0	10	89	1
Eucalyptus incrassata Yellow Mallee	60	580	9.0	0	0	100
Eucalyptus leptophylla Narrow-leaf Mallee	13	600	7.0	0	0	100
Eucalyptus socialis Grey Mallee	7	800	8.0	0	0	100

Discussion

There are three species of large mammalian browsers in Murray Sunset National Park – Red Kangaroo *Macropus rufus*, Western Grey Kangaroo *Macropus fuliginosus* and Feral Goat *Capra hircus*. Red Kangaroos are rare in the Park and are largely restricted to the open plains, the nearest of which is some 8 km or more distant from Mt Crozier. They are very rarely seen in dense mallee.

Western Grey Kangaroos and Feral Goats are common in the Park and scats and footprints from both species occurred in the mallee at Mt Crozier. The browsing impact here described is attributed largely to Feral Goats on the following grounds:

1. Goats are frequently seen in the surrounding mallee and disturbed woodland. Kangaroos are apparently less common.
2. The scats observed within the quadrat, and along the Mt Crozier dune, were strongly dominated by goat scats (>82% of all scat deposits). Footprints of goats were common. Kangaroo footprints were rare.
3. Physical damage to individual plants indicated goat damage. For example, a few large horizontal branches of veteran Scrub Pines had been climbed to access the foliage, leaving broken and dislodged bark strips, consistent with a hard-footed animal with some climbing ability (*viz*. goats), rather than a soft-footed animal with scant ability to climb (*viz*. kangaroos).
4. There were very few (and no current) scrapes dug in sheltered situations along the Mt Crozier dune (as would be expected if kangaroos were common). Kangaroos excavate shallow scrapes for shelter in the heat of the day. Goats do not dig such scrapes.

Browsing impact was most evident on Broom Baeckea and Scrub Pine. Such impact will rapidly eliminate Broom Baeckea, otherwise common in and characteristic of the community (White *et al.* 2003). Scrub Pine also will disappear grad-

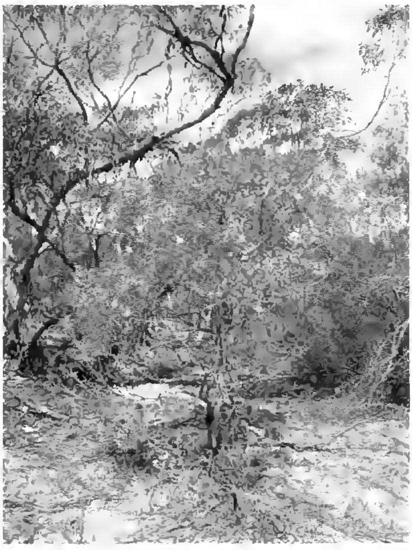

Fig. 4. Small Cooba *Acacia ligulata* amongst Yellow Mallee *Eucalyptus incrassata* at Mt Crozier. The browse line is difficult to distinguish.

ually from the community, as there is scant regeneration in the absence of fire. Scrub Pine is by far the most common woody plant at this site, which could otherwise be expected to gradually mature to Scrub-pine Woodland, a threatened vegetation community. With continued browsing this scenario is now impossible.

Small Cooba is palatable to browsers and is suspected to have been browsed, but with subsequent rapid canopy recovery to obscure any former browsing impacts.

The year preceding the data collection was unusually dry. Annual rainfall from nearby Walpeup Post Office was 176 mm in 2002 cf. 305 mm mean annual rainfall for the 6 years from 1998 to 2003 inclusive (Bureau of Meteorology, data extracted February 2004). Droughts force browsers to utilise, and rely on, forage of otherwise non-preferred species. The recent extended drought may have led to greater browsing impact on the perennial shrubs here discussed. There is some evidence that Small Cooba had been browsed, but that browsing pressure had recently relaxed. The heavily-browsed Scrub Pine showed some regrowth. Nevertheless, these mallee communities are subject to seasonal drought every year and significant browsing pressure can be expected as annual forage disappears. Browsing impact is also a function of the density of the browsing mammals. High densities of browsers can mimic the impacts of severe droughts.

These data are from a single (representative) quadrat, but provide an indication of the quantitative impact of browsing in mallee. Broom Baeckea has been almost eliminated from mallee shrublands at Mt Crozier and, presumably, elsewhere in Murray-Sunset National Park. Scrub Pine also is threatened with local extinction. It is reasonable to expect that other palatable shrubs and perennials are being locally threatened by Feral Goats as well. This impact is insidious, as it does not produce large areas of obviously-eroding, bare landscapes. However, Feral Goats are causing severe and effectively permanent ecological degradation.

Acknowledgements

The participants in the Mallee Ecology Course who assisted in data collection included Barrie MacMillan, Brendon Thomas, Bronwyn Merritt, Cameron Bennett, Claire Wilkinson, Damian Wells, Denise Whyte, Donna Tidey, Glen Smith, Glennis McKee, Greg Ogle, Helen Frania, Jennifer Alexander, Joanne Robinson, Kate Maddy, Kath Biesaga, Michelle Dickson, Noreen Jones, Rebecca Curren, Rebecca White, Shelley Rozario and Tim Britton.

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Regardfully Yours. Selected Correspondence of Ferdinand von Mueller, Volume I: 1840-1859, Volume II: 1860-1875

edited by RW Home, AM Lucas, Sara Maroske, DM Sinkora and JH Voight

Publisher: *Peter Lang, Bern, 1998, 2002. 842 pp, 865 pp, b & w illustrations and colour frontspieces. RRP $140 each (hardback).*

Ferdinand Mueller, or 'the Baron', as he was usually known, looms large in the collective memory and records of the FNCV. When the Club was established in 1880 Baron Ferdinand von Mueller was member number 36 – one of the 56 'original members' – and in 1886 he became the Club's first patron. He was a prestigious patron, with scientific status and field experience. As Victoria's first Government Botanist, from 1853 until his death in 1896, Dr Ferdinand Mueller developed a substantial reputation as botanist and field naturalist. He trekked across thousands of kilometres of often undocumented landscapes within and beyond the Colony of Victoria – collecting, collecting, collecting, always collecting plant specimens; and always on the lookout for useful and novel plants. Mueller used his own and others' specimens to document the flora of Australia, and earned an international botanical reputation. He made the very first botanical surveys of many of the areas he visited, and many of these later became popular sites for Club excursions. Mueller shaped the botanical understanding of Victoria's flora which the FNCV welcomed and continued to elaborate.

Mueller's image as the grand exemplar of the field naturalist was not dimmed by his death and, as described in the special issue of *The Victorian Naturalist* which was published in 1996 to commemorate the centenary of his death, Mueller's life and work became woven into the Club's tradition. The Baron was remembered during Club conversaziones, excursions and wild flower exhibitions; and the FNCV's president, Charles Daley, prepared the first published biography, *Baron Sir Ferdinand von Mueller, botanist, explorer, and geographer* (1924), to celebrate the centenary of his birth in 1825.

Try finding an expanse of Victorian, or even Australian, bush without a single plant named by Mueller. His imprint on the botanical lexicon of the Australian landscape is huge. As Shakespeare claimed long before Mueller's time, *a rose by any other name would smell as sweet*. True. We can certainly appreciate the beauty of plants and their flowers without knowing their names; but to discuss them we need a lexicon of mutually-agreed names.

Naming plants on a southern outlier of the British Empire in the nineteenth century was no easy task. But, despite enormous problems, Mueller grasped the opportunity to document Australia's largely undescribed flora, and named thousands of species of Australian plants. Some of his names endure in the current censuses of Victorian and Australian plants. He used specimens he collected when venturing into often unmapped landscapes and specimens from his vast network of collectors explorers, pastoralists, missionaries, government officials and their wives and daughters. In order to circumvent European editorial control and the possible loss of specimens and manuscripts during their long sea voyages across the equator, Mueller often sought to establish his plant names by describing new taxa in local journals, which, before the establishment of the FNCV, meant journals of the Royal Society of Victoria and sister societies in other colonies.

In an era before the telephone and e-mail, Mueller was forever writing letters. He sent thousands of letters and plants to individuals and institutions around the world. His letters are predominantly botanical, but sometimes include personal details and feelings. As his network of collectors proliferated across Australia, he wrote thanking them and requesting further botanical information and specimens. He wrote official letters and reports to the Victorian government and often long, informative letters to accompany herbarium specimens, and sometimes living plants, to botanists on the other side of the world. Regardful of the place of his taxonomic and other botanical work and his own perceived position in the Eurocentric world of botany, Mueller corresponded with numerous European botanical authorities. Not surprisingly, his copious correspondence with three eminent British botanists, Sir William Hooker and his son, Dr Joseph Hooker, the first two directors of the Royal Botanic Gardens at Kew, England, and George Bentham, whose *Flora australiensis* (1863-78) relied heavily on herbarium specimens which Mueller generously lent him, is particularly botanically illuminating. Much of the botanical information in Mueller's letters was subsequently published, sometimes in updated form.

His letters were important to Mueller because, apart from face to face contact, they provided the sole means by which he communicated with the rest of the world. They are important now because they contain information not included in the public or published record, and they provide glimpses of the social, political and environmental context in which Mueller carried out his various botanical activities. In their discussion of Mueller's correspondence at the distressing time of his dismissal from Melbourne's Botanic Gardens in 1873, the editors point that he 'drew strength from the sense that his science transcended the petty unpleasantness of his situation in Melbourne and enabled him to participate in a larger and vastly more civilized world, the international republic of letters' [Vol. II p. 47]. Mueller's correspondence also provides a veritable Who's Who of botanists in the second half of the nineteenth century and plant collectors in Australia during that period.

Regardfully Yours were the words with which Mueller commonly signed his letters. The editors are involved in an ambitious project to recover, translate, clarify and collate extant letters to and from Mueller in repositories all over the world. The Mueller Correspondence Project is an international project based at Melbourne's Royal Botanic Gardens and led by Professor Rod Home of the History and Philosophy of Science Department at the University of Melbourne. In libraries, archives and private collections scattered across the globe, researchers have winkled out thousands of notes, letters and reports written by and to Mueller. These probably represent a tiny fraction of his prolific correspondence. So many letters have disappeared; but some keep turning up. You can read about the complex and tragic fate of Mueller's extraordinary epistolary activity in the Introduction to Volume I.

Some correspondence has already been published in *The Victorian Naturalist*. Soon after the 1924 publication of Daley's biographical memoir of Mueller, a packet of letters was found in the National Herbarium of Victoria. They were from William and Joseph Hooker and George Bentham. Chas Daley wove them into a long article, 'The history of *Flora australiensis*', which appeared in eight parts in volume 44 [not 43] of *The Victorian Naturalist* (1927-28). These letters, some of which are published in *Regardfully Yours*, are now safe and secure in the Library in the National Herbarium building in the Royal Botanic Gardens in South Yarra.

The correspondence in these two volumes spans the pre-FNCV period, 1840 to 1875, for half of which Mueller was the director of Melbourne's (not-yet-Royal) Botanic Gardens as well as Government Botanist. Letters are arranged chronologically, from personal letters from his sister, Iwanne, in the early 1940s to official government letters, after his dismissal from the Gardens, about the organization of his botanical department. English translations are provided for letters which, like a couple from Iwanne, are written in languages other than English. The published letters show the breadth of Mueller's interests, most of which are in some way linked to natural history – Australian exploration, plant geography and taxonomy, plant acclimatisation and agriculture, and economic botany and education. I shall not attempt to summarize the scope or content of the letters. Instead let me try to whet your appetite with a few early snippets that relate to two areas which are now much-loved national parks, well-known to FNCV members – Mt Buffalo and Wilsons Promontory.

Mueller provided the first botanical records for both places during his first official Victorian collecting trip, a circuitous five-month expedition in 1853, during which he was, as always, on the lookout for novel and useful plants. His first annual report as Government Botanist [53.09.05] records some of the botanical discoveries he made during that expedition, which included 'a brief stay' on 'the Buffalo ranges' in late February and early March. He suggested that a shrub he found there, *Baeckea utilis*, 'might serve travellers in those desolate localities as tea, for the volatile oil of its leaves resembles greatly in taste and odour that of lemons – not without a pleasant peculiar aroma'. This was before he used his Buffalo specimens to formally name and describe *Baeckea utilis*. On the Buffalo ranges Mueller 'examined the rich almost tropical vegetation, which borders the rivers, rising to the mountains. It was in this locality, that our exertions were rewarded with the discovery of the high majestic Grevillea Victoriae and other rarities.' He sent a specimen to William Hooker [53.10.18] and informed him that it was 'the most brilliant shrub, that I ever discovered (12' high and higher) and I would venture to adorn it as a token of my loyalty with the name of our most gracious Majesty, should this step be honored by the Queens sanction.' He would later use specimens he collected on Buffalo and other alpine peaks to formally name and describe *Grevillea Victoriae* in the journal of a precursor of the Royal Society of Victoria.

Mueller's 1853 report mentions his 'several weeks travelling in the neighbourhood of Port Albert and many excursions through Wilsons promontory'. He had sailed from Port Albert to Sealers Cove in May. In an official letter written on his return to Melbourne in June [53.06.27] he discussed the last part of his expedition, which included Wilsons Promontory. He reported that several weeks had been 'exclusively devoted for examining Wilson's promontory, in order to elucidate fully the connection, that exists between the Flora of this country and Van Diemen's Land [Tasmania]'. He saw impressive timber trees. Without mentioning the help of saw-millers at Sealers Cove, Mueller reported: 'In the deep Ferntree-ravines of Sealers cove I discovered for the first time on this continent the Tasmanian Beech tree (Fagus Cunninghami [*Nothofagus cunninghamii*]), the only timber here, that bears comparison with that of Great Britain, (Pines excepted), otherwise closely allied to the Beech-tree of Patagonia. I did howev[er] not succeed in finding any of the remarkable pines (Microcachrys, Phyllocladus, Arthrotaxus [sic]), with which this useful tree in Van Diemens Land is consociated.' This was many years before Australian species of Beech were transferred to the genus *Nothofagus*.

Despite the absence of Tasmanian 'pines' which Mueller had hoped to find on Wilsons Promontory, he was so impressed with the timber there, that he organized the collection of timber specimens for both an exhibition and William Hooker. Volume I includes correspondence relating to the International Exhibition held in Paris in 1855 and mentions '*24 Native Woods*' exhibited there [footnote p. 301], but not that they came from Wilsons Promontory. In July 1857 Mueller informed 'My dear Sir William' [57.07.15] that he had 'despatched a man to Wilsons Promontory with 6 Wardian Cases, to secure young plants of Fagus Cunninghami, Atherosperma, &c &c, and hope to be able to send in a very short time one or two cases with living plants and as large a collection of timber as obtainable'. The following year he reported [58.03.01] 'that the owners of the Sealers Cove saw-mill have been generous enough to disclaim a debt of £15.8/- incurred last winter ... when securing plants and timber specimens ... at Sealers Cove'.

Regardfully Yours includes more than correspondence. Introductions to both volumes discuss Mueller's life and work. There are illustrations of people, plants, landscapes and maps. There are biographical registers of Mueller's correspondents and people mentioned in the letters, bibliographies of Mueller's publications and publications about him, and publication details of Mueller's plant names. Both volumes have a general index for people and places and an index for botanical names. These volumes show the importance of archives and libraries, and provide a fascinating and substantial historical botanical resource. They should be in any library that boasts a good botanical or Australian history collection.

For details of the Baron's correspondence relating to the FNCV you will have to wait for the publication of the third volume of *Regardfully Yours*, the CD-ROM of the collected correspondence and a biography of Mueller based on the findings of the Mueller Correspondence Project.

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Old Land, New Landscapes: a story of farmers, conservation and the landscape movement

by Chris Williams

Publisher: *Melbourne University Press, Carlton, Victoria, 2004. 208 pp. RRP $34.95*

Apart from the continuous and lethal stream of trucks, I adore driving along the Newell Highway through central NSW.

I love its broad vistas, hazy low blue ranges, flood plains lined with red gums and wetlands, ever-changing box and ironbark woodlands, generous travelling stock reserves, pristine pastoral towns, bulk canola crops, dense roadside thickets of native pine seedlings, companies of apostle birds, paddocks spotted with kurrajongs.

This is quintessential *Australia Felix*, but its bushland patina is slightly illusory – the native vegetation you admire is mostly linear – along roadsides, railways, stock reserves and creek-lines and on stony country too rough to readily graze or crop.

Chris Williams did his PhD research here in the late 1990s, living intimately with a farming community north west of the mining town, Peak Hill, combining ecology and sociology with a little rural economics. This was superb preparation for his current work with Victoria's Trust for Nature.

Not long before, from 1992-94, Genaren Hill Landcare Group had raised funds for, and co-ordinated the establishment of, a 400 hectare wildlife reserve on *Genaren*, the 3300 hectare grazing-cropping property owned by group president Mike Sutherland and wife Kylie. The reserve required 8.6 kilometres of high electrified predator-proof fence.

This was a huge and admirable project for a small community group with few resources – but great resourcefulness! By enclosing a long stony ridgeline mainly carrying tumbledown gum, mugga ironbark and currawang wattle, the new sanctuary greatly reduced kangaroo damage on farms throughout the district, and protected a major landscape feature and bushland remnant. Later the group stocked the reserve with brush-tailed bettongs and bridled nailtail wallabies – both long extinct from Genaren.

This all required considerable commitment, patience, thought, internal and external debate, ingenuity, hard work, new partnerships and liaison with many government organizations. But the group learnt a great deal about the environment and developed admirably better relations with the regional Aboriginal community. As well, most group members protected their own bushland remnants and connected them to Genaren Hill with corridor plantings.

Chris Williams chronicles this story well. Williams' thoughts are comprehensive, and indeed cerebral, so his style demands your attention. But the reader is well repaid in ideas, information and inspiration. And what a delight it is to see a PhD study transcribed into a reasonably accessible form for the real world! Moreover he respects his diverse social samples – the farm families striving to be viable having to decide between grazing and cropping, the Aboriginal elders and archaeologists, the regional university people, and many of the local departmental staff. This is an illustrated, intriguing, generally positive story of rural Australia, which demonstrates the flexibility and creativity of the Landcare concept.

The only deficiency was a final dot-point summary of what Chris Williams and the community had learnt from the Genaren project – how to better utilize farmland for conservation – something that a politician or executive of a multi-disciplinary government department might find thought-provoking.

Let me enlarge. Throughout the book the departments involved appear distant, unsympathetic and purist – which includes an aversion to commercial activities. Yet anyone who goes to a John Walmsley-type sanctuary will find it moving and exciting to see rarities like bettongs and quolls, even if enclosed. They are a beautiful link with old Australia! So this management concept needs to be worked on further, because it has rewarding aspects!

Williams reports that when the Sutherlands sold their property two years ago the sanctuary did not influence the price; I believe this will change. Moreover, I look forward to the next generation of Australian philanthropists establishing extensive bushland reserves on former farmland – the way people like Malcolm Forbes are buying buffalo rangeland in western USA.

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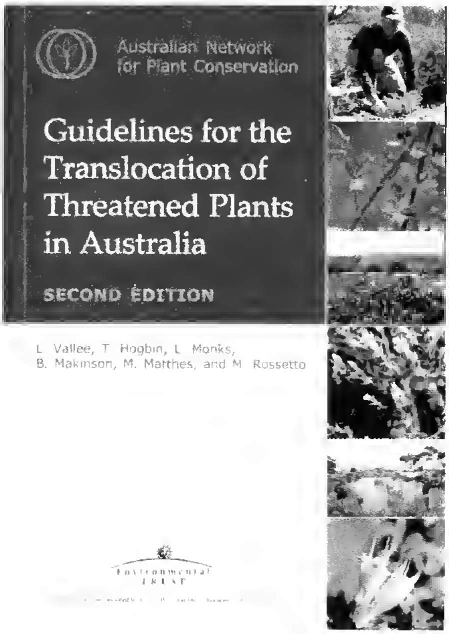
Guidelines for the Translocation of Threatened Plants in Australia

by L Vallee, T Hogbin, L Monks, B Makinson, M Matthes and M Rossetto

Publisher: *Australian Network for Plant Conservation, 2004 Second Edition, 80 pages, paperback. ISBN 0 975219103. RRP $22*

The past decade has seen significant development in *ex situ* techniques for conserving biodiversity. Germination of rare and endangered plant species is being enhanced by advanced understanding of compounding factors such as smoke chemistry, fungal associations and pathogens. There comes a time, however, when *ex situ* populations must become *in situ*, as this is the ultimate aim of conservation efforts. Translocation is the term given to this process. Simply, it involves deliberately transferring an *ex situ* collection, or a threatened native population, to another more suitable location in order to increase the species chance of persisting in the wild. More detailed consideration of this notion, however, highlights a myriad of potential pitfalls for the uninitiated! How does one know if the benefits of translocation outweigh the risks? Indeed, what *are* the benefits and risks? How does one manage them, or monitor them?

Guidelines for the Translocation of Threatened Plants in Australia (2 ed.) considers these points and much, much more! Developed by the Australian Network for Plant Conservation, the revised edition provides step-by-step, clear and concise instructions for planning, implementing and monitoring translocation activities. Chapters include deciding whether to translocate, pre-translocation assessment, translocation proposal writing, preparation and translocation, post-translocation management, monitoring and evaluation and,



among others, community and support. Each chapter provides well-developed checklists and fascinating Australian case studies are used extensively throughout the text to encapsulate the theme of the chapter.

Significant improvements have been made to the original edition, which was published in 1997 and was quickly adopted as a standard for translocating rare or threatened plants in Australia. For example, the NSW Parks and Wildlife Service's Application for a Scientific Licence for the Purpose of Science, Education or Conservation states that translocation of threatened flora should adhere to the ANPC's Guidelines for the Translocation of Threatened Plants in Australia (1997). The most notable format improvement is the addition of colour throughout, including headings, subheadings, box information making it far easier to navigate. Photos, too, have been reproduced in colour, improving not only aesthetics but engagement with the subject matter! Chapters have all been completely revised and expanded to the extent that the original truly is outdated.

This publication is a real gem. In addition to thought-provoking text, the ubiquitous information boxes are insightful and informative. Box 1.1 (p. 2) introduces the types of translocation action (undertaken for conservation purposes or as an ameliorative measure for development), whilst box 2.2 (p. 8) presents management options available for threatened plants, including habitat protection, habitat rehabilitation and removal of threatening processes (no mean feat!), and active management which may or may not involve translocation. I think the discussion on population genetics (albeit somewhat brief) and supporting information box (box 3.1) and case study (case study 3.2) is highly valuable, and the chapters considering post-translocation management, monitoring and evaluation, and community participation and support, both greatly improved from the original, are vital reminders.

If you own the original edition, you will find the second edition a sound investment. If you own neither, perhaps you should! ANPC have fulfilled their self-professed role in connecting conservation scientists, managers and community and private sector practitioners with this very handy reference book. And, if your interests are aimed more squarely at fauna conservation, I believe this publication will offer you a fresh look at conservation biology more generally. Finally, I feel the book will be of interest to all nature-lovers, if only to highlight how complex conservation measures can be and how important suitably qualified practitioners really are!

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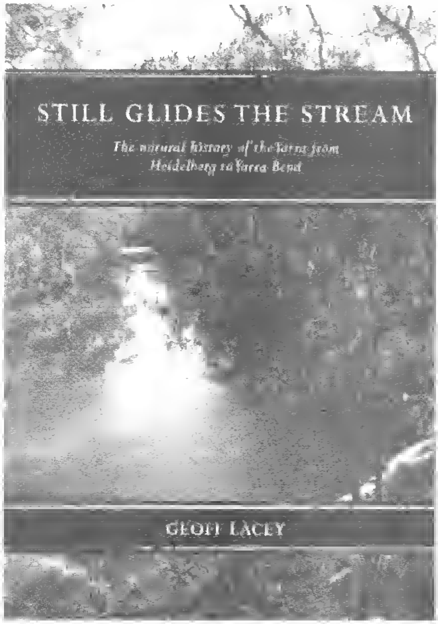
Still Glides the Stream: the natural history of the Yarra from Heidelberg to Yarra Bend

by Geoff Lacey

Publisher: *Australian Scholarly Publishing, Melbourne, 2004. 281 pp. RRP $34.95*



The El Niño events of recent years, threats of global warming and the degraded state of so many Australian streams have focused attention on the issues of water supply and the ecological health of our water systems. One manifestation has been a substantial number of new published and thesis histories of water and waterways. Among those who have been working on aspects of Melbourne's Yarra River have been Tony Dingle, Helen Doyle, Judith Buckrich, Gary Presland, David and Cam Beardsell – and retired engineer and naturalist Geoff Lacey.

Lacey's book is the product of a lifelong interest in and a love of the Yarra and its surroundings. It is a study of the Yarra from its confluence with the Plenty River at View Bank and Templestowe downstream to Yarra Bend near Studley Park Road in Kew. It is a meandering stretch of river which, prior to European settlement was dotted with wetlands and billabongs and was rich in flora and fauna. Much of this has been transformed and degraded by the spread of Melbourne.

Lacey's study is divided into four main sections: the first outlines the geology and 'natural history' of the region, and the occupation by the 'traditional custodians'; the second divides this reach of the Yarra into seven sections and outlines the post-European changes including the efforts by various community groups to restore the natural vegetation (in some of which Lacey has been involved); the third looks briefly to the future of the region, within the context of the changes in the past; and finally there are five very valuable appendices which list the historical floods and the flora, avifauna and much of the other fauna found in the region.

The main body of the work is contained in the second section with its detailed discussions of the river in seven geographically-based chapters – Banyule Flats and Warringal Parklands, Yarra Flats Park, the Bulleen Flats, Wilson Reserve and Chelsworth Park, some billabongs in Kew, the Fairfield bank, and Yarra Bend Park. Typically, these chapters contain a description of the area under discussion, an attempt to identify the pre-European vegetation and its distribution, the post-settlement usage of the land and the changes these have brought to flora, fauna and the river, observations on the avifaunal inhabitants, detailed examination of particular features, and an account of the efforts to restore and revegetate the region.

While such an account makes this sound a very utilitarian book, it is more than that. Lacey's love for the region, his expertise as a naturalist in observing both flora and fauna (particularly birds) and his involvement in the restoration groups give the book a personal and enthusiastic touch. At the same time, his fascination with the Yarra and its biota has motivated him to read widely into its history and environmental history, and to bring to the book some analytical understanding of changing attitudes to water systems which underlie the post-settlement changes.

The book is well presented with some excellent maps and historical and contemporary photographs

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High density hibernacula in Southern Water Skinks *Eulamprus tympanum*

On Sunday, 5 September 2004, I was seeking cockroaches and other insects for a 'bugs party'. To that end, I broke into a fallen and decaying log derived from a large Acacia.

The log had been cut as a section and was about 30 cm in diameter and 180 cm long, but it was not hollow in the sense of containing a large open air space. However, the log's inside was a mass of loose wood material that had been partially decomposed by insects. Although it was moist. there was no evidence of free water or condensation.

The log was situated on the ground, but not embedded in any way. It received dappled sunlight and was in an area with a strong northerly aspect on the southern bank of the Yarra River, adjacent to a walking track immediately behind the main township of Warrandyte. Inside the log I found numerous beetles, cockroaches, mealworms and some other insects.

Witchetty Grubs had ensconced themselves near the external surfaces on all sides of the log. The mid section of the log had been decomposed to densely packed wood shavings.

It was in this section of the log that I found 12 Southern Water Skinks *Eulamprus tympanum*. a common species in Victoria. They were not found as a group, but individually where they had burrowed inside the woody material.

Although some lizards were immediately adjacent to one another, they were not aggregating to make use of each other's heat. From the positioning of the lizards, it appeared that each lizard was effectively hibernating on its own.

Five were adults and seven were juveniles from last summer. None was sexed. In my view, the only reason so many occurred in this log was because it provided such an effective hibernation spot in an area with a limited choice of sites. These lizards are very common in this area.

Under the same log, between it and the ground, was a single adult Weasel Skink *Saproscincus mustelina*. None of this species was found in the log and no Southern Water Skink was found under it, indicating distinct microhabitat preferences for the two species.

As I had destroyed the hibernacula in my search for 'bugs', I moved the skinks to another similar log nearby that was not broken open.

The weather at the time had been seasonally mild and mainly sunny with a top temperature about 17° C and little wind. Although the log was broken open at about 3.00 pm, the warmest part of that day, all the lizards appeared to be in a state of torpor and it would be reasonable to infer that none had been active on that day or any of the cooler days preceding it.

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'Drunken' Honey Bees

Apiarists have revealed a previously undocumented phenomenon: that, under certain climatic conditions, some Eucalypt species can produce a substance(s) that significantly affect the Honey Bee *Apis mellifera*. 'Symptoms' include drastically high bee mortality and, therefore, reduced hive health and critically reduced honey yields. The bees themselves appear 'drunk' (unstable), are unable to fly, suffer diarrhoea (observed as 'streaking' in the hive) and, less often, vomiting.

In a broader study investigating flowering patterns, apiarists were asked whether they believed 'toxic' pollen and/or nectar to be the cause. Sixteen of twenty-five apiarists answered the question and most (15) believed it was due to 'toxic' nectar. Five believed it also could be due to toxic pollen and one apiarist believed it was only due to toxic pollen.

Eucalyptus microcarpa (Grey Box) was identified as the species most commonly producing this 'toxic' nectar. This species flowers from (mainly) mid-February until mid-April however, flowering can extend to late May.

Apiarists proposed that nectar produced during the latter weeks (particularly when extending into May) is 'toxic', whilst rarely being so earlier in the flowering season. They theorise that higher rainfall and, therefore, higher humidity, which occur in the later weeks of flowering, dilutes the nectar in the cups and allows nectar fermentation. Apiarists in South Australia, New South Wales (Melanie Birtchnell pers. comm.) and Western Australia (Robert Manning pers. comm.) also report this phenomenon.

Chris Tyshing (pers. comm.) observed similar symptoms from a planted eucalypt (*E. botryoides*) following uncharacteristic summer rainfall. Microscopic analysis of the dead bees indicated a prevalence of diarrhoea.

Pollen feeding trials in Western Australia resulted in the same symptoms. Analysis of the sugar solution revealed:

- the solution was too dilute;
- yeasts, particularly *Candida albicans*, were present;
- the solution had fermented.

This phenomenon is being investigated further by M Birtchnell and M Gibson. Should any readers notice bees acting in a 'drunken' manner, could they please notify one of the authors as soon as possible.

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One hundred years ago

GENERAL BUSINESS

Mr A. Mattingley said that the letter from the Club which recently appeared in the public press, protesting against the destruction of wattle, appeared likely to give the public the idea that the Club was opposed even to a sprig of blossom being taken from a tree, and thought it would be well if the Club would define what it regarded as destruction of wattle trees.

The .President said that his view of the matter, and one which he thought all would agree with, was that the mere picking of small sprays of of blossom in the public parks shoud be overlooked, but it should be considered destruction where boys climbed the trees and broke down the branches with the intention of making up large bunches of blossom. Such a case he had witnessed the previous day on the banks of the river at Ivanhoe, but being on private property the police could take no action.

From *The Victorian Naturalist* **XXII**, p.77, September 1905

FNCV Environment Fund

Report for the grants of 2004

The Hillcrest Association Inc is a community based non-profit organisation with the purpose to serve the local community of Donvale in matters of concern to local residents.

The Association contributes to discussions with local government authorities, VicRoads, local councils, community groups and individuals. The Committee researches and addresses issues raised by local residents. Members have been involved in decisions pertaining to traffic management and the management of Hillcrest Reserve and have provided input into public forums, proposals for policy and planning documents, and matters to do with local amenity.

The Committee consists of volunteers elected by the members of the Association, which has an excellent reputation for committment to achieving good relations with individuals and agencies.

The group has taken an active role in caring for the bushland and reserve of Hillcrest Park and Hillcrest Reserve bushland. Regular working bees are held throughout the year. Of concern to the Association in recent years has been the proposed building of the EastLink tollway.

The Hillcrest Association received a Grant from the FNCV Environment Fund in 2004. The Grant was awarded to assist in the production of educational pamphlets and newsletters. The first Newsletter was produced in October 2004 and thanks to the funding the group was able to reach a broader section of the Donvale community.

Five hundred copies of the Newsletter were produced. The production of the Newsletter was done by a member of the committee in her own time. The results were pleasing and another Newsletter was planned for early in 2005. Some of the Grant will be used for the planned update of the Association's small brochure.

The contract for the EastLink tunnel was awarded in October 2004 to Connect East. Hillcrest Association plans to maintain a high profile with authorities during the works. To this end I have mailed the first Newsletter to Mr Brian Wilson, Director of Communications for SEITA, the company overseeing the contracted works.

In March 2005, the Association produced its second Newsletter. Three hundred copies of the Newsletter were printed and distributed. The Association was pleased with the positive result, with some new subscriptions and renewed interest within the community.

I have continued to maintain contact with the contractors (now Theiss John Holland); engineering works have now commenced in the Mullum Mullum Valley on the EastLink project.

It has been a long and anxious time for the Association as well as the members of the community who have assisted with trying to save at least partof this lovely valley. The tunnel saves about 98% of the forestway, although massive devastation has occurred at both ends of the tunnel.

Fauna surveys and animal rescues were done to correct procedures - eventually!

We continue to monitor flora and fauna in the Hillcrest Forestway and have been pleased to note an increase in sightings of Black (Swamp) Wallaby and Echidna. Koalas are heard and seen all through the year although sadly no joeys have been sighted for some years.

The birds (in spite of construction noise) are as brilliant as ever. On a good morning, starting early, it is still possible to see between 30-40 birds, including Powerful Owl and the resident Brown Goshawk.

The Hillcrest Association is very grateful to FNCV Environment Fund Committee for their help. It is important at the moment for us to be active and information for the residents is part of that action.

Cecily Falkingham
Vice President
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Flora and Fauna Guarantee Act 1988

Final Recommendations in regard to nominations for listing under the Flora and Fauna Guarantee Act 1988. The nominations for the following taxa to be listed as threatened are supported by the Scientific Advisory Committee, November 2004.

1. Taxa

Abutilon oxycarpum var. *malvaefolium*	Mallow-leaf Lantern-flower
Abutilon oxycarpum var. *subsagittatum*	Flannel Weed
Acacia binervia	Coast Myall
Acacia caerulescens	Limestone Blue wattle
Accipiter novaehollandiae	Grey Goshawk
Alectryon subcinereus	Native Quince
Anseranas semipalmata	Magpie Goose
Aristida jerichoensis	Jericho Wire-grass
Aristida obscura	Rough-seed Wire-grass
Aristida personata	Purple Wire-grass
Asperula ambleia	Stiff Woodruff
Botrychium australe	Austral Moonwort
Caladenia sp. aff. *fragrantissima* (Central Victoria)	Bendigo Spider-orchid
Callistemon kenmorrisonii	Betka Bottlebrush
Cardamine franklinensis	Franklin Bitter-cress
Cardamine gunnii	Tuberous Bitter-cress
Correa lawrenceana var. *genoensis*	Mountain Correa
Craspedia canens	Grey Billy-buttons
Cyperus rigidellus	Dwarf Flat-sedge
Daviesia laevis	Grampians Bitter-pea
Deyeuxia affinis	Allied Bent-grass
Deyeuxia pungens	Narrow-leaf Bent-grass
Egernia guthega	Alpine Egernia
Epilobium brunnescens subsp. *beaugleholei*	Bog Willow-herb
Eucalyptus alligatrix subsp. *limaensis*	Lima Stringybark
Eucalyptus molyneuxii	Little Desert Peppermint
Euphrasia crassiuscula subsp. *glandulifera*	Thick Eyebright
Ficus coronata	Sandpaper Fig
Grevillea infecunda	Anglesea Grevillea
Hakea macraeana	Willow Needlewood
Hesperilla flavescens flavescens	Yellow Sedge-skipper Butterfly
Hypochrysops ignitus ignitus	Fiery Jewel Butterfly
**Hypocreopsis* sp. 'Nyora'	Clasping Hypocreopsis
Jalmenus icilius	Amethyst Hairstreak Butterfly
Juncus antarcticus	Cushion Rush
Muehlenbeckia gracillima	Slender Lignum
Ogyris genoveva araxes	Southern Purple Azure Butterfly
Philotheca difformis subsp. *difformis*	Small-leaf Wax-flower
Sclerolaena ventricosa	Salt Copperburr
Sminthopsis leucopus	White-footed Dunnart
Trapezites luteus luteus	Yellow Ochre Butterfly
Westringia lucida	Shining Westringia

* This taxon is the first fungus to be recommended for listing under the Flora and Fauna Guarantee Act in Victoria.

The nominations for the following processes to be listed as potentially threatening processes are supported by the Scientific Advisory Committee. November 2004.

2. Potentially Threatening Processes

Wetland loss and degradation as a result of change in water regime, dredging, draining, filling and grazing

Inappropriate fire regimes causing disruption to sustainable ecosystem processes and resultant loss of biodiversity

Infection of Amphibians with Chytrid Fungus, resulting in Chytridiomycosis

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Scientific Advisory Committee recommendations and consideration of nominations, 15 February 2005

(advertised in newspapers April 2005)

1. Final Recommendations

Callistemon nyallingensis	Boggy Creek Bottlebrush
Bazzania hochstetteri	Caducous Whipwort
Orthotrichum hortense	Gardener's Bristle-moss
Eucalyptus strzeleckii	Strzelecki Gum

2. Preliminary Recommendations

Fish

Mugilogobius paludis	Pale Mangrove Goby

Mammals

Conilurus albipes	White-footed Rabbit-rat

Plants

Spyridium sp. 1 (formerly *Spyridium sp nov.* Little Desert)	Forked Spyridium
Nematolepis squamea ssp. *coriacea* (formally *Phebalium squameum* subsp. *coriaceum*)	Harsh Nematolepis
Nematolepis frondosa (previously *Phebalium frondosum*)	Leafy Nematolepis
Westringia cremnophila	Snowy River Westringia
Pseudophryne bibronii	Bibron's Toadlet

Potentially threatening processes

Use of Lead Shot Cartridges for hunting of Waterfowl – Nomination for de-listing

Invasion of native vegetation by Blackberry *Rubus fruticosus* L. agg. (potentially threatening process)

For assistance in preparing this issue, thanks to Virgil Hubregtse (editorial assistance), Dorothy Mahler (administrative assistance) and Mimi Pohl (labels).

The Field Naturalists Club of Victoria Inc.

Reg No A0033611X

Established 1880

In which is incorporated the Microscopical Society of Victoria

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The Victorian Naturalist

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From the Editors

The symposium held on the weekend of 28/29 May, to celebrate the 125th anniversary of the founding of the Field Naturalists Club of Victoria, was a great success, not the least from the perspective of this journal. A number of the speakers gave papers that focused attention on aspects of *The Victorian Naturalist*, such as the way the content has varied through time, and the degree to which papers in the journal have been a source of data to researchers. It was also clear from some of the papers presented that *The Victorian Naturalist* was a primary source of information for many of the presenters. This is all the more gratifying (for both the editors and speakers) because we anticipate that in the fullness of time these papers will themselves become part of the greater body of work that is the content of this journal.

Those papers will comprise the content of a future issue, and perhaps be the subject of a future editorial; in the meantime, in this issue, we offer a diversity of subject matter,.no doubt as readers have come to expect. There is, in fact, an even wider than usual coverage because of the inclusion of an essentially historical piece. In something of a link to the reason for the symposium, one of the papers offered here surveys The Victorian Naturalist across its entire run, for articles referring to the Eastern Pygmy-possum Cercartetus nanus.

The issue leads off, however, with a report of research on the effects of firefighting foam on soil invertebrates. Also included here are a contribution on the unexpected occurrence of Bobucks in The Gurdies, and the first in a series of studies on Victorian Bryophtes. Diverse reading indeed.

Ian Endersby has drawn our attention to OWL (Ornithological Worldwide Literature).

OWL was an initiative of the American Ornithologists Union, the British Ornithologists Union and the Royal Australasian Ornithologists Union to abstract and database all bird-related literature references. It was originally called ROL (Recent Ornithologist's Literature) but it now has the aim of including historical data.

Every article from *The Victorian Naturalist* with ornithological information since 1992 has been included with title, author's address, citation and one-line abstract. More recently, key words have been used. A search of the database at www.birdlit.org/OWL shows that 50 bird articles have been incorporated to date.

One Hundred and Twenty-five Years Ago

VICTORIAN FERNS AND THEIR HABITATS, BY C. FRENCH
[Read before the Field Naturalists' Club of Victoria June, 1880]

During the last few years there has been a perfect mania for ferns, and many fine species have been imported from European nurseries and elsewhere, so that there are now some excellent collections to be found in the colonies - private as well as public. According to Bentham and Mueller, there are nearly sixty species of ferns to be found in Victoria, some of which are also natives of New Zealand and other parts of the world.

From *Southern Science Record* 1, pp. 2-3, December 1880

The

Victorian Naturalist

Volume 122 (3) 2005 June

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Cover: Photograph of Bobuck *Trichosurus caninus*. See article on p. 141.

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Does application of firefighting foam affect soil invertebrates?

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Abstract

Firefighting foam (Class A foam) is an effective and widespread firefighting tool often used in environmentally sensitive areas. Although, firefighting foam is known to be ecologically damaging to aquatic invertebrates, application of 1.0% foam to heathland soils showed no detectable impacts on soil invertebrate orders sampled over several months. The results are encouraging for the continued use of Class A foam as a fire suppression technique in areas with high conservation value. (*The Victorian Naturalist* **122** (3), 2005, 128-133)

Introduction

Protection of natural resources and conservation values, in addition to the protection of life and property, is now a widespread community expectation of fire management agencies (Sutton *et al.* 1999; Nature Conservation Council NSW 2000). However, many fire management practices may conflict with biodiversity management (Morrison *et al.* 1996), or have the potential to disrupt critical ecological processes such as nutrient cycling, energy flow, and hydrology (Lefroy and Hobbs 1992).

The philosophy behind minimum impact suppression tactics (Mohr 1994) is a 'do least damage' one, where the objective is to contain the fire while producing the least possible impact on protected resources. These resources include forest products, soils, fences, livestock, remnant native vegetation, rare species, critical limiting resources such as habitat trees or, in many areas, simply bushland character. Changing community values, and increasing emphasis on biodiversity conservation require the re-examination of the acceptability of fire suppression actions and tools, such as Class A foam, particularly where there may be adverse ecological impacts (Adams *et al.* 2004). If the environmental resources being 'protected' by fire suppression do not recover from the suppression activities and tools used, those activities and tools are inappropriate in that environmental context (CFA 2003) and in the current social and legal climate.

Biodiversity and ecological processes, which show resilience to disturbances such as bushfire, must also be able to recover from the bushfire suppression activities. Where these suppression activities cause ecological damage to natural resources it is incumbent on good managers to examine those activities and, where possible, use only sustainable environmental suppression practices in their operations (DNRE 1998; Barnes 2000). An assessment of the appropriateness of a bushfire suppression tool such as Class A foam is not possible without data indicating the type and severity of any impacts.

Bushfire fighting foams (Class A foams) are alkaline surfactants containing foaming and wetting agents, and are used extensively during bushfire suppression in environmentally sensitive areas (Finger 1995; Larsen *et al.* 1999). Foam impacts at the species or ecosystem level are still relatively unknown (Norecol 1989; Adams and Simmons 1999; Adams 2000) but they have potential ecological impacts which should be considered before they are used near protected resources (Larson and Duncan 1982; Adams and Simmons 2002; Adams *et al.* 2004).

Class A foams have the potential to change ecological processes such as nutrient cycling, as surfactants are known to affect soil physical and biological properties including changing structural stability (Cardinali and Stoppini 1981). Soils may become hydrophobic, altering infiltration rates (Batyuk and Samochvalenko 1981;

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Sebastiani *et al.* 1981a), soil microorganism growth may be stimulated (Simonetti *et al.* 1981), and microorganism mobility altered (Sebastiani *et al.* 1981b).

Class A foam damage to plant communities and species appears negligible or at least very short-term (Larson and Newton 1996; Larson *et al.* 1999; Hartskeerl *et al.* 2004). Riparian zones (Larsen *et al.* 1999) and aquatic habitats (McDonald *et al.* 1997) are known to be more vulnerable to the negative effects of foams. In freshwater ecosystems Class A foams are known to adversely affect fish and aquatic invertebrates, and disrupt ecosystem functions (Gaikowski *et al.* 1996; McDonald *et al.* 1997). Studies on Class A foam impacts on terrestrial vertebrate fauna are limited, but suggest Class A foams are not harmful (Vyas and Hill 1994; Vyas *et al.* 1996), and there are almost no data on potential impacts on terrestrial invertebrates (Vyas *et al.* 1996).

Sclerophyllous heathlands are fire prone (Keith *et al.* 2002) and bushfire suppression activities in these heathlands frequently include the use of Class A foams. Heathlands are also characteristically invertebrate rich (Specht 1994). As invertebrates play a critical role in ecosystems (Kim 1993), they may have the potential to act as biological indicators of less easily measured ecosystem functions (Clausen 1986; Disney 1986). This study aimed to investigate the impacts of Class A foam on selected soil parameters and changes in soil dwelling invertebrates (Koehler 2001).

Materials and methods

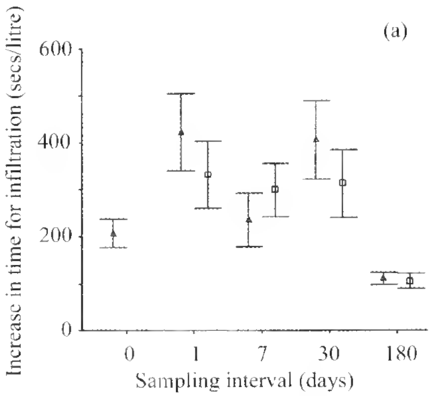
Soil and surface-active invertebrates were sampled from heathland sites on French Island, Victoria. Ten 20 m x 20 m plots, subdivided into twenty-five 4 m x 4 m quadrats, were randomly assigned to one of five sampling times; 0 days (before foam application). 1 day, 7 days, 30 days and 180 days after foam application. Five quadrats from each plot were sampled at each time. Five plots were left untreated as controls. Angus ForExpan S (Angus Fire Armour 1997) Class A foam was applied at maximum field concentration (1%) in May 2000, using standard fire service foam proportioning equipment. The foam was applied evenly across the sites and readily penetrated the vegetation to form a layer on the soil surface.

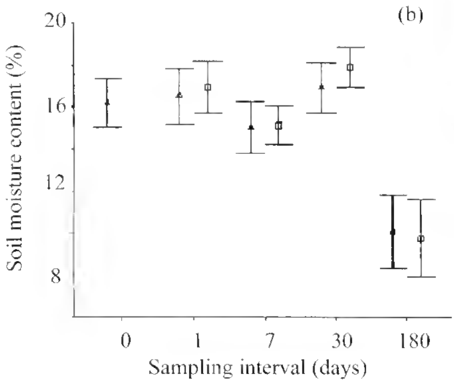
Invertebrates were recovered from a surface litter and soil sample 30 cm x 30 cm x 5cm collected from each of the 5 assigned quadrats (50 samples per sampling time). The sample was bagged and sealed until sieved. The large number of samples to be processed in a short time (150 samples in one week) precluded the use of more time-consuming recovery techniques. All individuals collected were counted and identified to order (Harvey and Yen 1995). Invertebrate abundance data from the five within-plot quadrats were pooled for analysis. Soil water infiltration capacity (seconds/litre), soil moisture content (%), and soil pH were measured from five samples per plot at each sampling interval, and the five within-plot samples pooled for analysis (Koehler 2001). Multivariate analyses of all sampling times and all orders, using the Bray-Curtis similarity measure and multidimensional scaling (MDS) (PRIMER analysis package) were used to examine overall patterns in the data. Soil parameter data were examined using one- way ANOVA (SPSS 11.5) (Koehler 2001).

As Class A foam biodegrades in about 28 days, any effects of foam would probably be most apparent in the four sampling times immediately following foam application. Invertebrate populations are known to fluctuate seasonally in response to plant growth and flowering rhythms (Majer and Greenslade 1988), and initial examination of the data indicated extreme soil dryness 180 days after foam application, rather than any foam effect, could account for the population changes. Therefore invertebrate data for only the ten common orders and only the first four sampling times were analysed using two-way ANOVA (SPSS 11.5).

Results

Water infiltration capacity varied over time with a marked increase six months (180 days) after application (Figure 1a). However, there was no detectable effect due to Class A foam. Soil moisture content (Figure 1b) was not significantly different between the first four sampling times, but had decreased significantly six months





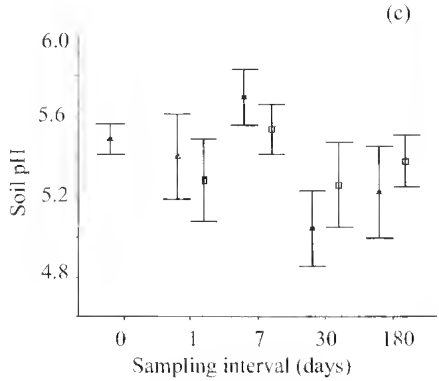


Fig. 1. Mean (±SE) for (a) soil water infiltration capacity, (b) soil moisture content and (c) soil pH for five sampling times. Foam Treated: squares. Untreated: triangles.

after application. However, this decrease was associated with a substantial decrease in rainfall during November (Koehler 2001) and there was no detectable effect of Class A foam. Class A Foam is an alkaline surfactant but appears to have no detectable effect on soil pH (Fig. 1c). Initial mean soil pH was 5.5 (n=50) and pH ranged between 5.1 and 5.7 over the sampling period (Koehler 2001).

Seventeen orders were recorded (Table 1) of which ten (Diptera to Haplotaxida) occurred relatively consistently over the sampling period, while individuals from the other seven orders (Lepidoptera, Nematomorpha, Dermaptera, Isopoda, Hemiptera, Blattodea, Orthoptera) were found infrequently and in very low numbers, and have been omitted from Table 1. The mean number of orders per plot decreased over time with the lowest number of orders per plot recorded 180 days after Class A Foam application. This decrease reflects the decrease in soil moisture content and an increase in temperature at the six month sampling time (Koehler 2001).

The ANOVA indicated no significant interactions between time and Class A foam for any orders (Table 2), suggesting there was no detectable effect of foam application. Six of the ten orders examined (Coleoptera, Acarina, Spirobolida, Araneae, Hymenoptera, Haplotaxida) showed significant changes in population numbers over the 30 day period (Table 2), but these were not related to foam application. Julida was present and relatively abundant across all plots, while Diptera, Coleoptera, Araneae, Scolopendrida and Geophilida were usually present, but less abundant (Table 1).

Multivariate analysis indicated two distinct groups of sampled plots (Fig. 2). The grouping indicates a seasonal time sequence rather than any pattern associated with a Class A foam effect. Group 1 consists of a mix of sample times and treatments and suggests invertebrate presence and abundance over late autumn-winter-spring. The samples taken before foam application (0 days) form a relatively cohesive sub-group of this larger group. Group 2 consists of samples taken 180 days after foam application and may indicate orders with members more abundant in the drier soils of late spring–early summer.

Table 1. Invertebrate population abundance of the 10 common orders at five sampling intervals from five plots treated with Class A foam and five untreated plots. Values are means and (standard errors).

Time	Treatment	Total Orders	Diptera	Coleoptera	Julida	Araneae	Scolopendrida	Geophilida	Hymenoptera	Acarina	Spirobolida	Haplotaxida
0 days	foam	14	9.4 (2.9)	20 (6.1)	10 (3.3)	7.8 (1.2)	0.8 (0.6)	7.8 (1.9)	14.4 (8.4)	4.8 (1.2)	4.6 (1.6)	2 (0.3)
	control	15	8.6 (1.5)	15.2 (5.5)	12.8 (3.3)	4.2 (1.9)	1.6 (0.5)	4.6 (1.4)	12.2 (10.2)	6.8 (3.0)	4.6 (2.0)	2.2 (0.7)
1 day	foam	16	4.8 (1.5)	8.6 (2.3)	9.2 (3.2)	3.4 (1.6)	2.4 (1.4)	4.6 (1.6)	0.2 (0.2)	1.4 (0.7)	2.8 (1.3)	3.4 (1.3)
	control	11	2.4 (0.9)	10.8 (4.8)	22.4 (8.7)	2.0 (1.4)	2.4 (1.0)	4.6 (0.7)	0.8 (0.4)	1.8 (0.8)	2.6 (0.4)	4.4 (2.0)
7 days	foam	13	17.2 (13.3)	3.4 (0.9)	51.4 (36.0)	1.4 (0.4)	1.8 (0.9)	6.6 (1.9)	0.2 (0.2)	0.8 (0.5)	1.2 (0.6)	3.0 (0.7)
	control	10	6 (4.5)	3.2 (0.5)	27.6 (12.2)	2.2 (1.5)	1.8 (0.7)	3.8 (1.1)	0.2 (0.2)	0.2 (0.2)	0.6 (0.4)	5.6 (0.7)
30 days	foam	11	2.2 (1.0)	4.2 (2.2)	31.4 (17.1)	2.6 (1.9)	0.8 (0.4)	2.8 (1.2)	0 (0)	0.2 (0.2)	0.6 (0.2)	8.0 (2.7)
	control	11	2 (1.1)	1.8 (0.4)	60.8 (33.8)	0.2 (0.2)	1.2 (0.7)	4.0 (0.8)	0.6 (0.4)	0.4 (0.4)	0.2 (0.2)	6.6 (2.7)
180 days	foam	11	0.4 (0.2)	0.6 (0.4)	7.2 (1.4)	1.2 (0.4)	0.6 (0.4)	1.2 (0.6)	2.2 (1.7)	0.8 (0.6)	0 (0)	0 (0)
	control	12	1.2 (0.5)	1.8 (1.0)	2.4 (0.7)	2.6 (1.1)	0.4 (0.2)	0.4 (0.2)	0.2 (0.2)	0.2 (0.2)	0 (0)	0 (0)

Discussion

Invertebrate populations are extremely variable, with their composition largely determined by environmental factors. Responses to disturbance such as Class A foam may be difficult to detect where a broad level of taxonomic resolution, such as order, has been used (Friend 1994), however higher-level taxonomic assessment in some terrestrial invertebrate groups can adequately detect disturbance and environmental change (Pik *et al.* 1999). A number of the orders recovered during this study contain predators and have potential as bio-indicators of disturbance, particularly Araneae, Diptera, Acarina and Coleoptera (Friend 1994; Neumann *et al.* 1995). Sampling was designed to maximize the detection of changes in invertebrate orders due to Class A foam, however no foam impacts were detected at this taxonomic level. No detectable changes in these indicator groups suggest the soil processes mediated by other less easily sampled microbiota continue after foam application. The changes in number of orders over time is likely to be the result of seasonal changes in soil moisture and soil temperature, or small scale colonization (Friend 1994), rather than foam.

These results, in conjunction with other field studies on plant species and communities (Larson and Newton 1996; Larson *et al.* 1999; Hartskeerl *et al.* 2004), are encouraging for the continued use of Class A foams for fire suppression. Typical exposures of invertebrates to foam do not appear to have had detectable impacts, although further examination of soil invertebrates at finer taxonomic level may reveal population changes. Riparian zones (Larsen *et al.* 1999) and aquatic habitats (McDonald *et al.* 1997) are known to be more vulnerable to the negative effects of foams, but where stream protection plans are in place, applications of Class A foam outside these habitats are likely to have minimal long-term effects (Norris and Webb 1989).

Acknowledgements

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Table 2. Results of two-way ANOVAs for numbers of individuals in ten most common Orders and for four sampling times (0 days to 30 days following application of Class A foam. *** = $P < 0.00$; N.S. = not statistically significant; df = degrees of freedom..

Source	df	Diptera Julida Scolependrida Geophilida	Coleoptera Acarina Spirobolida	Araneae	Hymenoptera Haplotaxida
Between Plots	39				
Amongst Foam levels	1	N.S.	N.S.	N.S.	N.S.
Within Plots	40				
Time	3	N.S.	***	**	*
Foam x Time	3	N.S..	N.S.	N.S.	N.S.

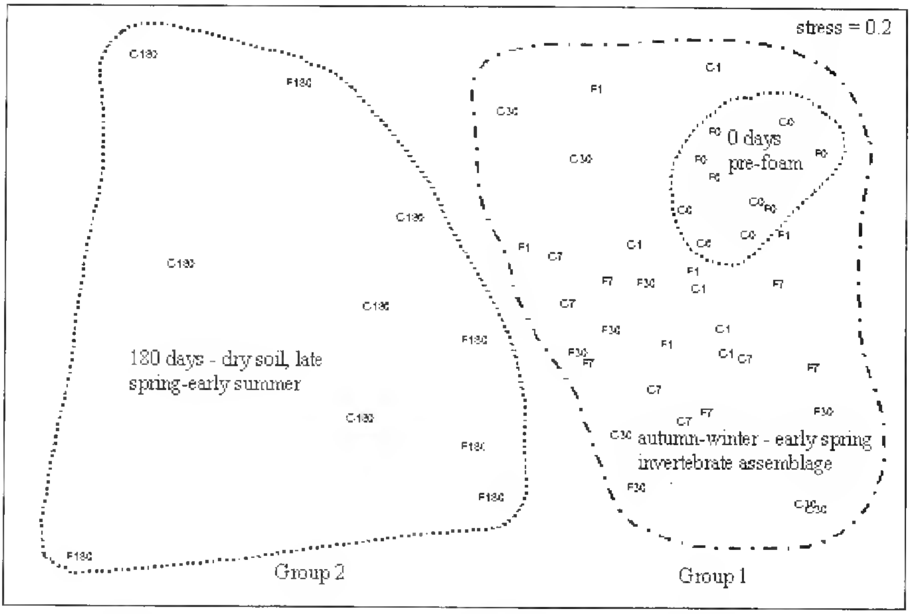

Fig. 2. Multidimensional scaling diagram (MDS) showing an autumn-winter-early spring invertebrate assemblage (Group 1), and a dry soil invertebrate assemblage of late spring-early summer (Group 2). The pre-treatment samples are a sub-group of Group 1. There is no grouping of Class A foam treated and control samples, suggesting no detectable impact of Class A foam.

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Studies on Victorian bryophytes 1. The genus *Orthotrichum* Hedw.

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Abstract
Five species of the moss genus *Orthotrichum* Hedw. are known to occur in Victoria. These species are described and illustrated, and their known distributions in Victoria are delineated. A key to species is provided. (*The Victorian Naturalist* **122** (3) 2005 134-141)

Introduction

The family Orthotrichaceae is represented in Australia by nine genera: *Groutiella*, *Macrocoma*, *Macromitrium*, *Muelleriella*, *Orthotrichum*, *Schlotheimia*, *Stoneobryum*, *Ulota* and *Zygodon*. Seven of these genera are present in Victoria. The general distinguishing features of those seven genera are shown in Table 1.

The *Index Muscorum* (van der Wijk *et al.* 1959–69) recorded 230 species of *Orthotrichum* Hedw. throughout the world, but many of these have since been reduced to synonymy. A thorough review of the genus in Australasia was undertaken by Lewinsky (1984a) who reported only five species from Australia, all from the temperate zone. Four of these — *O. assimile*, *O. cupulatum*, *O. rupestre* and *O. tasmanicum* — were reported from Victoria. In the current study the other Australian species, *O. hortense*, was found to occur in Victoria.

Features of the gametophyte, such as the height of shoots, the size and shape of leaves and the density of rhizoids, are rather variable, so that except in the case of *O. tasmanicum* they are not useful in separating Victorian species. In some cases the shape and wall thickness of the basal leaf cells is useful. The taxonomy, at least to species level, is based mainly on sporophyte characters, in particular the following:

- capsule — immersed, emergent or exserted
- outer peristome — reflexed, recurved or straight; 8 or 16 teeth
- inner peristome — present or absent; teeth wide, narrow or ciliate
- stomata on capsule — cryptopore (partly hidden by capsule wall cells) or phaneropore (not hidden by cells).

Fortunately, almost every specimen of *Orthotrichum* collected in Victoria has mature capsules, so the identity of most specimens can be determined with reasonable confidence, even in the field.

Similar taxa

Other genera of Orthotrichaceae may be mistaken for *Orthotrichum* in the field, especially if there are no capsules. *Macromitrium* and *Macrocoma* are immediately distinguished by their creeping habit, having prostrate primary stems from which arise short, erect secondary stems. In the one *Schlotheimia* species present in Victoria (*S. brownii*) the stems are very short and the leaves are tightly twisted in a spiral around the stem when dry. *Zygodon intermedius* and *Z. minutus* have sometimes been mistaken for *O. tasmanicum* because their capsules are rather similar, but they are very much smaller than *O. tasmanicum*, their leaves do not have tightly recurved margins, and their calyptrae are not hairy. *Ulota* species are restricted to wet forest and rainforest, where they are always epiphytic and usually grow in small tufts. Although they are often distinctive in the field, the surest way to separate them from *Orthotrichum* is to look at the cells on the margins of the leaf base. In *Ulota* these cells have distinctly thickened transverse walls, which is not the case in *Orthotrichum*. In the two Victorian *Ulota* species the inner peristome teeth are ciliate, which separates them immediately from *O. tasmanicum*, and the more or less spreading leaves separate them from the other *Orthotrichum* species.

On rocks in montane to alpine areas, *Racomitrium crispulum* and *Schistocarpum apocarpum* can sometimes resemble *Orthotrichum* species, especially if there

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Feature	*Orthotrichum*	*Macrocoma*	*Macromitrium*	*Schlotheimia*	*Ulota*	*Zygodon*
Peristome	single or double	double but greatly reduced	single or double	double	single	single
Calyptra	naked to hairy, conical to globose	hairy, conical	naked to hairy, conical	naked, campanulate	hairy, conical	naked, cucullate
Leaf margins	recurved, entire	plane, entire	recurved, entire	plane or ± recurved, entire	plane or recurved at base, entire	plane or recurved at base, entire
Leaf cells	papillose	smooth or mammillose	papillose or smooth	smooth	papillose or smooth	papillose or smooth
Habit	erect, in tufts	creeping stems with erect branches, in mats	creeping stems with erect branches, in mats	erect, in cushions	erect, in tufts	erect, in cushions
Leaves when dry	contorted to flexuose or ± straight	straight	contorted to twisted	strongly twisted	contorted to twisted or flexuose	contorted to twisted or flexuose
Substrate	bark, rock	bark	bark, rarely rock	bark	bark	bark
Habitat	various; lowland to alpine	various; rarely alpine	various; rarely alpine	wet forest	wet forest, rainforest	various; lowland to montane

are no capsules. *Racomitrium crispulum* can be distinguished by its very long seta and conspicuously long operculum, and by the leaves, which usually end in an apiculus or short hairpoint. In *S. apocarpum* the capsules are deeply immersed among long perichaetial leaves, and the flattish operculum is orange-red. Microscopic differences are well described in Scott and Stone (1976).

Finally, several *Orthotrichum* species that are thought to be endemic to New Zealand are similar to Victorian species, and should be kept in mind when determining unusual specimens.

Synonyms of all Australian species are published in Streimann and Klazenga (2002).

Description of species

In the following descriptions, dimensions are included only where they are of use in distinguishing species. In general, leaf and cell dimensions are not useful taxonomic characters for these species. Distribution maps are based on a review of all specimens in MEL, MELU and CANB. Grey dots represent records more than 50 years old. Although English names have been constructed for the species, they are not in common usage and are therefore not included here.

Orthotrichum assimile Müll. Hal.(Fig. 1). *Syn. Musc. Frond.* **1**: 704 (1849)

Known distribution in Australia: Vic, NSW, ACT (Fig. 2).

Habitat: epiphytic on shrubs and trees in montane to alpine regions.

Plants to 1.5 cm tall, yellowish green to olive green in life, fading to mid brown when dead. **Leaves** ovate-lanceolate to lanceolate, straight or slightly flexuose, appressed to the stem or very slightly spreading when dry, spreading when wet; leaf margins recurved for most of their length, plane (rarely denticulate at the apex); apex acute or sometimes obtuse. **Seta** very short. **Capsules** immersed to slightly emergent, straw-coloured, deeply 8-pleated when dry with the pleats extending to the capsule base, and the base often swollen in comparison to the upper portion; stomata cryptopore. **Operculum** very shortly conical, with a moderately long,

Key to *Orthotrichum* species in Victoria

This key relies on the presence of capsules, which is the common condition in the genus. All critical features, except stomata, are visible with a 10× hand lens. The key is also valid for Tasmania and New South Wales. Field identifications should be confirmed in the laboratory using the full key in Lewinsky (1984a).

1 Mature capsules mostly with outer peristome teeth strongly reflexed over mouth of capsule..........2
Mature capsules mostly with outer peristome teeth spreading, erect or incurved, not reflexed.........5

2 Leaves in upper half of stems mostly contorted and diverging widely from stem when dry; capsules on a long seta (stalk), somewhat to not at all pleated when dry, pleats mostly in top half of capsule; stomata phaneropore.......................................***tasmanicum* var. *tasmanicum***
Leaves ± straight to slightly divergent; capsules on a short seta, narrowly cylindrical and pleated along all or most of their length; stomata phaneropore or cryptopore..............................3

3 Plants growing on calcareous rock..***cupulatum* var. *cupulatum***
Plants epiphytic or rarely on non-calcareous rock..4

4 Older capsules ± cylindrical when dry, with ciliate, ± hyaline inner peristome teeth; leaf apex acute, apiculate; costa ending just below apex; stomata phaneropore.......................***hortense***
Older capsules ± cylindrical but usually bulging at base, with narrow, orange-yellow strap-like inner peristome teeth; leaf apex often rather blunt, generally not apiculate; costa reaching apex; stomata cryptopore...***assimile***

5 Leaves strongly contorted and spreading widely from stem when dry; capsules exserted; stomata phaneropore...***tasmanicum* var. *tasmanicum***
Leaves more or less straight when dry, not strongly contorted or spreading widely from stem; capsules immersed to emergent; stomata phaneropore or cryptopore.................................6

6 Outer peristome of dry capsules ± erect; capsules emergent; mature calyptra conical or conic-oblong, hairy or not; stomata phaneropore.......................................***rupestre* var. *rupestre***
Outer peristome of dry capsules spreading; capsules immersed to emergent; mature calyptra ± globose, always hairy; stomata cryptopore........................***cupulatum* var. *cupulatum***

narrow beak. **Peristome** double; outer peristome of 8 yellowish teeth, strongly reflexed over the capsule mouth in older capsules, erect to recurved in younger ones; inner peristome of 8 narrow teeth, often breaking off in older capsules so that the peristome appears single. **Calyptra** more or less conical, usually hairy.

Notes: This species is superficially similar to *O. rupestre* and often has been mistaken for that species. However, *O. rupestre* grows almost exclusively on non-calcareous rock, has phaneropore stomata, and is usually appreciably larger than *O. assimile*. Lewinsky (1984a) found that all Australian records of '*O. alpestre*' were *O. longithecum*, but later corrected the name to *O. assimile* (Lewinsky 1984b). *Orthotrichum assimile* is rare in Victoria, being known only from a few scattered localities in the higher country in the east of the state.

Orthotrichum cupulatum Hoffm. ex Brid. var. *cupulatum* (Fig. 3).
Musc. Rec. **2**(2): 25 (1801).

Known distribution in Australia: Vic, NSW, ACT (Fig. 4).

Habitat: limestone rock (rarely epiphytic) in montane regions.

Plants to 2 cm tall, olive to glaucous green in life, fading to yellow-green or pale brown when dead. **Leaves** ovate-lanceolate to lanceolate, straight or slightly flexuose, appressed to the stem or very slightly spreading when dry, spreading when wet; often long-decurrent; leaf margins recurved for most of their length (but sometimes on one side only), plane (rarely denticulate at the apex); apex acute or sometimes obtuse. Upper leaf cells thick-walled, isodiametric and papillose. **Cells** of leaf base thin-walled and more or less rectangular, rather rounded in basal corners. **Seta** very short. **Capsules** immersed to slightly emergent, ovoid to urn-shaped,

Fig. 1. *Orthotrichum assimile.* (Scale bar = 2 mm.)

Fig. 2. Known distribution of *Orthotrichum assimile* in Victoria.

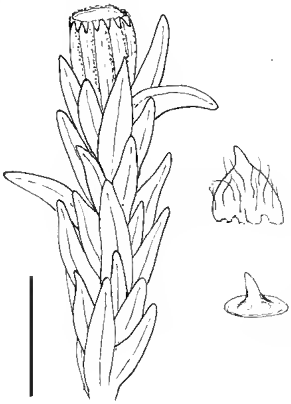

Fig. 3. *Orthotrichum cupulatum* var. *cupulatum*, with typical calyptra and operculum. (Scale bar = 2 mm.)

Fig. 4. Known distribution of *Orthotrichum cupulatum* var. *cupulatum* in Victoria.

straw-coloured, deeply 8-pleated when dry, pleats extending to the eapsule base and often with smaller pleats in between; stomata eryptopore. **Operculum** flat to slightly convex, with a short beak. **Peristome** single or rarely double; outer peristome of 16 yellow-orange teeth, erect to ineurved in younger capsules but mostly more or less reflexed in older ones; inner peristome (not seen in Victorian speeimens) of 16 short hyaline teeth, not visible under a hand lens. **Calyptra** almost globose, always hairy.

Notes: *Orthotrichum cupulatum* is listed as a threatened species under the Vietorian *Flora and Fauna Guarantee Act 1988*. It is rare and endangered in Vietoria, being known only from two loealities in the Buehan River district in the east of the state. Its habitat in both locations is threatened by human activity and wildfire. *Orthotrichum cupulatum* is superfieially similar to *O. rupestre*, but that species has not been found on limestone and has mostly erect outer peristomes on old capsules. *Orthotrichum cupulatum* var. *austro-cupulatum* is known only from New Zealand. It is a smaller brownish plant with exserted, cylindric-ovoid capsules and a well-developed inner peristome.

Orthotrichum hortense Bosw. (Fig.5). *Journal of Botany* **30**: 97 (1892).
Known distribution in Australia: Vic, NSW (Fig. 6).
Habitat: epiphytic on trees and shrubs.
Plants to 2 cm tall, yellow-green to olive green in life, fading to yellow-brown when dead. **Leaves** ovate-lanceolate, erect and slightly spreading when dry, spreading widely when wet; costa ending just below apex; apex with a long apiculus; leaf margins entire, recurved for most of their length. **Seta** very short. **Capsules** immersed to emergent, cylindrical, deeply 8-pleated when dry, slightly narrowed below mouth; stomata phaneropore. **Operculum** often tinged red, with a moderately long and straight beak. **Peristome** double; outer peristome of 8 pale yellow to whitish teeth, strongly reflexed over capsule mouth in older capsules; inner peristome of 8 ciliate hyaline teeth, mostly 1 cell wide and 3 or more cells long. **Calyptra** conic-oblong, usually lightly hairy.

Notes: In the field this species might easily be mistaken for *O. tasmanicum*, but is distinguished by the strongly appressed leaves when dry and by the capsule pleating, which extends to the base of the capsule. Under the microscope the very narrow (one cell wide) inner peristome is obvious, and the capsule stomata are phaneropore. In New Zealand *O. hortense* is common on both indigenous and introduced trees (Sainsbury 1952, Beever 1996). The Latin name reflects the habitat of the type specimen — on trees in a garden. There has been some speculation that the species was introduced to Australia, because it was known only from the Yarrangobilly Caves district where there has been much human activity. Recently confirmed records from Victoria established it as a genuinely indigenous Australian species (Meagher 2005). The single record from Lake Mountain, from a collection made in 1948, needs to be followed up to determine whether the species still exists at that locality. The species has been recommended for listing as a threatened taxon in Victoria under the *Flora and Fauna Guarantee Act 1988* (M O'Brien, Department of Sustainability and Environment, pers. comm. March 2005).

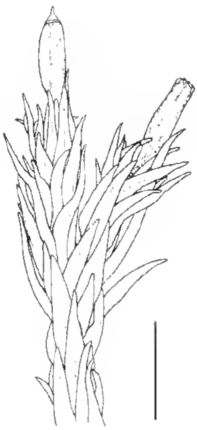

Fig. 5. *Orthotrichum hortense*. (Scale bar = 2 mm.)

Fig. 6. Known distribution of *Orthotrichum hortense* in Victoria.

Fig. 7. *Orthotrichum rupestre* var. *rupestre*. (Scale bar = 2 mm).

Fig. 8. Known distribution of *Orthotrichum rupestre* var. *rupestre* in Victoria.

Orthotrichum rupestre Schleich. ex Schwägr. var. *rupestre* (Fig. 7).
Sp. Musc. Suppl. 1(2): 374 (1816).
Known distribution in Australia: Vic, Tas, NSW, ACT (Fig. 8).
Habitat: granite and other non-calcareous rock in montane to alpine regions.
Plants to 4 cm tall (rarely taller), olive to dark green in life, fading to yellowish brown when dead. **Leaves** ovate-lanceolate, more or less straight when dry, spreading widely when wet; margins recurved for most of length, apex acute to apiculate; costa ending just below apex. **Cells** of upper leaf thick-walled, isodiametric, papillose; cells of leaf base rectangular to rhomboidal with thick, often nodulose walls. **Seta** very short. **Capsules** barely emergent, usually pale brown and cylindrical, not or barely constricted at the mouth, about 1.5 to 2 mm long, 8-grooved when dry with grooves often extending to base of capsule; stomata phaneropore, confined to middle of capsule. **Operculum** more or less flat with a pointed, fragile beak. **Peristome** single or double; outer peristome erect, consisting of 8 wide yellow-orange teeth that may be split in two; in older capsules teeth are often broken off or bent outwards over the mouth; inner peristome rarely present, consisting of 8 hyaline teeth one cell high, not visible under a hand lens. **Calyptra** conical, usually hairy.

Notes: In Victoria *Orthotrichum rupestre* is known from a small number of alpine or subalpine locations. The core of its distribution is on the Bogong High Plains, around and south of Pretty Valley. Non-calcareous rock (especially granite) is the only habitat recorded for this species in Victoria, although it is known to occur occasionally on trees (Lewinsky 1984a). It has therefore been largely spared, so far, from the effects of human activities in the alpine regions. Without capsules *O. rupestre* would be hard to separate in the field from *O. cupulatum*, but that species grows exclusively on calcareous rock. *Orthotrichum rupestre* var. *papillosum* is known only from New Zealand. It has very tall and often Y-shaped leaf papillae that are particularly visible at the leaf apex.

Orthotrichum tasmanicum Hook.f. & Wils. var. *tasmanicum* (Fig. 9).
London Journal of Botany 7: 27 (1848).
Known distribution in Australia: SA, Vic, Tas, NSW, ACT (Fig. 10).
Habitat: epiphytic on indigenous and introduced shrubs and trees (also rarely on non-calcareous rock), from lowlands to alpine regions.
Plants to 3 cm tall, yellow-green to dark green in life, fading to yellow-brown when dead. **Leaves** ovate-lanceolate to tongue-shaped, usually flexuose and widely spreading; costa ending below the apex;

Fig. 9. *Orthotrichum tasmanicum* var. *tasmanicum*. (Scale bar = 2 mm.)

Fig. 10. Known distribution of *Orthotrichum tasmanicum* var. *tasmanicum* in Victoria.

leaf margins recurved and often rather undulate, sometimes denticulate in upper third; leaf apex acute, sometimes apiculate. **Cells** of upper leaf isodiametric and papillose, cells of leaf base long, narrow and often sinuous, thick-walled, without papillae; usually several rows of quadrate and often colourless cells at basal margins, forming a vague border. **Seta** straw-coloured, about 3 mm long (up to 5 mm long). **Capsule** exserted well above leaves, straw-coloured, cylindrical, about 2 mm long, mostly 8-grooved in the top half or so when dry, although sometimes more or less smooth; stomata phaneropore. **Operculum** shortly conical with a short, blunt beak. **Peristome** double; outer peristome of 8 wide teeth strongly reflexed back over the mouth in older capsules, often merely erect or recurved in younger ones; inner peristome of 8 triangular teeth, much the same as the outer peristome: several cells wide at the base, one or two cells wide at apex. **Calyptra** conical to conic-oblong, usually hairy.

Notes: In Victoria, any *Orthotrichum* west and south of the Baw Baw Plateau is almost certain to be this species. *Orthotrichum tasmanicum* is distinguished by the flexuose, widely spreading leaves, which give the shoots a rather dishevelled appearance. This characteristic is more or less constant in all specimens examined, and separates the species from all others in Victoria. *Orthotrichum tasmanicum* is by far the most commonly collected species, accounting for more than 90% of all herbarium specimens. It occurs from sea level to the alpine region, but at higher altitudes it may be mixed with *O. rupestre* or *O. assimile*. It is most commonly epiphytic on trees and shrubs, but occasionally grows on rock. It seems equally at home on both indigenous and introduced plants, especially willows and poplars.

A straighter-leaved form with shorter setae, from the Bogong High Plains, is difficult to separate from *O. hortense*; only the width of the inner peristome teeth seems to be consistently different, and even then there seem to be intermediates. It might represent an undescribed variety, but further study is needed.

All Victorian specimens identified as '*Orthotrichum calvum*' on their herbarium labels have been examined, and all have been found to be *Orthotrichum tasmanicum* var. *tasmanicum*. There seems little doubt that *O. calvum* is endemic to New Zealand. *Orthotrichum tasmanicum* var. *parvithecum* is also known only from New Zealand. It has emergent, entirely smooth capsules, typically with two or often more arising from the same perichaetium, and is known only from areas of high rainfall. It is possible that this variety exists in Australia, but it has yet to be found here.

Acknowledgements

Thanks to the curators of MEL and CANB for loans of specimens, and to Nic Middleton and Kathy Vohs (MELU) for providing facilities and arranging loans. Special thanks are due to Helen Ramsay for confirming the identify of *Orthotrichum hortense* specimens. Many thanks also to the anonymous referee who pointed out several errors and kindly suggested numerous improvements to the manuscript. This paper would not have been possible without the pioneering work on the genus by the late Jette Lewinsky.

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Glossary

apiculus: a short, abrupt point
calyptra: a membranous and sometimes hairy cap covering the young sporophyte
campanulate: bell-shaped
costa: the thickened midrib or nerve of a leaf
cucullate: shaped like a hood
decurrent: extending below the point of origin on the stem
glaucous: having a waxy or powdery covering that gives a white, grey or blue colouration
hyaline: colourless and transparent, or nearly so
lanceolate: lance-shaped, narrow and tapering from the base
mammillose: having a single bulge in the external cell wall, into which the lumen extends
nodulose: having localised thickenings or swellings
operculum: a cap or lid that covers the capsule mouth until maturity
papillose: having one or more small, localised thickenings projecting from the external cell wall
perichaetial leaves: modified leaves surrounding the female sex organs

Presence of Bobucks *Trichosurus caninus* in The Gurdies on Westernport, Victoria

D Hynes[1] and M Cleeland[2]

Abstract

This article reports on the presence of Bobucks *Trichosurus caninus* in an open forest habitat abutting a swampy creek near the eastern shore of Westernport Bay, Victoria. Observations were made at night using infrared activated automatic cameras. (*The Victorian Naturalist* **122**, (3) 2005, 141-145)

Introduction

The Bobuck *Trichosurus caninus* also known as the Black Possum or Mountain Brushtail Possum, is common in cool-temperate wet forests and subtropical rainforest with luxuriant understorey of non-sclerophyllous shrubs and ferns along the Great Dividing Range from southern Queensland to Victoria. It is described as terrestrial in its habits: it often feeds at ground level and dens in fallen logs. It is larger, longer-lived and more sedentary than its relative the Common Brushtail Possum *T. vulpecula* (Menkhorst and Knight 2001). The sexes form long-term monogamous pairs and the young take significantly longer to wean than do the offspring of *T. vulpecula* (Strahan 1983). It seems plausible that these behavioural traits make Bobucks more vulnerable to environmental disturbance than Common Brushtail Possums and hence may account for the species' more restricted range.

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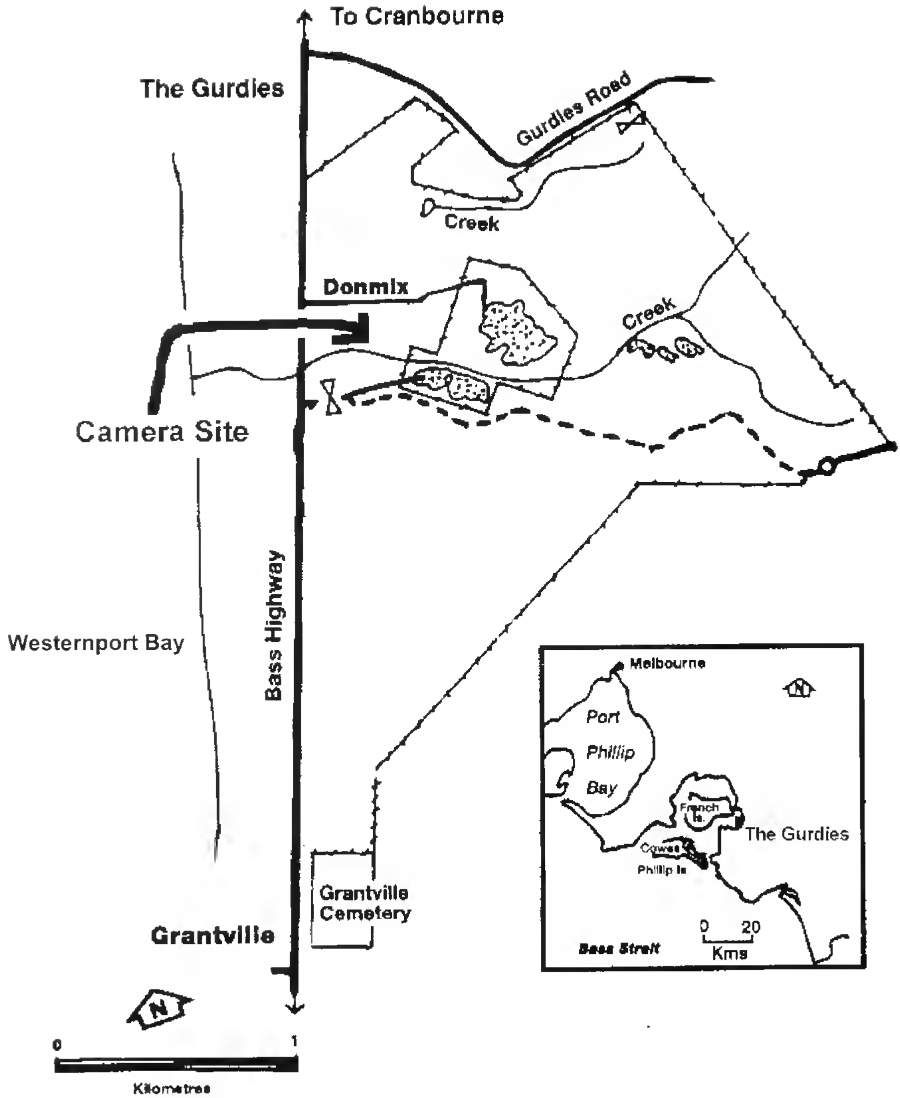

Fig. 1. Map of the camera site at The Gurdies Nature Conservation Reserve. From Department of Natural Resources and Environment. The Gurdies Nature Conservation Reserve. Resources Information Sheet, November 1997.

This article documents the discovery of a population of Bobucks in atypical lowland habitat in central coastal Victoria, and discusses the possible origins of the population.

Methods

The Gurdies Nature Conservation Reserve comprises an area of some 260 ha along the eastern side of the Bass Highway at The Gurdies, approximately 3 km north of Grantville on the eastern side of Western Port, Victoria. The surrounding area has been extensively cleared and is currently used mainly for beef cattle grazing.

A purpose-built infrared-activated automatic camera was deployed at ground level on the shores of the creek that separates the Donmix Quarry leasehold from The

Gurdies Nature Conservation Reserve (38° 22.865'S, 145° 33.420'E) (Fig. 1).

The Gurdies site was chosen because data presented by the regional catchment management body, Port Phillip and Westernport Regional Catchment Strategy (2004-2009), indicates it lies on the periphery of a zone of remnant native vegetation. The area thus offered an attractive prospect for a survey of nocturnal fauna. A camera was left out for three nights in August 2004. During that time it captured images of probable Bush Rats *Rattus fuscipes* and a single image of a Bobuck. After consideration of this picture, it was decided to employ two more cameras in the same area in order to search further for these animals. The cameras were deployed over another three nights from 1 September, 2004 to 3 September, 2004. One of these instruments, a little upstream from the first site, captured eighteen images of Bobucks. No attempt was made to trap or to interfere in any way with the animals.

Geology and Soils

Tertiary outwash sands and gravels overlie earlier Tertiary basalts and Cretaceous sediments in this part of West Gippsland. These sands and gravels are the subject of several extractive industrial operations within and nearby the Reserve. They supply material for road surfacing, concrete, mortar and glass manufacture. Soils developed over the outwash sediments appear to be low in nutrients including nitrogen and phosphorus, a factor that may have influenced early settlers to refrain from clearing the Reserve area. The topography is dissected by local drainage channels that flow into Western Port Bay.

Vegetation

A mixed age stand of Messmate *Eucalyptus obliqua* and Peppermint *E. radiata* dominates this open forest community. Understorey and ground level plants include Bracken *Pteridium esculentum*, Common Heath *Epacris impressa*, Hedge Wattle *Acacia armata*, Hop Wattle *A. stricta*, Prickly Tea Tree *Leptospermum continentale*, Spiny Mat Rush *Lomandra longifolia*, Sundew *Drosera* spp. and several species of orchids. A drainage line adjacent to the camera site supports populations of Common Reed *Phragmites australis* and Swamp Paperbark *Melaleuca ericifolia*. Sweet Pittosporum *Pittosporum undulatum* is scattered throughout the area. A view of the camera situated at the edge of the creek is presented in Fig. 2.

Fig. 2. Camera in creek next to Donmix Quarries.

Results

Two pictures are presented (front cover and Fig. 3). The best means of distinguishing the Bobuck from its cousin, the Common Brushtail Possum, is to examine the ears (front cover).

In the Bobuck the ears are shorter (around two thirds the length) and more rounded than the ears of the Common Brushtail (Kerle 2001).

Bobucks tend to be larger (2.5-4.5 kg) than the Common Brushtail (1.5-4.0 kg) (Menkhorst and Knight 2001). The animal shown in Fig. 3 exhibits its species' characteristic short rounded ears. Like its cousin, the Bobuck also possesses a long, luxuriantly bushy, black tail; hence another of its vernacular names, the 'Mountain Brushtail'. Generally the animals reported here were darker than Common Brushtail Possums, being very dark grey to almost black dorsally but paler grey ventrally.

They also appeared to be more robustly built than the Common Brushtail, especial-

Fig. 3. Gurdies Bobuck.

ly around the head, neck and forearms. The snout seems blunter and there was no black-white banding as is sometimes apparent immediately behind the rhinarium in Common Brushtails. One image showed an animal sitting upright, its long, powerful claws easily visible.

[Images collected by the cameras may be viewed at the following internet address: http://www.thylacoleo.com/publications/bobucks01/bobucks01.html].

Discussion

According to Menkhorst and Knight (2001) and also Kerle (2001) the range of *Trichosurus caninus* extends through the Great Dividing Range from southern Queensland to the mountains of Gippsland in Victoria.

However, it was stated to us that Bobucks are only known along the shores of Westernport near Grantville from three previous instances. There is said to be a pair living in thick foliage on a farming property near Grantville and one road-killed specimen was found on the nearby Bass Highway about 10 years ago. (P Westwood, pers. comm.) An injured Bobuck from Grantville was brought into a wildlife shelter at Inverloch during the 1990s, was rehabilitated and subsequently released in the Dandenongs, since it was assumed to be a vagrant (J Hillyard, pers. comm.)

Neither Wilson (1990) nor Kutt and Yugovic (1996) reported the presence of Bobucks in The Gurdies when their respective studies were conducted. This is puzzling because one of the present authors observes that vegetation within the Reserve itself has not materially changed during the last 25 years (M Cleeland, pers. obs.). It is also reported that the Gurdies Reserve is heavily infested with European Foxes *Vulpes vulpes* and has been so for many decades, (M Cleeland, pers. obs.). It appears, from occasional reports over many decades, that a very small but unreported population of them may have been present in or near The Gurdies over a time span of decades. Possibly their small numbers may account for their absence from previous biodiversity surveys. How they manage to survive in the presence of foxes is unclear.

Barring deliberate or accidental release, the most obvious scenario is that the animals reported here have migrated into The Gurdies from the north or the east, perhaps from the still timbered regions of the Strzelecki Ranges. But Lindenmayer *et al.* (1991) state that Bobucks tend not to move about much, one animal being recaptured after 10 years only 250 metres from where it was first caught and tagged. Given such sedentary habits of the adults it may be that the principal means of population spread by this species is through dispersal of the young. This method would presumably be quite slow, given their lower rate of reproduction and late weaning as compared with the Brushtail Possum. It also means that young, inexperienced animals would have to travel large distances across open farmland in order to reach the shores of Westernport. However, in view of their apparent affinity with the creek, one way for them successfully to disperse across farmland and main roads might be to follow natural watercourses wherever these provide suitable habitat. In this case the animals photographed in The Gurdies may represent a snapshot, literally, of a larger population movement that is presently taking place over a wider geographical area.

Two problems arise with this picture. Firstly, The Gurdies-Grantville region is hemmed in by open farmland on three sides and by Westernport Bay on the fourth. One of the authors (D Hynes) travelled around the West Strzelecki hills to ascertain if habitat corridors leading from further east are present. There appears to be none. In any case, if habitat corridors such as creek beds are being used as migration routes from far afield one would expect to find Bobucks in residence in most creeks in south-west Gippsland. If such were the case one should expect the frequency of reported road kills and sightings to be much higher than it actually is. Consequently the authors believe that any theory involving current or recent migration of Bobucks over large distances through the Strzelecki Hills to The Gurdies is untenable.

An alternative scenario is that Bobucks in The Gurdies were cut off from the parent population in the Great Dividing Range when the West Strzelecki Ranges were cleared of timber in the late 19th to early 20th century. In this case, the Grantville population may represent a relict that has, remarkably, survived since then in isolation. However the notion of a tiny colony or colonies lingering on in isolation over, perhaps, the better part of the 20th century presents severe difficulties, mainly to do with questions about the long-term viability of extremely small populations.

It is not likely that the Bobucks in the creek next to the Donmix Quarry are the only ones in The Gurdies. A population, albeit small, must be distributed throughout various parts of the Reserve and, presumably, in nearby areas of suitable habitat that are not formally part of the Reserve itself.

The question of how long a remnant population of Bobucks in The Gurdies may have been separated from others of their kind is fraught with uncertainty. A few kilometres to the east of The Gurdies Reserve the Bass River flows to the south-west. It seems possible this waterway may form a natural corridor or haven for Bobucks, allowing them to move into the Grantville-Gurdies area from the north-east. The Bass River has not, to date, been surveyed by the authors. It was stated to the authors (A Westwood, pers. comm.) that stands of connected vegetation, capable of forming corridors through which medium sized animals might pass, were indeed available north east of The Gurdies up until approximately twenty years ago. After that time, and especially in the past 10 years, the rate of vegetation clearance from countryside near The Gurdies district has accelerated.

Hence it may be that a Gurdies Bobuck population was sustained by immigration up until a decade or two ago but is now cut off. In this case the present day Gurdies Bobucks might represent a population that once was larger but now is dwindling towards extinction. There have been very few reports of sightings or captures in the past as in the present. Bobucks have been almost unknown in the Gurdies. Appar-ently Bobuck movement along any now vanished corridor was at such a low level as to remain all but invisible. Moreover if Gurdies Bobucks were more numerous ten to fifteen years ago, one would expect them to have appeared in the surveys that were done then.

The authors are thus unable, at the present time, to offer an hypothesis that might satisfactorily account for the presence of Bobucks in The Gurdies on Westernport Bay, Victoria. It is hoped that further photographic surveys may be carried out in order to discover more about their distribution and perhaps cast light upon how they came to be in their present situation.

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Annotated records of the Eastern Pygmy-possum *Cercartetus nanus* from *The Victorian Naturalist* 1884-2004

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Abstract
The Eastern Pygmy-possum *Cercartetus nanus*, while widely distributed throughout south-eastern Australia is encountered relatively infrequently. However, *The Victorian Naturalist* is a major source of records of the distribution of the species, beginning with a mention in Volume 1 (1884). Past issues of the journal were surveyed for records of the species, which were then annotated here. (*The Victorian Naturalist* **122** (3), 2005, 146-150)

Introduction

Although the diminutive Eastern Pygmy-possum *Cercartetus nanus* is widely distributed in the forests, woodlands and associated habitats of south-eastern Australia, it is encountered relatively infrequently (Bowen and Goldingay 2000). Therefore, records of this species are particularly significant. Many important records of Eastern Pygmy-possum are published in the volumes of *The Victorian Naturalist*. Hence, the aim of this contribution is to extract and present an annotated chronology of records of the Eastern Pygmy-possum published in *The Victorian Naturalist* during the past 120 years (1884-2004).

Eastern Pygmy-possum Records from *The Victorian Naturalist*

In the first volume of *The Victorian Naturalist*, Forbes-Leith and Lucas (1884) presented a check-list of the mammals of Victoria, and accepted the Eastern Pygmy-possum (as *Phalangista gliriformis* = *C. nanus*) as a component of the State's fauna. Following this, 'two Opossum Mice' were reported from Heathcote, central Victoria (Anon 1890). Hall (1904) refuted the suggestion by Waite (1904) that the Victorian Eastern Pygmy-possum (*Dromicia nana* = *C. nanus*) records were not authentic, and identified further records from Gembrook, The Black Spur, and Sale. Kershaw (1906) reported on an excursion to Wilsons Promontory, and although Eastern Pygmy-possums were not found during the trip, he stated that they were 'sure to exist there'. Kershaw's assertion was proved correct, and the species is known to be 'locally common' on Wilsons Promontory today (Menkhorst and Seebeck 1999). In 1911, at a meeting of the Victorian Field Naturalists Club, a young 'Dormouse Phalanger', from the Mallee at Underbool, northwest Victoria, was exhibited by AHE Mattingley (Anon 1911). It was noted that this was a new Eastern Pygmy-possum record for the Mallee, however, Wakefield (1963a) later clarified that the specimen had been incorrectly identified, and was in fact the Western Pygmy-possum *C. concinnus*.

In 1930, Norman Chaffer made a short contribution on the 'Opossum Mouse' and presented a photograph of an individual found in a disused nest of a New Holland Honeyeater *Phylidonyris novaehollandiae* in an area of heathland near Sydney, New South Wales (NSW) (Chafer 1930a; see also Chafer 1930b). He provided brief notes on the characteristics of the species, including the fattening of its tail and hibernation during winter. David Fleay also mentioned dormancy in the species (Fleay 1932) and reported that a captive animal was housed in a new section of the Melbourne Zoological Gardens (Fleay 1935). In 1939, Kathleen Conway from Eskdale provided an article about 'Bluey', a female Eastern Pygmy-possum kept as a pet for over four years (Conway 1939). Bluey was brought to Conway on 8 September 1934 and died on 6 January 1939, a day reportedly 44°C in the shade. Its captive diet included insects, honey, fruit, lollies and cream, and it became quite overweight. In winter 1935, it was noted

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Fig. 1. Eastern Pygmy-possum *Cercartetus nanus*. Photo Teresa DuBois.

that Bluey hibernated for five days. In this article it was also noted that common names for the species included 'Dormouse-Opossum', 'Dormouse-Phalanger' and 'Possum Mouse'. In a companion article by Miss JM Bocking, a report was made from the Blue Mountains, NSW, of a cat which brought in a Feather-tailed Glider *Acrobates pygmaeus*, which did not live long, and also an Eastern Pygmy-possum (Bocking 1939). This male animal was named 'Twinkle' and lived with the Bocking family for over a year. Some anecdotal notes on Twinkle were provided, including its ability to hang from a human finger by the tail and then climb it, and its meticulous grooming behaviour. Photographs of both Bluey and Twinkle accompanied the articles.

A decade passed before a 'Pigmy-Possum' was again reported (Learmonth 1949); a record from the Portland district. Another decade later (in the 1960s), the Eastern Pygmy-possum became a high profile species in the journal, under the editorial direction of Norman Wakefield. The front covers for both May 1962 (Volume 79, Issue 1) and August 1963 (Volume 80, Issue 4) showed photographs of Eastern Pygmy-possums. The former featured a family of three juveniles found by a wood-cutter in the Rushworth Forest (Anon 1962), while the latter showed a family found at Yackandandah (Anon 1963). Baines (1962) reported a meeting of the Fauna Survey Group held 1 March 1962 at which Mr RM Warneke displayed two very well-fed specimens of the 'Common Pigmy Possum' that were 'lively despite their obesity'. Notes from mammal reports of the Fauna Survey Group for June 1965 record the 'Pygmy-possum' from Tidal River, where the Ranger, Mr A. Miller found a female nesting in a cupboard in April (Anon 1965). Three young were produced and the nest was noted empty by 5 June 1965. A record of the 'Eastern Pigmy Possum' was also provided for Powelltown/Labertouche State Forest (Anon 1967).

The 1960s included the prolific work of Norman Wakefield on the sub-fossil mammalian fauna of Victoria (Wakefield 1960a,b; 1963b,c; 1964; 1967a,b) and his authoritative contribution on the 'Australian Pigmy-Possums' (Wakefield 1963a). In a pair of papers, Wakefield (1960a,b) noted the discovery of the Eastern Pygmy-possum as a fossil specimen in a number of caves in the vicinity of the Murrindal River in eastern Victoria (Pyramids Cave, Mabel Cave, M-27 and M-28) (see also Wakefield 1967a). Eastern Pygmy-possums were subsequently found in fossil deposits collected near Portland, in the far southwest of the State (Fern Cave and McEachern's Cave) (Wakefield 1963b; 1967b), in the Grampians (Victoria Range and Black Range) (Wakefield 1963c), and near Hamilton (Byaduk Caves and Mount Eccles) (Wakefield 1964). For a review of these sub-fossil records see Harris and Goldingay (In press).

Wakefield (1963a) reviewed around 40 mainland records including one from Millicent, South Australia (1925) and several from NSW including St. Leonards (1863), Jindabyne (1903), Royal National Park (1925), Bowral (1939), Blue Mountains (1958) and Newcastle (1958). The sources for these records included the Australian Museum, Krefft (1863), Waite (1904), Wood Jones (1925), and Marlow (1958). Wakefield (1963a) believed that the northern range limit was then Newcastle. Victorian records included Western Port (1880), Muckleford (1886), Mordialloc (1887), Avoca (1918), Buangor (1935), Portland (1945, 1946, 1948, 1957 and 1959), Erica (1947), Wilsons Promontory (1950), Mount Loch (1952), Tamboon Inlet (1958, 1962), Mallacoota (1958, 1962, 1963), Whitlands (1958), Nowa Nowa (1960), Snake Valley (1961, 1962), Rushworth Forest (1961), Cape Conran (1963), Grenville (1963) and Yackandandah (1963). Thirty-six museum and literature records from Tasmania were available, but most had no locality data or precise dates of collection. Those with recorded localities included its discovery by Europeans on Maria Island (1802), and also Waratah (1900), Mount Wellington (1957), Launceston, Westbury district, Fury Gorge near Cradle Mountain and Cloudy Bay on Bruny Island.

Wakefield (1963a) examined the subspecific taxonomy of *C. nanus* and assigned the mainland populations as *C. nanus unicolor* and the Tasmanian populations as *C. nanus nanus* (see also McKay 1988). He noted that the mainland form (*unicolor*) appeared to be 'widely scattered but uncommon' in the highland forests of Victoria and south-eastern NSW, and 'apparently less rare in contiguous densely scrubby coastal forests'. His data indicated that it was absent from the savannah formations of central Gippsland, the western district of Victoria, and the woodlands of the Monaro district of southern NSW. With regards to the Tasmanian subspecies (*nanus*), Wakefield suggested that it had suffered a marked decline in the preceding century, and its status was rare. He postulated that the decline was 'most likely due to the marked changes in vegetation brought about by the periodic forest fires that have occurred in Tasmania ever since European settlement there'. A preference for dry sclerophyll forest rather than wet sclerophyll forest was also advanced by Wakefield (1963a) for both subspecies on the basis of distributional records and from some earlier interpretations of sub-fossil data. He also suggested that Eastern Pygmy-possums are 'localised', and that there was a 'medium to dense element of shrubbery in most areas concerned'.

In a subsequent note on the 'Pigmy-possums', Wakefield (1970) referred to the discovery of the species in 1936 at Lamington National Park, southern Queensland (O'Reilly 1941). New records from Flinders Island, Tasmania and Mount Drummond, near Stawell, western Victoria were also identified. An observation of an individual with five nipples was reported, which was thought unusual since only four nipples had been previously described. However, later research has demonstrated that the species does in fact have six nipples (Turner and McKay 1989). Finally, Wakefield (1970) reviewed data on dormancy in captive Eastern Pygmy-possums, and also held a captive female and her five young under observation for 21 days. He found a positive correlation between periods of dormancy and the occurrence of rain, which he suggested demonstrated an adaptive advantage of torpor.

Other Eastern Pygmy-possum records in *The Victorian Naturalist* from the 1970s include further mention of the fattening and dormancy of the species (Anon 1974), and a photograph of a female with five pouch young on the front cover of the issue for March 1975 (Volume 92, Issue 3) (Anon 1975). This was of an animal caught by hand on the ground in Wiregrass *Tetarrhena juncea* during spotlighting at Nolan's Gully in the Upper Lerderderg Valley (Deerson *et al.* 1975). Gilmore (1977) also opportunistically captured an Eastern Pygmy-possum while it was crossing Kangaroo Swamp Road, 2km east of the Old Rosedale Road, in the Stradbroke area of South Gippsland. Galbraith (1977) provided additional records for the 1970s from Mallacoota, Cape Conran, Maffra, Connors Plains near Mount Skene, and Mullandang Forest near Won Wron. She also commented that the species is 'fairly widespread in eastern Victoria, but probably not common, for they are rarely seen'.

In 1980, an Eastern Pygmy-possum was caught by pitfall trap at Strathbogie (Anon 1980) and again recorded in this area in 1987 (Anon 1988). Hampton *et al.* (1982) compiled the Mammal Survey Group records from 1966-80, which included records already referred to (Anon 1967; Wakefield 1970; Deerson *et al.* 1975; Anon 1980) as well as several new records from the vicinity of Rushworth Forest, Sale, Anglesea, and the 'Alpine Area'. There is also a record from Tolmie, where an individual was found in a post-hole, and from Sheepyard Flat, Mount Timbertop, where three individuals were recovered from a felled dead tree (Nicholls and Meredith 1984). Lumsden and Schulz (1985) caught a male in a pitfall trap at Gellions Run, South Gippsland, and spotlit two animals in an area of woodland dominated by Manna Gum *Eucalyptus viminalis* and Saw Banksia *Banksia serrata*. Another individual was sighted in a thicket of Swamp Paperbark *Melaleuca ericifolia* adjacent to woodland. Wilson and Moloney (1985) trapped an Eastern Pygmy-possum within a recently burnt area of swampy heathland dominated by Scented Honey Myrtle *Melaleuca squarrosa* and Prickly Tea Tree *Leptospermum juniperinum* at Anglesea. Loyn *et al* (1986) found remains of Eastern Pygmy-possum at Mallacoota in five Sooty Owl *Tyto tenebricosa* pellets, of 14 examined.

Leahy (1990) mentioned that on a previous expedition to the Nooramunga region, the Fauna Survey Group recorded an Eastern Pygmy-possum. Another record is provided by Trainor (1992), who noted that Mr R Brouwers had found two individuals in an area of burnt Box-Ironbark forest (mixed stands of *Eucalyptus* spp.) south of Maryborough. In a mammal survey of Sunday Island, South Gippsland, an Eastern Pygmy-possum was pitfall-trapped in an area of secondary sand dune bushland, with Saw Banksia *B. serrata* and Manna Gum *E. viminalis* on the crest of dunes, and Swamp Paperbark *M. ericifolia* in the dune swales. Three more specimens were captured during this survey in an area of *Banksia* woodland, southwest of Gumboot Flat (Myroniuk *et al.* 1993). Quin (1996) undertook a mammal survey in South Gippsland (Mullungdung and Won Wron State Forests) and captured eight Eastern Pygmy-possums (six individuals) using Elliott traps, in two separate sites: heathy woodland and rehabilitated gravel scrape. An abundance of potential food shrubs, including Tea Tree *Leptospermum continentale*, occurred in the scrape, but not *Banksia*. Quin suggested that Eastern Pygmy-possums might have been taking advantage of fallen logs present at this site as diurnal nesting sites. Wallis *et al.* (1996) found traces of Eastern Pygmy-possums in four of the 1,992 fox scats collected from the Dandenong Ranges National Park (0.2 per 100 scats analysed). Thompson *et al.* (1998) reported the most recent record of the Eastern Pygmy-possum in *The Victorian Naturalist* during a post-fire survey at Wilsons Promontory. Here one individual was captured in an unburnt control site (25 years fire age), near the western foot of Mount Bishop, which was dominated by Coast Beard-Heath *Leucopogon parviflorus*, Bushy Needlewood *Hakea sericea*, Dwarf She-oak *Allocasuarina pusilla*, Hairpin Banksia *B. spinulosa*, Coast Tea-tree *L. laevigatum* and Messmate Stringybark *E. obliqua*.

Conclusion

The Victorian Naturalist contains around 110 distribution records of the Eastern Pygmy-possum, excluding multiple records from the same locality and excluding fossil records. These extend from 1802 to 1998, and cover some aspects of the species' discovery, life history, behaviour, taxonomy, and habitat utilisation. Included are the various vernacular names that have been used for the Eastern Pygmy-possum, and survey methods that have detected the species. There are many additional accounts of the species held in other journals, published and unpublished records in the Atlas of Victorian Wildlife (~617 records), and specimens within museum collections; although an unknown number of these records are overlapping with those presented here. Therefore, this paper provides a basis for crosschecking and reconciling such information. Furthermore, it demonstrates the value of an historical review of species records published in *The Victorian Naturalist*, particularly for elusive or relatively poorly known species.

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Tree Ferns

By Mark F Large and John E Braggins

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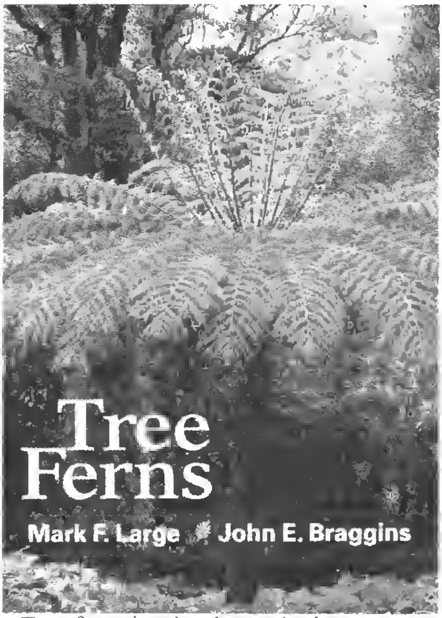

Tree ferns inspire the soul when encountered on a bush walk or found growing luxuriantly in the sheltered corner of a home garden. For some people, tree ferns engender thoughts of the primeval swamps and dinosaurs of ancient times, while for others these spore-bearing non-flowering plants are fascinating scientifically. In the Foreword to this book, Professor David J Mabberley acknowledges that:

> 'Mark Large and John Braggins have produced a book to do justice to tree ferns: there is nothing else like it. A guide to all the known tree ferns is a must for fern gardener and pteridologist alike, yet no one has ever before attempted such a thing.'

This well presented hook provides a wealth of information about tree ferns in a very readable form. It is well researehed, with references frequently cited in the text, and it contains an extensive bibliography. The 131 colour plates, mostly showing tree ferns growing *in situ*, are excellent, and attest to the authors' extensive travels across the globe studying these ferns. There are also several illustrations relating to tree fern anatomy, and maps showing distribution of genera. Technical terms used in the book are explained clearly in the glossary, while the index is user-friendly and includes speeies synonyms. Appendix 1 provides information regarding tree ferns with nomenclatural problems, while Appendix 2 lists tree ferns by geographic region, and Appendix 3 lists selected tree ferns suitable for gardens.

The introduction defines the term 'tree fern' and outlines distribution and history of these ferns over evolutionary time. A succinct, illustrated description of the tree fern life cycle demystifies alternation of generations, the sexual reproductive cycle common to all plants. Anatomical features of tree ferns are described along with scientific and cultural snippets, which occur throughout the book, giving it a satisfying richness.

Conservation and trade in tree ferns is discussed, with emphasis on those species endangered through overexploitation or loss of habitat. Use of tree ferns as food, medicine and building materials is also covered.

Chapter two describes many aspects of the cultivation and propagation of tree ferns. Technical aspects such as climate, temperature, humidity, soils, moisture, light and nutrition are dealt with, as well as practical hints on topics such as frost protection and landscaping. Vegetative propagation using trunk cuttings is described and the mysteries of propagation from spores is explained.

The diseases and pests of tree ferns are diseussed and the potential damage to these ferns by some modern chemical remedies is noted, as is damage due to various physiological faetors.

The third and largest chapter of this book discusses botanical nomenclature and the use of molecular data and morphological studies to construct tree fern phylogenic cladograms. The main tree fern families and families containing ferns with short trunks are highlighted. A tree fern key is provided to family/genus and sometimes clade level. This key requires a microscope and, probably, some botanical knowledge in order to be of maximum use, but the uninitiated would soon learn and maximize their value of the book because of its easy-to-read style. Significant attention is given to providing valuable taxonomic, descriptive, cultural and distribution information on each tree fern, enhanced at times with distribution maps and anatomical drawings, making the book ideal for the more scientifically minded as well as the 'lay' person.

This comprehensive and very interesting book is highly recommended for all.

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Herons, Egrets and Bitterns
Their biology and conservation in Australia

by Neil McKilligan

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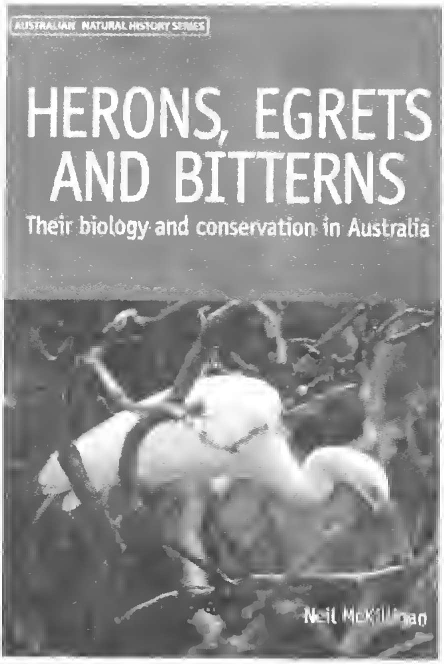

The author, Neil McKilligan, has observed and studied the Australian Ardeidae for many years and obviously has a special empathy with the group. This becomes clearly evident as one peruses this small, information-packed volume, which caters for both scientific and popular perceptions.

Until I examined this important natural history book the best popular reference to the Ardeidae available to me that included all Australian species was *The Herons Handbook* by Hancock and Kushlan (1984). McKilligan cites this publication in his 'References'. His book, a monograph of a special group of birds, the Ardeidae, now supersedes and greatly updates the Australian information in Hancock and Kushlan. Fourteen resident species are referred to and their biology is described in detail. Six additional species are recorded as 'occasional visitors'; four of these on distant offshore islands, and two, the Grey Heron and the Yellow Bittern, on mainland Australia. There are nine chapters: Herons of the World; What makes herons different?; The importance of herons; Distribution, movements and longevity; Feeding and food; Breeding; Population numbers and conservation; Species resident in Australia, and Occasional visitors. There is also an extensive References section and many excellent colour and black and white photographs and sketches of birds, besides numerous diagrams and maps.

Having myself observed all fourteen species of the 'Resident Australian Herons' referred to in this book, in locality and habitat, and watched most of them at length, I certainly agree with the author's sentiments that they form striking members of our avian fauna. For instance, the White-faced Heron, a special favourite of mine from early days, was once a common species along the lower Yarra River valley at Kew near Melbourne, Victoria. Winter flocks of these picturesque birds occasionally numbered up to fifty or more. Nowadays the species is considerably reduced in number in that area and the bird observer can no longer expect a sighting of even one White-faced Heron on a bird ramble there. The main reason for its present scarcity is the old story for it and others of its kind, the reclamation of prime habitat, swamps, billabongs and surrounds, although the few White-faced Herons remaining still have the edges of the Yarra River to patrol. Even at Werribee numbers are down significantly although more suitable habitat is presently available there than along the Yarra River valley.

Members of the Ardeidae are fascinating birds to watch as they hunt and obtain food items. Recently, March 26, 2005, at Werribee I watched a White-faced Heron stalking around in long grass. Suddenly its bill disappeared into the vegetation and reappeared clasping a fat mouse, which was promptly swallowed whole.

This book is a credit to Neil McKilligan It is a much desired and welcome addition to Australian ornithological literature and should be equally well accepted overseas.

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Australian Magpie: Biology and Behaviour of an Unusual Songbird

by Gisela Kaplan

Publisher: *UNSW Press and CSIRO Publishing, Collingwood, Victoria, 2004. 142 pages, paperback, illus. ISBN 0643090681. RRP $39.95*

Australia has too few monographs on birds, so this contribution on the Australian Magpie is most welcome.

Importantly, so much of the information in this book has been gathered at first hand and deals with both wild and tame birds. Additionally, it incorporates extensive study by Kaplan's colleagues. It '... represents the very first attempt to bring together what we know about magpies to date.'

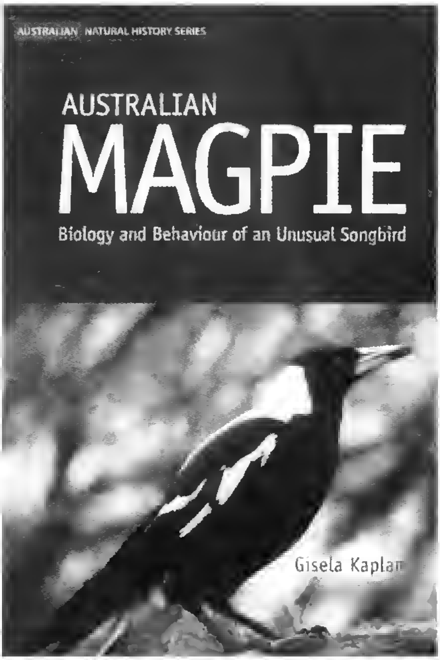
The 12-page list of References is an indication of just how thoroughly the subject has been researched.

In the interests of serious researchers and interested birdwatchers it is worthwhile noting the chapter headings. These show the extent of coverage devoted to this species, and will enable those eager to learn more to see at a glance if their particular need is catered for. Subsections within each chapter expand the subject matter under discussion. The chapters are headed: Origin and classification; Anatomy; Diet and feeding habits; Territoriality and dispersal; Bonding and breeding; Physical and social development; Agonistic and co-operative behaviour; Song production; Communication and mimicry; Magpies and humans; and the epilogue The success of magpies.

In the light of current, exciting research, 'Origin and classification' should be compulsory reading. This revision regarding the importance of Australian birds in the worldwide picture is riveting stuff.

The chapter on 'Anatomy' answers many questions, not only on magpies, but on birds in general. It sets out, succinctly, characteristics common to all birds, e.g. how many of us would have considered that 'there are about seven types of feet in birds.'

It is very satisfying to learn how DNA fingerprinting has destroyed all notions of faithfulness in pair-bonded birds. It is now '... possible to isolate the DNA and estab-



lish paternity reliably, … as a precondition for social parenthood.' (This is so topical when applied to humans. Producing a family tree these days can be a nightmare!).

Another valuable chapter, 'Agonistic and cooperative behaviour' deals with a situation frequently encountered by the public. The author explains, to the uninitiated, that in ornithology agonistic behaviour (NOT aggression) has developed '… to fulfil specific functions. … It represents a well-evolved strategy to enhance the chances of survival either of an individual, a group or of offspring. It ranges from mild warnings to attack, usually in defence of offspring, a mate, a food source or a territory or all of them, as the need arises.' Such behaviour is common to many birds, and is vital for the continuance of a species.

Many people have a set against magpies because they misunderstand the birds' behaviour. If all the exaggerated stories – and believe me, they grow in exaggeration with each re-telling! – were to be credited, these birds, as evil monsters, should be destroyed. An understanding of the birds' conduct would help alter the attitude of the public.

Behaviour is one of the more readily observed functions of bird life even if it is not readily understood, and it provides endless interest and speculation.

The excellent text is generously illustrated with diagrams, black and white photographs, and eight pages of superb colour photographs.

Don't be put off by the indispensable scientific data. A study of this book will have everyone looking anew at this ubiquitous bird.

It is a pleasure to bring it to the attention of interested bird lovers.

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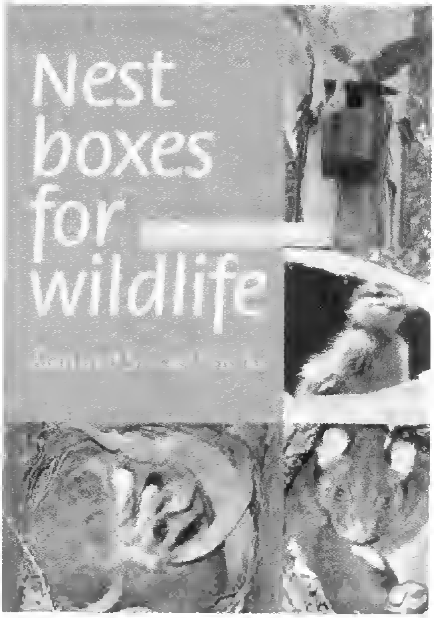
Nest Boxes for Wildlife: A Practical Guide

by Alan and Stacey Franks

Publisher: *Bloomings Books, Melbourne, 2003. 72 pages, softcover; colour photographs. ISBN 1876473207. RRP $16.95*

As the title suggests, *Nest Boxes for Wildlife: A Practical Guide* is a book concerned with instructing the reader how to provide artificial shelter for native wildlife. However, in addition to simply being a 'how-to' guide, the pages also contain various interesting anecdotes and basic ecological information for a variety of native animal species. Consequently, the book is not only a practical guide for anyone wishing to construct and install nest boxes, but also an entertaining read in its own right.

Australia is home to a large number of hollow-dependent animal species. However, it is a sad reality that, as a result of vegetation clearing, tree hollows have become a limited resource in many environments. This is especially true in



urbanised areas. The authors outline that, although nest boxes should never be seen as a substitute for natural hollows, they are a viable alternative in such areas. Not only do nest boxes provide shelter for various species, they can also provide people with the opportunity to learn about hollow-dependent fauna.

The book provides brief accounts for native species most likely to be encountered in nest boxes. These include a wide variety of birds (e.g. Rainbow Lorikeet, Australian King Parrot, Wood Duck) and mammals (e.g. Common Brushtail Possum, Sugar Glider, microbats). The species accounts include a combination of general ecological information and information specific to nest box use. Introduced species likely to use nest boxes are also discussed (e.g. the Common Mynah and feral Honey Bees), including tips for eviction.

For those wishing to construct and install their own nest boxes, this book would be a valuable resource. In addition to providing tips on what species to target, the book outlines what tools/equipment are needed to build boxes, what materials should be used in construction, and what the important dimensions are for various species (e.g. the depth of the chamber from the bottom of the entrance hole, the diameter of the entrance hole, and the height above ground at which the box should be placed). Detailed (but easy to follow) plans are also provided for nest boxes suitable for various species. These plans should be sufficient to allow someone with limited carpentry skills to successfully construct a nest box. Information is also provided on how to effectively and safely attach nest boxes to trees, and how to monitor nest boxes once installed.

The book contains a large number of high quality colour photographs, mostly of animals in and around nest boxes and hollows. These photographs provide detail for many species and will inspire readers to install nest boxes so that they too can have such beautiful wildlife in their backyards. The book is further enhanced by the inclusion of a variety of poems and quotes from authors as famous and well respected as AB 'Banjo' Paterson and David Fleay.

This book will probably answer all the questions you ever had about wildlife nest boxes. It is informative and entertaining, while also providing much practical advice. It is well written and can be easily read in an hour or two. However, for those committed to enhancing their local environment via the installation of nest boxes, it will no doubt be a valuable reference for years to come.

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From the Editors

Steps towards publication of a paper in *The Victorian Naturalist*

There are many steps involved in the publication of a paper in The Victorian Naturalist, over 20 in fact. The process, of course, starts with our erudite naturalists submitting their research to the editorial team, who are more than happy to accept the manuscript. We cannot show all the editorial steps towards publication, but the cartoon drawn by Gary Gibson shows part of the journey. As can be seen, it can be a dangerous game of survival.

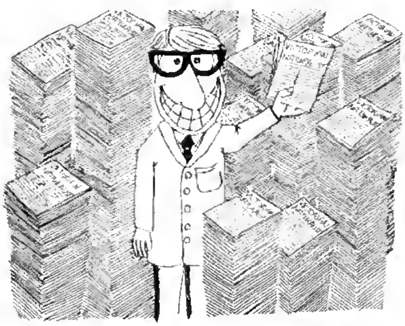
Sometimes there are differences of opinion between the referees and the authors and the editor has to jump the stepping stones carefully to avoid loss of limb.

Time always is an issue, snapping at the heels of the harassed editors and, if they are unwary, the printer swoops down seemingly from nowhere.

But in the end, the sharks, crocodiles and bloodthirsty pelicans are kept at bay and our author finally receives his or her publication(s!).

Publication of The Victorian Naturalist relies on volunteers. The editorial team consists of three editors and, most importantly, an assistant. All give their time freely. So, too, do the expert referees who check scientific content and accuracy and the dedicated proofreaders who help with readability and expression of articles, often at very short notice when a quick turn-around is required. Another important part of the process is occupational health and safety. This comes in the form of the editorial advisory team who step in when the sharks become too excited

....but, confidentially, the members of the editorial team are adrenalin junkies so send in the manuscripts so they can keep playing with the sharks, crocs and budgies.



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Cover: Hoverfly *Melangyna sp*. Photograph by Virgil Hubregtse. See article on p. 204.

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The distribution of fossil and sub-fossil records of the Eastern Pygmy-possum *Cercartetus nanus* in Victoria

Jamie M Harris[1] and Ross L Goldingay[1]

Abstract

The Eastern Pygmy-possum *Cercartetus nanus* has a variable status throughout its current geographic range. Investigating its prehistoric range may provide some perspective into its current distribution and abundance. We reviewed available information from the published literature and museum databases to document the fossil and sub-fossil sites in Victoria where bones of the species have been reported. This revealed 17 sites of late Pleistocene and Holocene age ranging from ca. 780 ± 100 to >33 000 years. The fossils from five sites (Bridgewater Caves South; Clogg's Cave; McEachern's Cave; McEachern's Deathtrap Cave and Pyramids Cave) are dated at >10 000 years, and extend from the far south-west to the far east of Victoria. The Steiglitz Cave (<6 000 years), located in south-central Victoria, provides evidence that Eastern Pygmy-possums were also present in that area in the mid-Holocene. The apparent prehistoric distribution of the species is likely to be an artifact of the availability of fossil sites. The fossil localities for the Eastern Pygmy-possum appear to be within the distribution of extant populations, and the available evidence does not suggest a contraction of geographic range. This may suggest that the available habitat for Eastern Pygmy-possums has not changed to any great extent during the last 10 000 years. Thus, this study provides a preliminary basis for examining modern contractions in the range of the Eastern Pygmy-possum, whether due to climate change, proximate anthropogenic disturbances, or other factors. (*The Victorian Naturalist* **122** (4), 2005, 160-170)

Introduction

The Eastern Pygmy-possum *Cercartetus nanus* (family Burramyidae) is a small (15-38 g) marsupial occurring along the south-eastern seaboard of mainland Australia and in Tasmania. It inhabits a range of vegetation communities including wet and dry eucalypt forest, *Banksia* woodland and heathland. Currently, it is officially classed as 'Vulnerable' in New South Wales (NSW) and in South Australia (SA), but 'not threatened' in Victoria, Queensland and Tasmania. Information on the modern distribution of the species in Victoria, NSW and SA (Menkhorst 1995; Bowen and Goldingay 2000; van Weenen 2002) has been assessed more recently and thoroughly than in Queensland (Van Dyck and Longmore 1991) and Tasmania (Rounsevell *et al.* 1991). However, data on its fossil distribution are poorly documented and have not been reviewed for any State.

This situation contrasts with the Mountain Pygmy-possum *Burramys parvus*, which has a famous history as a 'living fossil' (Anon 1966a,b; Lane and Richards 1967).

The Mountain Pygmy-possum was first discovered as a fossil in 1895 at Wombeyan Caves in NSW (Broom 1896; Ride 1960) and subsequently collected from Pyramids Cave in eastern Victoria (Wakefield 1960a). It was believed extinct until one was captured alive in 1966 in a ski hut at Mount Hotham, Victoria (Epstein 1981). Apart from its celebrated discovery, the species is also well known because of its endangered status, and because it is an example of how the fossil record can be used to inform conservation perspectives (Broome and Mansergh 1989; Brammall 1993; Mansergh and Broome 1994). Archer *et al.* (1991) noted that *Cercartetus* Pygmy-possums also appear to have declined in distribution. However, whether the Eastern Pygmy-possum specifically has suffered a range decline of a similar magnitude to that reported for the Mountain Pygmy-possum is unclear. Therefore, the primary aims of this study were to: (1) map the point occurrences of Victorian fossil and sub-fossil Eastern Pygmy-possum *Cercartetus nanus*; and (2) relate these localities to its modern distribution. Secondary aims were to document the reported ages for the fossil material, the agent/s responsible for their accumulation, and the frequency of Eastern Pygmy-possums collected from each of the sites.

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Methods

A literature search of lists of mammalian fossil and sub-fossil deposits was conducted to obtain records of the Eastern Pygmy-possum. Papers by Archer and Hand (1984) and Rich (1991) assisted with this. Enquiries were also made at Museum Victoria and the Australian Museum to ascertain the source of Victorian Eastern Pygmy-possum material held in their palaeontological collections (642+ specimens and 0 specimens respectively). The co-ordinates of the cave sites were determined using the Geoscience Australia online mapping place-name search and by correspondence with members of the Australian Speleological Federation (ASF). However, the co-ordinates for one Victorian cave remain unknown.

Beehive Cave, as it is referred to in the Museum Victoria database, apparently occurs in the Bats Ridge area, near Portland, but we found no mention of it in the literature reviewed. The Karst Index Database (KID), maintained by the ASF, has no entry for a 'Beehive Cave' from Victoria, therefore it may be a local name or one assigned at the time on account of a beehive being at the entrance (M Pierce 2004 pers. comm. 11 December). It is likely that the cave is one of the now numbered caves, but to suggest which one would require more information on the whereabouts of the subject cave and/or other nearby features. The fossil material collected from Beehive Cave forms part of the Wakefield collection at Museum Victoria. The Curator of Vertebrate Palaeontology, Tom Rich, advised that Wakefield provided brief, often cryptic, labelling of specimens, and the only locality data available are those with the specimens, as recorded in the museum database, and with the papers that Wakefield published. Therefore, for Beehive Cave we have had to assign approximate co-ordinates.

There may, potentially, be some confusion associated with the Natural Bridge (H-10) locality, referred to by Wakefield (1964a) as near Mount Eccles. In the speleological literature (Matthews 1985), this cave is referred to as 'Natural Arch' and/or 'Gothic Cave', and the term 'Natural Bridge' seems mainly to appear on Parks Service (Parks Victoria) maps (M Pierce 2004 pers. comm. 11 December). It could easily be mistaken for Bridge Cave (H-13), which is at Byaduk, and the Australian Karst Index records that Bridge Cave 'contains bones; important for paleontology' (Matthews 1985). However, Byaduk is a distinct and separate locality from Mount Eccles with the lava flows originating from separate volcanoes (Mount Napier and Mount Eccles respectively).

Definitions of Holocene (10 000 ya – present), Pleistocene (1.75 mya – 10 000 ya), and Tertiary (1.75 mya – 65 mya) follow Long *et al.* (2002). The body mass of small mammals referred to follows Menkhorst and Knight (2001). Modern records of Eastern Pygmy-possums were extracted from the Atlas of Victorian Wildlife (maintained by the Department of Sustainability and Environment), and use of a Geographic Information System (GIS) allowed the estimation of distances between modern and fossil records.

Results

Fossil and sub-fossil Eastern Pygmy-possums have been reported from 17 sites (Table 1). These were caves and/or rock shelters varying in size and origin. M-27, M-28 and Pyramids are caves formed within Early Devonian limestone in the vicinity of the Murrindal River, and Mabel Cave and Clogg's Cave are within similar substrates at East Buchan (Matthews 1985). The Victoria Range site, in the Grampians, is a rock shelter around 1 m wide and 3 m long occurring in sandstone (Wakefield 1963d). Black Range is also in the Grampians sandstone (Wakefield 1963d, 1969a), but its features have not been systematically recorded by cavers/speleologists in Victoria (M Pierce 2004 pers. comm. 11 December). Fern Cave, near Portland, occurs in Tertiary limestone and the dimensions of its chamber are approximately 18 m long, 12 m wide, and 9 m high (Matthews 1985). Also derived from Tertiary limestone is Amphitheatre Cave (Baird 1992), which has a vertical range of around 18 m, and a horizontal extent of 50 m long and 30 m wide (Matthews 1985). McEachern's Cave is formed in an Oligocene-Miocene Limestone, and is approximately 60 m long (Hope and Wilkinson 1982). The

Table 1. Location and frequency of Eastern Pygmy-possum remains in Victorian Holocene and Late Pleistocene cave deposits.

Cave No. = Alphanumeric identification system assigned to caves by the Australian Speleological Federation (Matthews 1985). Origin: OP= Owl Pellet, MS= Mammal Scat, PF= Pitfall. Total = Minimum number of individuals of all non-volant mammals in the deposit, and ( ) = number of terrestrial mammal species present. MNI = Minimum number of individual Eastern Pygmy-possums present. % = Percentage occurrence of Eastern Pygmy-possums calculated as MNI/Total x 100. The sites are listed in approximate order of age, with undated sites listed first. A dash (-) indicates that the data are unknown or not available. The age of the material is years before present (yr BP) ascertained either by radiocarbon dating as detailed by Lundelius (1983), or as provided by the source indicated. Sources: [1] W Gerdtz (Museum Victoria) pers. comm., [2] Wakefield 1963d, [3] Wakefield 1964a, [4] Wakefield 1964b, [5] Wakefield 1963b, [6] Wakefield 1972, [7] Baird 1991, [8] Baird 1992, [9] Wakefield 1960a, [10] Hope 1973, [11] Peake *et al.* 1993, [12] Kos 2001, [13] Kos 2003, [14] Godwin 1980, [15] Lourandos 1983, [16] Lundelius 1983, [17] Wakefield 1967b, [18] Wakefield 1969a, [19] Wakefield 1969b, [20] Link 1967, [21] Hope and Wilkinson 1982, [22] Wakefield 1960b, [23] Wakefield 1967a.

Site Name	Cave No.	Origin	Total	MNI	%	Age (yr BP)
Beehive Cave[1]	-	-	-	100+	-	-
Victoria Range[2]	-	OP	402 (19)	75	18.7	-
Natural Bridge[3,4]	H-10	OP, MS	1573 (24)	28	1.8	-
Flowerpot Cave[3]	H-19	OP	89 (18)	2	-	-
Harman Two[5]	H-12	OP, MS	323 (22)	16	-	-
Black Range[2]	-	-	- (5)	1-2	-	780 ± 100
Fern Cave[3,5,6]	KB-1	PF, OP	1552 (33)	18	1.2	3 000 to 4 000
Amphitheatre Cave[1,7,8]	G-2	PF	-	102	-	4 670 ± 90
M-27[9,10]	M-27	MS	878 (-)	43	4.9	<5000
M-28[9,10]	M-28	MS	552 (-)	16	2.9	<5000
Mabel Cave[7,9,10]	EB-1	OP, MS	1380 (-)	69	5.0	<5000
Steiglitz Cave[11]	-	OP	90 (20)	2	2.2	<6000
McEachern's Deathtrap Cave[12,13]	G-49	PF	- (29)	18	-	11 700 ± 160 to 9 840 ± 290
Bridgewater Cave South[14,15]	P-9	OP	611 (13)	45	7.4	<11 390 ± 310
Clogg's Cave[10,16]	EB-2	OP, MS	1374 (29)	26	1.9	22 980 ± 2 000 to 13 690 ± 350
McEachern's Cave[15,17,18,19,20,21]	G-5	PF	2260 (47)	67	3.0	25 580 ± 850 to 15 200 ± 320
Pyramids Cave[6,9,10,16,18,22,23]	M-89	OP, MS	10796 (31)	1125	10.4	>33 000 to 2 530 ± 90

nearby McEachern's Deathtrap Cave has a total surveyed length of about 122 m, although this is only about 80% of the total length (Ackroyd 1994). The Harman Two and Flowerpot Cave (part of the Byaduk Caves system near Hamilton) and Natural Bridge (near Mount Eccles) occur on the volcanic plains (Tertiary basalt), while Beehive Cave in the Bat Ridges Area, west of Portland, is formed on Quaternary aeolian limestone (Matthews 1985). Bridgewater Cave South is essentially an open rock shelter developed in an exposed calcarenite bluff (M Pierce 2004 pers. comm. 11 December). Steiglitz Cave in the Brisbane Ranges of southern Victoria is formed within an anticline of tightly folded and uplifted Ordovician shale, and is approximately 8 m deep by 6 m wide (LE Conole 2004 pers. comm. 12 October).

The minimum number of individuals (MNI) contained in the cave/rockshelter bone deposits was typically ascertained by counts of dentaries (lower jaw bones) or their fragments, and/or other skeletal elements. This permitted the size and frequency of the Eastern Pygmy-possum collection to be compiled for most sites (Table 1). For example, at Pyramids Cave, an extensive deposit was collected (31 terrestrial mammal species; 10 796 individuals), and the Eastern Pygmy-possum was present in large numbers (MNI=1125). Fourteen caves produced >10 individual Eastern Pygmy-possums, although the percentage occurrence for each cave differed considerably. At only two caves (Pyramids and Victoria Range) did the percentage occurrence exceed 10%.

None of these fossils was pre-Pleistocene, but the reported age of the material ranges from 780 ± 100 years (Black Range deposit) to >33 000 years (Pyramids Cave). There are also five undated deposits (Table 1). The oldest deposits from five sites are reported to be older than 10 000 years (Bridgewater Caves South; Clogg's Cave; McEachern's Cave; McEachern's Deathtrap Cave and Pyramids Cave). The caves occur in the far southwest and near Buchan in eastern Victoria (Fig. 1).

The deposits were reported to be the result of a natural pitfall where animals fell into the cave and became trapped (e.g. McEachern's Deathtrap Cave), or accumulations of regurgitated owl pellets (e.g. Bridgewater Cave South), or as a result of accrual of coprolites (fossil scats) of mammalian predators (e.g. some material from Clogg's Cave) (Table 1). Owls were attributed as the principal accumulating agent for most caves, but the identity of the owl species concerned for the various roost sites is ambiguous. For Pyramids and Mabel Caves, the late John Calaby considered that the Barn Owl *Tyto alba* and the Masked Owl *T. novaehollandiae* were the only candidates (correspondence cited in Wakefield 1960b). However, Wakefield (1960b) thought it unlikely that the smaller Barn Owl would be capable of handling some of the larger mammals found in the deposits, such as Short-nosed Bandicoot *Isoodon obesulus* (500-1500 g) and Common Ringtail Possum *Pseudocheirus peregrinus* (660-900 g). Other owls were considered, such as the Powerful Owl *Ninox strenua*, Barking Owl *N. connivens* and Sooty Owl *T. tenebricosa*, but were rejected on the basis of available information on their habitat and diet (Wakefield 1960b). Also considering the proportions of various species represented, Wakefield deduced that the owl responsible was the Masked Owl.

At the Flowerpot Cave and Victoria Range, the Masked Owl was also considered to be the accumulating agent (Wakefield 1963d, 1964a, 1969a). In contrast, Fern Cave was noted as both a death-

Fig. 1. Prehistoric and modern distribution of the Eastern Pygmy-possum in Victoria. Modern records are derived from the *Atlas of Victorian Wildlife*. Black dots indicate modern records. Diamonds indicate fossil sites with Eastern Pygmy-possum.

trap and an owl roost, but Wakefield (1963b) suggested that the Eastern Pygmy-possum and other small agile species such as the Feather-tailed Glider *Acrobates pygmaeus* (10-14 g) and the Sugar Glider *Petaurus breviceps* (90-150 g) would have been able to escape.

For Fern Cave, Wakefield more cautiously implicated owls of the genus *Tyto*, rather than specifically identifying the owl species concerned. This was probably because of the discovery of both Masked Owl and Barn Owl cave deposits in southwestern Victoria (Wakefield 1963b). In relation to Harman Two and Natural Bridge, Wakefield (1964a) notes them as mixed prey assemblages, resulting from the action of both owls and quolls (*Dasyurus* spp.), but suggests that the main part of the deposits may have been the responsibility of the Barn Owl (see also revision of the published article in Wakefield 1969a). However, whether avian or mammalian predators, or both, were responsible for the remains of Eastern Pygmy-possum specifically was not addressed, and cannot be determined without re-examination of the material.

The fossil localities identified for the Eastern Pygmy-possum allows its known paleodistribution to be mapped (Fig. 1). This reveals the tendency for the fossil sites to occur in groups, with the main groupings being from the limestone formation near Buchan in eastern Victoria, and the basalt/limestone caves and sandstone rock shelters of southwestern Victoria. There was also a fossil site (Steiglitz Cave, Brisbane Ranges) reported for south-central Victoria, which was well separated from those in eastern and western Victoria. There are many fossil cave sites in southern Victoria where the Eastern Pygmy-possum appears to be absent. The fossil sites identified for Eastern Pygmy-possum coincide with its present distribution, as modern records are present within 0 - 27 km of the fossil records. That is, there is a modern Eastern Pygmy-possum population in the immediate vicinity of McEachern's Deathtrap Cave (AM Kos 2005 pers. comm. 9 January) and both McEachern's Cave and Amphitheatre Cave are nearby. The nearest modern record to Pyramids and Clogg's Caves is at Nowa Nowa, which is 22 km SSW. Other nearby records include Balmoral (6 km SSE of Black Range), Cavendish (2 km W of Victoria Range), Mount Richmond (10 km ESE of Fern Cave), Cashmore (5 km NNE of Bridgewater Cave South), Portland (near Beehive Cave), Heywood (41 and 27 km SW from Byaduk Caves and Natural Bridge respectively), and Dereel (28 km WNW from Steiglitz Cave).

Discussion

Accumulating agents and biases of the assemblages

Animal remains may accumulate in caves by: (1) animals living and dying in caves; (2) animals falling in by accident; (3) animals taken into caves by predators; or (4) animal bones transported into caves after death (Andrews 1990). The McEachern's Cave (G-5) and the similarly named McEachern's Deathtrap Cave (G-49) contain examples of fossil assemblages where animals have fallen into the cave by accident and been trapped. These natural pitfalls have claimed numbers of the Eastern Pygmy-possum, and many other species of small mammals (Wakefield 1967b; Kos 2003). However, the fossil samples recovered from these caves are biased and as such may not reflect the presence or abundance of animals that have lived in that area over a defined period of time. Pitfall caves are selective in capturing fauna, and some taxa may be over-represented or under-represented, depending on factors such as the size and nature of the entrance holes, the ground cover immediately surrounding them, and on various aspects of the life history and activity patterns of the different species (Andrews 1990).

The Eastern Pygmy-possum appears to be susceptible to capture in pitfall caves, evidenced by its common occurrence in G-5 and G-49, and during pitfall trapping or in pipeline trenches in some modern fauna surveys (Bennett *et al.* 1988; Bowen and Goldingay 2000; Doody *et al.* 2003).

The fossil investigators suggested that for 11 caves, most of the small mammal bones were brought in by predators such as cave-dwelling owls and carnivorous marsupials (see also Lundelius 1966; Hope 1973; Andrews 1990; Baird 1991). However, the composition of the prey assemblages may be highly biased and not representative of the true relative abundance of the constituent species from a past community. This is because of the selectivity of different predators (Dodson and Wexlar 1979; Baird 1991), by the different ways in which predators eat and digest their prey (Andrews and Evans 1983; Marshall 1986; Andrews 1990; Geering 1990), differential fragmentation and disappearance rates of the remains of different prey species (Garvey 1999) and temporal variability of populations (Peterson 1977). There are other taphonomic (preservation) biases in the fossil record as well, but limitation of space precludes detailed discussion. Due to the biases and/or limitations, in this study we have not attempted to make comparisons between the various assemblages or to interpret the reported abundance of Eastern Pygmy-possums retrieved from the deposits. We note that for several caves (EB-2; G-5; G-49; M-89; P-9), the recovery of fossil material accounted for the frequency of small mammals in different stratigraphic units. Wakefield (1963a, 1969a, 1972) advanced an hypothesis in which the taxonomic composition and proportions of species present in various layers could be attributed to climatic and vegetation changes, which have occurred in the localities during the period of deposition of the bones (see also Hope 1973; Hope and Wilkinson 1982; Lundelius 1983). The accumulating agent may have shown a consistent bias, and temporal changes in composition may reflect real changes.

Identity of the predatory accumulators

Owls are known to be major contributors to the fossil record of small vertebrates, and it is likely they were responsible for much of the bone recovered from the cave sites referred to, because of the characteristic sausage-like 'casts' (Drummond 1963) and the presence of whole skulls (Wakefield 1960a). The recording of rock ledges used as daytime roosting places for owls in Mabel Cave, Pyramids Cave, Flowerpot Cave and Victoria Range (Wakefield 1960b, 1963d, 1964a) and the observation of a live Masked Owl in Clogg's Cave (McKean 1963) and a Southern Boobook *N. novaeseelandiae* in both Flowerpot Cave and Natural Bridge (Wakefield 1964a), also tend to support this conclusion.

The specific identity of the owls responsible is unclear. Baird (1991) re-examined quantitative data from Pyramids Cave (and several other cave deposits) and contrary to Wakefield (1960a, 1960b), concluded that the Barn Owl was most likely responsible for many of the cave deposits in south-eastern Australia. However, the Eastern Pygmy-possum has not been reported from studies of the contemporary diet of the Barn Owl (Morton 1975; Rose 1996a; Higgins 1999), and as the Barn Owl mainly forages in open country for terrestrial prey, we believe that it would rarely encounter the Eastern Pygmy-possum, which seems to prefer dense habitats (Wakefield 1963c; Harris and Goldingay 2005).

At Steiglitz Cave, the Masked Owl was reported responsible for the small mammal remains found there (Peake *et al.* 1993). This deposit was compared with a Masked Owl assemblage from Tasmania (Geering 1990), and a strong correlation between the two assemblages was found in terms of prey size and age structure. Peake *et al.* (1993) considered the Barn Owl but excluded the likelihood of this species being responsible for the fossilized pellets, based on the range and size of prey recovered from the cave. They also made a reappraisal of the Pyramids Cave data set (Wakefield 1960a, 1960b), and based on knowledge of the habits of the prey species, and the foraging and dietary preferences of the owls, they supported Wakefield's view that the Masked Owl was responsible for the deposit at Pyramids Cave. However, Peake *et al.* (1993) may have been unaware of the quantitative analyses undertaken by Baird (1991), as his research was not specifically referred to.

As Eastern Pygmy-possums are arboreal and nocturnal, they would be favoured prey for many owl species that occur within the forest, woodland and heath habitats of the subject species. For example, there are modern records of the species falling prey to the Masked Owl (Mooney 1992, 1993), Sooty Owl (Loyn *et al.* 1986; Hollands 1991; Lundie-Jenkins 1993; Kavanagh and Jackson 1997; Kavanagh 2002), Barking Owl (Menkhorst *et al.* 1984), and Southern Boobook (Green *et al.* 1986; Rose 1996b; S.

Debus pers. comm.). The Eastern Pygmy-possum is clearly susceptible to predation by these species and they are all known to roost in caves, albeit to varying extents (McKean 1963; Marshall 1986; Hollands 1991; Chafer 1992; Higgins 1999).

The authors feel that the possible involvement of any or all of these species in accumulating the deposits should not be immediately discounted, as it has previously, and that positive identification of the avian accumulator/s for each of the deposits remains equivocal. Hence, as noted by Chafer (1992) and other authors, caution should be exercised if attempting to assign a cave deposit of owl pellets to any particular owl species.

Several caves (M-27, M-28, Mabel Cave, Harman Two, Natural Bridge and Flowerpot) contained some highly fragmented bone material that was characteristic of prey of a small carnivore, such as the Eastern Quoll *Dasyurus viverrinus* (syn. *D. quoll*) (0.7-2.0 kg) or the Spotted-tailed Quoll *D. maculatus* (1.5-7 kg) (Wakefield 1960a, 1964a, 1964b; Baird 1991). The bones of these predatory species were also found in a number of the deposits, although the Eastern Quoll was collected more frequently than the Spotted-tailed Quoll (Mansergh 1983). Both species have been implicated as accumulators of the fossil material, but it is difficult to substantiate whether one or both species were involved at the relevant deposits. It appears that an introduced predatory species (e.g. the Red Fox *Vulpes vulpes*) (3.5-8.0 kg) was not involved because of the absence of other introduced species (e.g. the European Rabbit *Oryctolagus cuniculus*) (1.0-2.4kg) (Drummond 1963), but the possibility remains that parts of some deposits were due to the Tasmanian Devil *Sarcophilus harrisii* (7.0-9.0 kg). Remains of this species were also found in several deposits (Wakefield 1963b, 1967a), and it is believed that the Tasmanian Devil was responsible for at least part of the accumulation from Clogg's Cave (Hope 1973; Flood 1974). While there are modern records of the Eastern Pygmy-possum falling prey to both Quolls and Devils (Guiler 1970; Belcher 1995), the published accounts of the fossil deposits do not permit assessment of the relative contribution of these predators to the accumulations.

Past and present distribution of the Eastern Pygmy-possum

As far as is known, the 17 cave deposits referred to comprise the Victorian Eastern Pygmy-possum fossil record. The localities are well separated between far south-western Victoria, the Brisbane Ranges and near Buchan in eastern Victoria. The record suggests that in the Holocene and late Pleistocene, the Eastern Pygmy-possum was widely distributed in southern Victoria, as it is today, or alternatively, the species may have had a disjunct range in prehistoric times. This raises questions about the areas of origin of this species and its subsequent dispersal through Victoria. It would appear that present evidence is insufficient to allow definitive answers, and we emphasise that fossil localities for the Eastern Pygmy-possum are dependent on the presence of suitable caves as preservation sites, and consequently the fossil record is both incomplete and biased. In addition, more information on its distribution is obviously available for modern than for prehistoric populations. However, the available information does not indicate that the northern plains are part of the present or past distribution, although this probably reflects the paucity of caves in northwestern Victoria, as well as the unsuitability of modern habitats for the species in that region.

It would appear that the fossil localities identified have nearby records from extant populations, and at this juncture, the evidence does not suggest any striking contraction of geographic range as reported for the Mountain Pygmy-possum (Broome and Mansergh 1989). This could be due to wider ecological tolerances and/or a wider geographic range of the Eastern Pygmy-possum than that of the Mountain Pygmy-possum.

Although more than 700 caves of varying dimensions have been recorded for Victoria (Matthews 1985), only a small proportion contain mammal bones, and fewer still contain the remains of the Eastern Pygmy-possum. At the time of this study, it appears that Eastern Pygmy-possums have not been collected from deposits other than those of Holocene and Late Pleistocene age reported in this paper. Without documenting the distribution and composition of all fossil-bearing caves in Victoria (but see Horton 1984 p. 645; KID;

Museum Victoria database), it appears that the Eastern Pygmy-possum is absent from the much older Tertiary mammal fauna localities (Rich 1991).

An example of a cave where the species was not found, but may have been expected to be present, is the main lava cave at Mount Hamilton, 177 km west of Melbourne. Wakefield (1963a, 1963b) reported that Mount Hamilton is believed to have been a death-trap cave, 'similar in operation' to Fern Cave. The reason why the Eastern Pygmy-possum was found at Fern Cave but not at Mount Hamilton is unknown. Both were primarily death-trap caves, and both have yielded a variety and abundance of small mammals, including representatives of the families Dasyuridae, Peramelidae, Phalangeridae, Potoroidae, Macropodidae, and Muridae (Wakefield 1963b). The discrepancy may indicate that the Eastern Pygmy-possum was absent from the Mount Hamilton area during the period of deposition, that this natural pitfall was catch-deficient for the species, or neither of these hypotheses.

The age of the fossil and sub-fossil material ranges from late Pleistocene to recent. Several deposits (McEachern's Cave. McEachern's Deathtrap Cave; Pyramids Cave, Clogg's Cave and Bridgewater Cave South) are dated at more than 10 000 years. However, the accuracy and reliability of some of the reported radiocarbon dates requires qualification. For example, the age of the Bridgewater Cave South material (Godwin 1980; Lourandos 1983) was later shown to be 8000 years too young (Bird and Frankel 1991). The dates for Pyramids Cave may also be unreliable and should be treated with caution (Wakefield 1969a; Lundelius 1983). The Clogg's Cave date can be considered reliable (Ride and Davis 1997), but the majority of other dates may be inaccurate (Baynes 1999) and needs to be corroborated by other methods (as advocated by Moriarty *et al.* 1999).

Although we have limited our report to the fossil records from Victoria, further insight might be achieved by review of the fossil records outside Victoria. Records of the Eastern Pygmy-possum, of late Pleistocene or younger age, have been found from caves or archaeological deposits extending from south-eastern South Australia (Tidemann 1967; Smith 1971; Williams 1980; Wells *et al.* 1984; Pledge 1990; Brown and Wells 2000; Moriarty *et al.* 2000; Reed and Bourne 2000), through eastern NSW (Ride 1960; Drummond 1963; Turnbull and Schram 1973; Gorter 1977; Hope 1982; Recher *et al.* 1993; Morris *et al.* 1997), and into south-eastern Queensland (Archer 1978). Fossil deposits in Tasmania have also revealed the species (Bowdler 1984; Cosgrove 1995; Garvey 1999). A cursory examination of the distribution of the fossil sites outside Victoria appears to represent largely the known modern range for the species. These sites are reported to contain mainly cave accumulations of regurgitated owl pellets, as in Victoria.

Conclusion

This study has provided valuable data on the past distribution of the Eastern Pygmy-possum, and some insight into the long susceptibility of the species to predation by owls and carnivorous marsupials, as well as its propensity to capture by pitfall. Further research should involve closer study of the museum collections, as Wakefield's material held at Museum Victoria is at present only partly sorted. Microscopic reappraisal of the collection might be profitable in terms of identifying diagnostic taphonomic signatures of the predatory species, such as skeletal element representation and breakage, digestive corrosion patterns or tooth markings, which could allow specific attribution to predatory species or verification of pitfall origin.

Re-examination and refinement of the age limits of the materials are also desirable, and this would provide an opportunity to examine chronological aspects of the occurrence of the species, and to generate and test palaeobiogeographical hypotheses on dispersal or vicariance events. Further knowledge of the habitat requirements and of the limiting factors on distribution of modern populations are also necessary, to aid and inform interpretations of the temporal abundance of the Eastern Pygmy-possum in past vegetation communities, and to assess the effects of climatic fluctuations on the species. In this regard, further research on the plant communities that may have been associated with the fossil deposits is also important. It is hoped that this review will serve as an introduction to the literature on the relevant cave deposits, and promote further interest and understanding of the Eastern Pygmy-possum throughout its range.

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One hundred years ago

SOURCE OF THE YARRA RIVER

by Mr AE Kitson, FGS

... that our present maps of the source of the Yarra and Thompson Rivers were incorrect, as it had been found that the stream which had hitherto been regarded as the furthest source of the Yarra was really the head of the Thompson. The mistake had occurred through the latter river flowing first west, then north, and east, before taking its southerly course. It was probable that at one time the portion flowing westerly had belonged to the Yarra, but it had been captured by the stream flowing to the north, and was thus lost to the Yarra watershed. The country where this occurred was covered with very dense vegetation, and without the aid of instruments it was quite impossible to ascertain the positions of ridges and trends of the valleys.

From *The Victorian Naturalist* **22** (1905), pp.55.

The density and distribution of cattle and horse dung in Pretty Valley, Bogong High Plains, Victoria

David Meagher[1]

Abstract

Cattle dung pats and horse droppings were counted in Pretty Valley, on the Bogong High Plains, along one permanent transect in March 2004 and 14 transects in March 2005 (total length 19.9 km). The results show that cattle pat density is highest in vegetation where grasses are dominant, but that pats are distributed throughout all other vegetation types, in varying densities. Horses contributed 2.3% of the total droppings counted. The number of cattle pats on a permanent transect in *Poa hiemata* tussock grassland fell by 17% between 2004 and 2005, in the absence of cattle. In 2005, it is likely that at least 1 million cattle pats remained in *Poa hiemata* grassland in Pretty Valley. Some potential consequences of the presence of cattle pats are discussed. (*The Victorian Naturalist* **122** (4), 2005, 171-178)

Introduction

Until the wildfires burnt much of the Victorian high country in February 2003, up to 8000 head of cattle grazed some 60 licensed areas in the Alpine National Park between December and March each year (Parks Victoria 2005). About two thirds of these cattle grazed in alpine or high sub-alpine country, including Pretty Valley on the Bogong High Plains (Fig. 1). Since 2003 cattle have not been returned to the Bogong High Plains because of the risk of damage to the burnt areas. In May 2005 the Victorian Government announced that cattle would no longer be allowed to graze in the Alpine National Park, of which Pretty Valley is a part.

Cattle in alpine areas are free-ranging but prefer to graze within open vegetation communities where palatable plants are abundant, such as grassland, open heathland and snowpatch (van Rees 1984). Despite the observations of van Rees, it has often been assumed, and sometimes stated as fact, that cattle do not enter other vegetation types because palatable plants are not available there (e.g. closed heathland) or the terrain is too difficult for them to negotiate (e.g. sphagnum bogs).

Studies of cattle in alpine environments have understandably focused on long-term changes in vegetation structure caused by grazing, and on soil disturbance from trampling. However, bushwalkers and other visitors to the Bogong High Plains have long complained about the amount of cattle dung there, and concerns have been raised about the potential effects of the dung. Anecdotal evidence suggests that cattle dung could take several years to disintegrate in alpine regions. The aim of this study was to assess the density of pats in different vegetation types, and to begin measuring the change in abundance over time.

Methodology

Pretty Valley was chosen as the site for this study because it remained largely unburnt after the 2003 fires, and thus both the dung and the vegetation were intact and easily identifiable. The valley is also easily accessible, has been grazed by cattle over a long period, and supports a number of vegetation communities, although dominated on the valley floor by *Poa hiemata* grassland.

A two-metre transect width was found to be the largest practical width for one person. It enabled pats to be counted quickly and accurately, and allowed a simple measure with a metre rule to determine whether pats were within or outside the transect without having to leave the transect centre-line. The methodology was tested in March 2004 along three short transects, and at that time a transect was set up in *Poa hiemata* grassland as a permanent transect along which counts could be made each year to determine decomposition rates.

Fourteen transects of various lengths and orientations were selected so that all vegetation types in the valley would be sampled (Fig. 2).

Most transect starting points were selected at random along roads or tracks, so that

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Fig. 1. Pretty Valley, Bogong High Plains; a view from Cope Saddle Track towards Mount Jim. Darker areas on the valley floor are bog, relic bog and patches of open heathland. Darker areas on the slopes are open and closed heathland.

their positions could be accurately identified. Starting points were identified on a vegetation map before the survey, and were therefore not influenced by conditions at the time of the survey. Pole 333 on the Alpine Walking Track was selected as the starting point for transect 3 because it is a clearly defined landmark, and the direction was chosen to pass through many different vegetation types while traversing as much of the valley as possible. The commencement point of transects 4, 5, 12 and 13 was determined by selecting at random a point on transect 3, and their directions were determined randomly using a toy 'spinner'. Transect 14 commenced at the end of transect 13, and its direction was also selected at random. The alignments of other transects were determined either wholly randomly, as above, or semi-randomly (on the basis of the range of vegetation types they could pass through). Transect 2 consisted of a series of straight lines aligned more or less parallel to the Alpine Walking Track. This transect was aligned to sample *Poa costiniana* and basalt outcrop grasslands. The directions of transects 1, 6, 9, 10 and 11 were altered during the transects to ensure that they passed through some of the rarer vegetation types, or to avoid obstacles such as boulder fields.

Where possible, transects were walked by line-of-sight using clearly discernible landmarks. When landmarks were not available or not visible, transects were walked on compass bearings. Transect start and end points were identified by GPS, and a standard metre rule was used to define the lateral limits of the transect. Pats intersecting the transect boundary were counted only if more than half of their area was clearly within the transect. Fragments close to one another were counted as a single pat, even if it seemed likely that they had been derived from more than one pat. Droppings of horses were recorded separately. This method of counting ensured that over-counting did not occur.

Vegetation types, as defined by McDougall (1982), were recorded along

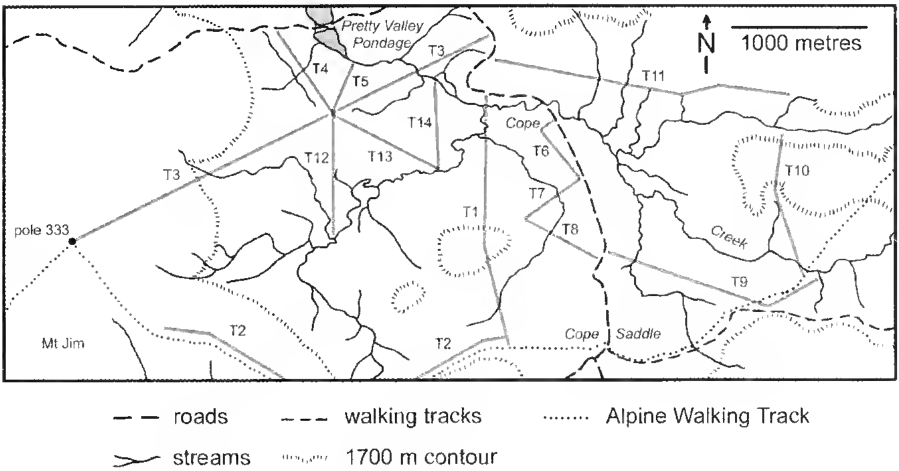

Fig. 2 Locations of transects in Pretty Valley, Bogong High Plains.

each transect. Along some parts of some transects the vegetation differed from the mapped vegetation. This is an artefact of the difficult nature of aerial photo interpretation during the original mapping. The results given in this paper are based on the actual vegetation encountered.

Results

Details recorded during each of the 14 transects are presented in Table 1, and summarised, for horses and cattle, in Table 2.

Other observations

Most cattle pats were intact, dry, and firmly attached to the soil or vegetation on which they were deposited, and there was no evidence of attack by insects or fungi (Fig. 3). In contrast, most horse droppings were actively disintegrating and weakly if at all attached to the substratum, and fungi were often seen on them (Fig. 4). Dung beetles (family Scarabaeidae) were found in one group of horse droppings, but they were dead and had not completed the disintegration of the droppings. Pats in closed heathland were found most commonly where cattle tracks formed narrow breaks in the vegetation, but many were deposited in untracked vegetation.

Little decomposition of pats was apparent. Thirty-eight pats selected at random on transect 1 were inspected for signs of biological activity such as dung beetle or fungal attack. Fungal mycelia were not visible in any of these pats, and no beetle or other insect activity was apparent. In contrast, fruiting fungi were found on numerous horse droppings, and dead dung beetles were found in one horse dropping.

For a broad comparison, a transect approximately 200 metres long and two metres

Table 1. Results of transects walked across a variety of vegetation types. Figures in the columns headed 'Cattle' and 'Horse' indicate the number of pats counted.

Vegetation	Distance (m)	Cattle	Horses
Transect 1, length 1950 m.			
Poa hiemata tussock grassland	90	14	–
bog/relic bog	285	35	1
Poa hiemata tussock grassland	390	82	1
open heathland	120	8	–
Kunzea heathland	225	6	–
open heathland	75	9	–
Kunzea heathland	225	3	–
Poa hiemata tussock grassland	150	17	–
bog/relic bog	240	16	5
Poa hiemata tussock grassland	150	46	4

Table 1. (Continued)

Vegetation	Distance (m)	Cattle	Horses
Transect 2, length 3705 m.			
Poa hiemata tussock grassland	210	59	6
open heathland	195	30	1
bog/relic bog	90	2	1
open heathland	480	52	1
Poa costiniana grassland	915	96	5
basalt outcrop grassland	450	28	3
snowpatch	195	15	–
basalt outcrop heathland	450	3	1
basalt outcrop grassland	720	21	2
Transect 3, length 3475 m.			
Poa costiniana grassland	270	57	2
open heathland	360	11	–
Snow Gum grassy woodland	25	10	1
Kunzea heathland	405	11	–
Poa costiniana grassland	525	20	1
Poa hiemata tussock grassland	1245	238	1
bog/relic bog	75	7	–
Poa hiemata tussock grassland	120	42	–
bog/relic bog	300	8	–
Poa hiemata tussock grassland	150	27	–
Transect 4, length 825 m.			
Poa hiemata tussock grassland	825	115	–
Transect 5, length 480 m.			
Poa hiemata tussock grassland	480	133	3
Transect 6 – permanent (2004), length 660 m.			
Poa hiemata tussock grassland	660	70	2
Transect 6 – permanent (2005, length 660 m.			
Poa hiemata tussock grassland	660	58	1
Transect 7, length 585 m.			
Poa hiemata tussock grassland	195	29	–
bog/relic bog	75	10	–
Poa hiemata tussock grassland	315	43	–
Transect 8, length 695 m.			
Poa hiemata tussock grassland	180	14	–
Kunzea heathland	45	3	1
bog/relic bog	105	2	–
open heathland	195	6	–
Poa hiemata tussock grassland	120	26	–
Transect 9, length 1710 m.			
Poa hiemata tussock grassland	195	27	–
bog/relic bog	105	1	–
Poa hiemata tussock grassland	75	28	–
bog/relic bog	225	5	3
Poa hiemata tussock grassland	1110	196	2
Transect 10, length 1140 m.			
bog/relic bog	30	2	–
Poa hiemata tussock grassland	40	10	–
bog/relic bog	80	4	–
Poa hiemata tussock grassland	45	10	–
open heathland	375	16	–
Poa hiemata tussock grassland	75	14	–
open heathland	60	7	–
Poa hiemata tussock grassland	225	49	–
closed heathland	210	12	–

Table 1. (Continued)

Vegetation	Distance (m)	Cattle	Horses
Transect 11, length 2370 m.			
Poa hiemata tussock grassland	705	87	–
closed heathland	135	3	–
Poa hiemata tussock grassland	120	21	–
bog/relic bog	20	1	–
Poa hiemata tussock grassland	1390	222	2
Transect 12, length 910 m.			
Poa hiemata tussock grassland	910	243	2
Transect 13, length 825 m.			
Poa hiemata tussock grassland	825	184	1
Transect 14, length 615 m.			
Poa hiemata tussock grassland	615	167	1

Table 2. Summary of results for all transects, for cattle and horses

Cattle, all transects 2005, length 19 895 m.

Vegetation	Distance (m)	No. pats	Mean (pats/m^2)
Snow Gum grassy woodland	25	10	0.200
Poa hiemata tussock grassland	11610	2213	0.095
snowpatch	195	15	0.077
Poa costiniana grassland	1710	173	0.051
open heathland	1860	139	0.037
bog/relic bog	1630	93	0.029
closed heathland	345	15	0.021
basalt outcrop grassland	1170	49	0.021
Kunzea heathland	900	23	0.013
basalt outcrop heathland	450	3	0.003

Change in count, permanent transect: 70 (2004) to 58 (2005) = -17%

Horses, all transects 2005, length 19 895 m.

Vegetation	Distance (m)	No. pats	Mean (pats/m^2)
Snow Gum grassy woodland	25	1	0.020
bog/relic bog	1630	10	0.003
Poa costiniana grassland	1710	8	0.002
basalt outcrop grassland	1170	5	0.002
Poa hiemata tussock grassland	11610	26	0.001
basalt outcrop heathland	450	1	0.001
snowpatch	195	0	< 0.001
open heathland	1860	2	< 0.001
closed heathland	345	0	< 0.001
Kunzea heathland	900	1	< 0.001

wide was made across a grazed paddock of exotic grasses at Wooragee, near Beechworth. The mean density of pats on this transect was 0.128 pats per square metre (n = 51), and 55% of the pats on this transect were being disintegrated by dung beetles.

Discussion

Although some caution is needed in comparing the results for different vegetation types because of the small sample sizes (except *Poa hiemata* grassland), some general observations can be made. The mean density of cattle pats was greatest in vegetation dominated by grasses (Snow Gum grassy woodland, *Poa hiemata* tussock grassland, snowpatch and *Poa costiniana* grassland). The high density in the single Snow Gum grassy woodland area surveyed is unlikely to be indicative of that vegetation type as a whole, since it was easily accessible from the adjacent grasslands and would be favoured as shelter in poor weather.

On the reasonable assumption that pat density is an indicator of the time spent at a particular location, the results suggest that cattle prefer *Poa hiemata* grassland over *Poa costiniana* grassland, and that snowpatch vegetation is about as attractive

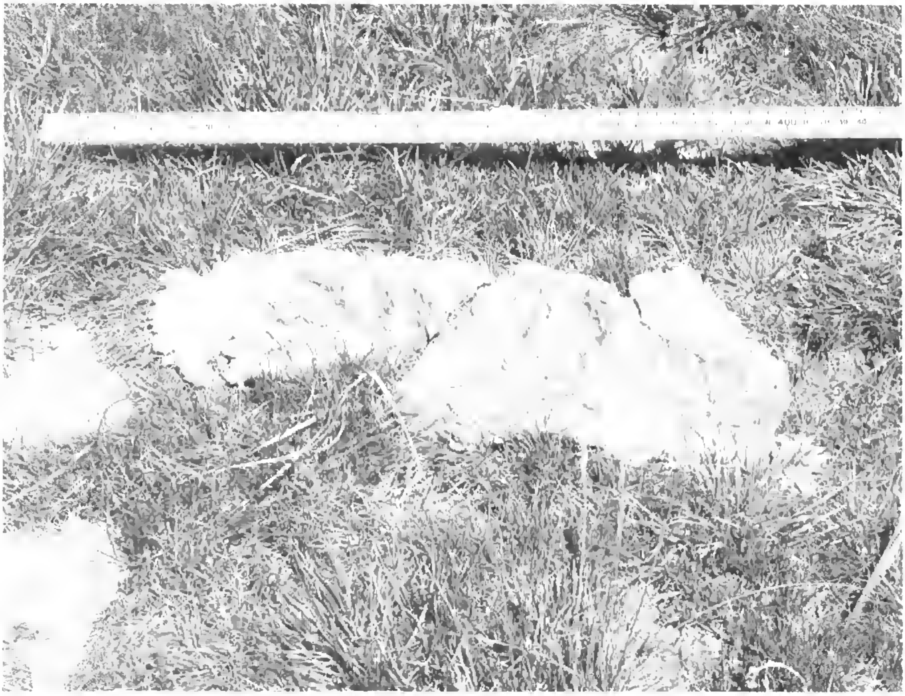

Fig. 3. Intact cattle pat, transect 2.

as grassland for cattle. Basalt outcrop grassland is the least preferred of the grassy vegetation, perhaps because it is rocky underfoot and the grass is sparse.

The results confirm that cattle enter all vegetation types, including bogs and relic bogs, closed heathland and *Kunzea* heathland. The lower densities of pats in these vegetation types suggest that cattle do not graze there. In bogs and relic bogs they are likely to be seeking water, and in closed heathland and *Kunzea* heathland they are likely to be moving from one grassland to another or seeking shelter.

The decrease of 17% in the number of pats on the permanent transect suggests that pats survive for many years in the alpine environment, and that the pats present are the result of several years of deposition. Cattle dung on lowland farmland is usually wholly decomposed within a few months of deposition, and disintegration may be exceedingly rapid in areas where there are two or more introduced dung beetles, such as *Onthophagus taurus* (Schreber) and *Onitis alexis* Klug (Tyndale-Biscoe 1994).

Ultimately, however fungal and bacterial decomposition destroys the dung. Decomposition rates are likely to be much slower in the colder climate of the high country, where insect, fungal and microbial activity is probably confined to the warmer months. It is possible that mechanical disturbance (by snowmelt, wind, rain, trampling, etc.) may be the main cause of pat disintegration and dispersal.

Horse droppings are much less common than cattle pats in Pretty Valley (2.3% of all counts), and most that were encountered were disintegrating. It is reasonable to say that their contribution to the overall dung abundance in Pretty Valley is very small, and that they break up rapidly. As cattle dung abundance declines over time, horses will eventually become the major source of dung in the area.

In this survey, only the data for *Poa hiemata* grassland can be treated statistically, as the sample sizes for other vegetation types were too small. In order to analyse this data, the mean pat densities in all transect segments passing through *Poa hiemata*

Fig. 4. Fungus on horse dropping, transect 1.

grassland were calculated, and the mean, standard deviation and standard error of these means were found (mean = 0.104 pats/m², s.d. = 0.038, s.e. = 0.0081). The relatively large s.d. indicates that cattle do not graze this grassland uniformly. The lowest density in any transect segment was 0.039 pats/m², and the highest was 0.187 pats/m².

The total area of *Poa hiemata* grassland in Pretty Valley is approximately 14 km² (Department of Sustainability and Environment, unpublished data). Thus the total number of pats in the valley in this vegetation type alone in 2005 is likely to be have exceeded 1 million. The total number of pats in Pretty Valley (total area at least 28 km², of which the remainder is mostly open heathland. *Poa costiniana* grassland and bog/relic bog) would clearly exceed this figure considerably.

What are the possible consequences of large numbers of cattle pats? Cattle pats attract house flies, bush flies and stable flies, which lay eggs around the edges of pats (DPI Victoria 1995, DPI Queensland 2004). The larvae crawl into or under the pats, where they are protected from heat, sunlight and predators. In the absence of introduced cattle, horses, deer and hares, only wombat droppings would be suitable for flies, but no wombat droppings were encountered during this survey. The cattle pats therefore must have contributed substantially to artificially raised populations of some flies on the Bogong High Plains. March flies and blow flies do not breed in pats, so their populations would be unaffected by the presence of cattle pats. One might expect, then, that the abundance of house flies, bush flies and stable flies would gradually diminish on the High Plains as cattle dung disintegrated and decomposed, but that the abundance of March flies and blow flies would remain unchanged.

Cattle pats are a major potential vector for the introduction and spread of palatable weed species in alpine vegetation (van Rees 1984, McDougall and Appleby 2000). A change in the nutrient status of the soil (which is the likely result of the localised release of nutrients into the soil from pats) might also encourage the establishment of exotic species, at the expense of native species that are adapted to lower nutrient levels (Rowe et al. 2004).

Another potential effect of the presence of cattle pats is an increase in the input of soluble nutrients such as potassium and phosphorus into the water table and directly into streams. Although this is likely to occur only where pats lie on damp soil or are close to streams (since dry soil and vegetation would act as buffers elsewhere), the presence of pats in bogs and relic bogs indicates that it is a possibility. Remarkably, no water quality data (and only historic stream flow data) have been published for the Bogong High Plains (VWRDW 2005). However, the water quality of the East Kiewa River, of which Pretty Valley is one of many source streams, was rated 'marginal' in 1999 (VWRDW 2005), and stream condition in the Kiewa catchment as a whole was rated 'poor' in 2002 (VCMC 2002).

Acknowledgements

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One hundred years ago

A LIZARD MIMICKING A POISONOUS SNAKE

By T. S. Hall, M.A.

A specimen was recently sent to me for identification which appeared to be the young stage of the brown snake, *Diemenia textilis*, D. and B., named by McCoy *Furina bicucullata*. On turning to McCoy's plate in his "Prodromus of the Zoology of Victoria," the colouring of my specimen appeared almost identical with that of the coloured figure. There were the same velvety black patches on the head and nape, with deep orange between the two bands and behind the last. The back had the exact tint of pale brown in both cases. True, there were no transverse black marks on the body, and the ventral surface was not mottled as in the figure and was of a paler tint. But these markings I knew were variable, and the bands and spots were often absent. The only other noticeable colour difference was a light transverse line cutting the anterior black patch into two nearly equal parts. Still, I felt satisfied as to the identity of my specimen. However, to make quite sure, I examined the plates of the head. They did not agree, and, glancing at the body, I saw that I was the victim of one of Nature's practical jokes, for the specimen was clearly one of the so-called legless lizards.

Having been deceived myself, I suppose it was only in accordance with human nature for me to wish to entrap as many of my friends as possible. One after another they pronounced it to be McCoy's Furina. I shall mention no names; they must confess themselves. I need only say that it was extremely comforting to me to find one naturalist after another falling into the trap which Nature had so cunningly laid.

From *The Victorian Naturalist* **22** (1905), p. 74.

Ecology of the endangered Southern Shepherd's Purse *Ballantinia antipoda* (Brassicaceae) and the associated moss mat community on Mount Alexander, Victoria

JE Seidel, GJ Ambrose, SK Florentine and ME Wilson

Abstract

Southern Shepherd's Purse *Ballantinia antipoda* (Brassicaceae) is a small, cool-season annual herb. It now occurs in only one of its previously recorded locations in Victoria and Tasmania. It is currently endemic to Mount Alexander Regional Park, Victoria. Tall plants and high densities of *B. antipoda* were associated with *Triquetrella papillata* and *Campylopus clavatus*. The field condition of *B. antipoda* was low, in terms of size, reproductive condition and health, in denser foliage of the robust mosses *Breutelia affinis*, *Polytrichum juniperinum*, *Campylopus bicolor* and *C. introflexus*. In spring, the thin soil and moist substrate of the moss mats present *B. antipoda* with suitable conditions for germination, sequential flowering and seeding events. Mosses frequently are dry and have their leaves furled in October and November, allowing *B. antipoda* seed released at this time to penetrate moss mats more effectively. Moss mat disturbance by foraging White-winged Choughs *Corcorax melanoramphos* could generate suitable microhabitats for *B. antipoda*. The remote location of the granitic outcrops provides *B. antipoda* with a refuge from most disturbances and the competitive effects of larger species of vascular plants. (*The Victorian Naturalist* **122** (4) 2005, 179-188)

Introduction

Biodiversity has become an issue of both scientific and political concern, primarily because of a rising public awareness of increasing extinction rates caused by human activities (Pausas and Austin 2001). Southern Shepherd's Purse *Ballantinia antipoda* (Fig. 1a) is an example of a species declining rapidly and now close to extinction. It is a small, cool-season annual crucifer currently known only from montane moss mats on granitic outcrops in Mount Alexander Regional Park, Victoria (Alexander 1999). *Ballantinia antipoda* is listed as endangered under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 and listed as Threatened under the Victorian *Flora and Fauna Guarantee Act* 1988.

Despite its rarity, conservation status and location within the regional park, there is only limited information on the ecology of *B. antipoda*. The significance of the microhabitat provided by the associated moss mat community is unclear. *Ballantinia antipoda* previously occurred at other locations, including Daylesford, Skipton, Mount Macedon, Mount Cole, Mount Buangor and Mount Langi Ghiran in Victoria. The species may have occurred on basaltic rock near Carisbrook and Werribee, and has not been located in Tasmania since the 1800s (Alexander 1999; DSE 2002).

Potential reasons for the decline of *B. antipoda* include the unknown effect of wildfire; disturbance from introduced grazing fauna (rabbits, pigs and goats); habitat destruction resulting from vehicles, bikes, trampling and abseiling; the presence of roads, tracks, quarries and tower installations; and changes in vegetative composition (weed invasion) (Alexander 1999). More recently, White-winged Choughs *Corcorax melanoramphos* (Corcoracidae) have provoked concern. They have been observed disturbing the moss mat habitat whilst foraging for invertebrates, mainly the introduced European Millipede *Ommatoiulus moreleti* (Julidae) (Simpson and Day 2000).

In view of the threatened status of *B. antipoda*, this study needed to identify the current status of this plant and the factors limiting its distribution and success on Mount Alexander, Victoria. The study aimed to: (i) produce large and small-scale maps of the distribution of *B. antipoda* populations on Mount Alexander in relation to aspect, physical and biological attributes, (ii) determine the parameters

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associated with the occurrence of *B. antipoda*, (iii) relate the phenology and field condition of *B. antipoda* to microhabitat variables, and (iv) apply an understanding of the ecology of *B. antipoda* to the development of potential initiatives in habitat management.

Methods

Target species

Ballantinia antipoda is an endemic Australian species belonging to the Cress or Mustard family, Brassicaceae (F Muell.). The sparsely haired, prostrate or weakly ascending stems grow to 5 cm, or sometimes up to 10 cm, high (Gray and Knight 2001). Stems arise from a basal rosette of stalked, entire or, more commonly, spoon-shaped leaves that are often divided into three parts (Fig. 1a). The insect-pollinated flowers are white, small and petiolate, reaching 4 mm in diameter (Fig. 1b). Flowers occur on indeterminate, axillary racemes extending above the foliage. The flowers consist of a corolla of four shortly-clawed petals and a calyx of four sepals (2-2.5 mm long) The fruit, a silicula, is ellipsoid, 3-5 mm long and 1.5-3 mm wide. It is dry and dehiscent at the apex, releasing wind-dispersed seeds (Carr 2003). The seed is without endosperm (Watson and Dallwitz 1992) and therefore unlikely to be long-lived or to emerge successfully if buried deeply. Seeds are produced from late September to early October, with a continual release of seeds until early November.

Fig. 1a. Habit sketch of Southern Shepherd's Purse *Ballantinia antipoda*, showing variable leaf shape. The hairy leaves form a rosette, but also climb the stem. Elliptical dry fruits (siliculae) are seen below the white flowers.

Study site

Mount Alexander Regional Park lies approximately 120 km north-west of Melbourne and 3 km east of Harcourt, Victoria (144° 19' S, 37° 00' E). Mount Alexander rises above an otherwise flat landscape in the North Central catchment region of Victoria. The mountain, with an elevation of 746 m asl, is a granitic intrusion estimated to be 367 million years old (Parks Victoria 2002). It receives a mean annual rainfall of approximately 700 mm.

During the 1870s, Mount Alexander was stripped of most of its vegetation to provide timber for the goldfields (Parks Victoria 2002). Sheep and cattle previously grazed the mountain. Since the release of myxomatosis in the 1950s for the control of rabbits, the understorey vegetation has been able to re-establish (DSE 2002). The current vegetation consists mainly of Manna Gum *Eucalyptus viminalis* woodlands, with Messmate *E. obliqua* occurring within deeper soils at higher elevations. Associated tree species include Candlebark *E. rubida*, Blue Gum *E. globulus*, Yellow Box *E. melliodora* and Peppermint species *E. radiata* and *E. dives* (Costermans 1994).

The higher elevations of Mount Alexander consist of igneous intrusive granodiorite with an estimated age of 416 million years (LCC 1978). Currently two granite quarries are in operation.

Mapping

Population locations of *B. antipoda* were determined using GPS and recorded on large-scale maps produced in MapInfo®. Scale maps of each site were produced, documenting the granitic outcrop area, moss mat patches, location of *B. antipoda* within moss mats, watercourses and associated over-storey vegetation (Seidel 2004). Scale-accurate computer-generated maps were produced using the grid system (m^2) in Paint Shop Pro 7®.

Microhabitat analysis

Soil moisture was calculated from random soil samples at four study sites, taken over four weeks on three occasions, using a cylindrical metal corer. An index of bryophyte desiccation was derived by recording moss shoot thickness (cm) and condition (consisting of estimates of moist-

Fig. 1b. Flower of *Ballantinia antipoda*, showing four clawed (narrow-based) petals, a superior ovary and six free hypogynous stamens (two short and four long).

ness through touch and visual analysis). Soil samples were weighed before and after oven drying for 48 hours at 32°C.

Randomly assigned quadrats of 50 cm x 50 cm were assessed at six study sites over a four-month period. The number of individuals of *B. antipoda* and other vascular plants was recorded for use in density and species richness values. The 'condition' or longevity of *B. antipoda* plants in each quadrat was documented and used to determine a quantitative value for a 'condition success' index (Table 1).

Cover estimation

Projected foliage cover was recorded for the dominant bryophyte and vascular plant species using the Domin-Krajina cover abundance scale (Brower *et al.* 1998). This was determined using a point frame. Vascular plant species were allocated to one of five groups according to life-form and origins: (i) native succulents, (ii) native grasses, (iii) native herbs and lilies, (iv) introduced grasses, and (v) introduced herbs and lilies. The field condition of the moss mats was allocated to one of five categories of hydration: desiccated, dry/closed leaves, moderately dry, moist/squeezable water and wet/free water with open leaves (Table 2). At the centre of each quadrat, soil depth and moss mat depth (cm) were measured using a metal ruler.

Statistical analysis

Species richness or α-diversity was calculated as the number of species present at a given site. The density of *B. antipoda* plants was recorded as the number of individuals of the species per square metre. Coverage of non-vascular and vascular plants was determined as the proportion of ground covered by a vertical projection of the aerial shoots of the plant. Relative coverage was calculated as the coverage of an individual species as a proportion of all species coverage recorded for a given area (Brower *et al.* 1998).

Analysis of variance was performed for quantitative variables, which met the assumptions required to perform an ANOVA. Pair-wise comparisons of statistically significant group variables were made using Minitab® statistical software programs to determine within-group variation. Significant variables were tested for Type 1 errors using Bonferroni's correction Post-Hoc analysis in Minitab®.

Results

Twenty moss species and four liverwort species were identified across eleven study sites (the total number of sites containing *B. antipoda*) (Appendix 1). Lichens, mainly squamulose and fruticose species from the genus *Cladonia*, were present on rock surfaces. The richest moss genera were *Campylopus*, represented by four species, and *Bryum*, represented by three species. Bryophyte richness of the sites ranged from three to 17 species. *Hypnum cupressiforme* was abundant as an understorey in the grassy communities on soil, but was not observed in the moss mat communities on granite. The fine moss *Brachythecium rutabulum* was uncommon in moss mats and more abundant in the grassy communities. Vascular plant species richness comprised 15 native species and 13 introduced weed species across the eleven study sites.

The number of *B. antipoda* plants per study site varied substantially, from 52 to approximately 500. The density of *B. antipoda* varied considerably between study sites, from 1.1 plants per m^2 at East Face sub-population 2 to 30.8 plants per m^2 at East Face. Moss mat area per study site ranged from 46 m^2 at East Face 1 to 569 m^2 at East Slope. Site elevation ranged from

Table 1. Field condition success index values for *Ballantinia antipoda*.

Index No	*Ballantinia antipoda* Condition Assessment	Success Value
1	Senescing/Withered/ Small size	Poor
2	Flowering	Insufficient
3	Fruiting	Satisfactory
4	Seeding	Sufficient
5	Flowering/Fruiting/ Large size	Good
6	Fruiting/Seeding/ Flowering/Large size	Excellent

Table 2. Bryophyte field condition index values.

Index No	Bryophyte Condition Assessment	Success Value
1	Desiccated - Brown/red	Poor
2	Dry crumbly -Brown	Insufficient
3	Moderately dry - Brown/green	Satisfactory
4	Moist/Squeezable - Green	Good
5	Wet/free water - Open green leaves	Very good

563 m to 729 m asl. *Ballantinia antipoda* was found only at sites where aspects were either easterly or westerly (Table 3).

Substrate data

Soil depth ranged from 0 cm to 4.6 cm and thickness of moss mat turf ranged from 0 cm to 3.1 cm across the six key study sites. Soil moisture content varied substantially between sites and over the sample dates. The mean soil moisture content was greatest at Shepherd's Flat (0.98 g) and least at East Slope (0.74g). Soil moisture content varied substantially between study sites and sampling dates (Fig. 2).

Target species phenology

Demographic analysis of *B. antipoda* showed individual plants undergoing their life cycle from July to early November 2003. Plants flowered during spring, from early September to late October. The annual growth cycle and indeterminate inflorescences of *B. antipoda* resulted in the plants flowering, fruiting and seeding sequentially over the period observed (Table 4).

Cover

The percentage cover by moss species ranged from 1.44% for *Bryum caespiticium* to 47.75% for *Breutelia affinis*. Three moss species showed very high relative coverages: *Breutelia affinis* (47.75%), *Campylopus clavatus* (38.38%) and *Polytrichum juniperinum* (32.44%) (Table 5). The dominant vascular plant group was the native succulents, notably purslanes *Calandrinia* species (family Portulacaceae). Succulent species showed the greatest coverage by flowering plants at all sites, particularly at Shepherd's Flat (14.79% per m^2) (Table 6).

Each moss species retained similar areas of cover through the study and the stands of each became more permeable in October and November, as the mosses became desiccated and furled their leaves around the stems. This coincided with the period of greatest seed release by *B. antipoda*.

Statistical analysis

An analysis of variance was performed on the dependent variable of *B. antipoda*

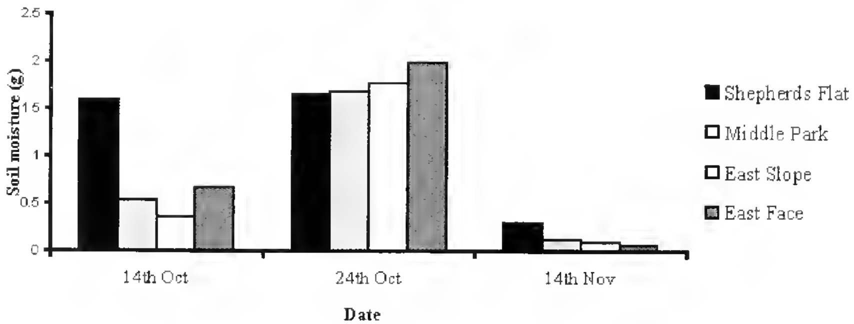

Fig. 2. Soil moisture content at four sites on Mount Alexander, Victoria 2003.

Table 3. Site characteristics and *Ballantinia antipoda* population size and density within the eleven study sites for the growing season of 2003 at Mount Alexander, Victoria. * These six sites were designed as key study sites on the basis of their representative nature as habitats and their accessibility. # Inclination was not determined for non-key study sites.

Site	Total moss mat area (m^2)	Moss mat area sampled (m^2)	No. of *B. antipoda* per area sampled	Density (indiv/m^2)	Elevation (m asl)	Aspect	Inclination
*East Face	290	10	308	30.8	665	East	23°50'
*East Slope	569	15	345	23.0	729	East	27°26'
*South West	275	15	308	20.5	621	West	20°11'
*Shepherd's Flat	125	15	219	14.6	645	West	19°34'
*Saddle Rocks	52	10	98	9.8	666	West	11°35'
*Middle Park	380	15	303	5.1	711	East	13°49'
East Face #1	46	46	180	3.9	587	West	#
South West #1	130	130	~400	3.1	563	West	#
East Track	171	171	~500	2.9	578	East	#
East Face #3	76	76	52	1.5	581	East	#
East Face #2	181	181	165	1.1	566	East	#

size against the independent variables soil depth and moss mat turf thickness. No significant association was found between *B. antipoda* size and soil depth at the six key study sites (F = 1.35; *P* = 0.143). A significant relationship was found between *B. antipoda* size and moss mat turf thickness (F = 1.87; *P* = 0.021). Pair-wise analysis showed that the moss species *Breutelia affinis* (*P* = 0.001) and *Campylopus clavatus* (*P* = 0.000) were significantly related to *B. antipoda* density.

Condition success comparisons for **Ballantinia antipoda** *and bryophytes*

Three-dimensional scatterplots allowed a visual analysis of possible correlations between *B. antipoda* field condition success and moss species cover. Seidel (2004) shows the three-dimensional scatterplot figures. Projected coverage of *B. affinis*, *P. juniperinum*, *C. introflexus* and *C. bicolor* exceeding 25% was generally associated with *B. antipoda* plants exhibiting smaller than average basal size and height, prematurely senescing or withering and flowering, but not fruiting. Cover exceeding 25% for *C. clavatus* and *T. papillata*, and greater than 10% for *Bryum caespiticium* and *Rosulabryum. billarderi*, was associated with *B. antipoda* plants that flowered, fruited and seeded and that were of greater than average size. Moss field condition indices of moist, squeezable, free water with green open leaves were positively associated with soil depths of 1-2 cm and moss mat turf thicknesses of 1-2.5 cm.

Table 4. Flowering phenology of *Ballnatinia antipoda* for the growing season of 2003 on Mt Alexander, Victoria. + = observed, - = not observed.

	Late Jul	Aug	Early Sep	Late Sep	Early Oct	Late Oct	Early Nov
Germinating	+	+	-	-	-	-	-
Flowering	-	-	+	+	-	-	-
Flowering/ Fruiting	-	-	-	+	+	+	-
Fruiting	-	-	-	+	+	+	-
Fruiting/ Seeding	-	-	-	-	+	+	-
Seeding	-	-	-	-	-	+	+
Senescing	-	-	-	-	-	+	+

Discussion

Topography and microhabitat in relation to **Ballantinia antipoda** *location*

The density of *B. antipoda* varied with the properties of moss mats within study sites, which changed with aspect, elevation, inclination and, in particular, hydrology. Sites at a greater elevation and with steeper inclination, such as East Slope and East Face, supported higher *B. antipoda* densities per square metre of moss mat area. These sites would experience increased water availability and rapid runoff (Hopper *et al.* 1997).

Ballantinia antipoda was generally found within the margins of moss mat patches, where water accumulated or flowed

Table 5. Coverage and relative coverage of the dominant moss species at six study sites at Mt Alexander, where quadrat analyses were undertaken. Note: densely overlapping stems can exceed 100% canopy coverage per quadrat. Coverage and relative coverage are defined in the Methods section.

Species	East Face	East Slope	South West	Shepherds Flat	Saddle Rocks	Middle Park	Relative Cover (%/m²)
	Sites						
Breutelia affinis	47.33	37.00	4.28	59.33	91.10	58.60	47.75
Campylopus clavatus	20.00	78.00	28.57	41.33	8.00	49.33	38.38
Polytrichum juniperinum	26.00	49.67	25.71	3.33	33.10	71.00	32.44
Triquetrella papillata	4.67	16.33	1.43	22.00		6.67	9.43
Campylopus introflexus	4.67	8.00	7.14	27.33	4.00	2.67	8.19
Campylopus bicolor	7.33	2.66	2.14	18.00		3.33	7.75
Rosulabryum billarderi	2.00	0.67	5.71	6.00		3.67	2.44
Bryum argenteum		5.71	4.67			1.33	1.62
Bryum caespiticium	3.33			0.67		3.67	1.44

Table 6. Comparison of coverage by vascular plant species groups and relative coverage per m² at the six key study sites.

Species groups	Middle Park	East Slope	South West	Saddle Rocks	Shepherd Flat	East Face	Relative Cover (%/m²)
	Sites						
Native succulents	4.59	6.89	12.97	5.54	14.79	7.43	8.60
Native grasses	1.76	1.76	3.24	0.95	5.67	2.70	2.68
Native lilies/herbs	0.81	1.08	0.41	0.27	3.92	1.62	1.35
Introduced grasses	2.03	0.81	0.81	0.95	0.95	1.35	1.15
Other weeds	0.91	1.08	0.27	0.27	2.16	1.49	1.01

parallel to moss mats. Moss mat patches accumulated free water and had shallow soils. Hydrological mapping showed that surface water flowed mainly within gradient depressions on outcrops. These depressions most likely formed as a result of the establishment of pioneer bryophyte species, vascular plants and soil. The humic acids plants produce through decay increase the rates of weathering of the granitic rock substrate (Campbell 1997). Sites supporting larger moss mats contained higher densities of *B. antipoda*. This was probably a consequence of the moist microhabitat created by the bryophytes at patch margins, which were holding water and acting as sponges. This increased the water-holding capacity of the surrounding vegetation (Jarman and Fuhrer 1995). The retention of water provides *B. antipoda* with more extended periods of moist conditions than the surrounding terrestrial environment.

Moss mats at higher elevations and with steeper inclination varied considerably in soil moisture content. The steepest sites rapidly obtained and lost water in succession. When water infiltrated into soil macropores, it would then flow rapidly out and down the slope (van Asch *et al.* 2001). This study's results suggest that sites with a lower inclination have the ability to retain water for longer periods than the steep sites. The Shepherd's Flat site sloped gently and reached the greatest mean soil moisture content, which fluctuated less between sampling dates than at all other sites.

Phenology and demography of Ballantinia antipoda

The phenology of *B. antipoda* plants was correlated with external environmental and localised microhabitat conditions created by the moss mat community. By November, all sites contained substantially less soil moisture than in early spring and the associated moss mat communities were dry. This corresponded with the phenology of *B. antipoda* plants, which were observed seeding and senescing during that period, rather than continuing to grow, flower and produce further seed. This supports the contention that soil moisture content ultimately affects the reproductive ability and survival of mature plants (Brouwer and Fitzpatrick 2002).

The sequential production of flowers on indeterminate inflorescences throughout September enabled *B. antipoda* to fruit and seed over an extended period from late September to early November. This trait should increase the chance of successful insect pollination, since the flowering period included a range of seasonal variability in weather conditions. Seeds were also released over a prolonged period, enhancing the prospects of seed being released and dispersed during favourable conditions.

The moist microhabitat provided by the moss mats may assist the successful germination of *B. antipoda* seeds. Seed germination success has been related to soil moisture and, to a lesser extent, temperature (Bell 1994; Colling *et al.* 2002; Brouwer and Fitzpatrick 2002). Smaller seeds, such as those of *B. antipoda*, show a greater tendency to exhibit dormancy, only germinating when conditions are optimal. Successful seed germination is positively correlated with soil moisture (Colling *et al.* 2002; Grundy *et al.* 2003). Dormant seeds are a feature of plants inhabiting unstable environments, such as habitats that experience fluctuations in water content (Kodela *et al.* 1994), similar to those encountered at the Mount Alexander sites.

The dry wind-dispersed seeds of *B. antipoda* were observed being explosively released. The seed is small (approximately 0.8 mm long) and lightweight, aiding in wind dispersion. The moss mat habitat is characterised by thin soil (depth on average <2cm), but of a suitable depth for the small *B. antipoda* seeds. The germination rates of smaller-seeded species are known to decline when burial depth exceeds one centimetre (Susko and Lovett-Doust 2000; Grundy *et al.* 2003). Leaf litter affects seed germination and growth by creating a barrier above the soil and altering the soil's light, temperature and moisture content (Xiong and Nilsson 1999; Xiong *et al.* 2003). Moss mat patches were characterised by an absence of leaf litter and tall vascular plants, which would aid in the successful germination of *B. antipoda* plants (Thiede and Augspurger 1996; Dalling and Hubbell 2002). The absence of nearby, wind-shielding tall plants may also aid in the dispersal of the explosively released seeds. Seed dispersal is also likely in water and via the wet or muddy feet of animals.

Bryophyte species cover and ecology

Bryophyte coverage was greatest at the margins of soil-based vascular plant environments in more exposed areas, often bordering bare rock and creating patches on granitic surfaces. Such locations can be attributed to many bryophytes being pioneer species. These have the ability to colonise bare soil and rock, creating conditions suitable for their own establishment and survival (Jarman and Fuhrer 1995; Main-York 1997; Downing *et al.* 2002). The species *C. introflexus, C. clavatus* and *P. juniperinum* have been found growing on disturbed or bare soil (Macmillan 1976), indicating they are pioneer mosses that can grow following disturbances. The granite substrate is susceptible to weathering by moisture (Campbell 1997), making granitic outcrops suitable for colonisation by mosses and other plants (York-Main 1997). In doing so, they can accumulate a thin layer of soil and retain moisture, providing a refuge for plants that are relatively intolerant of competition from larger vascular plants.

Positive correlations were found between bryophyte cover and water availability. The study sites supporting the greatest moss mat area were at the highest elevation, which would expose the bryophytes to moister weather conditions. Bryophytes are recognised as thriving in exposed situations, with their distribution being controlled mainly by water availability (Jarman and Fuhrer 1995; Pharo and Beattie 1997; Downing *et al.* 2002).

The evidence suggests that cover by some moss species reduced the density of *B. antipoda*. Cover by *B. affinis* or *C. clavatus* appeared to reduce *B. antipoda* density. This may be a result of *B. affinis* and *C. clavatus* forming dense turfs (Catcheside 1980; Scott and Stone 1976) that are relatively tall and accumulate significant amounts of soil. Tall dense foliage could impede *B. antipoda* seed penetration, germination or growth.

Dense coverage of the mosses *P. juniperinum, B. affinis, C. introflexus* and *C.*

bicolor were generally associated with *B. antipoda* plants of a smaller than average size that were observed flowering but not seeding, and prematurely senescing or withering. *Polytrichum juniperinum* is a robust medium-sized plant, usually 1-3 cm tall, and is ecologically widely tolerant (Scott and Stone 1976). It has been found to occupy bare, disturbed sites or grow on litter (Macmillan 1976; Mäkipää and Heikkinen 2003). Its large robust growth-form may cause *B. antipoda* plants to be of a smaller size by competing with them for space. The moss may compete with *B. antipoda* for water and nutrients or may prolong moisture retention in the mat.

Campylopus introflexus is recognised as a common moss of dry and wet sclerophyll forests, such as at Mount Alexander. It is an aggressive and dense spreading species, occupying open habitats such as moss mats. *Campylopus bicolor*, var. *bicolor* (with cucullate leaf tips) also occurs in small dense turfs on wet ground and rocks or on open soil (Scott and Stone 1976; Catcheside 1980; Frahm 1994). Both *C. introflexus* and *C. bicolor* form dense turfs, which are likely to pose a barrier to the lodgement of *B. antipoda* seeds and to their subsequent germination and growth.

Campylopus clavatus forms large areas of dense erect turf (Scott and Stone 1976). However, spaces between the bushy stems make the turf more permeable and allow the establishment of larger, vigorous *B. antipoda* plants. Stands of *T. papillata* also support vigorous *B. antipoda* plants. Importantly, it forms soft open cushions (Scott and Stone 1976; Catcheside 1980). *Triquetrella papillata* has a broad niche, growing beneath other plants, but also forming large mats in the open where light levels are high (Eldridge *et al.* 2000). The loose open growth-form of *T. papillata* would not impede *B. antipoda* seed penetration, germination or growth and possibly aids in retaining water, therefore providing a moister habitat than the surrounding environment. *Campylopus clavatus* has less open foliage, although the spaces between the bushy stems permit some seed penetration and the emergence of tall, vigorous plants of *B. antipoda*.

Vascular plant species cover and ecology

The density of *B. antipoda* was not affected by vascular plant cover, which appears consistent with it previously surviving in more soil-based environments. However, it must be noted that the cover of vascular plants per metre square was far less than for non-vascular plants. Furthermore, the dominant vascular plant species present were mostly small herbs or grasses. The most abundant vascular plant group coexisting with *B. antipoda* was the succulents, in particular, the purslanes *Calandrinia* spp. These are annuals, growing 10-30 cm tall (Gray and Knight 2001). However, within the moss mat community they were generally smaller, on average 5-10 cm tall. This is of a comparable size to *B. antipoda* and can most likely be attributed to the shallow soil layer, limiting available root space.

Effects of disturbance

White-winged Choughs disturb moss mats, upturning them in search of prey such as European Millipedes. This is believed to be happening more frequently than in the past. Moss disturbance was quite substantial at the East Face site, yet *B. antipoda* density was greatest here. The moss *B. affinis* accounted for the greatest overall coverage at this site. Its stems are matted with rhizoids, which can trap soil to within a few millimetres of the exposed shoot tips (Macmillan 1976). This would provide little cover for millipedes or other invertebrate prey, and this moss may not be disturbed as much by the birds if largely buried. Although *B. affinis* is regarded as a soil accumulator, little soil was present beneath it at East Face. This created larger spaces under the foliage for invertebrates. The upturning of moss turfs by the choughs and the subsequent disturbance created possibly may shift *B. antipoda* seeds around in the soil matrix. Ultimately, this disturbance may cause dislodgement and relocation of seeds by wind and water. In addition, seeds may disperse in soil or moisture on the feet and beaks of the choughs. Disturbance by choughs may favour the survival of *B. antipoda* by opening up dense turfs of moss or fostering pioneer bryophyte species that facilitate its establishment. Moss mat disturbance by choughs differs from disturbance resulting from trampling and off-road vehicles. Soil tends to remain more intact in chough-disturbed areas. Human disturbance tends to compact the soil, preventing infiltration of water.

Recommendations for future management

Ballantinia antipoda previously inhabited more terrestrial, lowland habitats in Victoria. Despite this, moss mat refugia on granitic outcrops offer, through necessity, more suitable habitats for sustaining this endangered species. Any proposed management initiatives will need to focus on protecting existing *B. antipoda* populations and discovering suitable reintroduction sites. It is essential to census *B. antipoda* populations over many seasons to provide further insight into its competitiveness, dispersal, potential inbreeding and causes of rarity. Furthermore, many seeds are produced, yet result in low plant numbers in the following season. This may be a consequence of low percentage germination or low seedling survival rate (Kodela *et al.* 1994). Alternatively, many seeds may be lost through dispersal to unsuitable microsites or deep burial. The causes need to be ascertained. Investigations are required into seed viability, to gain an insight into the effects of environmental phenomena such as drought. The collection of seeds is recommended. This would allow *in situ* reintroductions and the establishment of *ex situ* viable herbarium populations. These would aid the continued survival of *B. antipoda* plants in light of further decline or uncontrollable events such as wildfire.

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Appendix 1. Bryophyte species discovered in the eleven study sites on Mt Alexander, Victoria. (a) = moss species exhibiting acrocarpous (erect) forming habit, (p) = moss species exhibiting pleurocarpous (spreading habit).

DIVISION HEPATOPHYTA	
Family	**Liverworts**
Codoniaceae (Fossombroniaceae)	*Fossombronia intestinalis*
Marchantiaceae	*Lunularia cruciata*
Ricciaceae	*Riccia bifurca*
	Riccia crystallina
Frullaniaceae	*Frullania rostrata*
DIVISION BRYOPHYTA	
Family	**Mosses**
Bartramiaceae (a)	*Breutelia affinis*
	Philonotis tenuis
Bryaceae (a)	*Bryum australis*
	Bryum argenteum
	Bryum caespiticium
	Rosulabryum billarderi
Dawsoniaceae (p)	*Dawsonia longiseta*
Dicranaceae (a)	*Campylopus bicolor*
	Campylopus clavatus
	Campylopus introflexus
Ditrichaceae (a)	*Ditrichum difficile*
Fissidentaceae (p)	*Fissidens taylorii*
	Pleuridium nervosum
Funariaceae (a)	*Funaria hygrometrica*
Gigaspermaceae (a)	*Gigaspermum repens*
Grimmiaceae (a)	*Grimmia laevigata*
	Grimmia pulvinata
Hedwigiaceae (a)	*Hedwigia cillata*
Pottiaceae (a)	*Acaulon integrifolium*
	Barbula unguiculata
	Tortula muralis
	Triquetrella papillata
Polytrichaceae (p)	*Polytrichum juniperinum*

One hundred years ago

NOTES ON PHOSPHORESCENCE IN PLANTS AND ANIMALS

By Miss Freda Bage.

... In the vegetable world instances of phosphorescence are perhaps not so generally known as those which occur among animals, yet many cases of the radiation of light from plants have been recorded.

Among flowering plants, sometimes the flowers themselves have been seen giving out light on dark, dry nights. In 1762 the daughter of Linnaeus saw light coming from some orange-coloured nasturtiums. Later, Professor Haggern, in Sweden, drew attention to the phosphorescence of some marigolds in July and August – i.e., in summer. He carefully examined the flowers, and, satisfied that no animal organisms were present, attributed the phenomenon to the ejection of the pollen caused by the rupture of the anthers.

From *The Victorian Naturalist* **21** (1904-5), p. 93.

Observations of the ecological impacts of Sambar *Cervus unicolor* in East Gippsland, Victoria, with reference to destruction of rainforest communities

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Abstract

Damage caused by Sambar, particularly browsing, antler rubbing and physical removal of particular plant species, is resulting in serious ecological consequences. Threatening processes instigated or maintained by Sambar include: loss of individual taxa, altered vegetation structure and massive widespread removal and prevention of regeneration, which is now resulting in the loss of plant communities in some areas. These observations are particularly disturbing, as it is apparent that Sambar are yet to reach their full ecological and population potential in south-eastern Australia. The destruction documented in this article is now so widespread and so severe that in places it represents an ecological disaster for specific plant and animal species, ecological vegetation classes and floristic communities. We strongly recommend that Sambar in particular, and feral deer in general, should no longer be protected under the Wildlife Act 1975, so that control methods can be devised and implemented. It now appears that such measures will be essential for the long-term survival of some fragile plant species and communities in Victoria. (*The Victorian Naturalist* 122 (4) 2005, 189-200)

Introduction

Sambar *Cervus unicolor* were introduced into Victoria during the 1860's, and have since become the most successfully established deer species in Australia (Bentley 1978; Moriarty 2004). In Gippsland they occur throughout most habitats ranging from coastal to alpine areas, and their population and distribution is still increasing (Moriarty 2004). Sambar were first reportedly seen on the Wonnangatta River in 1951, and soon appeared in East Gippsland as they continued to move further east (Bentley 1978). In 1983, Sambar were still considered uncommon in the Gippsland Lakes Catchment (Norris *et al.* 1983). Currently, large numbers of Sambar are seen throughout East Gippsland, with their population increasing particularly in coastal and foothill country and they are now seen all year round (pers. obs. all authors). Up to 20 individual animals have been seen grazing at night on farmland adjacent to forest in the Mitchell River Catchment and on a property adjacent to the Colquhoun State Forest north of Lakes Entrance (Names withheld, pers. comm. to the authors). At Clifton Creek north of Bairnsdale, a dairy farmer shot more than 100 Sambar on his property, under permit during 2003, 18 of which were shot in one night (G Bowden pers. comm.).

Even though Sambar have been well established in Victoria for over 100 years, there have been few studies examining ecological impacts of this species (Stockwell 2003). However, the impacts of deer on the environment have been well documented overseas where introduced and native deer species are severely damaging the environment (e.g. Fuller and Gill 2001; Gill and Beardall 2001; Rooney 2001; Russell *et al.* 2001; Coomes *et al.* 2003). In early 2005 in New South Wales, the Scientific Committee made a final determination to list feral deer as a key threatening process under the *Threatened Species Conservation Act* (1995) (Scientific Committee 2005). In Victoria, a preliminary recommendation to list 'degradation and loss of terrestrial habitats caused by feral deer' as a threatening process under the Flora and Fauna Guarantee (FFG) Act 1988 (SAC 2004) has recently been rejected by the Scientific Advisory Committee (SAC in press) due to the lack of scientific evidence to validate such claims for all deer species across all of Victoria.

The purpose of this article is to highlight some observations by the authors on the severe impacts that Sambar are having on the environment in East Gippsland.

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Methods

Study area

Sambar damage was noted in 74 sites (gullies, creeks and coastal areas) visited by the authors between 2002-2005 in East Gippsland, Victoria. These sites ranged from the Mitchell River National Park in the West, to the Victorian border in the East.

Observational rationale

The following rationale was used to discriminate between the effects of different browsing animals in East Gippsland, with height ranges for various types of damage listed in Table 1. This was achieved by sourcing literature on the relevant animals as well as by observing animal signs in the field (see Triggs (1984) for identification of scats and footprints). The distinction between the effects of Sambar and Hog Deer *Axis porcinus* (see Table 1) was determined from locations where only one species occurs (Hog Deer – Maringa Creek, Nyerimilang: Sambar – Mitchell River National Park).

When damage to a certain individual plant was identified as being caused by Sambar, the species and particular type of damage, including the extent and severity were noted, along with the plant community in which it was growing.

Table 1. Height (m) of various types of damage caused by Hog Deer, Sambar, and Black (Swamp) Wallabies *Wallabia bicolor* in East Gippsland. N/A = Not applicable.

Damage	Hog Deer	Sambar	Black Wallaby
Antler damage			
Average height	<0.5	0.3 - 1.7	N/A
Max. height	0.8	2.1	
Browsing damage:			
Max.	1.10	2.5	0.75 – 0.85m*

*Stockwell (2003)

Results and Discussion

Sambar damage to individual plants

Effects of browsing

Sambar are known to incorporate a wide range of native plant species into their diet (Bentley 1978; Burke 1982; Stockwell 2003), with almost all available species being consumed (Stockwell 2003; pers obs. all authors) up to a height of 2.5 m. The effects of browsing can be devastating, as Sambar have prodigious appetites, so much so that concentrated grazing and browsing can easily be seen in many different vegetation types. Browsing in the lowlands by Sambar is concentrated on particular communities, usually those of gullies, lake shores and river flats where reliable food supplies are most abundant, and elsewhere on particular species.

The most severe and obvious impacts of Sambar are related to browsing, causing death or reducing the fitness of individual plants. This is usually done by removing stems, shoots and leaves (see Fig. 1), which reduces the plant's growth rate, resulting in shorter plants that remain reachable to Sambar for longer periods, eventually leading to understorey stunting and elimination. Reproductive output of certain species can also be reduced due to consumption of flowers, fruits, seeds and seedlings (e.g. Yellow Milk Vine *Marsdenia flavescens*, Prickly Currant-bush *Coprosma quadrifida* and Muttonwood *Rapanea howittiana*).

Browsing can lead to the physical removal of shallow-rooted species (particularly ferns and epiphytes) and vegetation in general, creation of paths, removal of vine or shrub thickets that act as regeneration refuges, and prevention of natural regeneration. Such browsing comes with a range of other behaviours that is also destructive and very effective at getting foliage within reach. These include, pulling down (vines) and pushing over (tree-ferns and shrubs), and once the plant's foliage is within reach it is often browsed to death. This behaviour is particularly damaging during drought periods, especially for species such as tree-ferns which rely on the first new flush of crosiers to begin photosynthesis. It is at this point that the damage by Sambar becomes critical, as these shoots are highly favoured. Once eaten, the fern has insufficient reserves to re-shoot, and dies. Many rainforest species are subject to increased browsing pressure during drought conditions, putting the entire rainforest under increased stress, as many plants are less able to recover in dry conditions.

Fig. 1. Damage to Muttonwood by Sambar browsing from the Mitchell River National Park.

Antler Rubbing

Antler rubbing is a major problem because particular species are targeted (see also Bentley 1978) and literally rubbed to death, and with those still alive their fitness can be severely affected (Bilney unpublished data). It should be noted that trees, shrubs and vines are attacked in this manner. Antler rubbing may not completely ringbark the tree, but many trees are subject to rubbing over many years: complete ringbarking is usually the end result, and the tree is unable to heal. So widespread and ubiquitous is the damage that at the current rate of attrition, several species are under threat just from antler rubbing alone. Over 100 individual rub trees have been recorded in one patch of the rare Yellowwood *Acronychia oblongifolia* within East Gippsland Coastal Warm Temperate Rainforest. This can seriously affect not only the health of the individual plant, but the community in which it is growing. Antler rubbing often occurs in close proximity to heavily browsed areas. Antler rub marks have been noted as high as 2.1 m.

Plant species affected by Sambar

One endangered species, Buff Hazelwood *Symplocus thwaitsii*, is adversely affected by Sambar. Saplings of *S. thwaitsii* up to 5 m in height are at risk from ringbarking because of antler rubbing, whilst those less than 3 m in height are being severely browsed and some have already died. A rescue of some seedlings for removal to a deer-free environment is currently underway in co-operation with Parks Victoria.

As noted previously, there are few native species (if any) that are not browsed by Sambar. Those from East Gippsland that are the most adversely affected (primarily from observations in Warm Temperate Rainforests and wetlands) are listed in Table 2.

Of these, one is listed as endangered, four are rare, and three are vulnerable (Department of Sustainability and Environment 2005a). Two (*Symplocus thwaitsii* and Prickly Tree-fern *Cyathea leichardtiana*) are listed as Threatened under the FFG Act 1988.

It appears only a matter of time before Sambar totally eliminate some species from an area, due to preferential browsing and grazing, and concentrated effort at particular sites and within specific plant communities (e.g. Muttonwood, Fig. 2). This is having a profound impact on the survival of several plant communities in the short to medium term (Table 3). Some rare species that have limited habitat, sparse distribution, small individual population numbers and occur in preferentially browsed habitats are under immediate threat (e.g. Yellowwood and Sandfly Zieria *Zieria smithii*). Continued attention from Sambar on these species will soon see them threatened in the wild.

Sambar damage to plant community processes and plant communities

Destruction of regeneration refuges, leading to the failure of regeneration

Perhaps the most severe damage caused by Sambar browsing is the destruction of regenerating plant species, which alters regeneration dynamics in plant communities. With the destruction of regeneration refuges, particularly in rainforest communities, regeneration is failing to occur.

Table 2. Some of the more noticeable plant species severely and adversely affected by Sambar in East Gippsland. r – rare, v – vulnerable, e – endangered, FFG – Listed as Threatened under the *Flora and Fauna Guarantee Act 1988*.

	Plant Species	Notes	Observed consequences
	Canopy species		
	Black Wattle *Acacia mearnsii*	Browsing, antler rubbing	Saplings browsed to death, lack of regeneration, opening up of rainforest margins, increased risk of fire entering rainforest
	Blackwood *Acacia melanoxylon*	Browsing, antler rubbing	Saplings browsed to death, lack of regeneration, opening up of rainforest margins, increased risk of fire entering rainforest
	Lily Pily *Acmena smithii*	Browsing, antler rubbing	Saplings browsed to death, lack of regeneration, opening up of rainforest margins, increased risk of fire entering rainforest
r	Yellowwood *Acronychia oblongifolia*	Browsing, antler rubbing	Saplings browsed to death, lack of regeneration opening up of rainforest margins, increased risk of fire entering rainforest
	Sweet Pittosporum *Pittosporum undulatum*	Browsing, antler rubbing	Saplings browsed to death, lack of regeneration, opening up of rainforest margins, increased risk of fire entering rainforest
	Muttonwood *Rapanea howittiana*	Browsing, antler rubbing	Saplings browsed to death, lack of regeneration, opening up of rainforest margins, increased risk of fire entering rainforest
	Shrub and tree species		
	Coast Banksia *Banksia integrifolia*	Browsing	Lack of regeneration
	Blanket-leaf *Bedfordia arborescens*	Browsing	Plants browsed
	Sweet Bursaria *Bursaria spinosa*	Browsing	Plants browsed
	Prickly Currant-bush *Coprosma quadrifida*	Browsing, antler rubbing	Low plants decimated, old shrubs pulled down and rubbed
	Cherry Ballart *Exocarpos cupressiformis*	Browsing, antler rubbing	Saplings browsed to death, lack of regeneration
r	Gippsland Hemp *Gynatrix macrophylla*	Browsing, antler rubbing	Saplings browsed to death, lack of regeneration
	Tree Violet *Hymenanthera dentata*	Browsing	Plants browsed
v	Yellow Loosestrife *Lysimachia japonica*	Browsing,	Plants browsed, physically removed, populations declining
	Tree Broom-heath *Monotoca elliptica*	Browsing	Saplings browsed to death, lack of regeneration, opening up of rainforest margins, increased risk of fire entering rainforest
	Common Boobialla *Myoporum insulare*	Browsing, antler rubbing	Saplings browsed to death, lack of regeneration, opening up of rainforest margins, inreased risk of fire entering rainforest
	Snow Daisy-bush *Olearia lirata*	Browsing	Plants browsed
	Hazel Pomaderris *Pomaderris aspera*	Browsing, antler rubbing	Saplings browsed to death, lack of regeneration, opening up of rainforest margins, increased risk of fire entering rainforest
	Kangaroo Apple *Solanum aviculare*	Antler rubbing, browsing	Crowns decimated, frosts kill weakened plants in the following winter
e	Buff Hazelwood (FFG) *Symplocus thwaitsii*	Browsing, antler rubbing	Saplings browsed to death, lack of regeneration
r	Sandfly Zieria *Zieria smithii*	Browsing	Saplings browsed to death, lack of regeneration
	Vines		
	Staff Climber *Celastrus australis*	Browsing, antler rubbing, pull down	Mature vines antler rubbed and pulled from the canopy, mature plants browsed, regeneration browsed to death

Table 2. Continued.

Plant Species	Notes	Observed consequences
Jungle Grape *Cissus hypoglauca*	Browsing, antler rubbing	Vine curtains destroyed, opening up of rainforest margins, loss of humidity homeostasis, increased risk of fire
Forest Clematis *Clematis glycinoides*	Browsing, antler rubbing, pull down	Mature vines antler rubbed and pulled from the canopy, mature plants browsed, regeneration browsed to death
Wombat Berry *Eustrephus latifolius*	Browsing, pull down	Mature vines pulled from the canopy, plants browsed. regeneration browsed to death
Scrambling Lily *Geitonoplesium cymosum*	Browsing, pull down	Mature plants browsed, regeneration browsed to death
Yellow Milk Vine r *Marsdenia flavescens*	Browsing, pull down	Foliage and seed pods consumed, whole plants destroyed
Milk Vine *Marsdenia rostrata*	Browsing, antler rubbing, pull down	Prevention of regeneration
Queensland Bramble *Rubus mollocanus*	Browsing, trampling	Colonies declining, previously such colonies acted as regeneration sites for palatable gap and mature canopy species
Small-leaf Bramble *Rubus parviflorus*	Browsing, trampling	Colonies declining, previously such colonies acted as regeneration sites for palatahle gap and mature canopy species
Rose-leaf Bramble *Rubus rosifolius*	Browsing, trampling	Colonies declining, previously such colonies acted as regeneration sites for palatable gap and mature canopy species
Pearl Vine *Sarcopetalum harveyanum*	Browsing	Lack of regeneration
Austral Sarsparilla *Smilax australis*	Browsing, pull down	Mature plants browsed, regeneration browsed to death
Tree-fern & Ferns		
Black-stemmed Maidenhair v *Adiantum formosum*	Browsing, trampling	Colonial species quickly destroyed by concentrated effort
Austral Lady-fern *Athyrium australe*	Browsing, trampling	Plants trampled and killed
Gristle Fern *Blechnum cartilagineum*	Browsing	Plants browsed
Fishbone Water-fern *Blechnum nudum*	Browsing, physical removal	Foliage browsed, whole plants physically pulled from the soil
Rough Tree-fern *Cyathea australis*	Browsing	Browsing leading to death, pushing over, populations declining
Prickly Tree-fern v *Cyathea leichardtiana* (FFG)	Browsing	Browsing leading to death, populations declining
Lacy Ground-fern *Dennstaedtia davallioides*	Browsing	Plants browsed
Soft Tree-fern *Dicksonia antarctica*	Browsing	Both young plants and the tallest ferns are browsed, browsing becomes critical during drought years and the death of many tree-ferns occurs at this time
Prickly Rasp-fern *Doodia aspera*	Browsing, physical removal	Foliage browsed, whole plants physically pulled from the soil
Downy Ground-fern *Hypolepis glandulifera*	Browsing	Foliage browsed, swards trampled, regrowth following drought immediately removed: at present hrowsing levels, whole swards likely to be destroyed
Shiny Shield-fern *Lastreopsis acuminata*	Browsing, physical removal	Foliage browsed, whole plants physically pulled from the soil
Mother Shield-fern *Polystichum proliferum*	Browsing	Plants browsed, hulbils eaten, vegetative reproduction prevented
Others		
Stinging Nettle *Urtica incisa*	Browsing	Plants browsed
Butterfly Orchid *Sarchochilus australis*	Browsing	Removes habitat (Sweet Pittosporum branches) viz consumption of leaves removes shaded habitat and branches and orchids by breaking limhs

Fig. 2. Muttonwood heavily browsed by Sambar, located in Dry Rainforest from the Mitchell River National Park.

Regeneration refuges include those in the form of thickets of thorny (*Bursaria spinosa*, *Coprosma quadrifida*, *Hymenanthera dentata*, *Rubus mollocanus*, *R. parviflorus*, *R. rosifolius* and *Smilax australis*) and stinging species (*Urtica incisa*), as well as tree-falls. Even plants unpalatable to most herbivores (such as *Solanum aviculare*) would normally act as a barrier and can hide more palatable species (e.g. *Acmena smithii*, *Acacia melanoxylon*).

Regeneration refuges are significant and effective barriers to native browsing species, particularly Black Wallabies, that seem to be 'effectively blind' to palatable species if they are hidden in a matrix of refuge species. In addition, Black Wallabies are particularly uncomfortable on uneven surfaces that are provided by tree-falls. As a consequence, these natural regeneration refuges have in the past been effective barriers to browsing of regeneration and have allowed natural regeneration, to occur in rainforests where small minor scale disturbances such as landslips or tree-falls can be quickly repaired.

Sambar seem impervious to thorns and stinging plants and can literally wipe them out over a number of weeks or months of concerted effort. This facilitates grazing and browsing by other species such as wallabies, Rabbits *Oryctolagus cuniculus* and Hog Deer, which are usually unable to access palatable species growing within regeneration refuges. In some cases in East Gippsland, Sambar damage has led to the contraction of specific plant communities from some sites and their replacement with grasslands dominated by exotic annuals, and even worse, bare ground. Areas of Littoral Rainforest are already being lost due to this process (Fig. 3).

In Rainforests, when a canopy tree falls, vine species entangled within the canopy usually ride with the tree to the ground. These vine species are quick to regrow, forming barriers around the tree head and form a regeneration refuge, where regenerating plants can establish in protection from native browsers. However, prior removal of vines by Sambar means such tree-fall regeneration refuges fail.

Table 3. Some plant communities that are severely and adversely affected by Sambar in East Gippsland.

Floristic Community or Ecological Vegetation Class	Observed consequences
East Gippsland Foothills Warm Temperate Rainforest	Loss of species, loss of structure, loss of vegetation, loss of fauna refuges from predation
Alluvial Terraces Warm Temperate Rainforest (Threatened, FFG Act 1988)	Loss of species, loss of structure, loss of vegetation, loss of fauna refuges from predation
East Gippsland Coastal Warm Temperate Rainforest (Threatened, FFG Act 1988)	Loss of species, loss of structure, loss of vegetation loss of fauna refuges from predation
Littoral Rainforest	Loss of species, loss of structure, loss of vegetation, loss of fauna refuges from predation
Riparian Shrubland	Loss of species, loss of structure, loss of vegetation
Riparian Forest	Loss of species, loss of structure, loss of vegetation, loss of fauna refuges from predation; erosion
Estuarine Wetland	Loss of species, loss of structure, loss of vegetation, loss of fauna refuges from predation; erosion
Sand Sheet Grassland	Loss of species, loss of structure, loss of vegetation, loss of fauna refuges from predation
Salt Marsh	Loss of species, loss of structure, loss of vegetation, loss of fauna refuges from predation; erosion
Swamp Scrub	Heavy browsing of species including shrubs, tree-ferns, herbs and grasses; wallows leading to loss of ground-layer plants; alteration of drainage patterns; and loss of predator refuges for ground mammals

In addition, the size of Sambar also means that tree-falls are quickly trampled and the otherwise protective branch structure is broken down, so that physical barriers to native herbivores are also lost. Therefore growth of adult vines does not occur, and Sambar remove the potential for communities to regenerate, leading to loss of community structure, diminution of reproduction and loss of regeneration and regeneration potential. Sambar also cause the loss of seed store for gap repair and regeneration.

Habitat regenerating after fuel reduction burns is creating feeding grounds for grazing and browsing species such as Sambar, which are devastating regrowth after fire. This is also altering natural regeneration, particularly in drought conditions when the only fresh green pick is this regrowth. Logging coupes also create ideal conditions for Sambar, which graze and browse the regrowth (Bentley 1978).

Plant communities affected by Sambar

Those plant communities most severely affected by Sambar in the lowlands of East Gippsland are listed in Table 3. The impact of Sambar on these communities significantly increases the risk to their long-term survival. Two communities are listed as Threatened under the FFG Act 1988 (see Table 3).

Impacts of Sambar on rainforest communities

Rainforest communities are sparsely scattered in small pockets along gullies in East Gippsland, being restricted to certain geologies and fire-protective landforms, in areas with adequate rainfall (Peel 1999). Consequently they are often no larger than a few hundred metres long, often less than 100 m wide. Being relatively small in the context of other plant communities, and containing a large proportion of palatable species, rainforests provide preferred living environments for Sambar, and as a consequence are suffering severe damage mainly due to browsing and antler rubbing. Several rainforest communities occurring in East Gippsland and southern New South Wales are therefore under serious threat as a direct result of Sambar damage (see Table 3).

Serious threats include alteration and deflection of rainforest successional dynamics at all levels, with pioneer to mature phase species killed or prevented from regenerating. With a lack of regeneration, soils can become degraded due to

Fig. 3. Failed gap regeneration and loss of Littoral Rainforest as a result of Sambar damage.

exposure to the sun (negative feedback loops, as seen in Fig. 3). This can lead to a disruption of internal rainforest moisture homeostasis through loss of vine thickets and curtains, canopy tree curtains, loss of understorey shrubs and regeneration, expansion of gaps due to destruction of regenerating plants; all of which lead to increased risk of fire and loss of rainforest. In many circumstances, browsing can lead to the loss of all regenerating individuals in an area, leaving only dead stalks of once healthy plants. Regeneration is failing in many rainforest stands across East Gippsland, and in areas that are regularly occupied by Sambar, this regeneration process is not occurring. In concert with antler rubbing, it seems certain that major tracts of rainforest are under threat of soon being lost from Victoria due to Sambar damage.

This threat upon rainforest in East Gippsland is also likely to affect fauna dependent on this habitat type, be it for roosting, nesting or foraging. The occurring of Warm Temperate Rainforest in Gippsland is at the edge of its biogeographical range (Peel 1999), and is also the most southerly limit of some migratory bird species, that rely on nectar and fruit resources mostly found in rainforest (e.g. Topknot Pigeon *Lopholaimus antarcticus* (Blakers *et al.* 1984; Barrett *et al.* 2003)).

Other ecological implications of Sambar occupation

Creation of paths

Sambar develop regularly used paths through even the thickest vegetation. Whilst the physical damage is not spatially large, paths serve to concentrate Sambar activity in the most favoured environments (particularly gullies). Perhaps the biggest impact is the fact that paths created by Sambar essentially become highways through the bush for introduced predators which use paths as movement corridors (May and Norton 1996; Claridge 1998). This fragmentation of the understorey allows introduced predators to gain access into areas of previously dense scrub or ground cover. These factors, along with the destruction of refuges, are likely to have a major impact on native animal pop-

Fig. 4. A Sambar wallow in Salt Marsh from Lake Tyers.

ulations, particularly small terrestrial mammals which rely on dense vegetation as a refuge from predators (Catling and Burt 1995; Claridge and Barry 2000).

When contemplating accessing a steep gully, gorge, or crossing a creek normally impassable because of dense vegetation, all you need to do is look for a Sambar trail and follow it to your destination. Access into areas of difficult terrain has become far easier in recent years primarily due to the presence of Sambar. Sambar are known to keep existing tracks open (Bentley 1978).

Wallows

Sambar choose areas of shallow water with a muddy base, often in a secluded position, to wallow. Wallows also provide a focus for Sambar activity, and physical damage to plants is more severe in the vicinity of the wallow (also see Bentley 1978). Vegetation is usually physically removed from around wallows rather than by browsing. Wallows have been noted in Swamp Scrub, Warm Temperate Rainforest, Salt Marsh (Fig. 4) and Estuarine Wetland.

Rutting areas

These areas are most likely related to rutting males during the breeding season. At these sites vegetation is completely cleared, mainly by trampling and physical removal, resulting in bare ground. Patches of bare soil up to 7 m in diameter have been observed on gully floors of Alluvial Terraces Warm Temperate Rainforest (Fig. 5), with surrounding vegetation also being rubbed and browsed. Along floodplains of small creeks, areas over 15 m long have been completely cleared amongst bracken fern, resulting also in bare ground. Such areas in the core of rainforest become sites for weed invasion and degradation of otherwise healthy and intact rainforest stands. Weed invasion is a well documented threat to the survival of many communities of Warm Temperate Rainforest.

Erosion

Erosion is becoming an issue as Sambar move down into the lowlands and begin to graze wetlands, with or without the presence of Hog Deer. The removal of swamp or riparian vegetation by these species is leading to bank exposure and erosion. Sambar, being much larger than Hog Deer, are able to wade out further and destroy plants in deeper water or mud. Those areas that are suffering the most from erosion are Estuarine Wetlands (*Phragmites/Bolbo-*

Fig. 5. A Sambar rutting area in Alluvial Terraces Warm Temperate Rainforest from Lake Tyers.

schoenus dominated) whose position along lake shores makes them more vulnerable to wave action once these fringing species are wiped out. The loss of these fringing wetlands is also degrading habitat of fish and other aquatic species and is mobilizing phosphorous-rich sediments. The sediment mobilization is likely to lead to more frequent and severe blue green algal blooms in these estuaries (Boulton and Brock 1999; Price and Lovett 2002). Much of the fringing wetlands around the Gippsland Lakes have been removed through domestic stock grazing. Significant efforts are now underway to fence stock out of such waterways. However, Sambar are capable of easily jumping over standard stock fences. Increased erosion is also likely in Riparian Shrublands, which are a focus of significant browsing attention from Sambar.

Wallows and rutting areas also create increased erosion, as they are usually in low lying areas such as in creek beds which are vulnerable to gully erosion during rainfall events.

A food source for predators

Although it is unlikely that wild dogs *Canis familiaris* kill many adult Sambar, they will kill juveniles and scavenge carcasses left behind by hunters (Bentley 1978; pers. obs.). From April to September there is significant Sambar hunting in many catchments of the Gippsland Lakes, with increased hunting effort now occurring (especially within the past decade) east of the Snowy River, as Sambar's range expands inexorably eastward and northward. This hunting is in the form of stalking, hound teams and spotlight shooting. Many hunters who seek a trophy head, or select cuts of venison, leave behind most of the carcass after a successful kill. Some hound teams will also dump multiple carcasses that are of little value to them in the one location (one author observed five carcasses in three dumps, in the winter of 2003, in the Bairnsdale area). Carcasses that are dumped are generally completely scavenged by wild dogs. As of April 2004, the number of licensed deer shooters in Victoria was approximately 12 000, with in excess of 8500 Sambar being harvested per year (Department of Sustainability and Environment 2005b). Although there is no data on the proportion of each Sambar carcass that is left behind in the forest, it seems reasonable to assume that several hundred tonnes of Sambar remains are left behind per year, resulting in a substantial and reliable food resource for wild dogs.

The height of Sambar hunting also corresponds with the birth and weaning of wild dog pups (Menkhorst 1995), and this provides a significant food source at a crucial time for the survival of juvenile wild dogs. A peak in Sambar calving also occurs during winter (Bentley 1978; Menkhorst 1995), providing wild dogs with easily killed prey. Anecdotal evidence from wild dog trappers from the 1940's to 1960's (E V Ellis and L Lees) strongly suggests that in the past, many young dogs perished at the end of winter/early spring due to a lack of food. Increased access to reliable food supplies during critical reproductive periods for wild dogs may be leading to improved survivorship and larger numbers of wild dogs in these areas. This may have devastating effects, particularly on small mammal populations and livestock. From faecal pellet counts in the Upper Yarra Catchment, it has been estimated that Sambar were 100 times more abundant than Black Wallabies (Houston 2003; Stockwell 2003), which may be due to competition from Sambar as well as predation by wild dogs. From 30 wild dog scats collected during late spring and early summer in the Yarra Ranges National Park, Sambar were recorded in six scats all collected in late spring (Anon. 2001).

Hunters in North America are required by law to completely salvage remains of all large game animals (other than visceral contents) that are shot (Alaska Department of Fish and Game 2004). One justification for this law is to avoid artificially affecting the population balance of predators (Wolf, Bear, etc.) over prey. This suggests that one of the prime reasons that we have large numbers of wild dogs in eastern Victoria may be due to the lack of regulations requiring hunters to remove carcasses from the forest.

Conclusion and Recommendations

Damage caused by Sambar on the Australian environment will spread far beyond those areas mentioned in this paper, as this species is yet to reach its full ecological or population potential. Even at current population levels and geographic extent, a large number of ecological processes in forested ecosystems are in decline, being disrupted or destroyed. Sambar are not only capable of damaging and killing individual plants, they are capable of significant, severe and possibly lasting alteration to vegetation structure, including negative feedback loops that lead to destruction of particular vegetation types such as rainforest and wetlands. With such destruction, Sambar are currently a major threat to many plant species and communities in East Gippsland, and are likely to adversely affect many native animals associated with such habitats.

With the Sambar population still increasing, and yet to reach its full ecological potential, appropriate immediate action is of the upmost importance. In order to control Sambar, they need to be regarded as a pest species, and should no longer be protected under the Wildlife Act 1975, so control methods can be readily implemented without permit and at any time of year. We stress the importance for long-term Sambar control across all land tenures as well as in vulnerable areas, including National Parks, to try to reduce this direct threat to fragile habitats. It is imperative that the management of Sambar be updated to try to increase the number of animals harvested per year, instead of allowing them to reach high population densities. Current restrictions on hunting methods are contributing to an overabundance of Sambar, and significantly impeding sound ecologically-based feral deer management in Victoria. One method of increasing the number of Sambar killed is to legalise spotlight hunting. Spotlight hunting is currently prohibited because it is seen by traditional hunters as being unethical, potentially 'reducing hunting opportunity for law-abiding hunters' (Department of Sustainability and Environment 2005b). Consequently it is also recognized that reputable and ethical hunters and hunting organizations are an integral part of the solution for controlling these alien and pest species in the Australian landscape.

Another recommendation is that legislation allowing hunting for trophy animals be changed, so that all remains are removed, except for visceral remains, to try and reduce a possible imbalance of wild dog populations in many areas.

It is essential that long-term ecological studies be conducted into the damage that Sambar, and other species of deer, are having on the environment. It has been a major failing of our governments not to have recognised, or even assessed, the impact that Sambar have had on the environment. Land managers including the Department of Primary Industries (DPI), Department of Sustainability and Environment (DSE), Parks Victoria and landholders need access to the full suite of control methods for these species, so they can be implemented as soon as possible, before Sambar populations reach their potential, and before irreversible damage is done to larger areas of forest and wetland ecosystems.

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Robert Graham Taylor

5 June 1941 - 17 May 2005

Bob Taylor with a Bearded Dragon. Photo Sally Bewsher.

With the passing of Bob Taylor, who died suddenly from a heart attack on 17 May 2005, the FNCV has lost an enthusiastic and popular member. Bob joined the FNCV in 1992 and had been a regular participant with the Fauna Survey Group, at meetings, surveys, and in particular, assisting in running the stagwatches for many years. He was also a regular at equipment days and club working bees.

His main love of nature was with the fauna of the night. Finely honed skills of observation, gained in the hunting and fishing days of his younger years, were used to the maximum to seek some of our more elusive possums, gliders and owls, in the Yarra Valley and Dandenong Valley, which he knew so well. He had an intimate knowledge of Powerful Owls, their preferred habitat and how to find these birds. Over many years, he monitored the breeding success of a number of Powerful Owl pairs in the nearby hills east of Melbourne. From Bob's point of view the Powerful Owl was the embodiment of the untamed wild beauty of nature.

Yellow-bellied Gliders and Sugar Gliders were also among his favourites, and he spent many hours searching for them and their nest trees, either alone or with a small group of naturalists. These surveys were sometimes with residents who were surprised to be shown what was living on their patch. At other times, Parks Victoria Rangers would accompany him as he surveyed at night in metropolitan and nearby State Parks.

He also took time to introduce many beginners to spotlighting and the ways of the animals. From showing us how to spotlight for Feather-tail Gliders and Pygmy Possums in flowering *Banksia* at Gembrook, or counting a remnant population of Sugar Gliders in Heathmont, to searching for Yellow-bellied Gliders at Macclesfield, Bob was eager to share his knowledge and the wildlife experience. He was a long-term participant in the Fauna Survey Group's Stagwatches for Leadbeater's Possum, and made a large contribution to the surveys, including planning. With his wide circle of naturalist friends he always managed to ring around and find a few more participants so we could cover the trees fully.

At meetings he featured in members' reports with detailed wildlife observations, often of the behaviour of possums and gliders, and of Powerful Owls and their breeding success.

Bob was a long-time active member of the Friends of the Helmeted Honeyeater, and a participant in surveys with the Trust for Nature. He also spoke to suburban field naturalist clubs, conservation groups and groups of school children. After his retirement from 40 years in insurance he used his skills working in environmental consultancy.

Bob will be sadly missed by the many people who got to know him well over the years and had a close personal relationship with him. He is survived by his wife Anne, children Robert and Julie, and his mother Eleanor.

Raymond Gibson, Russell Thompson
Fauna Survey Group
Field Naturalists Club of Victoria

Unusual 'outbreaks' of a diatom (*Tabellaria flocculosa*) in the Australian Alps

Diatoms are found in all of the world's waterways, both fresh and saline. As a group they are amongst the most important life forms on earth. In recent times they have been used as indicators of the health of freshwater systems (John 2000). Whilst changes in water quality also may have an impact on terrestrial vegetation, a direct link between diatoms and terrestrial plants does not appear to have been reported. This is not surprising as the two would seldom meet.

In January 2004, a thick white substance covering plants (Fig. 1) next to Cope Creek on the Bogong High Plains of north-eastern Victoria (1660 m asl) was noticed (KLM). The material was confined to a short, continuous section of creek, its upper margin apparently planar, suggesting that the substance had been deposited during a higher water level. In December 2004 the same phenomenon was observed on the banks of Betts Creek, in Kosciuszko National Park (1770 m asl), over a distance of about 100 m between Guthrie Creek and Spencers Creek. Both sites are in subalpine treeless valleys, which are generally covered in snow during winter. The vegetation bordering both perennial creeks is a low open heathland (dominated by *Epacris glacialis* in Cope Creek and by *Grevillea australis* and *Cassinia* sp. aff. *uncata* in Betts Creek) containing herbaceous species more commonly found in wetland vegetation (e.g. *Carex gaudichaudiana* and *Empodisma minus*). The tussock grass *Poa costiniana* provides most ground cover at both sites.

At the Betts Creek site, a piece of the shrub *Grevillea australis*, which was covered in the substance, was removed for identification. The substance was identified as the frustule of the pennate diatom *Tabellaria flocculosa* (Roth) Kützing.

Apart from the stark contrast of the dense white patches against the surrounding green vegetation, the phenomenon was notable because of the apparent poor health of the plants covered. At the Cope Creek site, shrubs of *Epacris glacialis*

Fig. 1. The dense covering of *Tabellaria flocculosa* frustule on heathland vegetation beside Cope Creek on the Bogong High Plains, Victoria.

were shedding their leaves and, when the white substance was removed from herbaceous plants, most appeared to be pallid and some appeared to be dead (at least above the ground). At Betts Creek, the shrub of *Grevillea australis*, from which the material was collected for identification, was shedding leaves.

The Betts Creek site was re-inspected in March 2005. The plant of *Grevillea australis* had shed most of its leaves and all remaining leaves had lost their green appearance. Since this species does not resprout following destruction of above ground parts, the plant was probably dead. It is uncertain if it died because of the white covering, as there was a healthy plant of *G. australis* within a few metres at a similar level above the river. The white covering was still evident on the leaves of *Carex gaudichaudiana* but was otherwise obscure. A narrow line of dead tillers of *Poa costiniana* plants was evidence of where the deposits had been, but all of the plants of this species were apparently alive and had produced new tillers. The damage to vascular plants from the *Tabellaria* coating appears to be negligible and hardly of concern. It is curious though and we can find no reference to a similar phenomenon in the literature.

KL McDougall has worked in the Australian Alps since 1978 and had not seen the *Tabellaria* patches before 2004. Philibert *et al.* (2003) found, by examining sediment cores, that diatom populations increased for about five years after wildfires in late Holocene forest in Canada. The 'outbreaks' in the Australian Alps may thus be a further consequence of the January 2003 fires, the first major fire event in the Australian Alps since 1939. The catchments of both sites where it was observed were partly burnt. Changes in water properties are likely to have occurred following the fires, as a large amount of ash was washed into waterways.

The vegetation of both affected sites will be monitored over the coming years. Although the impact appears to be negligible at present, further 'outbreaks' causing death of plants could make stream banks unstable and lead to erosion.

Acknowledgements

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One hundred years ago

FOXES

Mr AE Kitson, FGS

...said that the Geological Survey party, in charge of Mr. W. Baragwanath, jun., recently working in the ranges to the north of Mt. Baw Baw, had noticed English foxes in the locality, which, besides destroying the Lyre-birds in great numbers, had developed a liking for grasshoppers. The animals seemed to show a slight variation from the ordinary fox, being smaller and greyer in colouring.

From *The Victorian Naturalist* **22** (1905), pp.55.

Bush creatures: animals observed on a *Thryptomene* shrub

Introduction

The *Thryptomene* growing near the north-facing wall of our house in the Melbourne suburb of Notting Hill, Victoria, is a low, spreading shrub approximately 2.4 m across and 1.2 m high. It has dainty pink flowers and blooms for most of the year. When I bought it in 1995 it was labelled 'Grampians Thryptomene *Thryptomene calycina*', but I think it is probably the 'Payne's Hybrid' form of *T. saxicola*, a popular garden plant. With its beautiful long-lasting floral display, this shrub seems to attract more insects than any other plant in our garden. In the spring of 2003 I decided to find out what types of creatures live on or visit it. I had little idea of the fascinating experience that awaited me.

Animals seen

I began my observations (about 1 hour per week) in September 2003 and kept a record of each animal I saw on the shrub for the first time. In order to facilitate subsequent identification, I aimed to photograph each creature I could find, but many were too quick, too shy, too small, or so well camouflaged that I couldn't see them once they landed on the shrub. By the end of August 2004 I had listed over 90 kinds of arthropods and two species of passerine birds.

Arthropods

As expected, arthropods were the most common animals observed. These included Arachnida, in particular Araneae (spiders) and Acarina (mites); while in Insecta, the dominant Orders included Mantodea, Orthoptera, Phasmatodea, Hemiptera, Thysanoptera, Coleoptera, Lepidoptera, Diptera and Hymenoptera, with the latter two Orders together accounting for more than half the species seen.

Araneae

Flower spiders (Thomisidae) were numerous. One of these was a creamy colour (Fig. 1), easy to see on the pink flowers; but there were also many smaller, better-camouflaged individuals dressed in varying patterns of cream, green and brown, looking just like part of the shrub. Late one afternoon I watched one of these crab spiders climb straight up into the air until it was so high that it disappeared from view! There must have been a spider web 'highway' up there, connected to the treetops several metres away. The distance seemed vast for so small a creature, and the journey hazardous with birds and wasps in the vicinity.

Jumping spiders (Salticidae) explored the shrub and nearby plants, while what looked like a scrap of dead leaf hanging motionless between the *Thryptomene* and *Grevillea* 'Robyn Gordon' turned out to be a humped spider (Uloboridae) on its long strand of web. In January a leaf-curling spider *Phonognatha* sp. (Argiopidae) anchored its web to the *Thryptomene* and adjacent *Correa* 'Dusky Bells'. There was also a lynx spider (Oxyopidae) with very spiny legs; an unidentified very small shiny black spider; and a minute, almost black spider (possibly Linyphiidae), identifiable as such only with a x10 hand lens. Its globose abdomen was streaked with short light brown hair-like lines, while its legs were striped light and dark brown. Miniscule insects were caught in its tiny web.

Fig. 1. Creamy coloured flower spider

Acarina

In the first week of October one predatory mite, orange in colour and very fast moving, was seen scurrying along the twigs.

Mantodea

Several green Praying Mantids *Tenodera* sp., and also a few robust-looking brown individuals were present. During December at least a dozen mantids were on the shrub. When the weather remained hot and dry for an extended period they appeared dehydrated, so I gently sprayed a little water on the leaves near them. They drank immediately: desperation evidently dispelled any fear of predators noticing their movements. I was fortunate enough to find a green Praying Mantid just after it had shed its skin, and also watched one of these insects eat a blowfly. As far as I could tell, they all disappeared from the shrub before reaching adulthood.

Orthoptera

One nymph and one adult form of a long-horned grasshopper (Tettigoniidae), green with a dark reddish colour on the upper surface, were seen in spring and summer respectively. I don't know if there were any more. Some mornings I watched an adult half walking, half hopping from the *Thryptomene* to the *Grevillea*, but I didn't see it return.

Phasmatodea

A beautiful brown female stick insect *Ctenomorphodes tessulatus* (Phasmatidae) arrived in the shrub on the afternoon of 23 January 2004. With a body about 18 cm long, this was the largest arthropod I saw. I watched it for a considerable time without seeing it move, except for swaying occasionally as if in a light breeze. Next morning it had gone.

Hemiptera

Bugs seen on the plant included a green psyllid (Psyllidae); aphids (Aphididae); white fly (Aleyrodidae); 'Greengrocer' cicada *Cyclochila australasiae* (Cicadidae); planthopper *Siphanta acuta* (Flatidae); a small green bug (Lygaeidae); a minute leafhopper and a grey leafhopper (Ricaniidae); Passion Vine Hopper *Scolypopa australis* (Ricaniidae); and the introduced Green Vegetable Bug *Nezara viridula* (Pentatomidae).

Thysanoptera

At just 1 mm in length, thrips were among the smallest creatures I could see on the shrub. They looked yellow when caught in a spider web but brown when on my hand or in the flowers. What sorts of images do they see with their minute eyes?

Coleoptera

Although almost one third of insect species in Australia are beetles (Zborowski and Storey 2003), I found only five, and all were less than 3 mm long. Two were round and three were oval in shape, and they came in a variety of colours including black, grey, red and shades of brown.

Diptera

An amazing variety of flies accounted for approximately one third of the arthropods seen on the shrub. Species recorded included cranefly (Tipulidae); moth fly (Psychodidae); mosquito with striped legs (Culicidae); two species of fungus gnat (Mycetophilidae); robber fly (Asilidae); a bluish-green, black-striped long-legged fly *Austrosciapus* sp. (Dolichopodidae); hover fly *Melangyna* sp. and bee-like hover fly *Eristalis tenax* (Syrphidae); a dark-coloured fly (Platystomatidae) that 'exercised' its wings when resting; a small fly (Lauxaniidae) with speckled wings and green eyes; bush fly *Musca vetustissima* (Muscidae); blowflies *Calliphora stygia* (Fig. 2) and *Chrysomya* spp. (Calliphoridae); and Grey-striped Flesh Fly *Sarcophaga aurifrons* (Sarcophagidae). Blowflies were regular visitors, but some others, such as the robber fly, were seen only once.

Several other flies, resembling blowflies and bush flies in shape, came in a range of sizes and colours. For example, one was small and pale brown, one small and grey, and another shiny blue-black with orange-brown wings. One blowfly had an emerald green (not shiny) thorax, while another was brownish with a pale thorax.

There were also many different small flies that folded their wings back over their bodies when resting. Some showed distinctive features: one had a large head, another a glossy black thorax, and yet another a shiny brown thorax.

It was fascinating to observe the way a cranefly with a body about 7 mm in length managed to shift its long legs into position

Fig. 2. Blowfly *Calliphora stygia.*

when it landed, and to witness the exaggerated up-and-down movements of its head as it fed on nectar in the flowers. When at rest this insect was very well camouflaged. It lay along a twig with its front and back legs stretched out and its middle legs folded back then forward from the first joint. In this position the species I saw occupied a 3.7-cm length of twig.

Lepidoptera

Larval stages present included those of casemoths (Psychidae) and three species of looper caterpillars (Geometridae). Adult individuals visiting the plant included Painted Lady *Vanessa kershawi*, Australian Admiral *V. itea* (Nymphalidae), Common Grass Blue *Zizina labradus labradus* (Lycaenidae), White-banded Grassdart *Taractrocera papyria papyria* (Hesperiidae) (Fig. 3), a yellow moth (Oecophoridae), and several unidentified moths in various shades of grey or brown.

When I saw a White-banded Grassdart for the first time I raced outside with my camera and approached the insect very slowly. As I did so a Red Wattlebird *Anthochaera carunculata* swooped overhead, and it was wondrous to see the Grassdart instantly close its wings and – from the bird's viewpoint – effectively disappear.

Perhaps most interesting of all were the casemoth *Clania* sp. larvae (Fig. 4). Being slow-moving, relatively large and resident in the plant, they were easier to observe than the speedy visitors. Over a period of about half an hour I had the pleasure of watching one cut off a piece of twig, deftly manoeuvre it with its feet, apply caterpillar silk to it, then stick it to the top of its case. I didn't see it attach the far end, but according to Common (1990) these creatures withdraw into their cases, make a hole at the point where the stick is to be attached, put out their heads and 'glue' the stick down, then repair the hole!

I had often wondered why many of these larval cases have one long twig which projects past the rest. Then I saw a larva resting the long stick on one twig while it ate leaves on another twig. Was it taking a short cut or taking the weight off its feet? Days later I saw a larva apparently defying gravity! While its head end munched on young leaves at the tip of a fine, thin twig, its encased body lay horizontally in the air with no obvious means of support. Close examination revealed that the long stick was held by a loosely constructed web. Had the larva made the web, or had it used a spider web that happened to be there?

During November several of the casemoth larvae migrated from the shrub to the eaves of the house to pupate. Others stayed on the shrub. Some of these were small, had no long stick in their cases, and may have been dormant, but two larger ones also stayed. I think one of these might have died, because I saw two species of fly feeding from the bottom of the case. One was a small shiny

Fig. 3. Grassdart

blue-black fly with orange-brown wings, which I haven't seen before or since, and the other was the larger Grey-striped Flesh Fly that is common in our garden. I didn't see any flies on the other cases.

On 2 January I had the good fortune to watch a casemoth larva climb the brick wall of our house and attach itself to the eaves. It had started ascending the wall when I found it, but I estimate that the entire journey of approximately 3.4 m must have taken at least two hours. How I admired the larva's strength and tenacity as it climbed, constructing a 'silken ladder' as it proceeded, in the manner described by Broadberry (1999) for the Saunders Casemoth *Oiketicus elongatus*. The 'rungs' were each about 4 mm long and 7 mm apart. The larva did not climb straight up, but took a wavy diagonal route (Fig. 5). Faint remnants of older 'ladders' on the wall indicated that other larvae had done likewise. At the time of writing (19 September 2004) the case is still hanging there, but I don't know if an adult has emerged from it.

Hymenoptera

The wide variety of wasps and bees surprised me, particularly since I had previously noticed only the introduced Honey Bee *Apis mellifera* (Apidae) and European Wasp *Vespula germanica* (Vespidae) on the plant.

A small reddish-brown wasp *Heteropelma* sp. (Ichneumonidae) looked 'angry', constantly waving its long antennae as it ran along the twigs. A larger reddish-brown wasp, belonging to the same family, had iridescent wings and was extremely wary. There were two types of Braconid wasp (Braconidae), one very handsome with a reddish-brown head and thorax and black eyes, and the other much smaller, with a black head and thorax and a reddish-brown abdomen. Three different sizes of the slender gasteruptid wasps (Gasteruptiidae) had me puzzled for a long time: at first all I could see were creamy-coloured dots and fuzz flying around. A cuckoo wasp (Chrysididae) with a greenish gold metallic sheen, spider wasps (Pompilidae) and a small male black wasp (Tiphiidae) (the female is wingless) were also present. The above-mentioned European Wasp was often seen. There were other wasps too, including two tiny parasitic wasps, one black and one yellow, each less than 2 mm long. In February black wasps (probably *Odynerus* sp.) rather smaller than the Honey Bee, with two yellow (or sometimes orange) stripes on the abdomen, visited many of the cocoons on the plant. After careful inspection, each insect would insert its ovipositor into cocoons of its choice. I don't know the outcome of this activity.

Small ants (Formicidae), some black and some brown, fed on nectar. The black ants also ran along the branches to the *Correa* bush, but because of the density of the vegetation I didn't locate their destination.

There were several species of bees, including two belonging to the family Colletidae and three to the Halictidae. Mason bees (Megachilidae), grey and black with orange-brown tipped abdomens, came to the flowers in summer. Sometimes up to four would arrive and attempt to drive each other away. Being solitary bees they were no doubt competing for the food source, but I didn't see them attack any other species. There was also a small black bee with two yellow stripes, and another small bee *Exoneura* sp. (Apidae) with a black-striped reddish-brown abdomen. The Honey Bee, already mentioned, visited the shrub whenever the flowers were blooming (i.e. in all months except November) and when weather conditions were suitable. This bee was definitely the boss, dismissing any other species that happened to be in its way.

Fig. 4. Casemoth larva feeding

Fig. 5. Casemoth larva climbing wall. Part of the 'silken ladder' is visible on the left.

Arthropods in cocoons

During September and October many tips of the twigs were joined together by a substance resembling spider- or caterpillar silk, so that the plant appeared to be covered in knots of various sizes and shapes. I opened one of these 'knots' but found no animal inside. Flowering ceased at the beginning of November and the 'knots' 'unravelled' soon afterwards. By mid December flowering had resumed, and by the end of December new cocoons were appearing. Again I missed seeing which animals constructed or emerged from them. Oh for video surveillance! In February I noticed that the leaves encasing some of the cocoons were dead. I opened one of these cocoons but found nothing inside. A dead leaf at the entrance to one small cocoon had fallen off, and the dark speck I saw there turned out to be a minute spider (see Araneae, above). One other cocoon I examined with a hand lens had caterpillar frass in the silk, as though a miniature webworm had been there.

Birds

Passeriformes

On 31 January a House Sparrow *Passer domesticus* paid several visits to the shrub. The bird appeared to be feeding on something but I couldn't see what: I just hoped it would leave the Praying Mantids alone. On the mornings of 26 and 27 August a Red Wattlebird flew into the shrub a number of times and seemed to be tugging at something. I could not see whether it was feeding or collecting dry thin twigs for nesting material.

Conclusion

It is astonishing how much happens on just one garden plant. Observing the animals on this shrub has been immensely rewarding, though I am left with more questions than ever. Having experienced the thrill of discovery, I shall continue to 'shrub-watch' and marvel at what I see.

Acknowledgements

My grateful thanks go to Cuong Huynh, of Deakin University Burwood, for generously donating his time to identify the insects and spiders from my photographs and specimens. My thanks also go to Dr Ken Walker of Museum Victoria, who identified many creatures from my photographs and also made several helpful comments and suggestions.

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Observations of movements of Water Rats *Hydromys chrysogaster* on Cat Island, Furneaux Group, Bass Strait, Tasmania

Introduction

There appear to be few recent or detailed studies of the Water Rat *Hydromys chrysogaster* in Australia (e.g. Brazenor 1936; Troughton 1941; McNally 1960, but see Gardner and Serena 1995). This may reflect its apparent abundant status, with its overall range thought not to have altered much since European Settlement (Olsen 1995). The Water Rat is a native rodent, restricted to Australia, New Guinea and adjacent islands (Olsen 1995). The Water Rat has been recorded in many different habitats from temperate and tropical rainforests (Hocking and Guiler 1983; Laurance 1994), rivers, swamps and irrigation areas, to some marine beaches (Peterson 1965; Woollard *et al.* 1978; Olsen 1995). Woollard *et al.* (1978) studied the ecology, food and feeding habits of the Water Rat at a swamp in New South Wales, and found fish to be the most important food item. The biology of the Water Rat is discussed by McNally (1960) and Fanning and Dawson (1980).

This note reports on the movements of Water Rats that were observed opportunistically on Cat Island, Bass Strait (39° 57' S., 148° 21' E). While the Water Rat is known to occur on some marine beaches, and has been recorded on Cat Island previously (Whinray 1971), there do not appear to be any studies of the Water Rat in a marine habitat, and this note aims to provide some insights and inspire interest.

Site description

Cat Island is located about 7 km from the eastern coast of Flinders Island, and forms part of the Babel group which in turn is part of the Furneaux Group (Fig 1). Cat Island is a Wildlife Sanctuary managed by the National Parks and Wildlife Service, Tasmania. The island is about 0.8 km by 1 km and approximately 49 ha. in size (Warham 1979). The island is wholly granitic and rises to approximately 32 m above sea level (Warham 1979). There is no permanent fresh water (Warham 1979). Most of the coastline is rocky, except for two sandy bays (North Bay and South Bay) (Fig. 1).

Most of the island is covered in low vegetation growing over sandy soil. To the west of the hut (Fig. 1), the vegetation is dominated by *Poa poiformis* with a few areas of bare ground or rock. The area east of the hut is dominated by saltbushes *Atriplex cinerea* and *Rhagodia baccata*, and an Australian Hollyhock *Lavatera plebeia*. The eastern area is more sparsely vegetated than the western side of the island.

Cat Island once supported an extensive gannetry for Australasian Gannets *Morus serrator*, which has disappeared through overexploitation (Warham and Serventy 1978). Little Penguins *Eudyptula minor*, Short-tailed Shearwaters *Puffinus tenuirostris* and Tiger Snakes *Notechis* sp. are common. Whinray (1971) records the Water Rat as 'common'.

Observations

Water Rats were observed on Cat Island during November, 1994. For three weeks, some mornings and most evenings were spent recording movements of some of the island's Water Rats. Movements of the Water Rats were mapped through sightings, tracks, scratchings, distinctive scats and odour. The number of Water Rats on the island at the time is not known.

Movement patterns

Olsen (1995) states that the Water Rat is unusual among Australian rodents in that it is not entirely nocturnal, with most activity taking place around sunset. Woollard *et al.* (1978) reported that Water Rats could be seen feeding at any time of the day, but particularly in the evenings. Gardner and Serena (1995) report that most activity takes place two to three hours immediately after sunset. Water Rats will move in and out of the water regularly to avoid hypothermia, as they cannot maintain their body temperature in cold water (Gardner and Serena 1995).

Water Rats on Cat Island often were observed to emerge from the water at dusk but also were sighted to emerge in the early morning. Upon emerging, the Water Rats were seen to scratch the sand vigorously, then disappeared among the rocks, and either went back into the water or were not seen again (Fig. 1). Scats, scratchings in the sand and feed 'tables' were found amongst the rocks to the west of the bay (see hatched area in Fig. 1). It is unknown where the Water Rats went after emerging from the water as the grass tussocks behind the rocks were very thick and no tracks inland could be found.

Water Rats were observed going into the water in the mornings (after dawn) and late at night (at around 9-10 pm, approximately one to two hours after sunset). This suggests that feeding by the Water Rats on Cat Island can occur at any time, day or night.

The regular route from the island to South Bay, for at least one group of Water Rats, included passing under the accommodation hut, which was situated between the two bays (Fig. 1). In the mornings, one to usually three sets of tracks would lead under the hut and down the man-made path to the middle of the beach at South Bay, and into the water (Fig. 1). We knew when the Water Rats were moving under the hut as these were accompanied by raucous cries from the penguins and Shearwaters that nested under the hut. The birds under the hut did not make burrows, but had scrapes in the sand in which they nested, the hut presumably providing adequate shelter. Water Rats moved independently down to the beach at various time intervals, but times were at least half an hour apart.

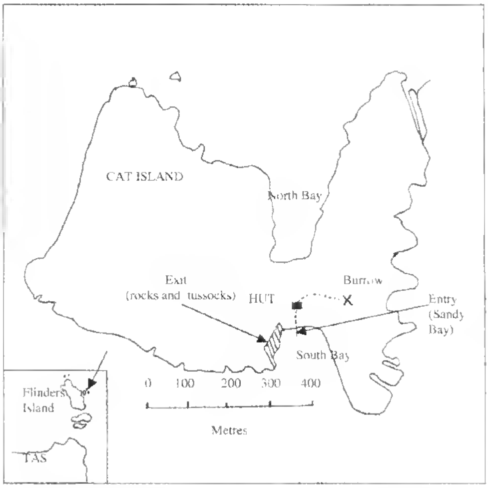

Fig. 1: Cat Island, Bass Strait Tasmania. Approximate locations are given for Water Rat observations. X marks the location of the burrow of the Water Rats; the dashed line represents the approximate location of the tracks found. The hatched area to the west of South Bay, shows the area where the Water-rats were observed to emerge from the water amongst rocks and tussocks.

Water Rats appeared to go into the water at a different location from where they emerged. Tracks going into the water were seen only in the middle of the beach, and they were seen moving only in a southerly direction along the man-made path associated with the hut (Fig. 1). However, no tracks were seen going out of the water in the middle of the beach and animals were only seen emerging from the water amongst the rocks and tussocks at the western edge of the beach (Fig. 1).

Other records tend to suggest that Water Rats live very near the edge of water (Gardner and Serena 1995 (within 2 m of waters edge); Olsen 1995). However, on Cat Island this was not the case. After the Water Rats had emerged from the water at dusk or in the morning, their tracks were followed. The tracks leading away from the beach went under the hut and lead to a burrow, approximately 100 metres inland (Fig 1), on a rising dune. The burrow had two entrances amongst the roots of *L. plebeia*. There was nothing unusual about the vegetation or 'look' of the area surrounding the burrows, and without following the tracks they would not have been found easily. The burrows were approximately 20 cm wide, of an elongated shape, and approximately one metre apart in the same clump of Hollyhock bushes. The roots of the Hollyhock supported the 'roof' of the burrows.

Olsen (1995) suggests that individual Water Rats may be territorial. However, on Cat Island many tracks appeared to lead in the direction of the burrow, suggesting that there may be some communal living. (The constant wind would cover any 'old' tracks with sand). Gardner and Serena (1995) report two juvenile females sharing a den.

The location of the burrow in the middle of the east part of the island may be a response to the threat of predation. Young Water Rats can be preyed upon by snakes (Olsen 1995), which are numerous on Cat Island. The Tiger Snakes feed on the eggs and chicks of the Shearwaters by going into their burrows in the sand. The Water Rats' burrows were away from the main area where the majority of Shearwater nests occurred. The Shearwaters' nests seemed to be in greater densities amongst the grass tussocks, where a few scattered rocks provided launching platforms. Therefore, the Water Rats' burrow was presumably located in an area where Tiger Snakes were in lower densities. Another explanation may be the threat of storms and high tides. However, the bay in which they entered the water is quite sheltered and the threat of storms and high tides may not adequately explain the location of the burrows.

The adaptive nature of the Water Rat has been noted (Woollard *et al.* 1978) and it may be this adaptive nature that leads to Water Rats observed on Cat Island to display some different behaviour from that reported for those occurring elsewhere. This note, however, is based on casual observations rather than a scientific study. It is clear that there is more to learn of this adaptable animal. Detailed studies of Water Rats in a range of environments would provide further insights.

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One hundred years ago

NOTES ON PHOSPHORESCENCE IN PLANTS AND ANIMALS

By Miss Freda Bage.

The light emitted by flowering plants is not, however, limited to the flowers themselves Gardner records the phosphorescence of the sap of a Brazilian plant, *Euphorbia phosporea*; and in a certain palm the rupture of the spathe or shield covering the flowers is accompanied by a noise and spark.

Perhaps the cases of vegetable phosphorescence best known to us are those shown by certain luminous fungi. Some of these – Rhizomorphae – light up coal mines, and, in England, they occasionally show a light bright enough to read by.

From *The Victorian Naturalist* **21** (1904-5), p. 93.

A road-killed exotic snake in a Melbourne suburb

The keeping of exotic reptiles by amateur herpetoculturalists is a popular practice in many countries. This practice (along with the import or procurement of such animals) is illegal in Victoria. Despite this, there is an apparently thriving 'underground' trade in these animals, exemplified by declarations by some people during a recent amnesty held by the Victorian Department of Sustainability and Environment, and the periodic prosecution of people found to be holding such reptiles. Here I report the discovery of a road-killed exotic snake in suburban Melbourne.

In early December 2004 Mr Malcolm Doreian noted a road-killed snake in the Melbourne suburb of Rosanna. With knowledge of snake species that naturally occur in that area, he noted that this specimen was unusual, collected the snake and tentatively identified it as a North American Corn Snake (*Elaphe guttata guttata*). He subsequently delivered the specimen to me and I was able to confirm his identification. The specimen was a male, measuring approximately 615 mm in total length, with a tail length of approximately 108 mm. These dimensions are within those known for the species (Conant and Collins 1998). The specimen has been lodged at Museum Victoria (specimen number D72919).

The discovery of this snake highlights some of the issues surrounding the illegal importation and keeping of exotic reptiles. Whilst many of the people who keep these animals undoubtedly exercise great care with the husbandry and security of their animals, this incident demonstrates that these animals can and do enter the wild, although it is not known whether this particular snake was released or had escaped.

The introduction to the wild of individual animals beyond their natural range is a concern for several reasons. Such occurrences pose an unacceptable risk of introducing disease and/or parasites to indigenous wildlife. Indigenous species are frequently naive to these foreign pathogens, and lack immunity and other defences that may be present in the original host. Whilst there is valid concern about known diseases and parasites, even greater concern is perhaps warranted regarding diseases of which we are not currently aware. This point is demonstrated by the inadvertent introduction to many parts of the world of the amphibian fungal pathogen that causes the disease Chytridiomycosis. This disease, believed to have been the primary agent of devastating declines and losses of amphibians on several continents (e.g. Berger *et al.* 1998), probably entered Australia several decades ago, via infected frogs imported from South Africa (Weldon *et al.* 2004). This case exemplifies the extreme risk that currently unknown diseases can pose to naive wildlife exposed to exotic transplants.

The consequences of exotic species becoming established beyond their natural range can be devastating, and can range from competition with local species to elevated rates of predation that may threaten the future of some prey species or perturb local predator-prey relationships. An example of the devastation that may be caused by the introduction of a snake to areas beyond its natural range is the extensive damage to the avifauna of Guam caused by the Brown Tree Snake *Boiga irregularis* (Savidge 1987).

Several herpetofauna that do not naturally occur in the Melbourne area have become established there. These include Marbled Geckos *Christinus marmoratus*, Water Dragons *Physignathus lesueurii*, Common Long-necked Tortoises *Chelodina longicollis* and Eastern Dwarf Tree Frogs *Litoria fallax*. The ecological consequences of the establishment of these animals are unknown. However, the natural geographic range of each of these taxa includes south-eastern Australia (just so for the frog), and their potential to introduce novel pathogens is considerably less than that of animals from overseas.

The natural geographic range of the Corn Snake encompasses the eastern and south-eastern states of the United States of America (Conant and Collins 1998). Consequently, this species is likely to be able to survive in southern Australia's climate. Similarly, the Corn Snake is found in a variety of terrestrial habitats (and also climbs well) (Conant and Collins 1998), suggesting that it may cope well in local environments.

The introduction and potential establishment of exotic species such as the Corn Snake poses unacceptable ecological and conservation risks. Although several government agencies continue to try to prevent occurrences such as that documented here, this case demonstrates the need for greater responsibility amongst those who keep reptiles.

Acknowledgements
I thank Malcolm Doreian for collecting the snake and delivering the specimen to me, and Dianne Bray (Museum Victoria) for processing the specimen. Geoff Brown provided a critique of this note.

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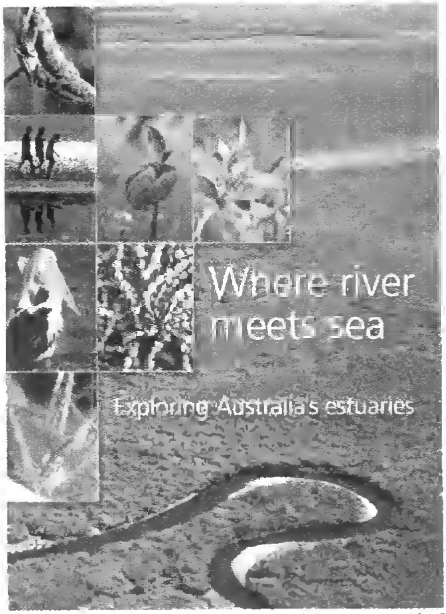
Where river meets sea: Exploring Australia's estuaries

by Lynne Turner, Dieter Tracey, Jan Tilden and William C. Dennison

Publisher: *Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management, Indooroopilly, 2004. 278 pages, paperback; colour photographs. ISBN 0957867883. RRP $49.95*



It's good to see one of our CRCs writing to inform the general reading public, rather than confining its output to science and industry. While river management, river health (or condition) and river restoration are currently big ticket issues at State and Federal level, it is well to remember that the river many of us think we live near may actually be an estuary. The post-glacial sea level rise onto this low-relief continent created many estuaries (over 1000 according to this book) and the low rates of sediment delivery from our catchments has determined that most of them have infilled very little in the 6000 years since they were created.

This book is about more than just estuaries in the strict meaning of that word. It deals with six different kinds of coastal environment – wave dominated estuary, strandplain, tide dominated estuary, tidal flats, wave dominated delta and tide dominated delta – in an attractive, well written and beautifully illustrated format. The authors aim to 'enhance estuary literacy' (page v) in 14 chapters, after reminding their readers that most of the things we do in catchments will have impacts in estuaries. Throughout the book, the interactions between people and estuaries are highlighted.

Chapter 1 defines the six estuary types, explains their basic dynamics and maps their distribution around Australia, concluding with a discussion of the management implications of this classification. An overview of Australia's estuaries is provided by drainage basins in Chapter 2 with an interesting synthesis of their condition, population, major features, threats and management arrangements. The general association between high population in the drainage basins and condition of the estuaries is clear but there are some real surprises, notably, in the South West and the Pilbara. Despite tiny populations, these estuaries are among the most stressed in the country.

A general discussion of estuary habitats in a distributed Australian context follows in Chapter 3, and the interactions between people and estuaries are reviewed in Chapter 4. Chapter 5 provides an overview of methods for assessing estuary health. The remaining half of the book is devoted to a state-by-state assessment of estuaries, arranged by coastal regions. Here we are provided with an exposition of the way the overall drivers of estuary type – climate, wave regime, tidal range, topography – interact with catchment land uses and specific activities in the estuary to produce outcomes in terms of estuary condition and ecosystem stress levels. To most of these regional surveys is added one or more specific case studies. Read the one on the Peel-Harvey Estuary in the South West and see how a specific set of natural conditions can combine to create a fragile estuarine environment easily damaged by catchment agricultural practices that in another location would have inflicted far less damage. Each state chapter concludes with an overview of estuary management arrangements for that state as well as relevant community initiatives.

If you get to the end of Chapter 12 (estuaries of Queensland) and are still in any doubt about the central message of this book, then Chapter 13 will set you straight. Entitled 'Looking Back – Moving Forward', this chapter describes eight examples from history (and mostly recent history at that) of estuarine disaster stories. One of the most pertinent to us is the case of the Colorado Delta in Mexico. The United Sales takes 90% of the water before it gets into Mexico and Mexican farmers use the remaining 10%. The result? A dead delta. If this has a familiar ring to it, go back to Chapter 9 where the Murray mouth is discussed as one of the estuaries of South Australia. At least in the case of our largest river system, the jurisdiction boundaries within it are between states and not international.

The book provides a list of contact details for organizations with responsibility for estuaries nationally and by state, a glossary, and a comprehensive bibliography and index. At $49.95 it is good value.

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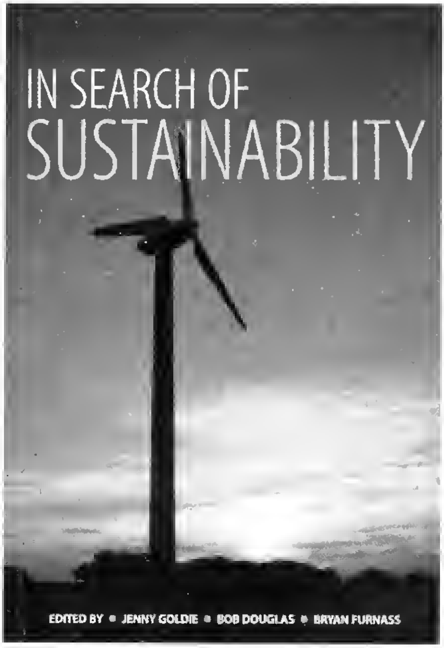
For assistance in preparing this issue, thanks to Virgil Hubregtse (editorial assistance), Dorothy Mahler (administrative assistance) and Mimi Pohl (labels).



In search of sustainability

Edited by Jenny Goldie, Bob Douglas and Bryan Furness

Publisher: *CSIRO Publishing, Collingwood, Victoria, 2005. 187 pages ISBN 06430906202. RRP $29.95*

This book lives up to its title, being the culmination of a nine month Internet conference in 2003, culminating in a face-to-face meeting of 200 people in Canberra. The result was 34 recommendations to government for action. These are contained in the appendix of the report. The full content of the conference is available at: www.isosconference@org.au

The book came about when speakers from the conference were each offered the opportunity to expand their message, in a chapter, within a printed volume. The authors are all national leaders in their respective fields. Professor Peter Cullen AO of the Wentworth Group, for example, writes about water, and Dr Clive Hamilton, from the Australia Institute about the transition to a post-growth society.

Being a collection by different writers, the book varies in style; this is both a blessing and a curse. I found some authors engaging, whilst others were so dry that I lost interest in trying to follow their direction. On the other hand, one likeable aspect of having different authors was that I could dip into the book at any chapter that took my fancy.

The second-last chapter in the book, on population, was written by one of the editors, Jenny Goldie, so she was able to draw on the previous writers to highlight how all the issues are in fact interrelated.

The focus of the book and the final recommendations are big picture directions for our society. The idea is to set a new agenda for government policy, to give a direction to take Australia closer to sustainability

I was a little frustrated by a lack of ways to implement the reforms suggested; however, the book is a great resource. It covers the issues in all areas, to a level of detail that will leave the reader informed enough to want to do something about seeing the uptake of the recommendations as soon as possible.

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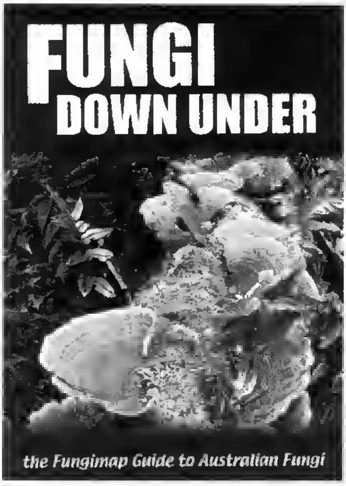

Fungi Down Under

by Pat and Ed Grey

Publisher: *Fungimap, Royal Botanic Gardens, Melbourne, 2005, 146 pages. Paperback ISBN 064644674-6 RRP$29.95*

Fungi Down Under, written by Pat and Ed Grey and published by Fungimap, includes photographs, descriptions and distribution records of the 100 Fungimap 'target' species, as well as other information relevant to the study of larger fungi.

This field guide had its genesis in the Fungimap project, a scheme to map 100 easily identifiable species of mushrooms and other fungi using information sent in by volunteer recorders. Thus far, the Compendium of Fungimap Target Species (CD-ROM) has been the only resource that contains information about all the target species.

The immediate appeal of this book lies in its design and layout, and full credit should go to Leon Costermans for overseeing its production. Each species is assigned a page, with one photograph indicating the diagnostic features of the fruit body and another showing typical habitat. Detailed descriptions of the fungus, typical substrate, habit, habitat, main fruiting period and 'look-alikes' are also included.

The maps are a first for a fungi book in Australia. To some extent they will, like any other mapping project which relies on information sent in by volunteers, reflect the distribution and favourite foraying sites of fungimappers. However, these maps, based on over 20 000 records, are valuable for a number of reasons.

Firstly, anyone contributing to the project will appreciate seeing that their record lodged at Fungimap central (housed at the Royal Botanic Gardens, Melbourne) has resulted in a red dot on the map. It is also useful to know if a species is often or rarely seen, and if it is likely to occur in a particular location. For instance, fungi recorded in southern Tasmania would probably also occur in the north of the state - am I simply overlooking them?

Appendices include a glossary of technical terms, which in this book have been kept to a minimum, a list of alternative names of species, and the pronunciation of scientific names. Appendix 4, which includes the derivation of scientific names, is my favourite. Knowing the meanings of the Latin, Greek and the one Aboriginal name invariably stimulates interesting discussion in the field and is a useful mnemonic. Appendix 5 lists books, field guides, specialised literature, general articles about fungi and fungi-related web sites. The colour chart is useful for people wanting to describe fruit bodies and the ruler on the end page is invaluable – every field guide should have one!

The two pages of credits encapsulate so much about the Fungimap project and this beautifully presented book is testament to the generosity of its many contributors. These include senior mycologist at RBG, Melbourne, and convenor of Fungimap, Dr Tom May, the mycologists who proofread the text, the various coordinators, volunteers and the many photographers who contributed their work. I have no hesitation in recommending this book to any keen field naturalist, and feel proud to be associated with Fungimap.

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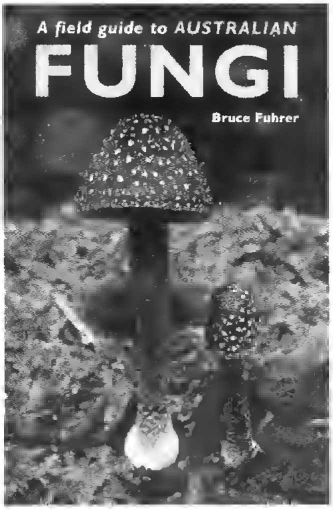
A Field Guide to Australian Fungi

by Bruce Fuhrer

Publisher: *Bloomings Books, Melbourne 2005. Octavo, paperback, 360 pages., colour photographs. ISBN 1-876473-51-7RRP $49.95*



It's currently peak fungus season in northern Tasmania and since receiving Bruce Fuhrer's beautiful new book, I have consulted it daily.

A Field Guide to Australian Fungi is an ambitious project. It is the culmination of many decades of field work and study and includes descriptions and photographs of over 500 species. Many of the photographs have appeared previously in *A Field Companion to Australian Fungi* (Fuhrer 1993) and *Rainforest Fungi of Tasmania and South-east Australia* (Fuhrer and Robinson, 1992), but there are additional species and much of the text has been revised and extended to include descriptions of some of the microscopic features of fungi.

Many Australian fungi were originally named because of their resemhlance to northern hemisphere species, but recent taxonomic work has found them to be distinct. This has resulted in name changes that I know many naturalists find exasperating. For me, however, it reflects an important scientific process and a growing knowledge of these organisms. Nonetheless, a new book on Australian fungi should help to clarify identification, not lead to more confusion. While it would be nearly impossible to include all previous names ascribed to a species (*Melanotus hepatochrous*, for example, has 14 synonyms) one would expect the inclusion of those names used in the author's previous books. These omissions, the occasionally confusing layout and the misidentification of the fungus on the front cover suggest a hasty production.

I was disappointed that the book does not assign each species to a family. When I first 'discovered' fungi, being able to place a genus in a family enabled me to make sense of the overwhelming number of fungi I was encountering. I also found the brief descriptions of the sub-genera of the Cortinariaceae family, the Hygrophoraceae family and the genera *Entoloma* and *Mycena* in *Rainforest Fungi of Tasmania and South-east Australia* particularly useful. It may have been more helpful to include this information rather than many pages of photographs of yet to be named species.

Technical terms are used throughout the text, and drawings of spores, cystidia and basidia are included on the end papers. I find such information invaluable. Every taxon has its jargon and learning this language is, for me, part of the journey towards further understanding.

There are numerous field guides to the birds or plants of Australia, but no definitive field guide to fungi, primarily because many species are yet to be formally identified and named. For amateur mycologists, this can be both frustrating and challenging and most recognise the need to have as many books as possible. This is the most comprehensive photographic field guide to have been published so far in Australia and thus is an extremely worthwhile addition to any natural history library.

Sarah Lloyd
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Fuhrer, BA (1993) *A field companion to Australian fungi*. (Field Naturalists Club of Victoria: Melbourne)

Fuhrer, BA and Robinson, R (1992) *Rainforest fungi of Tasmania and South-east Australia* (CSIRO and Forestry Commission, Tasmania: Melbourne)

Royal Botanic Gardens Melbourne: http://www.rbg.vic.gov.au/plant_science/fungi

The Complete Field Guide to Butterflies of Australia

by Michael F. Braby

Publisher: *CSIRO Publishing, Melbourne, 2004. 339 pages, paperback; ISBN 0 643 09027 4*

This eagerly-awaited field guide to Australia's 416 butterfly species (including more distant islands) complements Braby's (2000) superb two volume book, *Butterflies of Australia. Their Identification, Biology and Distribution.* This A5 size field guide is the first comprehensive popular guide to Australian butterflies since the Common and Waterhouse's 1982 version of their 1981 hardcover edition of *Butterflies of Australia.*

The introduction to the guide covers an overview of the structure of adult butterflies, their higher classification, distribution and habitats, with notes on the behaviour and typical life cycles. Six Families are now recognised within Australia, the single representative of the Riodinidae (the Harlequin Metalmark), previously being considered a subfamily of Lycaenidae (Braby 2000).

The major part of the book comprises adult species' descriptions ordered systematically and reflecting the higher classification of butterflies. Species notes are under the headings: similar species, variation, adult behaviour, habitat, status, larval food plants and larval attendant ants. There are no descriptions of the immature stages. Recently described subspecies and species are included, and distribution maps with flight periods have been updated. The maps are small, within the text on the left-hand pages and near the spine, making them a little difficult to examine without straining the spine. The choice of yellow to illustrate the distribution of some subspecies is inappropriate for showing restricted distributions on a yellow background. The right-hand pages are quality colour images of set specimens (male, female, upper and lower), the images being adjacent to the relevant species text. Generally there are three species per page. Most, but not all subspecies/forms are illustrated and, unlike in Braby 2000, there are spaces on many pages where additional images could have been added.

Some new preferred common names have been added, some from a previous list of common names (Braby 2000) and others completely new. This, at least in the short term, will cause some confusion. Errors from Braby (2000) have been corrected; however, some new errors have appeared. The distribution map for the Dusky Knight (Dusky Night under the image) is incorrect with no occurrence shown in Victoria where it is found in east Gippsland as far west as Nowa Nowa.

A major fault occurs in the checklist of species at the back of the book. All species that have more than one recognised subspecies in Australia are listed with their author and date, but where a species was described from a location outside Australia, and a single different subspecies was subsequently described from Australia, these subspecies are not listed. This has resulted in more than 80 recognised Australian subspecies not being listed.

Despite the minor errors and few shortcomings, the guide is an excellent, up-to-date, affordable publication for anyone, amateur or professional, interested in studying adult butterflies in the field.

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Braby MF (2000) *Butterflies of Australia: Their Identification, Biology and Distribution.* (CSIRO Publishing: Melbourne)

Common IFB and Waterhouse DF (1982) *Butterflies of Australia.* (Angus and Robertson Publishers: Sydney)

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Department of Primary Industries
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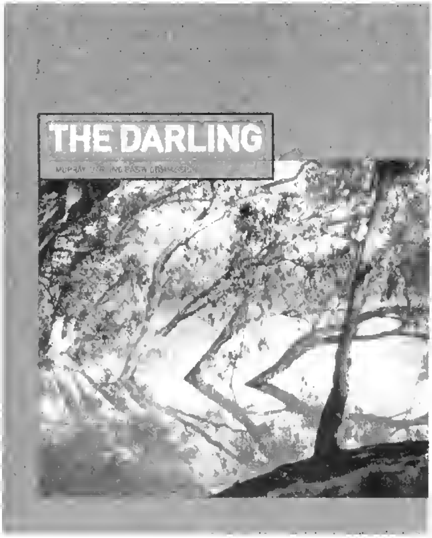

The Darling

edited by Roland Breckwoldt, Robert Boden and Jenny Andrew

Publisher: *Murray-Darling Basin Commission, Canberra, 2004.*
486 pages, paperback
ISBN 1 876830 93 X. RRP $79.95

The Darling River is an important part of the Murray-Darling Basin, and this book documents and celebrates this river system. The Darling River is an impressive river with a catchment area vaster than that of the Murray River, but its flow is sporadic and volume considerably less. The inland catchment includes areas that were inhabited for a long time by Indigenous Nations before undergoing a short but intense period of European occupation, characterised by rapid change in water and land use.

The Darling is the companion volume to *The Murray*, published in 1990 by the Murray-Darling Basin Commission. Thirty-seven authors, all experts in their own fields, contributed on a voluntary basis to this comprehensive and accessible book. It starts with four chapters exploring the social and land use systems of the Darling River and its catchment, presenting attitudes and issues of the region, and their influence on the river's future.

The second set of chapters examines the biophysical environment, the species that live in the vicinity of the river and its catchment, including mammals, reptiles, amphibians, birds and fish. These chapters describe the past and present condition of the ecosystems and examine the changes to the species and habitats associated with the Darling River. The authors also highlight what is required for continued growth and survival of these ecosystems. The macroinvertebrates are the only group that isn't covered in detail (only two pages are dedicated to them), which is surprising given their importance in aquatic ecosystems.

The third set of chapters addresses the issue of the sustainability of the system. Environmental flows, water quality and the river's responses to differing land use and other changes are documented. The conservation of terrestrial environments is also investigated.

The final chapter – *The way ahead for the Darling*, examines the future of the river and its catchment, emphasising the need for integrated management. A six point plan is presented, identifying the need for nature conservation and biodiversity protection.

There are many tables and graphs presenting scientific data/information on a wide range of topics including water storage, discharge, nutrient concentrations, distribution and habitat requirements of reptiles, vegetation communities – to name just a few. The page layout is clean and attractive, with well-chosen, high quality, colour photographs. It provides the reader interested in seeking further information with an extensive list of references for each chapter at the end of the book. *The Darling* is a readable and well illustrated book suitable for managers, scientists, or anyone with an interest in this river's past, present and future.

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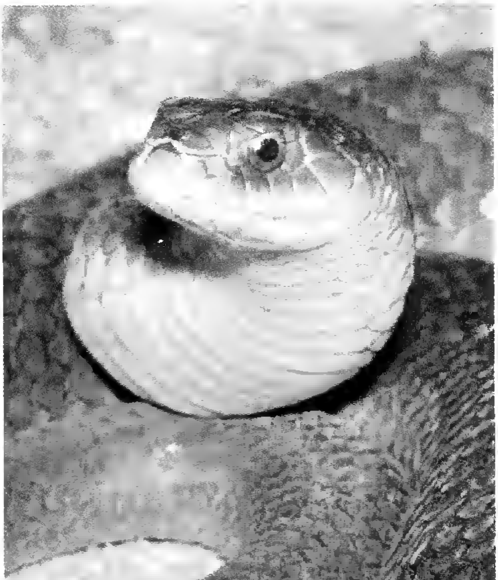

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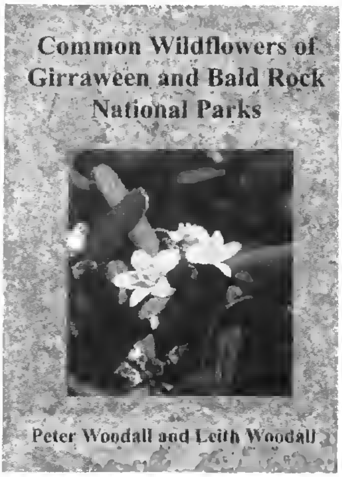
From the Editors

The wide-ranging interests of members of the FNCV, as well as that of contributors to *The Victorian Naturalist*, is once again well illustrated by the papers published in this issue. This feature of the journal was noted by a number of the speakers at the recent History Symposium, and is an indication of the high regard with which this journal is held.

Another reason for the standing this journal has is the variety and range of books that are reviewed in its pages. In this issue, for example, one of the reviews draws attention to the topical themes of the state of the environment, and the need for its conservation. The book, as well as the review, is a worthwhile read.



Common Wildflowers of Girraween and Bald Rock National Parks

by Peter Woodall and Leith Woodall

Publisher: *Taita Publishers, Brisbane, 2005. 40 pages, paperback, colour photographs. ISBN 0975682407. RRP $6.95*

This small book comprises photographs of wildflowers found in Girraween and Bald Rock National Parks. The photos are excellent, presenting each subject very clearly. They are variously grouped according to families, such as wattles, daisies or peas; by colour, e.g. whites or yellows; or locality e.g. swamp and aquatic. Ferns are also included, as are rare and threatened, and insectivorous or parasitic plants. Even the ubiquitous weeds and aliens rate a mention.

In all 138 species appear out of the 700+ that have been recorded here. These two National Parks are in different states but share a common boundary that is the border of Queensland and New South Wales respectively.

There is a caption with each photograph, which includes information on common name, height, leaf size, previous names and when the flowers might be seen. As well, general information about each grouping is given at the top of the page.

According to the Introduction, Girraween means 'place of flowers' and the display of spring flowers is among the best in eastern Australia. All of which makes me keen to visit there, particularly in spring. That brings me to the only flaw in the publication – there is no map to show you where to go.

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The

Victorian Naturalist

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Cover: Lowland Copperhead *Austrelaps superbus* from Gisborne, Victoria. Photograph by Raymond Hoser. See article on p. 249.

Web address: http://www.vicnet.net.au/~fncv/vicnat.htm
Email vicnat@vicnet.net.au

Wetland vegetation of the Ewing Morass and eastern Lake Tyers Reserves, East Gippsland

Alexander B Pollock[1,2] and Jeanette E Kemp[1,2]

Abstract
Six wetland communities of the Ewing Morass and eastern Lake Tyers Reserves were identified and described in detail. Ewing Morass is a nationally significant, but often overlooked, wetland complex. Wetlands of the Ewing Morass were undisturbed within a landscape context, and contained large populations of native herbaceous wetland plants. The salt marshes of the Nowa Nowa Arm were floristically simple, appeared intact, and formed part of the saline Lake Tyers wetlands. Ewing Morass contained few plants of conservation significance in Victoria. Its value lies in its relatively undisturbed state, free from alteration that characterises similar systems further west. It is currently protected within the Ewing Morass Wildlife Reserve. (*The Victorian Naturalist* **122** (5) 2005, 224-230)

Introduction

Most wetlands of the lower Snowy River have been studied intensively, particularly eastern areas such as the lower Brodribb, Snowy River and Lake Curlip, occurring close to the settlements of Marlo and Orbost (Timms 1973; Corrick and Norman 1980; Hull 1996). Its western extent, however, is much less well known and comprises the relatively inaccessible coastal wetlands of the Ewing Morass. This marshland occurs east of the Nowa Nowa Arm of Lake Tyers, and extends east to Corringle Creek, due southwest of the township of Newmerella (Fig. 1). It is located on the far western edge of the East Gippsland natural region (Conn 1993).

Ewing Morass was formed by a series of depositional and erosional processes where Quaternary sand dunes of the Ninety-mile Beach blocked the south-flowing Hartland River and Hospital and Simpsons Creeks (Fig. 1). Alluvial deposition subsequently occurred and, as this stream network became enclosed, resulted in the development of dense swamp vegetation (McRae-Williams *et al.* 1981). Similar processes have resulted in a network of freshwater lakes along the southern coastal fringe of East Gippsland (Timms 1973).

Nowa Nowa Arm is located within the significant Lake Tyers wetlands, a set of flooded incised valleys with a well-developed tidal delta (Hull, 1996), and occurs immediately west of the Ewing Morass.

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Comprising some 1200 ha, the Morass forms a significant part of the freshwater wetland complexes adjacent to the lower Snowy River (Corrick and Norman 1980). The vegetation of the Morass has been outlined briefly by Woodgate *et al.* (1994), but not described in detail. Similarly, the saltmarsh vegetation of the Nowa Nowa Arm has not been described.

This paper defines the floristic communities of Ewing Morass and the adjacent Nowa Nowa Arm of Lake Tyers.

Methods

Twenty-two wetland quadrats were sampled between 9 November 1992 and 27 February 1993, during a wider study of the vegetation of the Hartland-Tildesley Forest Block (Kemp *et al.* 1994). Most locations were accessed on foot. Plant identifications were confirmed by comparison with reference specimens from the National Herbarium of Victoria (MEL). Where specimens were of good quality, or represented important range extensions within Victoria, they were lodged within MEL as voucher specimens. Plant nomenclature follows Ross (2000), with the exception of *Potamogeton tricarinatus*, which follows Walsh and Entwistle (1994), and is probably referable in this locality to form II (H Aston pers. comm.). Introduced taxa are denoted by an asterisk (*).

Standard sampling methods of the Flora Survey groups of the Department of Conservation and Natural Resources (now Department of Sustainability and Environment) were used. This involved

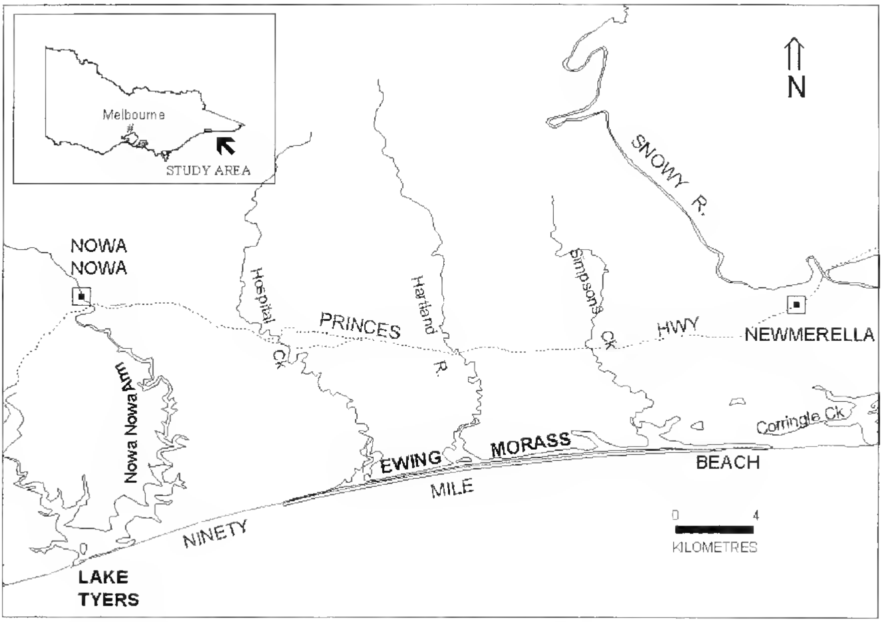

Fig. 1. Location of the Ewing Morass-Nowa Nowa Arm study area, East Gippsland.

placing 30 x 30 m (900 m^2) quadrats across stands of uniform wetland vegetation. All vascular plants within each quadrat were recorded, and each species assigned a visually assessed cover/abundance value (Gullan 1978). This value was an estimate of the foliage cover. These values were: + cover < 5% (few individuals); 1 cover < 5% (many individuals); 2 cover 5-25%; 3 cover 25-50%; 4 cover 50-75%; 5 cover 75-100%.

Sites were chosen with the aim of sampling the floristic and structural range of wetland vegetation across the Ewing Morass, and within the Nowa Nowa Arm. Sites were selected using a draft vegetation map (Woodgate *et al.* 1994), aerial photos, perceived homogeneity during a reconnaissance traverse, and ease of access. As most sites were sampled only once, some ephemeral, annual or seasonally dormant wetland plants have probably been overlooked.

The Ewing Morass was traversed extensively through use of waders, canoe or surf-ski in deeper areas. Two full traverses across the Marsh from north to south were made near the southern mouths of Hartland River and Hospital Creek.

While systematic observations of artificial disturbances (grazing, tracking, physical erosion) were made during the course of the overall floristic survey, there was no obvious evidence of gross physical disturbance by ruminants or vehicle use in the wetland sites visited.

Water depth was recorded informally, e.g. 'shallow' refers to areas between ankle and knee-depth (approx. 0.5 m or less), 'moderate' depth was approximately between 0.5 m and 1.3 m depth, while 'deep' refers to areas able to be measured safely or comfortably only by watercraft such as canoe or surf-ski (greater than about 1.3 m deep). References to water depth in the floristic descriptions used the above classification, which is consistent with the earlier classifications of 'shallow' and 'deep' by Corrick and Norman (1980).

The collected data were analysed with a nearest neighbour classification procedure (NEAR), using the Jaccard similarity coefficient (Gullan 1978). Character species subsequently were identified and used to determine vegetation communities (Gullan 1978).

Results

Between late 1992 and early 1993, Ewing Morass was generally of 'moderate' depth , allowing a full north-south traverse in two locations. At least three areas close to the mouth of feeder streams were considered 'deep' during the period of observation, as were several areas in the centre of the Morass, and within the centre of adjacent smaller lakes (of Lake Beatle and Lake Little Beatle). Sampling occurred during and immediately after rainfalls (recorded at Nowa Nowa) of up to 1.6 times the monthly means (Bureau of Meteorology, unpubl.). Thus sampling was conducted when the Morass was at or near capacity.

All of the freshwater communities sampled within Ewing Morass and surrounds occurred on Quaternary peats or sands overlying impermeable clays (Newell and Woodruff 1962), and were associated with the gently sloping edges or interior of the Morass. Three communities of Wet Swale Herbland/Sedgeland (communities WSHS1-3), one of Aquatic Sedgeland/Grassland (community ASGL) and two of Coastal Saltmarsh (communities CSM1 and CSM2) were identified (Table 1).

A total of 93 vascular plant species was recorded. Total species richness per quadrat ranged from a high of 25 to a low of six species (Table 2). 'Deep-water' sites recorded the fewest species, for both saline and freshwater habitats. Sites with 'shallow' water depths recorded the greatest total numbers of species, although they also recorded the highest numbers and greatest cover of exotics. These were typically along the northern or southern margins of the Morass.

Freshwater wetland communities of Ewing Morass and adjacent lake systems

Wet Swale Herblands / Sedgelands (WSHS-1-3)

WSHS1 was differentiated from other freshwater communities by its high richness and abundance of herbaceous semi-aquatics, most of which grew in 'shallow' water. These included species such as *Agrostis avenacea*, *Asperula subsimplex* and *Myriophyllum simulans* (Table 1). WSHS1 also contained a consistent presence and cover of mat-forming grasses tolerant of inundation, such as *Hemarthria uncinata* and *Pseudoraphis paradoxa*. The structure of this association varied from a dense herbfield to a tall emergent herbland/sedgeland, with the latter associated with extended rainfall events causing longer periods of inundation.

WSHS1 contained a significant percentage (12%) of exotic species (Table 2), which may have been a result of previous pastoral activity. The Ewing Morass area has had a long grazing history (Land Conservation Council 1985), although it apparently was not grazed at the time of this study. Weed propagules also may have been carried by stream flow into the Morass from farmland further east and north.

In contrast to WSHS1, WSHS2 was associated with water of 'moderate' depth, and supported a greater cover of some deep-water plants, such as *Ludwigia peploides* subsp. *montevidensis* and *Ranunculus amphitrichus*, which were confined to this community. *Rumex bidens*, *Persicaria praetermissa* and *Alisma plantago-aquatica* also were frequent. WSHS2 was floristically distinct through an absence of certain species present in both WSHS1 and WSHS3 (Table 1).

Community WSHS3 contained a suite of species within an environment apparently intermediate between WSHS2 and WSHS1, such as *Centella cordifolia* and *Villarsia reniformis*. This was also within water of 'moderate' depth.

Aquatic sedgelands/grasslands (ASGL)

Sites classified as ASGL were characterised by a predominance of species associated with 'deep' water, and were very species-poor in comparison to the other aquatic communities. This association was strictly confined to the deeper parts of small lakes and lagoons separate from the Morass, and within deeper central sections of the Morass itself. Tall sedges or grasses, in contrast to the herb-rich, shallower water plant communities, always dominated this association. The dominant species in Ewing Morass and Lake Beatle were either *Eleocharis sphacelata* or *Phragmites australis*, while in other locations *Baumea rubiginosa* predominated. Other tall sedges/rushes occasionally present included *Baumea articulata*, *Typha domingensis* and *Carex appressa*.

Sites identified as ASGL represented the 'deep-water' element of both Wet Swale Herbland and Coastal Lagoon Wetland as described by Woodgate *et al.* (1994). All sites sampled appeared undisturbed.

Table 1. Character species of Ewing Morass/Lake Tyers vegetation communities, their frequency (%FQ) and cover abundance (C/A). WSHS, Wet Swale herbland/sedgeland; ASGL, Aquatic sedgeland/grassland; CSM, Coastal saltmarsh. * denotes introduced taxa.

	Vegetation community											
	WSHS1 (n=4)		WSHS2 (n=3)		WSHS3 (n=4)		ASGL (n=7)		CSM1 (n=2)		CSM2 (n=2)	
SPECIES	%FQ	C/A	%FQ	C/A	%FQ	C/A	%FQ	C/A	%FQ	C/A	%FQ	C/A
Agrostis avenacea	100	1	25	+	-	-	-	-	-	-	50	+
Asperula subsimplex	100	2	67	+	-	-	-		-	-	-	-
Eleocharis sphacelata	100	2	100	2	100	2	57	3	-	-	-	-
Hemarthria uncinata	75	2	-	-	-	-	-	-	-	-	-	-
Hydrocotyle sibthorpioides	100	2	100	2	75	2	-	-	-	-	-	-
Isolepis fluitans	75	2	33	+	100	1	15	+	-	-	-	-
**Juncus articulatus*	75	1	-	-	-	-	-	-	-	-	-	-
Myriophyllum simulans	100	1	-	-	-	-	-	-	-	-	-	-
Persicaria praetermissa	25	+	67	+	25	+	-	-	-	-	-	-
Potamogeton tricarinatus	75	2	100	1	100	2	43	2	-	-	-	-
Pseudoraphis paradoxa	100	3	-	-	75	2	29	+	-	-	-	-
Triglochin procerum	100	2	-	-	100	2	85	1	-	-	-	-
Alisma plantago-aquatica	25	+	67	+		-	-	-	-	-	-	-
**Juncus bulbosus*	25	+	100	1	100	2	-	-	-	-	-	-
Ludwigia peploides	-	-	100	1	-	-	-	-	-	-	-	-
Ranunculus amphitrichus	-	-		100	+	-	-	-	-	-	-	-
Rumex bidens	50	+	100	2	25	+	-	-	-	-	-	-
Centella cordifolia	-	-	-	-	75	1	-	-	-	-	-	-
Juncus procerus	-	-	67	+	75	+	-	-	-	-	-	-
Persicaria decipiens	-	-	67	1	75	+	-	-	-	-	-	-
Utricularia australis	-	-	67	+	75	1	57		-	-	-	-
Villarsia reniformis	-	-		-	-	75	2	-	-	-	-	-
Baumea rubiginosa	-	-	-	-	-	-	43	2	-	-	-	-
Juncus kraussii	-	-	-	-	-	-	-	-	100	+	100	3
Samolus repens	-	-	-	-	-	-	-	-	100	2	100	1
Sarcocornia quinqueflora	-	-	-	-	-	-	-	-	100	4	50	+
Selliera radicans	-	-	-	-	-	-	-	-	100	2	100	+
Wilsonia backhousei	-	-	-	-	-	-	-	-	100	1	100	1
Apium prostratum	-	-	-	-	-	-	-	-	-		100	1
Disphyma crassifolium	-	-	-	-	-	-	-	-	50	+	100	+
**Festuca arundinacea*	-	-	-	-	-	-	-	-	-	-	100	1
Isolepis cernua	25	+	-	-	-	-	-	-	-	-	100	+
Isolepis nodosa	-	-	-	-	-	-	-	-	-	-	100	2
**Plantago coronopus*	25	+	-	-	-	-	-	-	-	-	100	1
Senecio glomeratus	-	-	-	-	-	-	-	-	-	-	100	+
Spergularia species	1	-	-	-	-	-	-	-	-	-	100	+

Percentage frequency (% FQ) refers to occurrence within a community, e.g. 75% for a community of four sites means the species was recorded three times out of four. Cover abundance (C/A) refers to the averaged cover of a given species within a community, e.g. C/A = 2 refers to a species with an average cover across a community of between 5-25 % foliage cover (see Gullan 1978).

Table 2. Mean species richness and mean weed composition of Ewing Morass/Lake Tyers vegetation communities WSHS, Wet Swale herbland/sedgeland; ASGL, Aquatic sedgeland/grassland; CSM, Coastal saltmarsh

	WSHS1	WSHS2	WSHS3	ASGL	CSM1	CSM2
Mean species richness	25	20	18	6	7	22
Mean % weed species	12	10	11	0	0	27
Mean % weed cover (FPC)	9	6	11	0	0	10

Saltmarsh communities of Lake Tyers

All of the saltmarsh communities (CSM1 and CSM2) sampled were confined to the eastern shores of the Nowa Nowa arm of Lake Tyers. CSM1 occurred on low broad estuarine flats on wet unconsolidated grey sands exposed to periodic tidal inundation. The vegetation of this community was distinctly zoned, each zone usually consisting of only one or two main species. *Sarcocornia quinqueflora* subsp. *quinqueflora* was the dominant small shrub of this community (Table 1). This species, together with *Samolus repens*, appeared on the wettest areas of this environment, such as drainage lines, micro-depressions or low areas closest to the lake. In contrast, the small shrub *Wilsonia backhousei* and the prostrate *Selliera radicans* occurred on the drier margins of this wetland, while the driest, most elevated zones were dominated by *Juncus kraussii*.

CSM2 occurred on elevated estuarine flats and sand lenses. Substrates included fine shallow white to grey beach sands and silts over coarse saline peaty sands or wind-blown siliceous sands, above regular tidal influence. Sedges and rushes dominated CSM2 (Table 1). *Juncus kraussii* was the most frequent of these, with *Isolepis nodosa* subdominant. In one example of this community, *Gahnia filum* formed tall dense clumps, excluding other plants. Erect shrubs included *Wilsonia backhousei* and *Senecio glomeratus*, generally in areas of low *J. kraussii* cover. Fleshy prostrate herbs were frequent and included *Selliera radicans*, *Disphyma crassifolium* subsp. *clavellatum* and *Spergularia* species 1, while *Apium prostratum* var. *prostratum* was a common twiner in the ground layer. Grasses were regularly present in CSM2, with the weedy, clump-forming **Festuca arundinacea* the largest of these. The smaller native *Distichlis distichophylla* was less frequent.

The number of weed species within CSM2 was high, although of low cover (Table 2). Common species included flatweeds such as **Plantago coronopus* subsp. *coronopus*, **Leontodon taraxacoides* subsp. *taraxacoides* and **Hypochaeris glabra*. Their abundance was probably due to disturbances associated with close proximity to farmland, historical sand mining for glass making, and walking trails for beach access.

Discussion

The limited observations of this study suggest that Ewing Morass is relatively shallow (between 1-2 m) even when full, as noted for most other coastal dune lakes studied in southern NSW and East Gippsland (Timms 1973; Corrick and Norman 1980; Timms 1997).

The vegetation of the Ewing Morass is dominated by herbaceous taxa, justifying its classification as Wet Swale Herbland/Sedgeland (Woodgate *et al.* 1994). It has clear affinities with the freshwater marshes of the Gippsland Plains further west (Corrick and Norman 1980; Conn 1993).

This study found that marginal sites were the richest in species, a pattern also observed by Kirkpatrick and Harwood (1983) for similar communities across Tasmania.

Wet Swale Herbland/Sedgeland would be broadly classified as a herb-dominated, shallow freshwater marsh, under the categories of Corrick and Norman (1980). The species-poor communities of wet swale herbland/grassland and aquatic sedgeland/grassland in 'deep' water would be included in 'reed or rush-dominated deep freshwater marshes' (Corrick and Norman 1980).

As in Kirkpatrick and Harwood (1983), our results suggest a lack of clear floristic zonation. We attribute this partially to the large-sized quadrats used in this study (more generally used for terrestrial forest ecosystems). We also believe some of the patterns in WSHS are probably due to the ability of free-floating aquatics (e.g. *Hydrocotyle sibthorpioides*, *Isolepis fluitans*, *Pseudoraphis paradoxa*) to form mats in either deep-water (sometimes entangled in colonies of emergent macrophytes) or shallow-water habitats. In some instances these species formed roots on drying sand-flats. In addition, apparently immobile taxa such as *Triglochin procerum* and *Eleocharis sphacelata* have floating seeds and seedlings that are able to rapidly colonise suitable habitats (Nicol and Ganf 2000), or produce seeds able to germinate or remain viable under a wide range of water levels (Bell and Clarke

2004). Macrophytes such as *Eleocharis sphacelata* may also compensate for some variations in water depth by increasing culm height (Sorrell *et al.* 2002).

The saltmarsh community CSM1 best fits the descriptions of 'semi-permanent salt meadows', while CSM2 can be categorised as intermediate between a 'salt flat' and a 'sea rush-dominated saline wetland' (Corrick and Norman 1980).

The patterns of species occurrence within saltmarsh vegetation at Lake Tyers appear strongly related to local drainage. Kirkpatrick and Glasby (1981) have described the environmental relations of analogous communities in coastal Tasmania, and noted that drainage and salinity appeared to be the major influences in species composition.

Saltmarsh communities dominated by *Juncus kraussii* (similar to CSM2), occur in sheltered sites within the major estuarine inlets of East Gippsland, and also within the Tidal River area further west (Corrick 1981; Conn 1993). These communities tend to occur in landward situations on gently sloping accreted muds, generally well beyond tidal influence (pers. obs.; Conn 1993). In contrast, communities dominated by *Sarcocornia quinqueflora* (such as CSM1) are widespread along coastal Victoria, particularly around the Anglesea River, Corner Inlet, Western Port and Port Phillip Bays (Corrick 1981; Corrick 1982), occurring as more seaward communities regularly subject to tidal inundation for 3-5 months per year (Corrick and Norman 1980; Conn 1993; Hull 1996). They are of limited occurrence within East Gippsland.

Plants of conservation and biogeographical significance

Two plants of conservation significance were observed. One of these, Woolly Waterlily *Philydrum lanuginosum*, is highly localised within Victorian coastal wetlands, and considered extinct in a number of previously recorded coastal locations near Melbourne. This species is listed as a vulnerable taxon in Victoria (Ross 2000), although widespread in wetlands along the New South Wales and Queensland coasts. Ewing Morass is an important known locality for Slender Mud-grass *Pseudoraphis paradoxa*, endangered within Victoria (Ross 2000). This species was recorded at nine separate locations across Ewing Morass. Like the previous taxon, this grass is widespread interstate, especially within slow-flowing freshwater riverine and oxbow wetlands in New South Wales and Queensland.

The Ewing Morass has biogeographic significance for the wetland flora of Victoria. Here, a number of taxa approach their eastern limit in Victoria, including *Chorizandra australis*, Star Fruit *Damasonium minus*, Clove-Strip *Ludwigia peploides* subsp. *montevidensis*, Short-fruit Nardoo *Marsilea hirsuta*, Mud Dock *Rumex bidens*, Floating Bur-reed *Sparganium subglobosum*, Narrow-leaf Cumbungi *Typha domingensis* and Narrow-leaf Wilsonia *Wilsonia backhousei* (Walsh and Entwistle 1994; Walsh and Entwistle 1996; Walsh and Entwistle 1999).

Conservation and natural values

No weeds of national significance (Thorp and Lynch 2000) were noted during the survey. The most frequent non-native taxa recorded were small introduced rushes such as **Juncus articulatus* and **J. bulbosus*. **Rorippa nasturtium-aquaticum* was recorded incidentally from one site along the Hartland River, but was clearly absent from most surveyed areas of the Morass in 1993. This species may be potentially problematic, as suggested by Carr *et al.* (1992).

Ewing Morass is fully reserved within the Ewing Morass Wildlife Reserve. Its future appears secure, given that there are currently no gross physical disturbances such as earthworks or native vegetation clearing occurring along its margins, and the Morass catchment is also largely protected under various tenures of public land. Efforts should be made to ensure potentially problematic aquatic weeds already observed in this system, such as **Rorippa nasturtium-aquaticum*, do not increase and spread. Limiting future sources of artificial nutrient input into the rivers and creeks of the Morass may help achieve this (Sainty and Jacobs 1994).

Because of the absence of intensive modification to the marsh and its upper tributaries, the Ewing Morass provides a good example of a coastal wetland in a highly intact state, a comparative rarity in Victoria. While other non-riverine, coastal freshwater wetlands occur in East Gippsland (Timms 1973), the Ewing Morass appears the largest in this region. Ewing Morass remains in stark contrast to similar wetlands within the Gippsland Lakes and other systems further west, which have suffered from the effects of artificially high nutrient run-off from urban and agricultural sources and have been extensively altered, drained or grazed (Corrick 1981; Corrick 1982). Ewing Morass was one of 53 significant wetlands (>100 ha) in the greater Snowy River/Gippsland Lakes Catchment, recorded by Corrick and Norman (1980). For the above reasons, the Ewing Morass is probably rightly considered a nationally significant wetland (Environment Australia 2001).

The saltmarshes of the Nowa Nowa Arm occur as floristically simple but intact associations, unlike some saltmarsh communities elsewhere in Victoria, e.g. Yugovic (1984). They form part of the nationally significant Lake Tyers wetlands (Hull 1996), and are fully conserved within Lake Tyers Coastal Reserve.

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Pediastrum wintonense sp. nov. (Chlorophyceae, Neochloridales, Hydrodictyaceae) from Lake Mokoan, north-east Victoria, and Lake Elphinstone, Queensland

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Abstract

Pediastrum wintonense sp. nov. (Chlorophyceae, Neochloridales, Hydrodictyaceae) is described from turbid Lake Mokoan, north-east Victoria, and recorded also from Lake Elphinstone in the north-west of the Fitzroy River catchment in Queensland. The occurrence of *P. wintonense* as a minor component of the plankton within the two lakes is documented, and it is described from a shoreline accumulation of up to 900 000 colonies/ml in Lake Mokoan. (*The Victorian Naturalist* **122** (5), 2005, 231-235)

Introduction

The genus *Pediastrum* occurs widely in the plankton of surface waters in Australia and elsewhere. Indeed, Melkonian (1990) asserts that *Pediastrum* and *Scenedesmus* are probably the most commonly occurring green algae in freshwater phytoplankton.

The most recent review of *Pediastrum* lists 24 species (Komárek and Jankovská 2001).

Pediastrum is also listed as one of the members of the Chlorococcales that is often involved in algal blooms (Melkonian 1990). One bloom of *Pediastrum* (species unknown) has been recorded from Australia, albeit simply as a photograph of the surface of a pond (Mitrovic 1995), and several species of *Pediastrum* were co-dominant within a midstream phytoplankton bloom in the lower Fitzroy River following major flooding in 1991 (Fabbro 1999). Discrete blooms of *Pediastrum* have occurred in a lake in the Canadian arctic (H Kling 1997, pers. comm., 13 February) and in small cement cisterns in India (Jyothi *et al.* 1992).

Lake Mokoan and Lake Elphinstone are two shallow lakes in eastern Australia (Fig. 1). Both have a history of being markedly affected by drought, and substantial blooms of *Microcystis* have occurred in each storage.

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Lake Mokoan

Lake Mokoan was formed as an off-river storage in 1971 by the construction of a 7 km long impounding wall which flooded Winton Swamp. Water quality within the lake was good until the early 1980s, when a drought led to the storage being almost emptied. A decline in water quality then occurred due to the colloidal suspension of clays. Since 1990 turbidities have routinely been in excess of 100 Nephelometric Turbidity Units (NTU), and often above 200 NTU, with Secchi transparencies of 0.17 m or less.

Lake Elphinstone

Lake Elphinstone is, by contrast, a naturally occurring water body that dried completely in 1995. Rapidly declining water quality was noted in 2000 and early 2001. This coincided with increased abiogenic turbidity during the rainy season (January and February) followed by sedimentation of suspended clays giving increased water clarity in the dry season. By October 2001 the euphotic depth had extended to the sediment surface of this shallow lake.

In this paper, an accumulation of a new species of *Pediastrum*, *P. wintonense*, is described from the shoreline of the turbid Lake Mokoan, far better known for its nuisance blooms of *Microcystis* (O'Brien *et al.* 1996). Also, the new species is formally described.

Materials and methods

Lake Mokoan

The phytoplankton population of Lake Mokoan was sampled monthly from September 1992 to June 1995 using a stan-

Fig. 1. Map showing locations of Lake Mokoan and Lake Elphinstone.

dard three-metre flexible hosepipe sampler. Samples were preserved in Lugol's Iodine and counted using a Zeiss Jena Sedival microscope and an Utermöhl chamber. A 2-3 minute phytoplankton tow was also made using a net of 35 μm pore size. The pH of surface water samples was determined using a portable Metrohm E588 meter, conductivity was measured using a portable Orion Model 126 meter, and turbidity was determined in the laboratory using a Model 2100A Hach Turbidimeter. A Secchi disc was used to assess light penetration within the lake. On 15 December 1992, an accumulation of *Pediastrum* was discovered during an inspection of the shoreline. Samples were collected in an open-mouthed jar and preserved in 5% formaldehyde and measured, photographed and drawn using a Zeiss Axioskop microscope.

Lake Elphinstone

The phytoplankton of Lake Elphinstone was sampled in November 2000, February 2001 and then weekly between June and November 2001 using a standard three-metre flexible hosepipe sampler. Samples were preserved in Lugol's Iodine and counted using a Zeiss Axioskop microscope and glass Sedgewick-Rafter Counting Chamber. A 2-3 minute phytoplankton tow was also made using a net of 25 μm pore size and a discrete surface grab sample was taken from the shoreline and examined fresh with a Zeiss Axioskop microscope prior to preservation in 3% formaldehyde. Detailed monitoring of physical and chemical conditions was undertaken on 12 June, 5 September, 10 October, and 6 November 2001 using a YSI 6600 multi-parameter water quality meter. A Secchi disc was used to assess water clarity on these occasions.

Results

The phytoplankton sampling conducted in Lake Mokoan between September 1992 and June 1995 showed the presence of a small (maximum < 0.1 $mm^3 L^{-1}$) and relatively constant standing crop of cryptomonads, with occurrence each summer of the cyanoprokaryotes *Anabaena* spp. and *Microcystis aeruginosa* (Kützing) Kützing.

Pediastrum wintonense was a constant member of the phytoplankton over this period, but never in sufficient numbers to be included in the counts. Rather, it was usually observed as a few colonies (usually less than 10) in the phytoplankton net tows. The only exceptions to this were samplings on 13 January 1994 and 18 February 1994 when an array of differently sized colonies was observed in the net tow (but the organism was still not present in sufficient numbers to be recorded in the cell counts). Very few colonies of *P. wintonense* were observed in the net tows over the 1992/1993 summer (10 November, 15 December, 19 January).

On 15 December 1992 a cursory examination of the shoreline of Lake Mokoan revealed an algal accumulation some 10 m long, 2 m wide and 2-3 cm deep, of a consistency such that it could be scooped up in solid handfuls. The accumulation consisted almost entirely of *P. wintonense*, although other algae such as *Euglena*, *Cosmarium*, *Closterium* and *Aulacoseira* were also present. Stream-lines of colonies of *P. wintonense* were sampled from the water surface adjacent to the accumulation. There were 886 000 colonies/mL in a representative sample of the shoreline accumulation. The measurement of 1000 colonies (Fig. 2) showed that maximum colony diameter ranged from 50 to 525 μm, with most colonies having a maximum diameter of 75 to 200 μm. The pH of Lake Mokoan on 15 December 1992 was 7.7, the electrical conductivity (K_{25}) 190 $\mu S\ cm^{-1}$, and the turbidity 125 NTU.

Phytoplankton sampling at Lake Elphinstone between November 2000 and

July 2001 showed dominance of *Cylindrospermopsis raciborskii* (Wolosz.) Seenayya & Subba Raju in the centre of the lake, and *Microcystis panniformis* Komárek *et al.*, *Microcystis botrys* Teiling and *Microcystis aeruginosa* in near-shore areas. This was followed by the dominance of *Ceratium hirundinella* (O Mueller) Dujard and then *Spirogyra* spp. with increasing water clarity in the spring and early summer of 2001.

Pediastrum wintonense was continually present in the nearshore samples taken from Lake Elphinstone (albeit in low densities) and yet absent from the hosepipe samples taken from offshore regions of the lake. Increased numbers of *P. wintonense* were present in nearshore samples taken on 17 July 2001. On 12 July the recorded temperature of the lake water was between 19.6 and 22.2 °C, electrical conductivity (K_{25}) between 709 and 716 μS cm^{-1}, pH between 7.4 and 8.1 and Secchi depth 45 cm.

Description

Pediastrum wintonense Croome *et* Fabbro sp. nov.

Diagnosis: Coenobia plana, irregulariter ovata, perforata, 32-, 64- vel 128-cellularia. Cellulae multiangulares ad rectangulares. Paries cellulae distincte reticulatus. Cellulae externae lobus conicus duobus minus longis quam dimidio cellulae latitudinis, cum processibus distinctis paulo minus longis quam lobis, cum sinu inter lobos profundo amploque.

Coenobia irregularly oval in outline and flat (Figs. 3-6), perforated by small holes at the outer sides of the inner cells, and with 32-64-128 cells concentrically arranged. Cells polygonal to rectangular in outline, thick-walled and joined together at their sides. A distinct net-like sculpturing is present on the surface of the cells. Marginal cells with two conical lobes less than half the width of the cell, and in the same plane as the coenobium. Processi distinct, length slightly less than that of the lobes, ending abruptly in formaldehyde preserved material. Between the lobes is a deep and wide U-shaped incision.

Dimensions: coenobia to 525 μm in length, cells 7-34 *x* 9-55 μm.
Type locality: Lake Mokoan, Victoria, Australia, 146° 5' E, 36° 25' S.
Holotype: R Croome s.n., Lake Mokoan, Victoria, 15 xii 1992 (National Herbarium, Melbourne MEL 2101365).
The specific epithet "wintonense" refers to the original Winton Swamp, flooded to form Lake Mokoan.

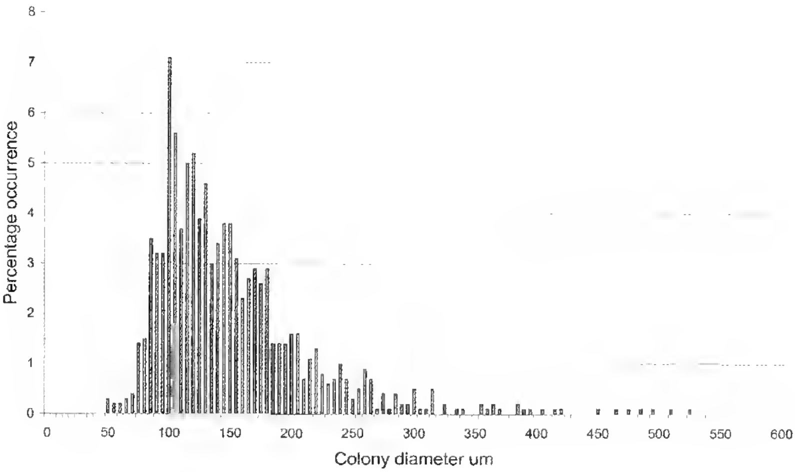
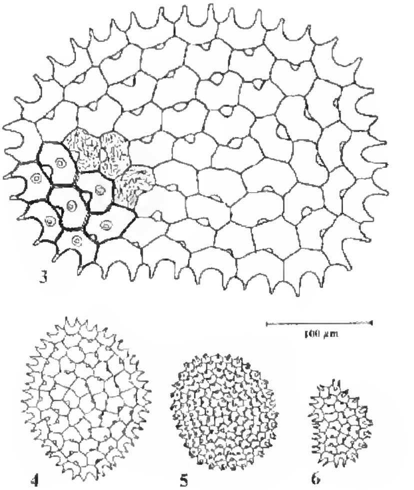


Fig. 2. Distribution of maximum colony diameter of *Pediastrum wintonense*, from accumulation beside Lake Mokoan 15 December 1992. 1000 colonies measured.



Figs. 3-6. Line drawings of *P. wintonense* colonies from accumulation at Lake Mokoan. Fig. 3. Relatively large colony with cell contents shown for 7 cells, and 3 cells showing patterning observed on empty cells. Figs. 4-6. Smaller colonies showing usual colony shape, perforations, and cell arrangement.

Material of a similar description (colony diameter 86-180 µm, cells 6-24 µm *x* 7-27 µm) was obtained from Lake Elphinstone, Central Queensland, Australia. Unpreserved material from this site showed a bulbous extension beyond the tips of the processi of the marginal cells (Fig. 7). This structure is lost in the preservation process.

Comment:

The relatively large coenobia of *P. wintonense* are irregularly oval and perforate, and the marginal cells have two conical lobes separated by a deep U-shaped incision. Of the 24 species of *Pediastrum* currently described, *P. wintonense* is most similar to *P. angulosum* (Ehrenb.) ex Menegh. Indeed, a drawing and photograph of *P. wintonense* from Lake Mokoan was provided for the recent taxonomic review of *Pediastrum* by Komárek & Jankovská (2001), in which it was included as '*Pediastrum angulosum* forma from Australia'.

Pediastrum angulosum has previously been reported from Australian freshwaters as *P. angulosum* (Ehren.) Meneghini by Playfair (1917), McLeod (1975) and Thomasson (1986); as *P. boryanum* var.

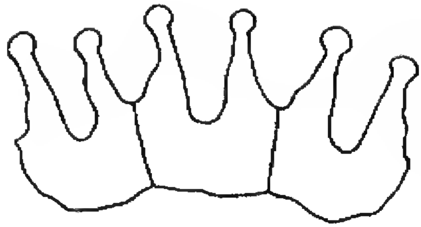


Fig. 7. Drawing of three marginal cells of a live specimen of *Pediastrum wintonense* from Lake Elphinstone, included to show bulbous extensions beyond tips of cell processi.

australe Playfair and *P. boryanum* var. *haynaldi* (Istvanffy) Playfair by Playfair (1918); as *P. boryanum* var *rugulosum* GS West by Bailey (1913) and McLeod (1975); as *P. araneosum* (Racib.) Smith by Ling and Tyler (1986); and as *P. araneosum* var. *rugulosum* GS West by Cheng and Tyler (1973). *Pediastrum angulosum* var. *asperum* Sulek was also reported from Australia by Thomasson (1986) but this taxon was synonymised with *P. duplex* var. *asperum* (A. Braun) Hansgirg by Parra (1979).

None of these observations accords with the description herein of *P. wintonense*. Moreover, the characteristics of *P. wintonense* do not conform to those of any of the varieties of *P. angulosum* currently described: most similar are *P. angulosum* var. *laevigatum* Racib. (but the coenobia of var. *laevigatum* are usually more circular, and its marginal cells have incisions which are narrower and more shallow) and var. *araneosum* Racib., which has a similar morphology of the marginal cells and cell sculpturing, but has an imperforate coenobium (Komárek pers. comm.).

While it is closely related to *P. angulosum*, we consider that the distinct size, colony form and cell morphology of *P. wintonense* separate it sufficiently from *P. angulosum* to justify its description as a new species. Its occurrence with consistent morphology at two geographically remote sites further supports this conclusion.

While not unknown, the occurrence of large accumulations of *Pediastrum* is unusual, and the collection of *P. wintonense* at the side of the turbid and eutrophic

Lake Mokoan, in which it is present within the water column in insufficient numbers to be recorded in the phytoplankton counts, is doubly intriguing. The size distribution of 1000 coenobia (Fig. 2) suggests the presence of a single clone, and the relatively large dimensions for a *Pediastrum* (coenobium length up to 525 μm, cell length up to 55 μm) make the observation of *P. wintonense* even more striking.

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One hundred years ago

NATIVE BREAD Under the title of "Native or blackfellows' Bread" Mr D. McAlpine contributes to the *Agricultural Journal of Victoria* for November, 1904, an exhaustive article on the fungus *Polyporous mylittae*, C. and M., known as "Native Bread" which is particularly well illustrated. It is just seventy years since the first account of this fungus was written by J. Backhouse in an article descriptive of the roots and other indigenous esculents of Van Dieman's Land. He remarks that its taste somewhat resembles boiled rice, but that like theheart of the tree-fern and the root of the native potato, - the orchid *Gastrodia sesamoides* - cookery produces little change in it. It has been doubted whether the fungus was ever used as food by the aboriginals. However, definite evidence is given by two gentlemen who had charge of aboriginal stations for many years that it was so used, but apparently, beyond creating a feeling of fulness, it could not have been very satisfying, for Mr. J.H. Maiden, F.L.S. Government Botanist of New South Wales, who tested the substance in a variety of ways, says that it does not contain nitrogen in any form, and is practically unalterable in water or reagents. When cut into pieces and placed in liquid no swelling takes place, the cut edges lose none of their sharpness, nor does the substance soften. When boiled in a dilute alkaline solution, only a small proportion of pectic acid is dissolved, and this is thrown down when the solution is rendered acid. It is immaterial whether it is eaten raw or cooked, as hot or cold water are equally ineffective in acting on it. It can therefore be of only infinitesimal value as a source of food. He considers the native bread to consist mainly of a modification of cellulose, most probably fungin.

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Cloacal microbes in wild birds: implications for conservation

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Abstract

A total of 129 birds from seven species was sampled in order to determine the prevalence of *Chlamydophila psittaci* and *Salmonella* in the South-eastern suburbs of Melbourne (Victoria, Australia). Polymerase Chain Reaction analyses indicated that none of the cloacal swabs or faecal samples (*Menura novaehollandiae* only) contained either *C. psittaci* or *Salmonella*. Comparison of these results with those obtained in two previous years indicated that *Chlamydophila* has declined in the area. (*The Victorian Naturalist* **122** (5), 2005, 236-243)

Introduction

Cloacal microbes are transmitted easily between susceptible individuals through either faecal contamination of the environment or sexual contact (or both) (Lockhart *et al.* 1996). Many microorganisms that can infect the avian cloaca may be pathogenic and cause mortality or decreased reproductive output in the hosts (Simpson 2002; Williams *et al.* 2002). *Chlamydophila*, for instance, has been found in more than 460 species of birds, some of them classified as endangered or threatened (Kaleta and Taday 2003). The capacity of cloacal microparasites to cause disease is related to the virulence of the strain, immunocompetence of the host, and various ecological factors relating to the risk of exposure (Wobeser 1997).

Within the genus *Chlamydophila* (formerly *Chlamydia*) (Everett *et al.* 1999; Everett 2000), *C. psittaci* is the most common species found in birds (Wobeser 1997; Everett 2000). Brand (1989) reported chlamydial infections in 159 species of birds, of which 114 were studied in the free-living state.

Salmonella is another genus of bacterium that can cause disease in free-living birds (Wilson and MacDonald 1967; Faddoul *et al.* 1966; Cizek *et al.* 1994; Pennycott *et al.* 1998; Morishita *et al.* 1999; Hudson *et al.* 2000; Fallacara *et al.* 2001; Pennycott *et al.* 2002; Reche *et al.* 2003). It belongs to the family Enterobacteriaceae and contains two species, *S. enterica* and *S. bongori*. *Salmonella enterica* consists of six subspecies (Clarke and Gyles 1993). Most salmonellae belong to *S. enterica* subsp. *enterica*.

Transmission of cloacal microparasites can occur in a number of ways including sexual activity, ingestion and inhalation of infectious aerosols, when chlamydiae and salmonellae are cast off in cloacal excretions (semen, faeces) by infected birds (Brand 1989; Wobeser 1997). Dried excrement can stay infectious for weeks or months. Faecal microorganisms are more likely to be transmitted under host crowding conditions and where feeding areas are more contaminated, especially for ground-feeding species (Brand 1989).

The pathogenicity of *C. psittaci*'s ranges in severity from the bird being a carrier of the pathogen but exhibiting no symptoms to the bird having severe, acute, or chronic disease (Everett 2000). Symptoms include excessive lacrimation, conjunctivitis, trembling, ataxia and cachexia with quite severe muscular atrophy, and watery and greenish excreta (Wobeser 1997).

The pathogenicity of salmonellae also varies, with the carrier state providing the most significant source of infection for animals including humans (Wray and Sojka 1977). There are several factors that influence whether an animal is a carrier or not, including the age of the animal, the serovar and the number of bacteria ingested (Clarke and Gyles 1993). General symptoms of salmonellosis include lethargy, diarrhoea, and anorexia, with more severe forms showing conjunctivitis,

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enteric fever, bacteremia, and gastroenteritis (Goldberg and Rubin 1988).

Chlamydophila psittaci is also a hazard to humans, and is recognized as an occupational disease of people working with birds (Palmer 1981; Hinton *et al.* 1993; Wobeser 1997). While wild birds are known to introduce and spread the disease to domestic and pet birds, it is also likely that *C. psittaci* can be spread from domestic fowl to wild populations (Sobeslavsky 1965). This pathogen has been associated with dead lyrebirds in the Dandenong Ranges National Park (DRNP) in the past.

Salmonella also has been known to pose a health threat to humans when zoonotic bacteria are shed through faeces. This pollution of the environment is of special concern in areas where humans congregate, such as picnic grounds (Simpson 2002). Zoonotic bacteria are quite persistent in the environment. which can facilitate cross-transmission of the pathogen (Fallacara *et al.* 2001).

The aim of this work was to determine the distribution and prevalence of potentially pathogenic microorganisms such as *C. psittaci* and *Salmonella* among seven species of Australian birds common in the DRNP and surrounding areas.

Data gathered will be used to develop a management plan for the control of potentially pathogenic microorganisms, especially in the Superb Lyrebirds *Menura novaehollandiae*. The results from this research will also determine if Crimson Rosellas *Platycercus elegans* that are fed daily by tourists present a health risk, and if guidelines should be put into place to prevent any transmission of disease to human populations.

Materials and Methods

A glossary of technical terms used in the text is provided in Table 1.

Study area

Field work was conducted between mid September and mid December 2002, in the DRNP, Victoria, Australia, and other locations in the South-eastern suburbs of Melbourne (Table 2). Data obtained from a previous study of four species (Bell Miner *Manorina melanophrys*, Superb Fairy-wren *Malurus cyaneus*, White-browed Scrubwren *Sericornis frontalis*, and the Red-browed Finch *Neochmia temporalis*) were collected during two consecutive breeding seasons from November 1998 to February 2000 from Jells Park in the Melbourne south-eastern suburb of Glen Waverley (Poiani and Wilks 2000a; 2000b; Poiani and Gwozdz 2002).

Data collection

Field data were gathered on individuals from seven of the most common avian species in the area: Crimson Rosella *Platycercus elegans*, White-browed Scrubwren *Sericornis frontalis*, Superb Lyrebird *Menura novaehollandiae*, Superb Fairy-wren *Malurus cyaneus*, European Starling *Sturnus vulgaris*, House Sparrow *Passer domesticus* and European Blackbird *Turdus merula*. Only adult birds were used in the sample; immature birds were released immediately. Adult birds were the main focus because this work is part of a larger project on the study of sexually transmitted cloacal microbes and, in the bird population, only the adults are sexually active. Individuals of all species (except for *Menura novaehollandiae*) were trapped by mist-netting and metal banded for future identification. A cloacal swab was

Table 1. Glossary of some technical terms used in the text

Polymerase Chain reaction (PCR)	Molecular genetics technique used to amplify selected sections of DNA.
RNA Lysis Tissue (RLT) buffer	Lysis buffer used to break up cell membranes and release genetic material.
Oligonucleotide primer	A short nucleic acid molecule used in PCR.
Ataxia	Decrease in the ability to move.
Cachexia	Loss of weight and muscle mass.
Serovar	Strain of any bacterium that can be distinguished by reactions to specific antibodies
Inhibited	Samples suffered from technical problems

Table 2. Field sites and their dominant vegetation.

Sites	Vegetation Description
Chesterfield Farm, Scoresby	Farmland with mainly introduced herbs, shrubs and trees
Grant's Picnic Ground (DRNP) [a]	'Wet forest' - dominated by Mountain Ash *Eucalyptus regnans*
Grey Gum Walking Track (DRNP) [a]	'Lowlands forest' - dominated by Messmate Stringybark *E. obliqua* and Red Stringybark *E. macrorhyncha*
Jells Park, Glen Waverley	Open woodland with dominant tree species being Manna Gum *E. viminalis*, Swamp Gum *E. ovata* and Silver Wattle *Acacia dealbata*, and understorey mainly consisting of Swamp Paperbark *Melaleuca ericifolia* and Prickly Currant Bush *Coprosma quadrifida*.
Sherbrooke Forest (DRNP) [a]	'Wet forest' - dominated by Mountain Ash *E. regnans* and 'Damp forest' - dominated by Mountain Grey Gum *E. cypellocarpa* and Messmate Stringybark *E. obliqua*
Sherbrooke Picnic Ground (DRNP) [a]	'Wet forest' - dominated by Mountain Ash *E. regnans*
Scotchman's Creek, Glen Waverley	Suburban parkland - dominated by several *Acacia* and *Eucalyptus* species
Silvan Road (DRNP)	'Shrubby foothills forest' - predominately Messmate Stringybark *E. obliqua* and Peppermint *E. radiata*

[a] (Friends of Sherbrooke Forest 2000)

taken from each bird to test for the presence of *C. psittaci* and *Salmonella* and stored in a 1 ml cryotube with 0.5 ml of RLT buffer solution (4M Guanidine thiocyanate, 15mM Pipes, pH 6.7). The cryotubes were transported to the laboratory approximately 2 hours after collection and frozen at -70°C. Bird body mass was measured to the nearest 0.1 g with a Pesola spring balance.

Menura novaehollandiae faecal collection

Menura novaehollandiae cannot be easily captured, therefore faecal samples (rather than cloacal swabs) were obtained from areas in Sherbrooke Forest in the DRNP. In order to minimize pseudoreplication (i.e. the use of statistically non-independent data, such as several samples taken from the same individual), only one faecal sample was taken from each locality, and sites were chosen as far away from each other as possible (Fig. 1). About 0.2 ml of faeces was taken from each bird with a clean plastic spoon and stored in a 1 ml cryotube. Each sample had 0.5 ml of RNA Lysis Tissue (RLT) buffer added, and was stored at -70°C after arrival in the laboratory in order to preserve the genetic material.

Estimate of relative abundance of birds

Two methods were used to estimate relative abundance of target species at all study sites. These were capture rates from mist-nets and linear transects The capture rate from mist-nets was calculated by recording the total time the nets remained open (TT), and the total mist-net area (TMA). These measurements were then used to calculate a value of mist-net exposure (ME) where ME = TT x TMA [in units of h x m^2] which was then used to estimate the Relative Population Size, (RPS) = Total Captures/ME. Thus RPS is an estimate of population size that takes into account the effect of capture effort.

Birds were also counted along two 100 m linear transects at each study site. All individuals observed within 20 m on each side of the transect were recorded, to give a total area (TA) surveyed per transect of $4000m^2$ (40m x 100m). The total time needed to walk the transect was kept constant (approximately 10 minutes) in order to standardise the amount of time spent looking for birds. All transects were surveyed in the early morning between 0800 and 1000 to keep the time of day constant within study sites.

The estimated relative population size from mist-net captures correlated with that obtained from the linear transects. The numbers from the linear transacts were chosen because they recorded the highest numbers of birds. The relative abundance of each species recorded in Table 4 is the mean value of relative abundance for that species across all study sites where the

Table 3. Oligonucleotides used in PCR to detect *Chlamydophila psittaci* and *Salmonella*.

Target organism	Primer	Sequence (5' – 3')	Genbank accession number	Expected size of band
C. psittaci (ompA)	ChlaF	ATGAAAAAACTCTTGAAATCGG	X56980	1093 bp
	ChlaR	CAAGATTTTCTAGACTTCATTTTGTT		
Salmonella (ompC)	S18fwd	ACCGCTAACGCTCGCCTGTAT	M31424	159 bp
	S19rev	AGAGGTGGACGGGTTGCTGCCGTT		

species was sighted. The sites with 0 values (where the species was not seen) were not used in the calculation of the mean value of relative abundance. This acts as a control for the fact that non sightings may indicate inappropriate habitat for that species. The main concern was the relative abundance of the avian species used in the study wherever they are present in the habitat. The immatures were recorded only for the purpose of calculating relative abundance.

Nucleic acid extraction

Nucleic acid extraction from cloacal swabs followed standard procedures (Archbold 2003). In the case of *Menura novaehollandiae* nucleic acids were extracted from faecal samples.

Faeces were vortexed and then transferred into labelled 1.5 ml microfuge tubes. The samples were centrifuged for 5 minutes at 14 000 rpm. The supernatant was then transferred into 1.5 ml microfuge tubes. These faecal samples were then treated in the same manner as the cloacal swabs for nucleic acid extraction (Archbold 2003).

Oligonucleotide primers were acquired from a commercial source (Geneworks Pty Ltd) (see Table 3). PCR for *Ch. psittaci* was carried out in 25 µL reactions containing 5 µL of extracted DNA sample in 1 x *Taq* DNA polymerase buffer (Roche Diagnostics, Mannheim, Germany), 2 mM $MgCl_2$, 200 µM of each dNTP, 1.0 µM of each primer (see Table 2), and 1.25 U *Taq* DNA polymerase (Roche Diagnostics). Each reaction was overlaid with a drop of mineral oil, and contamination of reactions by PCR product was avoided by using different working areas. Using a Hybaid OmniGene thermocycler (Hybaid, Middlesex, UK) reactions were subjected to 40 cycles of one minute at 95°C, one minute at 56°C, and one minute at 72°C, and then one cycle of five minutes at 72°C.

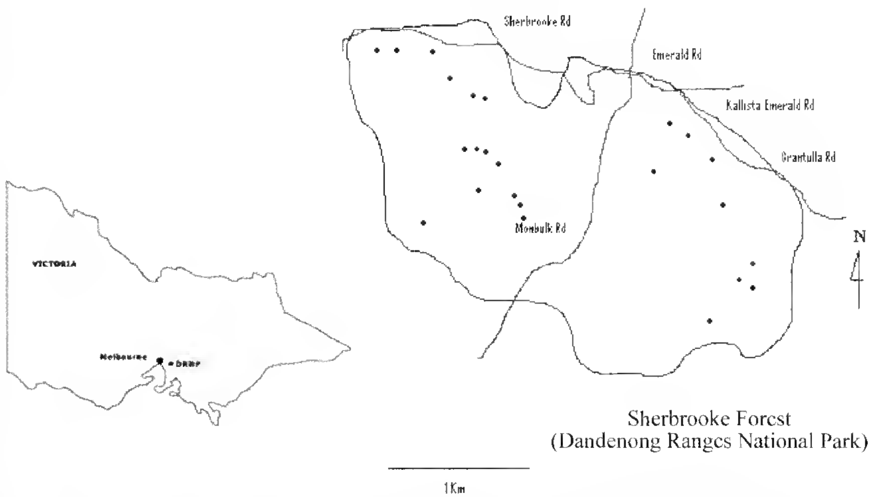

Fig. 1. Map showing the range of locations where *Menura novaehollandiae* faecal samples were collected. The map was compiled by Draughting Section, Division of Forest Management 1974.

Table 4. Relative abundance, number of birds sampled, mean body mass, and number of inhibited samples in the *Salmonella* PCR in seven species of Australian birds.

Host species	Relative[a] abundance	n	Mean body mass (g)	No. of inhibited samples in the *Salmonella* PCR
Menura novaehollandiae	0.16	24	972.50[b]	20
Platycercus elegans	125.00	25	144.20 ± 8.50	5
Sericornis frontalis	6.68	10	13.45 ± 1.12	0
Malurus cyaneus	7.50	2	9.25 ± 0.35	0
Passer domesticus	75.00	33	26.97 ± 1.90	3
Sturnus vulgaris	7.50	25	78.88 ± 5.65	4
Turdus merula	6.88	10	89.05 ± 6.04	4

[a] Birds/ha as estimated from linear transects. The value for *M. novaehollandiae* was estimated by the Friends of Sherbrooke Forest Group (pers. comm.) on the basis of an annual survey of 802 ha in the Sherbrooke Forest.
[b] Information taken from Higgins *et al.* (2001).

Table 5. Number of individuals sampled in the 1998-1999 and the 2002 season that tested positive for either *Ch. psittaci* or *Salmonella*.

Year	Parasitised	Not parasitised	Total
1998-1999[a]	10 (9.7 %)	93 (90.3%)	103
2002	0 (0%)	129 (100%)	129
Total	10 (4.3%)	222 (95.7%)	232

[a] Data taken from Poiani and Wilks (2000a)

Table 6. Number of individuals in the 1998-1999, 1999-2000, and 2002 breeding seasons that tested positive for *Ch. psittaci*.

Year	Parasitised	Not parasitised	Total
1998-1999[a]	10 (9.7%)	93 (90.3%)	103
1999-2000[b]	8 (3.8%)	201 (96.2%)	209
2002	0 (0%)	129 (100%)	129
Total	18 (4.1%)	423 (95.9%)	441

[a] Data taken from Poiani and Wilks (2000a). [b] Data taken from Poiani and Gwozdz (2002)

The feline strain WB96 (Sykes *et al.* 1999) of *C. psittaci* was used as a positive control, and double distilled water was used as a negative control. The DNA of the positive control was extracted from a swab in the same way as previously described. For more details on nucleic acid analyses see Archbold (2003).

Results

This research tested 129 individuals from seven bird species for *C. psittaci* and *Salmonella*. Neither microorganism was detected in any of the cloacal swabs nor faecal samples, and none of the birds processed showed the typical symptoms of chlamydiosis or salmonellosis. Thus, infections by *Salmonella* and *C. psittaci* were not detected in the species sampled despite the wide range of both relative abundance and bird body size.

Relative abundance

Relative abundance estimated from mist-net capture rates and the counts from linear transects carried out in each study site were highly correlated (Pearson's product-moment correlation: $r_5 = 0.920$, $p = 0.003$). Estimates of relative abundance differed markedly among bird species, from 125 birds/ha for *Platycercus elegans* to 0.16 birds/ha for *Menura novaehollandiae* (Table 4). Species also differed markedly in their body sizes (from 9.25 g in *Malurus cyaneus*, to 972.5 g in *Menura novaehollandiae*) (Table 4).

Samples inhibiting PCR

Table 4 lists the number of samples that were inhibited and therefore did not show a PCR product in the *Salmonella* test. Overall, 27.9% of samples were inhibited, that is, suffered from technical problems. This percentage is mainly explained by the strong inhibition detected in the *M. novaehollandiae* faecal samples (83.3%, 20/24).

Comparison of microorganism prevalence between years

There was a significant difference in the overall microorganism (*C. psittaci* and *Salmonella*) prevalence between the 1998-1999 and the 2002 breeding seasons (Fisher's exact test: $p = 0.0002$, Table 5) when all host species were considered. Overall, prevalence decreased from 1998-1999 to 2002.

A significant difference in the prevalence of *C. psittaci* occurred between breeding seasons of 1998-1999, 1999-2000, and 2002 when all host species were considered (Pearson's Chi-square: $X^2 = 13.85$, $p = 0.001$, Table 5). *C. psittaci* prevalence tended to decrease from 1998 to 2002.

Discussion

All species tested negative for both *Salmonella* and *C. psittaci* in spite of large differences in host relative abundance and body size values, which suggests that the results are not confounded by small host body sizes or low relative abundances. Previous studies have indicated that usually, but not in all cases, small-bodied hosts tend to have less diversity of parasites than large-bodied hosts (Kuris *et al.* 1980; Gregory *et al.* 1991). The same is generally said for the size of host populations, with birds in small populations generally harbouring fewer parasites (Gregory *et al.* 1991).

Samples inhibiting PCR

Even though there was a significant difference in the overall prevalence of *C. psittaci* and *Salmonella* between the 1998-1999 and 2002 seasons, it must be noted that the tests used to detect these microorganisms were different each time. Poiani and Wilks (2000a) used a commercial kit (Clearview, Unipath Ltd) to detect *C. psittaci* antigens, and cell culture was used to test for the presence of *Salmonella*.

A number of studies has been carried out to evaluate PCR in comparison with other diagnostic methods for the detection of *C. psittaci* in avian samples (Hewinson *et al.* 1997; Elder and Brown 1999; McElnea and Cross 1999; Trevejo *et al.* 1999). Generally it is considered that PCR is more sensitive than the enzyme-linked immunosorbent assay (ELISA) commercial kits such as Clearview, and cell culture, although one study (Trevejo *et al.* 1999) found that the test performance of PCR was low compared to ELISA. This implies that the results of this study are conservative, as the less sensitive method (Clearview) gave higher prevalence values than the more sensitive method (PCR). Thus the trends detected are not an artefact of the different methods used.

Hewinson *et al.* (1997) detected *C. psittaci* in faecal samples using PCR, which contrasts with the findings of this study, where 20/24 of *Menura novaehollandiae* faecal samples appeared to be inhibiting the PCR. This may be due to methodological differences in extracting the DNA from the faeces, or the fact that Hewinson *et al.* (1997) used a sample from a clinically sick parrot rather than faeces that had remained exposed in the field for variable periods of time. The likelihood of obtaining false negative results may be increased in faecal samples where the presence of inhibitors are in high concentration and the target microorganism may be in low concentration (Gelfland 1989). Inhibition among species ranged from 0-83.3% (Table 4).

Comparison of microorganism prevalence between years

Finding zero prevalence of *C. psittaci* in all seven host species sampled may not be as surprising as at first appears. Previous studies (Poiani and Wilks 2000*a*; Poiani and Gwozdz 2002) showed that the prevalence of *C. psittaci* across four species sampled decreased from 9.71% in the period November 1998 - January 1999 to 3.83% in the period June 1999 - February 2000.

The same four host species were tested for *Salmonella* in the 1998-1999 breeding season, but it was not detected in any of the individuals (Poiani and Wilks 2000*a*). Rates of detection of *Salmonella* in free-living avian species is usually fairly low compared with poultry (Fallacara *et al.* 2001; Reche *et al.* 2003). Thus the results of this study are consistent with previous research carried out in wild populations.

There are a number of potential reasons why the prevalence of *C. psittaci* appeared to decrease over this time frame. One possibility is that the individuals were not shedding chlamydiae or salmonellae at the time of sampling. A negative PCR result does not always indicate that an individual is not carrying the microorganism, as infected birds shed the organism intermittently (Hewinson *et al.* 1997). Holzinger-Umlauf *et al.* (1997) found that clinically healthy Tits (Paridae) intermittently shed *C. psittaci* when tested several times over a period of nine months. In addition, microparasites may vary in their intensity and prevalence across seasons (Pennycott *et al.* 2002; Poiani and Gwozdz 2002). Lublin *et al.* (1999) found that pigeons (*Columba livia domestica*) shed higher numbers of *C. psittaci* in the hottest period of the year. However, the above does not seem to be a good explanation for our results as it would require perfect synchronization of microparasite shedding across seven species of birds. A general environmental trend towards a decrease in parasite populations seems to be a more likely explanation. For instance, there is a possibility that the amount of rainfall may affect the distribution of microorganisms in the host populations. The period from September 2002 to December 2002 was drier than 1998/1999/ 2000, this may partially account for the low prevalence of *C. psittaci* found in 2002, particularly if the stress imposed by the drought reduced survival of infected birds.

Autopsy revealed that three recently reported incidences of mortality in the *Menura novaehollandiae* population in the DRNP (K Curran, pers. comm.) were caused by *C. psittaci* infection. Since none of the sampled individuals in this study tested positive to this pathogen (although it must be remembered that many samples appeared to be inhibiting the PCR), it is possible that the *C. psittaci* strain(s) likely to be introduced in the DRNP from time to time, may have been virulent enough to kill all birds infected with the pathogen, and thus may have limited the transmission of the pathogen to other individuals. If the strain of the pathogen was not endemic, then the death of the birds could be explained by their lack of immunity against that pathogen.

Although prevalence of *C. psittaci* among wild populations of native birds may fluctuate from year to year, lack of immunity of resident birds against specific strains may cause mortality among infected individuals from time to time. Feral or domestic cats and dogs may be important carriers of *C. psittaci* into the park, as it is well known that they harbour the pathogen (Sykes *et al.* 1999). Any management plan aimed at limiting introduction of domestic mammals into the park certainly will be of benefit in the control of *Chlamydophila* infections among native birds.

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Contribution

Diet of a Barn Owl *Tyto alba* at Snake Island, Victoria, including Eastern Pygmy-possum *Cercartetus nanus*

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Abstract

A sample of 23 pellets was collected at a Barn Owl roost tree on Snake Island, a coastal sand island off the coast of southern Victoria. Prey analysis of the pellets revealed that the Eastern Pygmy-possum constituted 27% of captures and an estimated 13.6% of the biomass of prey items in these pellets. The major prey item by capture was the introduced House Mouse (50%) but the major proportion of estimated biomass was provided by Bush Rats (38.0%) and unidentified rats (29.6%). (*The Victorian Naturalist* **122** (5), 2005, 244-246)

Introduction

The Barn Owl *Tyto alba* is a well-known predator of small terrestrial vertebrates, e.g. rats and mice (Higgins 1999). Most Australian studies have been conducted in farmland, where the species is common, or in arid inland habitats. Little is known about the prey of the species in natural habitats of southeastern Australia. This report describes the prey contents of 23 regurgitated pellets from a Barn Owl roosting in relatively unmodified coastal habitats on Snake Island off the coast of southern Victoria.

Snake Island (38° 45' S, 146° 32' E) is a large sand island (3452 ha) approximately 3 km from the mainland, at the eastern edge of Corner Inlet near Wilsons Promontory. The island is uninhabited by people and contains very little cleared land, although it is seasonally grazed by stock and supports a population of introduced Hog Deer *Cervus porcinus* (Menkhorst 1995).

The vegetation consists of woodland with a heathy understorey. Ten major Ecological Vegetation Classes (EVCs) are represented, namely Damp Sands Herb-rich Woodland, Plains Grassland, Mangrove Shrubland, Coastal Saltmarsh, Swamp Scrub, Coastal Tussock Grassland, Estuarine Wetland, Heathy Woodland, Sand Heathland and Wet Heathland (source: Biomap, Department of Sustainability and Environment Corporate Geospatial Library).

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Methods

A deposit of regurgitated owl pellets was found within a hollow of an old Manna Gum *Eucalyptus viminalis* on 12 March 2002. The appearance of the pellets was consistent with those of the Barn Owl (see Triggs 1996). A wing covert found at the site was confirmed as belonging to a Barn Owl after comparison with a reference skin.

The roost tree was half a kilometre inland from the southern coast of Snake Island in Damp Sands Herb-rich Woodland. This comprised open woodland of Manna Gums *Eucalyptus viminalis* and Coast Banksia *Banksia integrifolia* with a scrubby middle-storey of Coast Wattle *Acacia longifolia*. There were large openings in these woodlands where a shrubby ground cover replaced the wattle. To the north, the vegetation thickened and became predominantly *B. integrifolia* with copses of Paperbark *Melaleuca* sp. in the wetter swales and along the coastal margin.

The hollow entrance was 8 m above ground with an entrance of 200 mm diameter, widening to 300 mm at the base, approximately 1.5 m below. There was an accumulation of detritus and pellet material 700 – 800 mm deep. A side vent allowed successive deposits to roll to the outside, thus self cleaning the remaining 700 mm deep chamber. A sample of 23 pellets was collected from the top 50 mm of the chamber accumulation for analysis. Contents of the pellets were identified by comparison of skull, dentary and major limb bone material with reference skeletons. Hairs were identified microscopically using the methods described in Brunner and Coman (1974). Estimated biomass of prey was based on mean weights of mammals from

Strahan (1983). Mean weight of unidentified rats was based on the range of rat species known to occur in the Snake Island area (Source: Atlas of Victorian Wildlife).

Results

Forty-eight individual prey items were present in the pellets. Two pellets contained three prey species, 10 pellets contained two species and 11 pellets contained one species. An introduced species, the House Mouse *Mus musculus* was the most frequent prey taken (50% of all captures) followed by two native species, Eastern Pygmy-possum *Cercartetus nanus* (27%) and Bush Rat *Rattus fuscipes* (15%). Unidentified rats provided the remaining proportion (8%) (Table 1). Rats provided 67.6% of the total prey biomass, House Mouse 18.8% and Eastern Pygmy-possum 13.6% (Table 1). An unidentified bird feather was not included in the analysis.

Discussion

The Barn Owl is an opportunistic predator of a wide range of prey (Higgins 1999). Detailed studies have shown small rodents to form the main proportion of the diet. For example, the House Mouse can provide more than 90% of the rodent part of the owl's diet in areas where native terrestrial mammals have become scarce (e.g. Debus and Rose 2004). Heathy habitats such as those on Snake Island are known to support populations of the House Mouse as well as a range of native mammal species (Menkhorst 1995). This note shows that at least two of these native species (Bush Rat and Eastern Pygmy-possum) constitute 51.6% of the prey biomass of the Barn Owl under consideration.

This is the first documented record of a Barn Owl preying on Eastern Pygmy-possum although there are a few records of Barn Owls taking another small native phalanger, the Feathertail Glider *Acrobates pygmaeus* (e.g. James 1980). The Eastern Pygmy-possum proportion of total captures (27%) in the owl pellets indicates that this species may be reasonably common on Snake Island. Although there are records of this species from the island (Menkhorst 1995) little information is available on its status.

Barn Owl *Tyto alba*. Photograph by Edward McNabb.

The Barn Owl is typically a predator of terrestrial prey and the Eastern Pygmy-possum is regarded as predominantly arboreal (Strahan 1988). However, Pygmy-possums often will travel across the ground between flowering trees such as Banksias to glean nectar when trees are scattered or a middle-

Table 1. Contents of 23 regurgitated Barn Owl *Tyto alba* pellets from Snake Island, Victoria. Number of pellets in which each prey species occurred, total individuals of each prey species, proportion of total captures, biomass of each species (mean weight x total individuals captured) and proportion of total prey biomass.

Prey species (mean weight)	No of pellets	Total individuals captured	% Total captures	Biomass (g)	% Total biomass
House Mouse (18g)	14	24	50	432	18.8
Bush Rat (125g)	9	7	15	875	38.0
Eastern Pygmy-possum (24g)	10	13	27	312	13.6
Unidentified rat (170g)	4	4	8	680	29.6
Total		48	100	2299	100

storey is absent (Turner 1995). This brief study shows, again, the value of owl pellets as a resource for surveying cryptic mammal species (e.g. Loyn *et al* 1986).

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Bary Dowling

18 June 1933 – 30 May 2005

Bary Dowling joined the FNCV in 2000. He was a keen bird observer and a member of the Bird Observers Club of Australia and the Ringwood Field Naturalists Club.

From his early childhood, growing up in the Western District of Victoria, his knowledge and passion for all animals and plant life grew. He had an acute eye for detail and the naturalist's enquiring mind, coupled with a talent for writing. His autobiography *Mudeye: an Australian boyhood and beyond* (1995) describes his early life growing up on a dairy farm. A keen interest in farming saw Bary and his wife Margaret on a mixed farm in Tasmania and later at Learmonth, Western Victoria, and Pomonal near the Grampians.

His early training was from the Burnley College of Agriculture but he went on to many varied positions. As a landscape gardener he was involved in managing several different gardening positions, as curator of the Carlton Gardens and the Lae Botanic Gardens. He also had a position as Agricultural Officer in New Guinea. He was a man who was keen to try anything as long as it was outdoors!

As well as the previously mentioned book he wrote *Exploring Australia's South-east* (1989) and a collection of short stories, *Eye of the White Hawk* (1997).

In more recent times most people will have read at least some of his beautifully written natural history articles in *The Age*. These newspaper articles chronicled his most special times in his beloved bushland and his rambles along the Yarra River.

His understanding of the environment and his despair at its destruction meant many passionate discussions between himself, friends and fellow naturalists. He supported the removal of cattle (and brumbies) from the High Plains and fortunately lived long enough to hear a result – the end of the cattle leases. He felt very strongly that spending vast amounts of money on individual isolated species without consideration of the environment as a whole or preserving the species' habitat was futile. He felt that in saving the environment we save everything, without it nothing.

His religion was the environment and all it contained, no matter how small or how ordinary it was. He took pleasure in its existence. Bary's enquiring mind refused to accept anything at face value, and he was always seeking deeper understanding.

He joined my regular Wednesday walks several years ago and soon endeared himself to everyone with his sense of humour, kindness and thought-provoking discussions. He willingly shared his knowledge and used some of the highlights of the walks as material for his *Age* articles.

This modest man with a storehouse of experiences on the land, in formal gardens and bushland (especially if it was wild and rugged like his beloved Grampians) was at his happiest striding under a clear blue sky or commenting on the extraordinary shape of the billowing clouds or examining a tiny leaf gall.

He died grateful for all life, in harmony with his fellow man and in awe of the environment. Those of us who were privileged to have known him mourn his loss but rejoice in his life and its many contributions.

He adored his grandson Osca, delighting in sharing natural history experiences with him, with the result that Osca became a member of the FNCV Junior Club.

Our sincere condolences to his family and partner Catherine.

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A modern peat deposit at Rosebud

On a Marine Research Group excursion to Rosebud on 30 April 2005, the author became interested in a peat outcrop south of the Jetty Road pier at the back of the beach, latitude 38° 25.27'S, longitude 144° 54.35'E. It is on the northern edge of the Tootgarook Swamp (Keble 1950).

On closer examination of the peat deposit, it was evident that there were angular clasts of Dromana granite, building bricks, concrete and bitumen fragments and sawn logs. The included coalified wood fragments appeared to show preferred orientation. The presence of human artifacts in the peat suggested that the deposit occured since settlement in the area (or modern late Holocene). The deposit was approximately 30 m wide and an average of 1 m thickness. The outcrop extends easterly beneath a terrace 1 m above low tide and may be an indication of an earlier slightly higher sea level.

The length and width (in cm) and orientation of 36 lignified wood fragments found within the peat was calculated. From this data, the alignment of the fragments is shown in three different rosettes (Fig. 1). All three rosettes show significant orientation in the south-east north-west (135°) direction sector. This direction is significant beyond

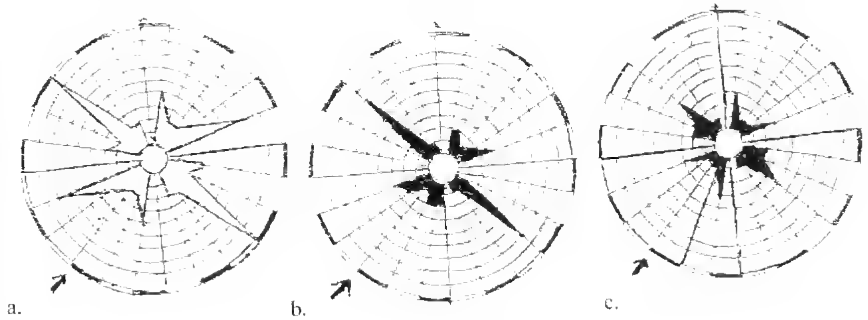

Fig. 1. Rosettes showing the frequency of linear log and wood fragments. Each circle = 1 fragment. All 3 rosettes significant beyond $p = 0.05$. a. Frequency of 36 wood fragments (all sizes) with a preferred orientation of 135°. Inferred south-westerly current aligned wood fragments in the peat deposit as indicated by the arrows. b. Frequency of 20 wood fragments exceeding 30 cm in length. Longest pieces prefer 135° class sector, whilst shorter lengths radiate from 15° to 75°, sub parallel to the inferred current of 225° (SW). c. Frequency of 19 wood fragments with e = L/W exceeding 5. Stronger orientation is perpendicular to the current, with a secondary mode sub-parallel to the SW.

Fig. 2. Lignified branch (under ruler). Angular rock fragments of Dromana granite, bitumen and concrete above branch. Ruler = 16 cm.

Fig. 3. Peaty wood projecting from peat deposit at Rosebud. Ruler = 16 cm.

p = 0.05 for the twelve 15° classes. This means that, with chance factors reduced to less than 5 in 100, some factor other than chance must be operating to align the wood fragments perpendicular to the onshore current. Fig.1b demonstrates that only the longest fragments (upwards of 20 cm in length) align perpendicular to the current. Shorter fragments tend to be subparalleled to the current from 10° to 75° (with a mean of 45°). The same pattern is suggested by Fig.1c with the most elongate fragments, i.e. e > 5, with elongation ratio defined as e = l/w.

The author has found this pattern is common in the distribution of current aligned linear fragments such as graptolites (*Diplograptus* spp.) in Ordovician slates at Gisborne and Toolern Vale (Schleiger 1968 Figs.1b,1c). Shorter linear shapes tend to be fickle and fan out in the direction of the current. The distribution of linear wood fragments in the peat would be aligned by wave action breaking on the beach from a south west to north east swell associated with the passing of a cold front from west to east across southern Victoria.

The sequence of events for the formation of peat is as set out below.

1. In modern times since settlement in the Rosebud area, strong south-westerly winds whipped up strong waves which scoured the shallows of sea grass and kelp offshore. Marine plant material and litter from trees nearby was piled up at the back of the beach. Logs, rock fragments and human artifacts were incorporated in the deposit.
2. Sand from offshore was piled over the plant mixture to quickly bury the material. The sand cover is essential to exclude the oxygen if the humification process is to produce carbon in the residue (Holmes 1965).

$$2C_6H_{10}O_5 \rightarrow C_8H_{10}O_5 + 2CO_2 + 2CH_4 + H_2O$$

Cellulose — Humite — Carbon dioxide — Methane — Water

3. Beach erosion to the present day has since exposed the peat deposit at the surface. Strong onshore winds and higher tides would be the principal agents of erosion.

The concrete, bitumen and brick fragments, etc. are present day artifacts, and testify to the recent formation of the peat. They are the equivalent of fossils in the deposit, which would date the deposit as forming in the last 50 years.

The author has seen similar sea grass humification on flat terraces just above low tide on the Edward's Point peninsula on the Bellarine Peninsula, south of St Leonards. Here the peat layers are thinner, but still several centimetres thick. They appear to have been washed in by swell from north-east to south-west.

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Utilisation of man-made telephone pits as winter hibernacula

On Wednesday July 20, 2005, I received a phone call to remove a snake from a man-made pit at the Heritage Golf Club, Chirnside Park North, Victoria, on Melbourne's northern outskirts.

Upon arrival I was directed to a grassy knoll (top of a slight rise) in a treeless area, generally surrounded by mainly manicured grass and tracts of longer uncut grass. Underneath a plastic cover measuring about 40 cm x 65 cm was a rectangular hole about 60 cm deep. At the bottom was some pipe or cable. The hole was lined with standard sized bricks that were not cemented together.

There at the bottom was a 40 cm male Copperhead *Austrelaps superbus* (the size indicated it had been born in the summer of 2003-4). It was facing out into the hole from a crack between two bricks.

In the same pit were 17 Spotted Grass Frogs *Limnodynastes tasmaniensis* of varying sizes, but all more or less mature. These were merely sitting at the bottom or partially under the bricks lining the sides of the pit. There was no water in the pit and most of the bottom was lined with moist sandy dirt.

The plastic cover at the top of the pit was sited in an area exposed to the full day's sunlight and hence would be useful in terms of attracting heat. The depth of the pit was also such as to enable the inhabitants to escape the consequences of severe frosts if they occurred.

In two other similar pits within two metres of the first, other animals were found. One pit contained a skink *Pseudemoia* sp. and 10 *Limnodynastes tasmaniensis*, while the other contained three *Pseudemoia* sp. and seven *Limnodynastes tasmaniensis*. All were more or less adult in size.

While the ground staff at the golf club had not noticed the presence of the frogs and lizards in the first pit, they said that the Copperhead had been 'living there' for at least a month, indicating it was overwintering in the site. That snake was released the same day a few kilometres west of where it was caught.

As a licenced snake catcher (DSE controller's permit), I have in the last two years been called to remove an Eastern Brown Snake *Pseudonaja textilis* from a Telstra pit at Mickleham on Melbourne's north-west edge, a Copperhead from another Telstra pit at Arthur's Creek on Melbourne's northern fringe, as well as approximately another hundred snake removals. Both pits were in similar situations to that of the golf course and both cases occured in the cooler inactive season, indicating that the snakes had taken up semi-permanent refuge in the pits. Those snakes found in the Telstra pits were first uncovered by the linesmen who opened up the pits to repair the phone network. In all cases, the pits inhabited were in open grassy situations in flat to undulating coun-

Spotted Grass Frogs *Limnodynastes tasmaniensis* from Somerton, Victoria.

try with little if any other 'hard cover' on the ground,

On another occasion, in winter 2003, a young Copperhead was seen in a similar situation in a Telstra pit on a dairy farm at Boorool Road, Mirboo North (about 100 km south-east of Melbourne). Evidently the thermal properties of these pits are conducive to reptiles and frogs overwintering in them.

Based on the positions of the animals seen in these pits when found, it is clear that the animals do move about in these pits as time of day and weather conditions vary. This indicates that overwintering in these species in the relevant parts of Victoria is better defined as brumation, rather than hibernation in the stricter sense.

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The Little Green Handbook: a guide to global trends

by Ron Nielsen

Publisher: *Scribe Publications, Melbourne, 2005. 384 pp. ISBN 1 920769307. RRP $35.00*

Most of us, some significant politicians and industrialists aside, now appreciate that our future depends on the Environment. This not-so-little book (the size of a solid novel) does a fine job of helping us to understand why this is so. Instead of a biased polemic, Ron Nielsen provides us with a robust package of data on the health of the environment and humanity, and succeeds in synthesising and objectively commenting on (as far as one can) the important issues. Nielsen, a nuclear physicist, rightly describes his work as an '...attempt to provide a comprehensive summary of the essential facts and figures that we need to know in order to understand global environmental change, and to try to give a broader view of the implications for all of us...It surveys not only the deterioration of the environment, but the economic, social and political trends, including the increasing tensions and conflicts between nations.' *The Little Green Handbook* is a call for us to ensure that our children's future is 'safe, nurturing and sustainable'.

Clearly it is a big picture book – and the picture is bleak. It points to trends that even the most optimistic proponents of 'technology-will-save-us' will find depressing.

The Introduction is a useful summary of the issues addressed in the book, and it also answers the questions that some readers will ask at the outset; for example, how reliable are the data, and can we make accurate predictions? The following seven chapters deal in turn with: the population explosion, diminishing land resources, diminishing water resources, the destruction of the atmosphere, the approaching energy crisis, social decline, conflicts and increasing killing power. These detailed chapters comprise the bulk of the book; they are littered with numbers and impeccably referenced tables and graphs, as well as commentaries that are not exaggerated, but rather rely on the data to make the points.

The reading of the book, though disturbing, is mostly easy because of the use of simple language and clear layout. The chapter on The Destruction of the Atmosphere, for example, gives a lucid introduction to the troposphere and how it is changing – gently bringing even this humble biologist up to speed on essential Earth Sciences. There are headings to break up the chapters and focus the various points: 'Projected carbon emissions', 'Carbon storage', 'How reliable is the prediction of global bankruptcy?', and 'What are the effects of climate change on the oceans?' and so on.

One can use this book quickly to check not only the projected carbon emissions for Chad and the USA out to 2050, but also the discretionary figures for the US budget, the numbers of nuclear weapons in various places around the world, and snippets such as … 'anti-satellite weapons can be as simple as launching a bin-full of junk into the path of one'. We learn that though the biologically productive surface area of the Earth is 11 billion hectares, our footprint is now nine hectares per person (largely because of the consumption of the likes of us, and other western gadget nations). At this level, Earth can support a population of 1.2 billion people – this happens to be the current population of the *us* group, and the Earth's total human burden back in 1857! Yes, we are in trouble – and most of the rest of the world knows this already from bitter experience (need I mention Africa?). Nielsen then describes the beginnings of the end that we've seen in the past decades – the collapse of fisheries, reduction in biodiversity, global warming and its immediate consequences of extreme weather (need I mention New Orleans?).

I was wondering if Nielsen was going to inject a bit of optimism by discussing the view that the internet empowers the common man through awareness of these global trends — but then a quick search of the index and glance at the text reminded me of the blindingly obvious: that only 14% of the 6 or so billion of us is connected, and that figure is likely to increase soon only for the you-know-who's of the world.

For those wanting a quick summary, Chapter 9 puts it all 'In a Nutshell' and offers suggestions as to what we should do: we have to eliminate gross inequality between countries, move away from fossil fuels, challenge globalisation, and restructure economies to always put the environment first. These are not easy tasks, and the list sounds like a syllabus for Utopia 101, but as Lord Robert May, Jared Diamond, and others have recently reminded us, if we don't act now, we will bequeath to the next generations a *Blade Runner*-like world that ticks over for the privileged few survivors of the collapse.

I can imagine many readers taking some issue with what Nielsen says; for example, that we must fight globalisation on all fronts, but his case, to this reader at least, is well presented and finds a sympathetic ear. The bottom line, as most of us suspect already, is that with proper global management, reflected in 'selfless care for one another and dedication to the environment', we *can* have 'global economic growth and a sustainable future' – so let's go to it!

The Little Green Handbook should be bought and distributed widely; at this 'greatest turning point in our history' I suggest it be kept close at hand by all over the age of sixteen, especially your local pollie.

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From the Editors

In the lamentable absence of a complete and detailed published history of the Field Naturalists Club of Victoria (FNCV), this issue of *The Victorian Naturalist* will stand as a good summary of the subject. Almost all of the papers published here originated as talks given at the symposium held in May 2005, to celebrate the 125th anniversary of the FNCV. As such, most have been modified only slightly, and then only to take account of the different format required for publishing.

These papers cover the widest range of aspects relating to the history of this fine Club. They focus on the notable men and women of the Club; on the famous and significant incidents to have occurred through its history, many of which were instrumental in achieving a wider aim, and often related to the conservation of Victoria's natural resources. The papers draw attention also to a spectrum of activities undertaken at various times for members of the FNCV, but also for a wider public. And there are papers here that indicate the wide-ranging connections that exist between this Club and both other organizations within this State, and individuals working in many scientific contexts.

What is amply demonstrated is that the FNCV has played a central role in many areas of endeavour within the Victorian arena. Nobody reading these papers could doubt that the FNCV has not only a long, but a glorious history, of which we should be proud.

We commend this issue to all readers, and particularly to those members and friends who were unable to attend the 125th symposium.

Cover: .The History Symposium attendees pictured in the Royal Botanic Gardens, Melbourne, May 2005. Photographer: Michael Rayner, courtesy of *The Age*.

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Welcoming speech by President of the FNCV

Karen Muscat[1]

As President of the Field Naturalists Club of Victoria, it is my great pleasure to welcome you to this grand occasion, the celebration of the 125th anniversary.

It was on the 6 May 1880, that a meeting was held in the home of Charles French, which was situated close to where we are now assembled. At that meeting, it was decided to call a public meeting to establish the Club. This was held on the 14 June 1880, and the Club has never looked back. In its 125 years, membership has steadily grown, and despite all of the competing alternative interests available to society today, the Club has a membership of just over 1000 members. As in all Clubs, there have been peaks and troughs. Yet the legacy left by its members is so great that a booklet had to be prepared to list just some of them.

Very briefly, achievements include discoveries made during the many excursions run by the Club, the continued publication of *The Victorian Naturalist* since 1884, the different organisations that were spawned within the FNCV that have now become organisations in their own right, the Australian Natural History Medallion, and the role of the Club in conservation issues such as the establishment of Wilson's Promontory National Park.

Despite enormous social changes over the last 125 years, several things have remained the same: the interest in natural history, a desire to look and learn, the need to preserve and protect our flora and fauna for future generations.

These ideals, along with an important mixture of amateur and professional members, young and old, male and female, and a willingness to volunteer, have kept the Club vibrant. It is these same factors that will keep the FNCV active and relevant for the next 125 years.

This symposium would not have occurred without the hard work of the organising committee (Sheila Houghton, Anne Morton, Mimi Pohl, Gary Presland, and Alan Yen) and the members who, in the tradition of the FNCV, volunteered their time to help set up and run the symposium: Lyn Ansell, James Berriman, Joan Broadberry, Rosta Buc, Barbara Burns, Arthur Carew, Annie Lamb, Dorothy Mahler, Jenny Porter, Ray Power, Noel Schleiger, and Phil Scully. I also wish to thank the speakers who we will hear over the next two days for their interest and endeavour in getting their presentations together.

Special thanks are in order for our two sponsors: the Royal Botanic Gardens and the Department of Sustainability and Environment. I wish to thank Dr Phil Moors and Professor Lindsay Nielsen for their generous support.

We chose Mueller Hall for this symposium because the FNCV met here for many years, and its former office, before the move to Blackburn, was in the Astronomer's residence nearby. Another institution that has had a close link to the FNCV is the Royal Society of Victoria, and I wish to call upon the Immediate past President of the Royal Society, Professor Neil Archbold, to open this symposium. Professor Archbold is Professor of Palaeontology at Deakin University and is an active member of the FNCV.

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Opening Address

Neil W Archbold[1]

It is a great honour and pleasure for me to be here today to represent the President, Council and Members of the Royal Society of Victoria on the occasion of this special birthday symposium to celebrate the 125th anniversary of the Field Naturalists Club of Victoria. Congratulations on this great anniversary, which serves well to illustrate the long-term links between our two societies. 125 years ago, on the 17 May 1880, at an adjourned meeting held at the Melbourne Athenaeum, the FNCV was inaugurated (an inevitable event, following the initial public meeting held on the 6 May 1880 at the Melbourne Athenaeum where 30 people attended). The adjourned initial meeting was resumed on the 17 May at which the rules were adopted, the subscription set at ten shillings, and the office-bearers elected. Professor (later Sir) Frederick McCoy was elected President, thereby establishing firm links with the Royal Society of Victoria, the National Museum of Victoria and the University of Melbourne. Initially the FNCV met in the Royal Society's rooms in the Temperance Hall in Russell Street, Melbourne, but this was to change in 1881.

Checking the pages of the *Southern Science Record* (Vol. 1, No. 6, 1881, p. 88), it appears that the first 'official' link between the Royal Society of Victoria and the FNCV took place on 6 April 1881. Members of the FNCV were present at a special meeting of the RSV 'by invitation'. The occasion was the visit to Melbourne by the distinguished naturalist Baron Miklouho Maclay, who desired to establish a Zoological Station at Watson's Bay, Port Jackson. The Baron had received partial monetary support for the plan from the Sydney Government, but was also seeking support from other Australian colonies. It is of note that the FNCV supported the plan at its meeting of the 11 April 1881. Clearly, there were firm linkages between the RSV and the FNCV before this 'official' request.

The first annual *Conversazione* of the FNCV was held on the 17 May 1881, at the RSV's Hall 'kindly placed at its disposal by the Council'. Professor McCoy was to observe in his anniversary address that 'many of our ordinary members are not only well-known as accomplished naturalists, but lovers of the open air studies and excursions for the purpose of making and recording observations which are the main characteristics of our Club'. Further on in his address he was to note that 'some of (the Club's) collections, as well as a small library, it is intended ultimately to have for the general use of members when suitable permanent chambers can be obtained'. This was achieved in time for the meeting of 8 August 1881, when the FNCV met at the RSV's Hall and notice was given that future meetings would be held at that location 'where it is requested all communications may be addressed'.

The FNCV now owns its own property and rooms in Blackburn, but strong linkages still exist between the two societies – perhaps most notably through the RSV's support for the Australian Natural History Medallion. The RSV presents its best wishes and congratulations to the FNCV and trusts that the FNCV may have many more anniversaries and birthdays, and is confident that this symposium will be the success that it promises to be, judging from the programme.

Thank you for your courtesy and attention.

Editors' note

We regret to inform readers of the death of Professor Neil Archbold, on 30 November 2005.

[1]Immediate Past President, Royal Society of Victoria

Rambles, reports and reserves. The FNCV's early conservation of Victoria's natural heritage

Linden Gillbank*

Abstract

From its inception in 1880, the Melbourne-based Field Naturalists Club of Victoria (FNCV) visited rail-accessible species-rich areas to collect specimens. The FNCV soon used its productive triad of monthly meetings, excursions and issues of *The Victorian Naturalist* to observe and record the natural history of increasingly distant landscapes. To ensure the accuracy of these records the FNCV updated species' lists for Victoria's flora, fauna and fungi in *The Victorian Naturalist* and prompted and published descriptive handbooks; thereby helping specimen collectors, nature study teachers and conservationists. Early excursions prompted the reservation of Cabbage Tree Palms in east Gippsland and Wilson's Promontory National Park. (*The Victorian Naturalist* **122** (6), 2005, 258-274)

Introduction

As a member of the most destructive species on the blue planet, I am delighted to participate in the celebration of an organisation which for so long has encouraged an interest in and understanding of the planet on which we are completely dependent. I thank and congratulate all those who have contributed to the Club's first 125 years, including the organisers of this symposium, and hope that together we can do justice to the efforts and values of the Club. Survival over a period, during which various scientific, natural history and conservation groups have emerged, and ideas and practices in science and conservation have changed considerably, is a truly remarkable effort.

My aim is twofold. Firstly I wish to show how, from the 1880s, the Field Naturalists Club of Victoria has provided an effective voice for the conservation of Victoria's natural heritage–how it orchestrated the collection and recording of specimens and observations, and engaged the public and politicians in conservation issues. I use records and recollections published in the Club's journal in order to fulfill my second aim–to show the importance of *The Victorian Naturalist* as a rich historical record of Victoria's natural heritage and early efforts to conserve it. In order to provide historical foundations for other symposium papers I focus mainly on the Club's early decades.

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Collecting around Melbourne in the 1870s

To try to understand the birth of a field club for naturalists in almost-marvellous Melbourne in 1880, a Melbourne so different from today, we must do more than turn off the mobile phone and grasp a pencil instead a computer. In order to understand something of the environmental, social and intellectual context of Melbourne 125 years ago, we have to attempt the possibly impossible–to try and un-know so much that we now take for granted. That requires a huge imaginative effort. We must peel away the sprawl of suburbs to re-imagine heathlands, swamps and forests around a Melbourne devoid of so many of today's institutions and impedimenta–research-rich departments in universities and other institutions, popular and academic periodicals and books on the indigenous flora, fauna and fungi, scientific and conservation groups and their journals, databases, and, of course, the Internet.

The nineteenth century was a great century for collecting and collections. In post-Enlightenment Europe and her colonies, cabinets of curiosities bulged and proliferated. Natural history specimens, living and dead, were proudly exhibited in public and private museums and gardens, and at international and other exhibitions. Echoing her European sister-cities, British colonial Melbourne was no exception. Thanks largely to Lieutenant-Governor La Trobe and other public-minded leaders of gold-rich Victoria in the 1850s, Melbourne was enriched with a good set of public institutions. In the late 1870s those providing the public with 'rational recreation' included the following:

- National (natural history) Museum in the grounds of the University of Melbourne - under the honorary director, Frederick McCoy, Professor of Natural Science;
- Technological Museum in a building off the Public Library;
- Botanical Museum in the Domain (near the Botanical Gardens) - under Victoria's government botanist, Baron Ferdinand von Mueller;
- Botanical Gardens - under William Guilfoyle;
- Zoological Gardens at Royal Park, where Dudley Le Souef was assistant director.

McCoy, Mueller, Guilfoyle and Le Souef would become Club members, along with assistants, like William Kershaw in the National Museum and Charles French in the Botanical Gardens and later the Botanical Museum (1884-89).

Field-collecting was recreational and scientific. In the nineteenth century collecting bugs or blossoms was considered a healthy outdoor activity, and was eminently socially acceptable, even for women. A collection which began as a pleasant outdoor hobby could grow into a scientifically important collection. You probably need no reminder of the scientific importance of collections. Collections of authenticated specimens are still absolutely essential for taxonomic work - for flora, fauna and fungi.

Professor McCoy sought crowd-attracting as well as scientifically important zoological and geological specimens for the National Museum; while the Botanical Museum under Mueller was more strictly scientifically focused. To develop an herbarium which would challenge European collections as the premier taxonomic reference collection for the Australian flora, Mueller collected plants widely himself, exchanged specimens with other collectors, attempted to convince the Victorian government to purchase overseas herbaria, and encouraged an expanding network of collectors to send him specimens. By the 1870s, thanks to the ever-botanising Baron, much of Victoria's flora was named and described, and the collection of Australian specimens in the herbarium in the Botanical Museum was enormous - many specimens being sent by people who would later join the Club. Mueller's unremitting efforts had converted much of the indigenous flora from novelty to known, but there were still some parts of the colony (e.g. north-western Victoria and much of east Gippsland) which remained botanically un-surveyed and there were many unknown gaps in the taxonomy of Victoria's flora. Despite McCoy's efforts, Victoria's fauna required further documentation.

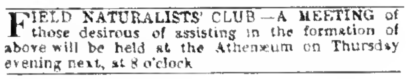
There were no handy books on Victorian natural history to help enthusiastic but inexpert collectors select beetles and butterflies and organise their collections. Collectors shared their knowledge and expertise and compared specimens - with each other's and with Museum collections. As subsequent reports in *The Victorian Naturalist* show, plant collectors, who invariably sent specimens to Mueller, knew when, where and by whom a species was first (and subsequently) collected in a particular area. Collectors knew and valued the public collections to which they referred and contributed. This was especially true of entomological collections in the National Museum and herbarium collections in the Botanical Museum.

Melbourne was still small enough for collectors to know each other and their collecting haunts. And a developing web of railway lines could take them there. Perhaps it is not too much of an overstatement to say that, by the 1870s, the scene was set for a Melbourne field club that would facilitate and encourage the collection and description of Victoria's flora and fauna.

Melbourne naturalists knew of the only Australasian natural history society - the young Linnean Society of New South Wales, which, from the 1870s, held field excursions and picnics, but enjoyed the elitism of a royal society. They also knew of flourishing field clubs in Britain where, across the nineteenth century, natural history societies had proliferated and transmogrified. In the early nineteenth century natural history societies held debate-serious meetings, had libraries of expensive books and crowded cabinets of curiosities, published their own Transactions and welcomed the wealthy; while groups of weavers and other manual workers met in public houses to share their mainly botanical interests and findings. By the middle of the nineteenth century regional field clubs were emerging, which combined the social cosiness of a club and the pleasure of outdoor excursions. An excursion could begin at an inn with a satisfying breakfast and, after much rambling and collecting, end with a substantial dinner including many toasts. By the 1870s members of over a hundred naturalists' field clubs were happily rambling and collecting across the British countryside, with some large city clubs attracting hundreds of members (Allen 1976).

If naturalists enjoyed inter-pub field rambles in Victoria in the 1870s, their tales have not survived in the Club's historical memory. Instead the scene of the origin of the Field Naturalists Club of Victoria is Melbourne's (not yet Royal) Botanical Gardens, where Charles French worked under William Guilfoyle.[1] French and his friends met in his cottage, in the Gardens near Anderson St, to discuss specimens, especially insects and plants, which they had collected during their rambles. French was in charge of plant propagation and the fernery, and happily combined two frequently-linked aspects of natural history - his professional interest in collecting plants and his recreational interest in collecting insects.

According to the oft-repeated historical narrative in *The Victorian Naturalist*, the idea for a field club was first mooted in French's house, prompting French and his collecting friend, Dudley Best, to put a small notice in *The Argus* for a meeting on 6 May 1880 (Pescott 1940; Willis 1950, 1980; Taylor 1996). *The Argus* of 5 May carried the following notice:



FIELD NATURALISTS' CLUB.—A MEETING of those desirous of assisting in the formation of above will be held at the Athenæum on Thursday evening next, at 8 o'clock.

Club membership

The Field Naturalists' Club of Victoria (FNCV) was formally inaugurated at a meeting in the Athenaeum on Monday evening, 17 May 1880, the first such soci-

A re-enactment of a meeting at Charles French's house, as performed by the Friends of Woodlands Historic Park at the Symposium, May 2005.

ety in Australia. It was not a peripheral club struggling on a forgotten fringe of Melbourne society. The Club's early membership was not quite a who's who of Melbourne society, but it included men from across the spectrum of power and respectability. And it soon dared to include women. The 1885 membership list includes several lawyers and politicians, and four men who gave their address as the Melbourne Club; and not all of the thirty women were wives, sisters and daughters of male members. Some of the scattering of country members were school teachers. Members' FLS (Fellow of the Linnean Society), and less-commonly FRS (Fellow of the Royal Society), indicate imperial scientific respectability.

The Club attracted members with diverse natural history interests and expertise. It is not surprising that it welcomed members from Melbourne's museums, zoological and botanical gardens, university and schools, and benefited from the participation of these already-knowledgeable people. The benefit was mutual. William Kershaw and Charles French, and the National and Botanical Museums also benefited from their participation in Club excursions and meetings. How many specimens in the vast collections of Melbourne's Herbarium and Museum were collected over the decades by Club members?

Of course amateurs, whose interests and skills had no bearing on their paid employment, also benefited. Some developed their natural history interests so keenly that they became acknowledged experts on particular groups of organisms, and some subsequently gained paid employment that used their amateur-gained expertise. Club participation was not unhelpful for the appointment of Charles French as government entomologist in 1889, and, in the twentieth century, his butterfly-collecting friend, the stonemason, Frank P Spry, as National Museum entomologist, and Charles C Brittlebank as government plant pathologist.

Brittlebank was an artist and farmer, whose interests spanned the full spectrum of natural history. His exhibition at Club meetings of exquisite entomological drawings led to his preparation of illustrations

Part of the audience at Saturday's proceedings of the History Symposium.

for two important books by Club members - *Destructive insects of Victoria* (1891-1911) by Charles French and *Nests and eggs of Australian birds* (1900) by Archibald J Campbell. Brittlebank, whose property 'Dunbar' overlooked the Werribee Gorge, revealed startling glacial evidence in the Gorge (Pescott 1946).

The Introduction to the first issue of *The Victorian Naturalist*, in January 1884, noted that 'the number of careful observers of Nature in the colony has been greatly multiplied. Many who before worked alone have been encouraged by association with workers in kindred branches, and a substantial enthusiasm has been aroused in many who had before felt no interest in the subject.'[2]

The Club's early membership was important because it spanned geography as well as natural history, and included a healthy mix of professional and amateur expertise and enthusiasm. Shared and overlapping interests blossomed. Rural members, like state school teachers, Daniel Sullivan, FLS, of Moyston near the Grampians, and Henry Tisdall, FLS, of Walhalla, provided regional natural history records for little-known parts of the colony, which inspired interest in Melbourne members. Sometimes country visits attracted new members. In the 1880s a Dimboola hotel proprietor and a manager of the nearby Lake Albacutya pastoral station helped Dudley Le Souef and Charles French during their collecting trips, and joined the Club.

The Club's monthly triad

The Club's collective strength came from its triad of monthly meetings, excursions and issues of its journal, *The Victorian Naturalist*. This monthly triad allowed the Club to facilitate and encourage the study and conservation of Victoria's natural heritage in increasingly distant and little-known parts of the colony by a sort of ripple effect. Members reported on their collecting trips and exhibited specimens at Club meetings; and the subsequent publication of their reports in *The Victorian Naturalist* further spread their news and inspired other members, and sometimes the Club, to organise trips to these new collecting grounds.

Henry Tisdall's reports of the local flora and fungi attracted naturalists to the mountains round Walhalla, even after he left Walhalla State School in 1886. Club interest in Wilson's Promontory was initiated by a report of a long walk by three Club members in search of healthy exercise, interesting scenery and specimens. They walked from the nearest railway station, which in 1884 was Trafalgar, trekked across the Strzelecki Ranges and followed the telegraph line to the lighthouse on the south-eastern tip of the Prom, and then walked to Dandenong to catch a train back to Melbourne. Gregory and Lucas[3] spoke glowingly of the 'the noble granite Promontory', commending it 'as full of interest to naturalists of all persuasions'. Their report was published in four parts in the second volume of *The Victorian Naturalist*.

Meetings

Monthly Monday evening meetings were soon being held in the Hall of the Royal Society of Victoria. The presentation and discussion of papers and the exhibition of specimens were important for developing ideas about natural history. Related issues, such as gun laws, protection of native birds, and land reservation, were discussed, correspondence read and deputations planned. Annual conversaziones, with lecturettes and landscapes of natural history exhibits, attracted hundreds of members and friends.

In the spring of 1885 the Club's annual wildflower exhibition was born. An exhibition of 150 species of wildflowers greeted members and visitors attending the October meeting. 'With a little effort on the part of the members to obtain flowers from distant parts of the colony, the evening may be made one of the most interesting and instructive gatherings of the Club', announced *The Victorian Naturalist*.[4] And so they became, interesting the public and providing the Club with money in the twentieth century.

Excursions

Right from the start, the Club organised excursions to rail-accessible regions, often known, from pre-Club days, to be rich in birds, bugs and blossoms. The first Club excursion was held near Brighton on the Saturday after the Club's first monthly meeting in June 1880. Even before the

Brighton railway line reaehed Sandringham, the loeality was 'a favourite one for Club exeursions'; but 'to reach the heath country near the Red Bluff meant a good walk either way. Would that a few aeres of that botanist's paradise had been retained in its original state for future generations', reminiseed Francis GA Barnard.[5]

Excursions enriched personal enthusiasms and friendships, and individual and institutional collections. In revisiting valued eollecting grounds, excursionists were reminded of past eollections and observations, whieh sharpened their realisation that some speeies were becoming inereasingly diffieult to procure. As Melbourne sprawled out along railway lines, forests and heathlands which, in the recently-remembered past, had yielded rich bags of floral and faunal specimens were shrinking and disappearing.

The working week of five and a half days, and Sunday's religious designation, limited monthly excursions to Saturday afternoons, when a train leaving Prinees Bridge station about midday picked up Club members at various stations and deposited them at a station near floristically-rich eoastal heathlands, or forests near Box Hill or Ringwood. In the mid 1880s, monthly exeursion reports were published as artieles in *The Victorian Naturalist*, but were soon reduced to paragraphs in the published proceedings of Club meetings. Publie holidays allowed the enjoyment of whole-day excursions near more distant railway stations, and the publieation of more substantial excursion reports in *The Victorian Naturalist*. How convenient for Mueller and the Botanical Museum that the assistant, Charles French, eould so usefully employ his keen botanical eye on Saturday afternoons and holidays, by leading Club excursions in search of specimens. French was then doeumenting Vietoria's orchids in a series of articles in *The Victorian Naturalist*, so the frequent mention of orchids observed during his excursions is unsurprising.

The monthly excursion in September 1884 was to the heathlands for the Club's first field day. On Saturday, 13 September, there was a 'good attendance of members, including several ladies, who left town by the midday train for Cheltenham, whence they rambled aeross the heath to the Red Bluff near Brighton. Wildflowers were very abundant, the botanists of the party being kept fully at work noting the various speeies'.[6] Brighton was still the end of the line, and Cheltenham was on the Frankston line.

Charles Freneh and Dudley Best (1884) prepared a more substantial report of a day exeursion to Frankston on Separation Day, Tuesday, 1 July 1884. They noted that the distriet 'by former experienee is known to be rich in botanieal speeimens, as it was near this plaee where the first specimen of *Thelymitra mcmillani* (then new to seience) was discovered 20 years since.' Mueller had named it in 1865. On sandhills they 'found speeimens of a minute species of *Prasophyllum*' which had yet to be determined by the Baron. 'Traees of the rare and beautiful Orchid *Orthoceras strictum*, were also found, and as it was upon this hill where it was discovered on a former exeursion, we took the liberty to christen it Orthoceras Hill.' They reported that there could 'be no doubt that the locality of Frankston offers a fine field to the eollector, more especially the botanical, and as the spring approaches we know of no place that we could or would so eonfidently recommend for members desirous of having a sueeessful day's outing.' Readers of the exeursion report eould turn a page of *The Victorian Naturalist* and learn about the orchid *Orthoceras strictum* in Freneh's series on Victorian orchids.

Charles French, FLS, led Club exeursions to revisit the Red Bluff heathlands on Saturday afternoons across the seasons. On a wintry 9 May 1885, the walk from Brighton station was reduced beeause 'a conveyance was in readiness, and drove the party to the Red Bluff Hotel, when a start was made inland.' Being May, 'Plants in bloom were but few', and French hoped that 'these excursions will be better attended as much may be gained physieally as well as intelleetually'.[7] In September Freneh led an excursion, still 'only moderately attended', from Cheltenham toward Brighton, across a landscape 'simply a blaze of bloom', recording over seventy species in flower.[8] On an oppressive Saturday afternoon the following January, few plants in flower greeted Freneh's exeursionists.[9]

The current and past presidents of the FNCV, pictured at the Symposium. Left to right: Back row: Brian Smith, Malcolm Calder, Jack Douglas, Tom May. Front: Wendy Clark, Karen Muscat, Margaret Corrick, Sheila Houghton.

Public holidays allowed the Club to organise 'camp-outs' in more distant landscapes. Fortuitously the holiday for the Prince of Wales' birthday, on 9 November, was in spring when many plants are flowering. The Club's first 'camp out' was held around that holiday in 1884 near Lilydale. Members arrived at Lilydale station on various trains on Saturday, which 'was devoted to perfecting the camping arrangements, and making short rambles amongst the adjacent scrub'. The next morning 'parties were made up for collecting purposes. ... Being Sunday the guns were left behind until the morrow. ... The ornithologists were successful in taking for the first time the nest and eggs of the rare and certainly the most beautiful of all the Australian honey-eaters, viz., the helmeted or sub-crested ... the taking of which nest involved a good ducking for the two naturalists, as the tree in which it was situated, gave way and precipitated the captors, nest and all, into the running stream.'[10] The ornithologist and oologist, Archibald Campbell, who had suggested the excursion, exhibited the 'helmeted honey-eater (*Ptilotis cassidix*) with nest and eggs, taken from Olinda Creek' at the next Club meeting.[11]

Another public holiday was often well-timed for fungi – the Queen's Birthday holiday in May. On the Queen's Birthday in 1885 Club members returned to Olinda Creek. The 6.15 a.m. train to Lilydale collected about 25 members and friends at several suburban stations. Two parties explored the Olinda Creek valley – 'sportsmen ... intent on shooting' had 'almost empty bags', while the 'rest of the party, consisting principally of botanists and entomologists', were more successful; 'tea was soon manufactured in the orthodox Australian style, and a vegetable beafsteak (*Fistulina hepatica*) cooked. However this latter proved uneatable, being too old.' Afternoon observations included 'some large fungi, *Agaricus* sp., which were pronounced edible by our mycologist', Miss Campbell. Flora Campbell listed macro-fungi in the excur-

Speakers on the first day of the Symposium. Left to right: Wendy Clark, Doug McCann, Brian Smith, Linden Gillbank, Helen Cohn, Danielle Clode, Tom May, Sheila Houghton, Valda Dedman.

sion report[12] and exhibited 'rough drawings' of the fungi when the excursion was reported at the June meeting.[13]

Two Prince of Wales' birthday excursions were shared with the Ballarat Field Club – to the Lal Lal and Moorabool Falls in 1885 and the You Yangs in 1886.[14]

Monthly Saturday afternoon excursions and full-day excursions on public holidays continued, and, towards the end of the 1880s, the Club embarked on excursions even further afield, lasting weeks rather than days. They followed a suggestion by the Club's elderly patron, Baron Ferdinand von Mueller, and involved Melbourne's new professor of biology, Walter Baldwin Spencer. In December 1886 Mueller pointed out 'the desirability of organising excursions to ... East Gippsland and King's Island, the fauna and flora of which are at present almost unknown';[15] and members spent three weeks on King Island in November 1887 and East Gippsland in January 1889. Both excursions excited the press as well as the Club, with an extensive article in the Melbourne *Argus* and a whole issue of *The Victorian Naturalist* devoted to Professor Baldwin Spencer's account of each.

The Victorian Naturalist

The Club's journal spread information and ideas beyond the participants in excursions and meetings, and, by the common practice of journal exchange, enriched the Club's library with publications from around the world.

A long quotation from the Introduction to the first issue of *The Victorian Naturalist* in January 1884 explains its origin and perceived purpose.

> Hitherto the proceedings of the Society have appeared in the "Southern Science Record," published by Mr. J. Wing [a Club member], but it is now deemed time to bring out a periodical of our own. It is hoped that a larger field of usefulness will thus be opened up, and that both members and the public will gain by the publication of a monthly record of work and results, of original papers on Victorian Botany and Zoology, and of current notices of the occurrences and habitat of interesting

forms. "The Naturalist" is also intended as a medium for the exchange of specimens, and space will be given for correspondence.

Lastly, the Club has decided to prepare, and to publish in this Magazine, scientific lists of the Victorian species of animals and plants for the use of collectors. Such lists cannot be considered to be complete even in the case of the most conspicuous and best-known groups. Additions may be made from time to time; in fact, the very publication is expected to stimulate members to the discovery and recognition of new forms. Great care will be exercised to exclude all doubtful species, and as the services of some of the most active practical naturalists in the colony have been secured, it is confidently expected that the catalogues will be of value in creating that exact knowledge of specific forms which will facilitate more advanced Biological studies, and in diffusing an acquaintance with the useful and hurtful organisms of Victoria, which must be of great practical and material benefit to the community.[16]

Early issues of *The Victorian Naturalist* carry species lists for various groups of Victoria's fauna, including birds by TA Forbes-Leith and AJ Campbell. But reliable collecting requires more than species lists, and a Club president had a better idea for Victoria's flora.

Mueller's *Key to the System of Victorian Plants*

In the preface to his *Key to the System of Victorian plants*, Mueller (1888a) acknowledges the part played by the Club and its lawyer-politician president, Frank Stanley Dobson:

> This work owes its origin to a desire, expressed by the Field-Naturalists' Club of Victoria, at the instance of the Honorable Dr. Dobson, that its members should be provided with a literary guide similar to the meritorious "Handbook of the Plants of Tasmania," written some years ago by the Rev. W. Spicer, for facilitating the study of our native flora, particularly during botanical excursions.

At the Club's crowded fourth annual conversazione in the Royal Society's Hall in April 1884, the Honorable Dr F Stanley Dobson, LLD, MLC, presented his presidential address. Dobson[17] noted that 'Botany is beyond all others a science for ladies' and suggested that bouquet-gathering ladies study a little botany. (How, I wonder, did Flora Campbell, a frequent Club exhibitor whose Australian fungi were exhibited at the conversazione, feel about these presidential words?) Tasmanian-born Dr Dobson was familiar with the dichotomous key in Spicer's Tasmanian Handbook and showed how it could be used to determine a plant's name. Dobson asked 'Now, why has not such a book been written, if not for Australia generally, at any rate for our colony?' He thought that 'the work of compilation should be easy' and suggested that it 'might be placed under the superintendence of the Baron'.[18] In October 1884 Dobson informed the Club that 'Baron von Mueller had undertaken the compilation of a students' Victorian Botany'.[19] Barnard later claimed that Dobson used his position in Parliament 'to urge the production of such a work by the Government Botanist, and, much against his will, Baron von Mueller undertook the task.'[20]

The Victorian Naturalist provides glimpses of hopes for and opinions of Mueller's *Key to the System of Victorian Plants*, which was published in two not-too-weighty volumes. Somewhat confusingly, the first volume off the press was Part II (Mueller 1885), which contains a taxonomically-arranged list of over 1800 species of Victorian vascular plants and illustrations of 152 species. Mueller exhibited it at the Club's annual conversazione in April 1886. The Club was pleased that 'The size of the publication is such as to allow it to be conveniently carried in the pocket during excursions, nevertheless, all the illustrations are given at the natural size or magnified.'[21]

Preparation of Mueller's *Key* provided a focus for the study of Victoria's vascular flora, but there was no such focus for non-vascular plants and fungi. In 1886, with Mueller's approval, the Club 'resolved to form a section for the closer study of Cryptogamic botany'.[22] *The Victorian Naturalist* soon carried papers on Victorian mosses by Daniel Sullivan and lichens by Rev FRM Wilson, as well as further fungal papers by Henry Tisdall and Flora Campbell.

Aware that the colony was still not completely botanically surveyed, Mueller continued to seek specimens from unbotanised landscapes. Unfortunately, the Club's East Gippsland excursion would not eventuate until after the completion of his *Key*, but another suggestion was timely. The railway line had reached Dimboola, and, perhaps inspired by Club news of a summer trip from Dimboola to Lake Albacutya pastoral station by Dudley Le Souef (1887) to observe Mallee fowl and their nesting habits, Mueller suggested that Charles French spend his annual leave collecting in the area.

French explained: 'Baron von Mueller being anxious to trace out and fix the geographical limits of certain plants, also to procure, if possible, (for the "Key") additional species from the north-western portion of the colony, suggested to me that I should spend my annual leave of three weeks in the Wimmera district for that purpose.' Taking the 6.30 am train late in August 1887, French arrived in Dimboola on a cold, wet wintry night, and with

> some useful hints from Mr. D. Le Souef, ... had but little difficulty in finding the hotel, the proprietor of which (Mr. McLellan), being a bit of a naturalist himself, made me very comfortable, and we were soon on very good terms.
>
> I found a very kind letter from Mr. Percy Scott of the Albacutya Station [who had helped Le Souef], proffering assistance in enabling me to get into the back country, as the Baron was desirous that I should proceed, so far as time would permit, towards the Murray River.'[23]

At the Club meeting in November 1887 Mr J McLellan was elected a member, and Charles French, FLS, 'gave an interesting account of a recent collecting trip in the district around Lake Albacutya, and for twenty-five miles in a north-westerly direction.'[24] One of the many plants French collected was a new record for Victoria – in time for insertion in Mueller's Key.

Part I of the *Key* was reviewed in *The Victorian Naturalist* before it was published. Early in 1888 the Club received advance proofs of about three-quarters of Part I,[25] whose unnamed reviewers concluded 'that the members of the Field Naturalists' Club ... have acquired a working "flora" of the colony of exceptional value.' They were pleased that it was more than a dichotomous key, with each order, genus, and species having 'a short pithy diagnosis', and heartily congratulated 'the Baron on having produced for Victoria one of the handiest, simplest, and most useful floras in the world.'[26]

Thanks to specimens which Mueller had received from Charles French and other collectors since the publication of Part II of the *Key*, he needed to add about 60 species of vascular plants to the Victorian species list. Mueller (1888b) used *The Victorian Naturalist* to publish a supplementary list, and anticipated future additions from 'the most eastern part of Gippsland, including the elevated Waratah region, the whole only quite recently opened up for itinerations and settlement'.

Meanwhile, on the other side of the colony, the railway line had stretched westwards from Dimboola into unbotanised territory, allowing French (1889) to collect many western Wimmera plants in flower during an early spring week in 1888. Two were 'additions to the flora of Victoria', in time for inclusion in Mueller's Key.

Extended excursions

The Club's East Gippsland trip the following summer was too late for any new records to be inserted into the *Key*. Mueller so wanted a survey of the flora of the rugged and little-known terrain between palms on Cabbage Tree Creek, near the lower Snowy, and waratahs growing over the border in the vicinity of the upper Genoa, both of which he had been thrilled to see decades earlier (Gillbank 1998b). Perhaps Flora Campbell spurred Club interest with her (unfortunately unpublished) account in April 1888 of a trek through 'almost inaccessible country' to the palms.[27] Three months later the Club resolved 'to organise a party to camp out and collect for two or three weeks in the Cann River District, East Gippsland, leaving town within a day or two after Christmas, 1888'.[28] And so, that summer, French and four fellow Club members followed the tracks which Mueller had suggested would provide access to this part of East Gippsland. In January 1889, with a guide and three packhorses, they trekked hundreds of kilometers from Orbost along narrow tracks recently etched through western Croajingolong. The artistic professor, Baldwin Spencer, braved a downpour to sketch the Cabbage Palms, and later a more accessible waratah tree (unfortunately after it had ceased flowering). Spencer's drawings, illustrating the expedition report (Spencer and French 1889), were the first pictorial illustrations published in *The Victorian Naturalist*.[29]

As usual Mueller supplied names for the rarer plants French brought back (Spencer and French 1889). Before a copy of the long-awaited Part I of his *Key* reached the Club's library,[30] Mueller joined about 70 members attending the February 1889 meeting to hear Professor Spencer's diary-report of the exhausting Croajingolong expedition and see French's herbarium specimens. Having reminded the Club that he had found the waratah he named *Telopea oreades* and had brought to public notice Victoria's patch of palms, 'Baron von Mueller advocated the reservation of the palm groves, and moved a vote of thanks to Professor Spencer and the party'; and the meeting 'decided to interview the Minister of Lands re the reservation of portion of the Cabbage-tree Creek district'.[31]

Perhaps helped by a huge report of the expedition in *The Argus* of 16 March 1889, the Club was successful, and was officially informed that 'in response to the Club's request, about 8,500 acres had been added to the forest reserve in the ... Cabbage Tree creek district'.[32] In his presidential address in May, Arthur Lucas was pleased to tell the 700 people attracted to the Club's ninth annual conversazione, about the Club's expedition and successful application to the Minister of Lands for the palms reserve.[33]

This was the same Minister (John Dow) who continued to give only unfulfilled promises about the reservation of another area that had occupied the Club's interest and energy for some time – Wilson's Promontory. And Arthur Lucas was one of the three Club members, whose long walk over Christmas 1884 had initiated interest in the Prom, and who, with fellow Prom rambler, the lawyer, J Burslem Gregory, prompted the Club's resolve to secure the permanent reservation of Wilson's Promontory as a national park – then such a new concept that it had barely had time to touch the imagination of the shapers of society. In response to Club correspondence and deputation in 1890, Dow's promised reservation of Wilson's Promontory (as a forest reserve) evaporated into silent inactivity (Gillbank 1998a).

Meanwhile the Club continued to organise extended excursions to distant and often little-known parts of Victoria. British-born Baldwin Spencer was keen to learn about the creatures in the varied landscapes of his new home, and enthusiastically participated in the Club excursions to King Island and East Gippsland. In November 1890 Professor Spencer joined five members on an intrepid rain-drenched fortnight's trek to the rarely seen Yarra Falls. With information and advice from the widely-trekked Burslem Gregory, they followed the Woods Point road (from Marysville) and the Tanjil Track to the Falls, collecting and photographing along the way. 'One view was particularly interesting, historically, being the first photograph ever taken of the Yarra Falls', taken with great difficulty from the narrow, slippery, spray-drenched gorge.[34] These are the first photographs used in *The Victorian Naturalist*. Because process engraving was still so expensive, photographic prints were inserted into some copies of *The Victorian Naturalist* for March 1891.[35] Spencer was pleased to find, under fallen logs and tree bark, planarian worms, often lacking taxonomic names. Planarian findings by Spencer's university colleague and fellow Club member, Arthur Dendy, FLS, had recently inserted a new word into the English language. In the report of his productive collecting trip in the bountiful moist mountain forests around Walhalla, Dendy (1889), with the help of a Greek dictionary, invented a new term to describe the small, soft-bodied, light-abhorring inhabitants of dark crevices under stones and logs – cryptozoic fauna.

After a Depression-induced interval of six years, annual Club 'camp-outs' were resumed in 1899 around 9 November (soon to become the King's Birthday holiday) to such relatively accessible places as Lerderderg River, Maroondah Weir, Gembrook, Shoreham, Launching Place and Warburton.

By then the Club was establishing another tradition - the ten-day Christmas-New Year camp-out, which allowed members to comprehensively collect and survey the flora and fauna of an area. They surveyed the Buffalo Mountains over Christmas 1903, then the Otways, and then Wilson's Promontory. Excursion reports include separate sections on various aspects of natural history, for example, zoology or entomology by James Kershaw, FES, of the National Museum, and botany by Alfred Hardy, FLS, a draughtsman in the Lands Department.

In the twentieth century the Club no longer had a patron-Baron to suggest places in need of botanical perlustration. But members could still be inspired by news of fellow members' trips. So it was for the Club's Buffalo Mountains camp-out. In the 1880s the railway-line crept up the Ovens Valley past Myrtleford, allowing Carl (Charles) Walter to visit Mt Hotham and the Buffalo plateau in one plant-collecting week in January 1899. Members were so impressed with the specimens he exhibited, that Walter was asked to prepare some notes on his excursion 'for the benefit of members who may desire to visit the district and see the great beauty and profusion of our Alpine flora'.[36] This inspired three Club members, Francis Barnard, Charles Sutton and Gustav Weindorfer, to take a copy of Mueller's *Key* on a slightly streamlined version of his trip over Christmas 1902 (Gillbank 1990). They were not disappointed. They presented their report, 'Among the Alpine Flowers', and impressive collections of photographs and plant specimens to the Club in March 1903.[37] Pleased with help given by the Manfields, who ran the Temperance Hotel at Eurobin, Barnard and Sutton suggested the Buffalo Mountains for an extended excursion, certain 'that no member who took part in it would ever regret the expenditure of time and money necessary for the outing.'[38] And from the exuberant report of the Club's camp-out on the Buffalo plateau over Christmas 1903, they were probably right. James Kershaw reported that Coghill's insect collection included over twenty species 'new to the National Museum collection'.[39]

The Club's exuberance was soon dulled by an awful realisation – that Wilson's

Fig. 1. Club camp on the Vereker Range, Wilson's Promontory National Park, Christmas 1912. (Kershaw Collection, Historic Places Section, Department of Sustainability and Environment)

Promontory had been reserved as a national park only temporarily (in 1898). And in 1904 it was threatened with subdivision. The Club and other societies were galvanised into action, often with Professor Baldwin Spencer, McCoy's successor as National Museum director, at the helm. Deputations and a public meeting in the Melbourne Town Hall bore some success, and in January 1905 Wilson's Promontory was reserved permanently, except for an encircling coastal strip (Gillbank 1998a). In order to provide biological information, the Club held its next Christmas-New Year camp-out at Wilson's Promontory. Fortunately, by then the nearest railway station was closer than Trafalgar. Foster on the South Gippsland line left a mere two-mile walk to a yacht trip across Corner Inlet. Alfred Hardy, who had alerted the Club to the temporary nature of the Prom's reservation, led the 1905-6 camp-out, which collected images as well as specimens. A brilliance of lantern slides brought the Prom's biological and scenic splendors to a huge Melbourne audience of about a thousand in February 1906.[40]

Nature study and plant names

The next Christmas-New Year camp served a very different purpose – to help teachers with a subject recently introduced into Victorian primary schools, nature study. Club members, 'Professor' Henry Tisdall (until his death in 1905) and Professor Spencer's star biology graduate, John Albert Leach, the future 'Mr Nature Study', had contributed to an in-service summer school for primary school teachers, and were teaching trainee teachers at Melbourne's Teachers' Training College and Continuation School. Leach (1907) organised an eight-day Christmas-New Year camp at Mornington for fifty state school teachers in December 1906. A dozen Club members led daytime field work and presented evening lectures on a wide variety of aspects of natural history. Another British-born professor, Dr Alfred Ewart (1907a), was in charge of botany, helped with local plant names by J P McLennan, a State School teacher. Teachers from across Victoria subsequently joined the Club.

Over the decades, so many members had contributed to and consulted the Herbarium collection that Mueller had built up, that the Club felt very protective of it. So it is not surprising that Ewart's dual appointment in February 1906 as university professor, as well as government botanist, immediately sparked fears that the Herbarium might be spirited away to the university and damaged by students. Very concerned, Hardy reported such a rumour.[41] Professor Ewart quashed the rumour, joined the Club, and began using *The Victorian Naturalist* to publish botanical papers.

Noticing the lack of plant names on labels of wildflowers exhibited in a display of school nature study work in September 1906, Francis Barnard (1906b) asked the Club 'Are popular names for our wild flowers desirable?'. He shared the view that 'popular names would greatly assist a general knowledge of the native plants', and 'outlined a scheme for collecting and compiling names by means of school children and teachers of nature study'.[42] Barnard suggested that, in order to avoid confusion arising from the use of different common names for the same plant, 'this Club of ours might take up the question, and endeavour to fix names for some at least of our most prominent or showy flowers'.[43]

Barnard's talk prompted the Club's involvement in the collection of much more than common names, and culminated in the publication of the Club's *A census of the plants of Victoria* in the 1920s – a huge, completely voluntary undertaking, to which Ewart, as government botanist, contributed. Progress can be followed through the pages of *The Victorian Naturalist*, beyond the Census' publication (facilitated by funds from the Club's annual wildflower shows) and revision, to Jim Willis's involvement in the 1940s, leading to his preparation of the two-volume *Handbook of plants in Victoria* (1962, 1972).[44]

Thus, just as the Club had prompted the production of Mueller's *Key* in the 1880s, in the early twentieth century another government botanist was helping the Club prepare another botanical text. Both reflect the Club's continuing concern for reliable botanical records. Arthur Lucas made this point in 1885 – that Mueller's 'determinations of difficult species, render this paper trustworthy in its record of plants'.[45] Professor Ewart (1907b) queried earlier botanical records, and was so concerned about the reliability of botanical records in *The Victorian Naturalist*, that he attempted, unsuccessfully, to persuade Club members that voucher specimens for all plants named in papers should be deposited in the Club's herbarium or the National Herbarium![46]

Willis[47] acknowledged the work of country school teachers in the elucidation of Victoria's flora, and

> the pre-eminent role in furthering botanical science that has been played by the Field Naturalists' Club of Victoria ... . This body of amateurs has always been a champion of systematic botany, and it is hard to imagine what would have become of the science in Victoria had the F.N.C.V. journal, *The Victorian Naturalist*, not been available as a medium of expression and interchange of information.

The Victorian Naturalist carries type descriptions for hundreds of taxa of Australian plants.[48] Some collections of Naturalist articles grew into books which the Club published to help nature study teachers and improve the reliability of collection records. The Club's descriptive handbooks on Victorian ferns (Bond and Barrett 1934), based on articles by French and others, and fungi (Willis 1941) were revised and expanded over subsequent decades.

Reservation of Wilson's Promontory National Park

Meanwhile, further deputations and discussions led to the permanent reservation of Wilson's Promontory in 1908, over two decades after interest was initiated by three Club members in 1885 (Gillbank 1998a). Half of the Prom's first (honorary) Committee of Management were Club members, including Professors Ewart and Spencer, and the Secretary, James Kershaw. Echoing the commonly-held idea that a national park should provide a sanctuary for species, Ewart hoped that Wilson's Promontory National Park would 'render it possible to preserve many species which seem in danger of extinction' and hoped 'that none of our endemic species will be suffered to become absolutely extinct when a special harbour and sanctuary exists for them'.[49]

The national park was officially botanically surveyed over three successive springs by two Club members, James Audas, from the National Herbarium, and Percy St John, from the Botanical Gardens. Ewart (1909, 1910, 1911) prepared reports incorporating Audas's botanical reports and St John's zoological report, and, in between botanical jousts with Hardy, read them at Club meetings. Ewart and Audas joined the Club's second Prom excursion, led by Kershaw, over Christmas 1912.

Photographs taken during both Club excursions are reproduced in the special issue of *The Victorian Naturalist* that was published in 1998 to celebrate the Park's centenary.

The Club's experience in the reservation of Wilson's Promontory National Park is important for several reasons. Firstly, it shows a route by which land was successfully reserved in Victoria:

1. Club member's ramble/excursion
2. Talk given and specimens exhibited at a Club meeting
3. Article published in *The Victorian Naturalist*
4. Club survey
5. Public meeting/s
6. Letter/s and deputation/s to goverment minister/s
7. Land reservation as a National Park

Secondly, it resulted in a model for national park management – via an honorary committee of management for each park.

Thirdly, it resulted in the establishment of a body which would press for the establishment of future national parks – the National Parks Association (which is not to be confused with the much later Victorian National Parks Association [VNPA]).

News of the National Parks Association and subsequent Club efforts to have areas reserved as national parks can be followed through the pages of *The Victorian Naturalist*, for example the reservation of Sperm Whale Head as the Lakes National Park in the 1920s, and subsequent collaborative efforts with the Portland Field Naturalists Club for the reservation of national parks on the Lower Glenelg and

Mt Richmond. And there are the Club efforts, prompted by the destructive results of wartime commando training on Wilson's Promontory, which eventually resulted in the establishment of the VNPA and National Parks Authority in the 1950s (Garnet 1980).[30]

The Victorian Naturalist has continued to carry species lists and descriptions of landscapes across Victoria, so it is not surprising that it was mined for information by the authors of two substantial surveys of Victorian national parks, John Landy (1960 unpubl.) and Judy Frankenberg (1971). The Club also helped publish books on the flora of Wyperfeld and Wilson's Promontory National Parks by J Ros Garnet (1965, 1971), active Club member and ardent advocate for Victoria's national parks.

The Club's commitment to conservation has continued, with recent conservation efforts (not always reported in *The Victorian Naturalist*) having diversified and proliferated.

In conclusion

From the 1880s the Club has engaged with the landscape, ideas and institutions and contributed to the documentation and conservation of Victoria's natural heritage. This was possible because of the Club's enthusiastic membership, its productive triad of monthly meetings, excursions and issues of *The Victorian Naturalist*, and its overlapping interests with museums and other public institutions. Club members collected specimens and observations, initially in rail-accessible, species-rich areas near Melbourne, and then further afield in lesser-known landscapes. *The Victorian Naturalist* records of biologically diverse areas now lost to Melbourne's suburban sprawl or reserved as national parks, and some parks themselves, bear witness to the Club's enduring contributions the conservation of Victoria's natural heritage.

I end with a double plea: firstly, for the (long-sought-for) production of a substantial Club history, with individuals, institutions and environments richly intertwined; and secondly, that all issues of *The Victorian Naturalist* be scanned into a database, to allow seekers of the rich historical lode running through its pages to find organisms and issues, people and places. I think the Club deserves both.

Notes

In the late 1870s French worked in the Gardens under Guilfoyle not, as is stated in historical papers in *The Victorian Naturalist*, Baron von Mueller.

Reprinted in 1984, *The Victorian Naturalist* **101**, 6.

Gregory and Lucas (1885-6) *The Victorian Naturalist* **2**, 43-48

Anon (1885) Exhibition of wild flowers. *The Victorian Naturalist* **2**, 82.

Barnard, FGA (1906a) *The Victorian Naturalist* **23**, 65

Anon (1884) Excursion of the Field Naturalists' Club *The Victorian Naturalist* **1**, 83.

Anon (1885) Excursion of the Field Naturalists' Club. *The Victorian Naturalist* **2**, 31-32.

Proceedings of Club meeting, 14th September 1885, *The Victorian Naturalist* **2**, 65.

Proceedings of Club meeting, 18th January 1886, *The Victorian Naturalist* **2**, 125.

Anon (1884) The "Camp Out" at Olinda Creek. *The Victorian Naturalist* **1**, 110-112.

Proceedings of Club meeting, 17th November 1884, *The Victorian Naturalist* **1**, 109.

Anon (1885) The Queen's Birthday excursion to Lilydale. *The Victorian Naturalist* **2**, 33-35.

Proceedings of Club meeting, 10th June 1885, *The Victorian Naturalist* **2**, 29, 30.

Anon (1885, 1886) Excursion to Lal Lal; Excursion to the You Yangs. *The Victorian Naturalist* **2**, 94-99; **3**, 99-103.

Proceedings of Club meeting, 13th December 1886, *The Victorian Naturalist* **3**, 113.

Reprinted in 1984. *The Victorian Naturalist* **101**, 6.

Dobson (1884) *The Victorian Naturalist* **1**, 41-2

Dobson (1884) *The Victorian Naturalist* **1**,44)

Proceedings of Club meeting, 13th October 1884, *The Victorian Naturalist* **1**, 97.

Barnard FGA (1906a)*The Victorian Naturalist* **23**, 68

Sixth Annual Conversazione, 20th April 1886, *The Victorian Naturalist* **3**, 9.

Proceedings of Club meeting, 9th August 1886, *The Victorian Naturalist* **3**, 54.

French, C. (1888) *The Victorian Naturalist* **4**, 169

Proceedings of Club meeting, 14th November 1887, *The Victorian Naturalist* **4**, 115.

Proceedings of Club meeting, 16th January 1888, *The Victorian Naturalist* **4**, 167; Presidential address by A H S Lucas (1888) *The Victorian Naturalist* **5**, 7.

Anon (1888) Review. *The Victorian Naturalist* **4**, 179-180. It was later mentioned in *The Victorian Naturalist* **5**, 136.

Proceedings of Club meeting, 9th April 1888, *The Victorian Naturalist* **5**, 17. A small patch of palms had been reserved early in 1887 (Gillbank 1998b).

Proceedings of Club meeting, 9th July 1888, *The Victorian Naturalist* **5**, 50.

Spencer's sketch of palms is reproduced in Willis (1980). An earlier illustration in *The Victorian Naturalist* is the map accompanying the King Island expedition report.

Proceedings of Club meeting, 11th March 1889, *The Victorian Naturalist* **5**, 169

Proceedings of Club meeting, 11th February 1889, *The Victorian Naturalist* **5**, 154.

Proceedings of Club meeting, 8th April 1889, *The Victorian Naturalist* **6**, 41. The letter did not mention that the area was reserved 'temporarily from sale and leasing' as recorded in the notice in the *Government Gazette* of 22 March 1889.

[33] Annual address by A H S Lucas, 16th May 1889, *The Victorian Naturalist* **6**, 47.

[34] Proceedings of a special meeting to receive reports of Club expeditions to the Kent Group of islands and the Yarra Falls, 15th December 1890, *The Victorian Naturalist* **7**, 119. The photograph of Tommy's Bend (on the Woods Point road not far from Marysville) is reproduced in Watkins E (1984) Ways of seeing nature: Attitudes to nature in the *Victorian Naturalist*, 1884-1982. *The Victorian Naturalist* **101**, 32. Spencer was not (as claimed by his 1985 biographers) the expedition leader.

[35] Barnard FGA (1906a) *The Victorian Naturalist* **23**, 72

[36] Walter C (1899) *The Victorian Naturalist* **16**, 81

[37] Proceedings of Club meeting, 9th March 1903, *The Victorian Naturalist* **19**, 158-159.

[38] Barnard FGA and CS Sutton (1903) *The Victorian Naturalist* **20**, 12

[39] Coghill *et al.* (1904) *The Victorian Naturalist* **20**, 150

[40] Anon (1906) Excursion to Wilson's Promontory. *The Victorian Naturalist* **22**, 179-180. See also Gillbank, 1998a, 270.

[41] Proceedings of Club meeting, 12th February 1906, *The Victorian Naturalist* **22**, 178.

[42] Proceedings of Club meeting, 10th September 1906, *The Victorian Naturalist* **23**, 115.

[43] Barnard FGA (1906b) *The Victorian Naturalist* **23**, 137

[44] For example, Sutton CS (1909) Progress report of the work of the plant records sub-committee. *The Victorian Naturalist* **26**, 105-110; Willis JH (1943, 1944, 1946) Plant names committee. *The Victorian Naturalist* **60**, 125-126; **61**, 127-128; **63**, 186-188.

[45] Gregory JB and Lucas AHS (1885-6) *The Victorian Naturalist* **2**, 153

[46] Proceedings of Club meeting, 8th July, 12th August, 9th September and 14th October 1907, *The Victorian Naturalist* **24**, 65-66, 67, 81-82, 94-95, 106.

[47] Willis, JH (1949) *The Victorian Naturalist* **66**, 127

[48] The Australian Plant Name Index database shows that Mueller contributed well over a hundred, Ewart a few, and Willis over twenty type descriptions. In 1955 the National Herbarium's journal *Muelleria* took over the reins of Victorian taxonomic botany.

[49] Ewart, AJ (1908) *The Victorian Naturalist* **25**, 83

[50] As secretary of the committee which began as the FNCV's National Parks and National Monuments Committee, Ros Garnet published five reports in *The Victorian Naturalist* during 1949-52; and later reported on further progress. See also Calder M (1998) John Roslyn (Ros.) Garnet, AM, 1906-1998. *The Victorian Naturalist* **115**, 70-71; Gillbank L (2001) Conserving the Museum's biological capital: Four men and a national park. In *A Museum for the people. A history of Museum Victoria and its predecessors 1854-2000* by C Rasmussen, pp 146-151. (Scribe Publications: Melbourne)

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Barnard FGA (1906b) Are popular names for our native plants desirable? *The Victorian Naturalist* **23**, 136-139.

Barnard FGA and Sutton CS (1903) Among the alpine flowers. *The Victorian Naturalist* **20**, 4-12.

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Popular and professional communicators: Edith Coleman and Norman Wakefield

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Abstract

Natural history societies such as the Field Naturalists Club of Victoria (FNCV) have long played an important role in the historical development and professionalisation of the biological sciences. Natural history remains one of the few areas where non-professionals or amateur enthusiasts can continue to make significant contributions to, and discoveries in, science. This paper examines the publications of two FNCV members, Edith Coleman and Norman Wakefield, who contributed widely to both the popular and scientific understanding of Victorian natural history. We will trace the fate of their written contributions, particularly those from the *Victorian Naturalist*, in the modern scientific community through a citation database and demonstrate that there is a significant and ongoing flow of information between amateur societies like the FNCV and professional scientists. (*The Victorian Naturalist* **122** (6), 2005, 274-281)

A collection of enthusiasts

The value of an organisation like the Field Naturalists Club of Victoria (FNCV) is immediately apparent to its members. As a social organisation it provides an opportunity for like-minded people to gather together and share their passions and interests. It also operates as a special interest group to represent and promote the values of its members within state and local circles of government. Unlike purely social and interest groups, however, the operations of the FNCV also intersect with one of society's primary mechanisms for knowledge generation — scientific research.

The origins of professional science

Social collectives of enthusiastic amateurs played an important role in the origins of professional science (Harrison 1999) in the late seventeenth to early nineteenth centuries. The pre-eminent scientific organisations of the day (like the Royal Society of London or the Academy of Sciences in Paris) were dominated by wealthy amateurs (Crosland 1995a). These 'non-professional' scientists laid the foundations of modern biological science and included the most eminent and influential thinkers of their time, such as Charles Darwin, Alfred Wallace and Charles Lyell.

Professional scientists, who were both trained in their speciality and employed to study their subject, began to emerge in the late 1700s and early 1800s (Crosland 1995b). The increasing professionalisation of science slowly eroded the role of amateurs in knowledge generation as scientific research became increasingly specialised, institutionalised and professional. The contribution of amateur societies today to the complex, highly structured and formalised activity of modern science is less direct than in earlier centuries. Biological science (which has perhaps always had the

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strongest following of amateur enthusiasts), remains one of the disciplines in which it is still possible for amateur researchers to make significant contributions to the field. With its mix of enthusiasts and experts, youth members and retired professionals, the FNCV provides an ideal melting pot to study the interface between popular and professional cultures in biological science.

Popular and professional communications

Articles are a significant feature of both popular and professional communication about biological discoveries and provide an enduring, and easily assessed, means of disseminating discoveries and knowledge. The extent to which FNCV members are able to disseminate their knowledge and discoveries through scientific journals, including the FNCV's own journal, *The Victorian Naturalist*, offers a concrete means of tracking the flow of information across public and professional spheres. The extent to which material published in a more popular, general interest journal such as *The Victorian Naturalist* has found its way into the more specialised scientific literature will provide a specific illustration of this information flow.

I would like to use two well-known figures from the FNCV history, Edith Coleman (1875-1951) and Norman Arthur Wakefield (1918-1971), to explore the connection between the professional and the amateur; between the scientific and the popular. I have chosen these individuals because of the significant contributions they made to both scientific and popular literature in their lifetimes, particularly within the pages of *The Victorian Naturalist*. They rank amongst the FNCV's most prolific authors, with a broad spread of contributions in both the popular and scientific domains. After an interval of 30-50 years, it is worth investigating what lasting impact their work has had in the wider scientific community.

Subject 1: Edith Coleman

Edith Coleman was born in 1875 in Surrey, England (Fig. 1). She arrived in Australia as a girl and initially worked as a teacher. She joined the FNCV in 1922, presenting her first paper on orchids the same evening as she joined. For the next few decades she was a prolific writer and correspondent on broad range of botanical and ecological topics ranging from orchid pollination to echidna hibernation to stick-insect development. Coleman contributed to a diversity of newspaper and magazines, such as the *Woman's Mirror*, the *Argus*, *The Age*, *School Paper* and *Wild Life*. She published an illustrated guidebook to wattles, *Come Back in Wattle Time* (1935) which was reprinted in 1943.

Edith Coleman was not a professionally trained or employed scientist and the bulk of her writings were popular in nature. Her contributions to the scientific literature, however, were substantial. She contributed many papers to scientific journals, including *The Victorian Naturalist*, *Emu*, *Proceedings of the Royal Entomological Society*, *Australian Zoology*, *Journal of Botany*, and *Australasian Journal of Pharmacy*. Her contributions to *The Victorian Naturalist* were impressively voluminous (as indicated in the Author Index). She wrote over 135 articles for the *Victorian Naturalist* more than 27 years—an average of five per year (Willis 1950).

Edith Coleman's work on Victorian orchids remains an important contribution to the field, but it was the discovery of a remarkable piece of wasp behaviour for which her work became more broadly known. Coleman's daughter Dorothy first noticed ichneumonid wasps *Lissopimpla*

Fig. 1. Mrs Edith Coleman. (Source: *The Victorian Naturalist*, 1950, vol. 67, p .98)

semipunctata visiting Small Tongue Orchids *Cryptostylis leptochila* in bushland near their home in Belgrave. Closer observation revealed that the wasps appeared to be mating with the orchid. Edith Coleman later verified that all the wasps visiting the orchids were male and that they often left a spermatophore. She first published her findings on the remarkable phenomenon of pollination by pseudocopulation in *The Victorian Naturalist* in 1927 (Coleman 1927). Her paper subsequently came to the attention of Sir Edward Poulton of the Entomological Society in England, who reformatted it, with the addition of new material (as detailed below), into a form suitable for publication in an international entomological journal, the *Transactions of the Entomological Society* (Coleman 1928). His preface to this paper makes an interesting observation on the attitudes of the time towards amateurs, female naturalists and/or, perhaps, 'colonials'.

> The interesting observations which from the subject of the following paper were first made by Mrs. Coleman's daughter, but afterwards frequently repeated by both naturalists at Upwey and Belgrave, Victoria. Mrs Coleman has published an account of the discovery in the Victorian Naturalist, xliv, p. 20 May 1927 and p. 33 April 1928. The present paper was sent to the Entomological Society by Mr AM Lea, together with the Appendix which records his own observation and a number of letters from the authoress. I have extracted from these letters and others written to me a number of paragraphs which have been incorporated in Mrs. Coleman's paper or added as supplementary notes. I regret that there has been no opportunity to consult the authoress on the arrangement, but hope that it will meet with her approval.

In 1949, Edith Coleman was the first woman to be awarded the Natural History Medallion, and she died in 1951. Her broader contribution to the study of natural history in Australia is probably immeasurable, as evidenced by the recollections of Coleman in life by Rica Erickson (1999):

> She maintains a voluminous correspondence with many people yet finds time for field work, photography, to attend lectures and meetings, visit friends, make jam and write a regular column for a Melbourne newspaper. Devotes much time and patience in observing nature, insects etc. especially to the study of pollination of orchids.

The following incident recalled by Jean Galbraith (1951) illustrates the diffuse and indirect ways in which a passion for natural history can inspire and be shared, far beyond the more concrete means of communication which will be analysed in this article:

> I like to remember a walk with her when, after finding and enjoying many orchids, we stopped at the fence of a little bush garden, watching the Spinebills among its salvia flowers. "Sometimes," she said, "when I see a garden like that I find out who it belongs to, and post them some roots or a packet of seeds. They don't know who sends them, but I like to think of their surprise, and of my seeds growing in so many different gardens.

Subject 2: Norman Wakefield

Our second subject is Norman Arthur Wakefield who was born in 1918 in Romsey Victoria. He trained as a teacher and used many of his early postings in Gippsland to conduct field trips. Wakefield was first introduced to the FNCV in 1938 by WH Nicholls. In 1955 he took up a lectureship in nature study at Melbourne Teacher's College. Wakefield completed his BSc in Botany at Melbourne University in 1960 but subsequently moved into zoological research, founding the Fauna Study Group of the FNCV and obtaining his MSc in 1969 from Monash University on Pleistocene and recent cave deposits. He maintained a voluminous rate of publications in both the popular and scientific domain including a weekly column for the *Age* which was subsequently converted into a book, the *Naturalist's Diary* (1955, reprinted in 1975). Whilst his early work was dominated by botany (particularly of ferns), Wakefield's later research interest resulted in numerous taxonomic studies of fossil and extant mammal species.

Wakefield's commitment to education was evidenced by a large number of articles in *School Paper* and *Education*

Magazine, as well as the production of a series of 54 *Nature Study for Schools* broadcasts (1961-62). He made significant contributions to both botany and zoology in Victoria with the publication of his seminal work on *Ferns of Victoria and Tasmania* (1955, reprinted in 1975) and contributions to many scientific journals such as *Emu* and *Proceedings of the Royal Society*. In addition to being the Editor of *The Victorian Naturalist* between 1952 and 1964 (with a brief break in 1957) he also wrote 126 articles for the journal over 33 years (nearly four per year).

Having begun his interest in natural history as an amateur, Wakefield became a professional naturalist, both trained and employed in the area. However, as Keith Dempster (1987) noted, Wakefield combined elements of both the amateur and professional in his work.

> Norman embodied elements of both [the amateur and the professional]. To some extent this alienated him from some people in each camp. He was quite open about the fact that his prime motive for editing *The Victorian Naturalist* was because of the opportunities it provided for him to publish his own articles. This idea is of course abhorrent to scientists who rely on journal referees to provide a disinterested imprimatur, and it must also be said that many of Wakefield's articles did not make attractive reading for the general membership of the FNCV. Against that it might be argued that the articles had some reconciling influence. Professional scientists were persuaded to take the work of naturalists more seriously and the club members were given a little more insight into scientific thinking. I think both these elements are still discernable in the style of *The Victorian Naturalist* today.

Wakefield came to international attention with the discovery of a trail of fossil footprints in the Devonian sandstone of Genoa River in Victoria (near NSW). These footprints were found to be 350 million years old and made by an amphibian about 2-3 feet long (Warren and Wakefield 1972). At the time, they were the oldest footprints known, but they have since been overtaken by older footprints found in Gippsland in some paving stones on a local farm.

Norman Wakefield was awarded the Natural History Medallion in 1962, (Fig. 2); he died in 1971 in an unfortunate and untimely accident (Anon 1972). Many have remembered him for his ease and enthusiasm with children, while others recall a less forgiving character (see Clode 2002). Keith Dempster (1987) noted:

> He wasn't at ease with strangers or those with whom he had nothing in common and some people found him taciturn and rather "heavy going". With those among whom he felt at ease he talked freely and was always ready to share his vast store of knowledge about Victorian natural history which was possibly unsurpassed in its breadth and depth.

Willis (1973) described Wakefield as:

> gentle, cheerful, helpful, open-hearted, honourable, meticulous and tidy, courageous, tenacious of purpose, inspiring confidence … loyal and stalwart.

Understanding scientific communication

Scientific articles can be considered intellectual maps (rather than chronologies of events or narratives, e.g. Dear 1991; Martin and Veel 1998). They typically begin by introducing the previous literature and research in a field, leading into a more

Fig. 2. Norman Wakefield receiving the Australian Natural History Medallion, 1962 (Source: *The Victorian Naturalist*, 1964, vol 81, p. 193)

and more specialised discussion that ultimately yields the question or hypothesis that the scientist wishes to address. After documenting the methodology used to approach the question, and the results obtained, the scientist then discusses her particular findings in relation to previous research mentioned initially, thereby carefully placing her own work within the intellectual framework of her discipline. At its heart, the article contains a claim to new knowledge (Myers 1997), distinguished and identified within the context of previous work and ideas. Signposting previous research and acknowledging the ideas of others is thus a vital component of the article as both a map and as a knowledge claim.

Before publication an article must run the gauntlet of scientific peers, whose task it is to assess the knowledge claim and either accept it, downgrade it or reject it. The more significant the knowledge claim, the more prestigious the journal in which it is usually published. A contemporary scientist might typically submit his best work to the most prestigious (broad audience) journals first, before working his way down through the more specialist or localised journals until the peers reviewing the article feel that it has reached a level appropriate to the knowledge claim being made (Myers 1997). Journals can thus be informally ranked in order of importance of the work they contain (See Table 1).

Although the peer review system is designed to ensure that knowledge claims are rigorous and valid before publication (Daniel 1993), the complexity and rigidity of the publication process may deter non-professionals from contributing to the most prestigious journals. Indeed non-professional contributions are likely to be viewed somewhat sceptically by reviewers for journals dominated by professionals. While amateurs and non-professionals contributions still find a place in the highly specialised and professional field of scientific publication, they tend to be restricted to the lower end of the publication spectrum. However, particularly in the field of observational natural history, discoveries which significantly alter the way in which a species or the environment is understood may be made and reported by amateurs, often in an anecdotal format. But when an amateur publishes a significant discovery, does the professional scientific community recognise their knowledge claim, irrespective of whether it is published in a prestigious scientific journal or a chatty anecdotal report? Is it possible for material to move up the publication hierarchy over time in relation to its scientific value?

Table 1. Hierarchy of journals with a description and a hypothetical example of their content

Super-journals—International journals with a multi-disciplinary audience, highly sought after by scientists of all disciplines (*e.g. Nature, Science*) and very competitively refereed. Have citation impact factors of around 30. *e.g.* 'The seeds of life in space: evidence of nanobacteria in an asteroid.'
International journals— Journals containing refereed papers of international significance with either a multi-disciplinary audience (*e.g. Proceedings of the Royal Society*) or a broad audience within a discipline (*e.g. Trends in Ecology and Evolution*). Have citation impact factors of 4-10. *e.g.* 'A review of evidence of bacterial life in meteorites.'
National journals—Journals with refereed articles of primary significance within their country of origin (*e.g. Australian Journal of Zoology*). Many of the international journals originated as national journals. Have citation impact factors of 0-4. *e.g.* 'Organic chemical elements in a meteorite of asteroid origin.'
Regional journals— Journals with refereed or unrefereed articles primarily of regional significance (*e.g. Victorian Naturalist*). Are rarely catalogued for impact factors. *e.g.* 'Crystalline patterns observed in the Blackburn meteorite.'
Local journals, magazines, newsletters—Unrefereed material of local significance, often anecdotal or popular in nature (*e.g. Wingspan, Field Nats News*). No impact factors. *e.g.* 'Illustrations of the Blackburn meteorite.'
Popular publications - Anecdotal material or material reporting on established scientific information rather than claiming new discoveries (*e.g. Australian Geographic*). No citation impact factors *e.g.* 'Meteor hits Blackburn and excites scientists'.

Citation databases

One way of exploring this question is to examine the scientific citation databases which record all publications in the major journals (national and above). Electronic citation databases first appeared in the early 1990s and offer a reasonably comprehensive coverage of all articles published since that date. The database used for this study is the ISI Web of Science (© Thomson Corporation 2005).

Although some databases have now backdated their references to the 1970s, few extend beyond this time as yet. As a consequence, none of Edith Coleman's papers is listed in the citation database both because of their age and because *The Victorian Naturalist* is not one of the journals catalogued. Only one of Norman Wakefield's articles is listed, his last article published posthumously in *Nature* (Warren and Wakefield 1972). This should not be seen as a reflection of the value of their work, however. The publications of Charles Darwin and Albert Einstein are similarly missing from these databases.

Citations are generally a positive reflection on the value of research. However they can also be negative and take the form of a rebuttal. Negative citations tend to occur where major experimental results are being disputed, particularly where the disputed results are influential or provocative. Neither Wakefield nor Coleman published experimental research and their careful observational natural history is not particularly prone to negative citation. Obscurity, rather than refutation, is the greater hazard for observational field work. In any case, there is no evidence that negative citations are necessarily bad for authors or their posterity. For example, Jean-Baptiste Lamarck's French evolutionary theory of transformation was probably rescued from linguistic obscurity only when Charles Lyell refuted it, thereby introducing it to an English-speaking audience (Young 1992).

Because of the importance of articles as a means of tracing the origin of ideas, the citation databases include (in addition to bibliographic information and the summary or abstract) all the references cited in the article. This function enables scientists to search both backwards and forwards through the literature by examining both the articles used to construct a paper and to search for more recent papers which have cited a particular article. The cited reference search function on the Web of Science enables us to examine whether or not Coleman and Wakefield's articles are still being used and cited by modern scientists in their fields.

Analysing their publications

Edith Coleman's publications have been cited in scientific articles on 129 occasions. Of these citations, 98 are for 45 articles in *The Victorian Naturalist*. The majority (53%) of her papers in *The Victorian Naturalist* have been cited only once, with the remainder being cited 2-7 times (Mean=3.67). Whilst Coleman's articles probably vary in the amount of scientifically useful information they contain, it is not possible to assess on an *a priori* basis whether some are more scholarly than others. For example, 'Fairylands of Silk' (Coleman 1944) may not appear to have much scientific merit, however, it contains observations of wild web-building spider behaviour that might be of value to future scientific studies. Her most cited papers are her 1927 paper in *The Victorian Naturalist* (with seven citations) and her paper in the *Transactions of the Entomological Society of London* in 1928 (also with seven citations), both of which were on the topic of pseudocopulation. Clearly contemporary scientists do not regard her publication in the more prestigious *Transactions* journal as more worthy than the earlier publication in *The Victorian Naturalist* (indeed, most cite both papers). Coleman's paper on pseudocopulation in the *Journal of Botany* (Coleman, 1929) also received six citations as does her paper on *Pterostylis* orchid pollination in *The Victorian Naturalist* (Coleman 1934).

Norman Wakefield's publications have been cited considerably more in the literature (231 times), as might be expected for someone who wrote articles which were more scientific in nature and who published more recently. All of the papers cited tend to be scholarly rather than anecdotal or entertaining. As with Edith Coleman, most of Wakefield's citations (168) are for papers in *The Victorian Naturalist* (citing 41 papers). Just over half

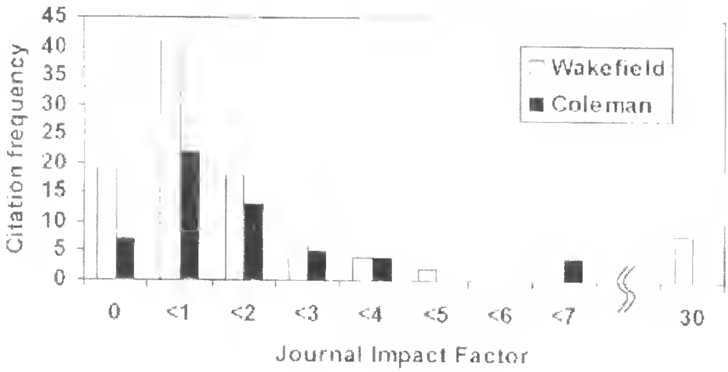

Fig. 3. The impact factor of journals containing articles citing the work of Edith Coleman or Norman Wakefield.

(21) of Wakefield's *The Victorian Naturalist* papers have been cited only once, with the remaining 49% being cited 2-28 times (Mean=7.3). His most cited individual piece is his *Nature* paper (Warren and Wakefield 1972) with 35 citations, however his second most cited paper (28 citations) is the second part of a revision of antechinus taxonomy published in *The Victorian Naturalist* (Wakefield 1967). Part one of this paper (Wakefield 1963) received 20 citations.

Citation levels of articles in *Nature* are disproportionately higher (an average of 30 per article) than citation levels in other journals (which tend to range 1-8 citations per article). Given the vast difference in international prestige and exposure between *The Victorian Naturalist* and *Nature*, the difference in citations between Wakefield's *Nature* paper and his antechinus papers in *The Victorian Naturalist* is insignificant and the latter must surely rate as being just as successful as the former.

Journal impact

Given the differences in prestige value of journals, it is worth exploring the hierarchy of the journals in which articles citing our two subjects are being published. The ISI calculates an impact factor for each journal based on the average number of citations received by papers published in the last year. Uncatalogued regional journals like *The Victorian Naturalist* are allocated an impact factor of 0. The normal spread of impact factors extends from around 0 to 4 for national or specialty journals up to about 8 or 9 for international journals (see Table 1). However, the 'super' journals *Science* and *Nature* have impact factors of around 30. Publication in these journals tends to attract citations by virtue of the prestige of the journals themselves, thus creating a somewhat self-inflating impact factor. Anecdotally it is worth noting that most professional biologists typically seek to have their papers published in journals with an impact factor of more than 1.

It is clear from Figure 3 that both Wakefield's and Coleman's papers are being cited in a full range of journals, from the lowest-ranking ones (with no impact factor) to the highest ranking ones. Not surprisingly, Norman Wakefield's *Nature* paper has been cited in a number of other *Nature* and *Science* papers (by citing publications from high impact journals, authors associate their own knowledge claim with other knowledge claims whose value has been acknowledged through publication in a high-impact journal). However, many of the other journals citing both Wakefield's and Coleman's paper also have high impact factors. Interestingly, despite having more citations and a *Nature* paper, only 39% of Wakefield's papers are cited in journals with an impact factor of more than 1, compared to 46% of Coleman's papers. This might be because Coleman's papers are often cited in reviews of the literature (which tend to be published in higher ranking journals) while Wakefield's papers are cited in a broader range of papers on active research.

In general, it is clear that both authors are travelling well in the scientific literature and their contributions are both well-recognised and well-acknowledged. The increasing dependence of modern researchers on electronic databases shows no sign of reducing the value of older papers (Pechenik *et al.* 2001) and indeed may facilitate awareness of older regional papers through cited reference searches. The continuing acknowledgement in the scientific literature of both Coleman and Wakefield's articles from *The Victorian Naturalist*, demonstrates that the journal has clearly served its function as a conduit for the two-way flow of information between the amateur and professional worlds of natural history and biological science. Nor is the value of an amateur society like the FNCV restricted to the publications of its journal. Both Coleman and Wakefield are examples of active participants who used their connections with the FNCV to broaden the distribution of their work to both a general and scientific audience. Their contributions, both within *The Victorian Naturalist* and in the wider scientific and popular literature, and its continued use by professional scientists today, demonstrates the important role amateur naturalists still have to play in modern biological science.

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The close union between the Herbarium and the Naturalists

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Abstract

The National Herbarium of Victoria and the Field Naturalists Club of Victoria have been closely associated since the Club was founded in 1880. This association has been mutually beneficial. The Herbarium provided Club members with authoritative botanical information and staff were active in the Club, many holding office. As members, staff were part of a community of botanists, which gave them contacts and opportunities for exchange of ideas lacking within the Victorian Public Service. Participation in Club excursions enabled staff to undertake field work at times when resources made this very difficult. The Herbarium's collections were significantly enlarged, particularly in the fifty years after the death of Ferdinand Mueller, by the accession of the personal collections of Club members. At times leadership of the botanical community in Victoria lay with the Club rather than the Herbarium. (*The Victorian Naturalist* **122** (6), 2005, 282-287)

Working quarters

On April 30 1884 Francis Dobson rose to deliver his presidential address to members of the Field Naturalists Club of Victoria at their annual conversazione. The occasion offered him the opportunity to reflect on how far the Club had come in its four short years. Members could not, he said, 'be too highly complimented' on the Club's usefulness and their efforts to date. For much of his speech Dobson encouraged members to continue with their efforts in making a valuable contribution to scientific knowledge while at the same time providing themselves with a healthy and convivial pastime. 'Most of us', he said, 'are engaged in occupations which confine us within doors, and the mere ramble in the country for a few hours is as good for the body as it is for the mind of the intelligent observer.' He went on: 'Socially, as well as scientifically, such an institution as ours must act beneficially, as it brings into closer and more intimate union those who are already held together by the tie of affection for some scientific pursuit' (Dobson 1884). It is the close union between the Club and the National Herbarium of Victoria that is the subject of this paper. All the people named in this paper were members of the Club.

The Club and the Herbarium have been closely connected since the inception of the Club. In the late 1870s, Charles French snr and George Luehmann met regularly with fellow naturalists in French's house in the Botanic Gardens. French was at that time on the staff of the Botanic Gardens, although he transferred to the Herbarium as 1st Assistant in 1884, while Luehmann was Ferdinand Mueller's deputy and succeeded him as Government Botanist. From these meetings the Club was born, and both French and Luehmann are recorded as founding members (Pescott 1940; Willis 1980). Since that time Herbarium staff members have been staunch supporters of the Club. Over 125 years Herbarium staff, with few exceptions, have been members of the Club. As members, Herbarium staff played a prominent role in Club activities. Many of them served on committees, some in more than one capacity. Alfred Ewart, Percy St John, Frank Morris, Margaret Corrick and Tom May all occupied the chair as President; Pat Bibby was Librarian; James Tovey was Secretary; Council members included James Audas and George Luehmann; Jim Willis and Arthur Court edited *The Victorian Naturalist*; Helen Aston and Neville Walsh were members of the Australian Natural History Medallion Award Committee; Marie Allender served an unprecedented term of 35 years as Excursion Secretary (Fig. 1)

Ferdinand Mueller, Australia's great 19th-century botanist and the man who established the Herbarium, was not a foundation member (although he joined in

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Fig. 1 Marie Allender (front, 2nd from left), Excursion Secretary for 35 years, with Club members in Albany, W.A., on 12 September 1963. (Reproduced with permission from the Archives of the Royal Botanic Gardens Melbourne.)

1880) and declined repeated invitations to take the chair as President. He was, however, no less active in his support of the Club than other Herbarium staff. In 1886 he consented to be Patron and remained so until his death in 1896 (Taylor 1996). When the Club decided to publish its own journal, Mueller offered not only to provide articles but also to subsidise the printing of his papers to the tune of 5/- per page (FNCV archives, Minute books 007, f. 59, meeting 4 August 1884). His willingness to identify specimens brought to him by Club members was noted many times in their accounts of collecting trips published by members in *The Victorian Naturalist* (French and Barnard 1887; Sayce 1887; Hardy 1907). In the matter of using up-to-date botanical names for Victorian plants, even as late as 1918 Francis Barnard declared that he personally preferred to follow Mueller's nomenclature (Cohn 2005). Such was the Club's veneration of Mueller that his exploits as recounted by fellow Club members reached heroic proportions. Of his early explorations of Wilsons Promontory JG Gregory and Arthur Lucas wrote: 'Here, alone, for four days without food, reduced one night to his last match wherewith to light a fire, while the rain was drenching him, our pioneer readily faced the chances of death by cold, exposure, and hunger, in order to add to science a knowledge of the Flora of these interesting districts' (Gregory and Lucas 1886). In 1892, at the height of Victoria's economic woes, Mueller's Herbarium was subject to the same cutbacks as other Government departments. The Club leapt to his defence, making representations to the effect that such reductions would leave him with a budget 'manifestly inadequate' to maintain the Herbarium in an appropriate manner (Walter Fiedler to Chairman, Royal Society, 2 February 1892, FNCV archives, Correspondence 010-001).

Mueller's place in Club history has become the stuff of mythology (Taylor 1996). There grew up a Club tradition of celebrating Mueller anniversaries and of conducting pilgrimages to his grave. Barnard's preference for Mueller's nomenclature can be seen as part of this mythology. But there was a more practical aspect of the Club's connection with the Herbarium. In 1885 President Jacob Halley referred to Mueller's Botanical Museum (that is, the Herbarium) as offering the botanist all that was needed to study the Australian flora (Halley 1885). Members readily donated specimens to the Herbarium 'under the impression that in a National collection they would be carefully preserved and more easily within the reach of those anxious to use them for the purpose of comparison'. The Herbarium, in fact, functioned as 'the working quarters of most of our local Botanists, who have always received the most courteous attention from those in charge' (Walter Fiedler to Chairman, Royal Society, 2 February 1892, FNCV archives, Correspondence 010-001). President O Sayce in 1904 spoke in a similar vein, calling for closer co-operation between the collector and the systematist, with greater attention being given to the provision of comprehensive field notes. In his view, Club members had an important role in furthering the work of Victoria's scientific institutions responsible for studying the local flora and fauna (Sayce 1904). This included the Herbarium. On a more practical level, after many years of using room in the Royal Society of Victoria for their activities, the Club was based at the Herbarium from 1955 (Willis 1980). All meetings were held in the Herbarium building and the Club's library was kept behind a partition at the back of the hall. This arrangement only ceased in 1988 when, following the construction of an extension to the building to accommodate the Herbarium's collections, the Club acquired its own premises in the Melbourne suburb of Blackburn.

From the Club's point of view its connection with the Herbarium provided considerable benefits over a long period of time. This came in the form of active contributors to its activities and leaders of excursions, ready access to botanical expertise and the specimens in the Herbarium's collections, and accommodation for its meetings and library. From the Herbarium's point of view, its connection with the Club was at least as important if not more so. Within 20 years of the foundation of the Club the Herbarium had been reduced to the Government Botanist, George Luehmann, and a staff of two, James Tovey and James Audas (Cohn 2003). For the next 40-50 years, with the exception of the period of Alfred Ewart's tenure of Government Botanist, the research that was central to Mueller's role in charge of the Herbarium had largely slipped off the official agenda. What the Government required of the Herbarium was little beyond an identification service, particularly in relation to the agricultural enterprise of the State, and that the specimen collections be maintained. The Herbarium entered a period of the doldrums during which the involvement of staff in the Club provided a lifeline. In fact the close union advocated by Dobson proved invaluable to the Herbarium. It was in their participation in Club activities that Herbarium staff associated with a community of like-minded naturalists and participated in field excursions, while Club members added significantly to the Herbarium's collections.

Community of botanists

One of the most important aspects of the Club was that it was a community of naturalists sharing their enthusiasm for the local natural history and helping each other learn about it. This was especially so when it came to botany. If you wanted to connect with a community of botanists in Victoria the learned Society, the Royal Society of Victoria, was not the place to find it. Some Naturalists,such as Ferdinand Mueller, Alfred Ewart and Herbert Williamson, were members of the Royal Society. These were the exception rather than the rule. It was the Field Naturalists Club of Victoria that provided this sense of community, which proved one of the principal attractions of the Club to Herbarium staff. It was particularly important during the middle period of the Herbarium's history, approximately 50 years between the death of Mueller and the post-World War II period, when the Herbarium staff numbered just two people plus the Government Botanist, when research was a sideline to the official work of the Herbarium, and when the government expected so little of the Herbarium. In the Club, the staff found people who shared their interests, who were knowledgeable about the flora, and who proved to be amiable companions in the bush. The Club was where much of the botanical activity in Victoria was centred. Most of those people who were making observations in the field and publishing articles about the native vegetation were Club members.

Alfred Ewart recognised this very quickly after arriving in Victoria to become Government Botanist and the first Professor of Botany at the University of Melbourne. He attended his first Club meeting in March 1904 as the guest of the President, Francis Barnard, became a member at the April meeting and was elected to Council in June. In addition he encouraged his two staff James Audas and James Tovey to join – or in the case of Tovey rejoin (Cohn 2005). All three became stalwarts of the Club. Life-long friendships were forged between Club members and staff. Jim Willis referred with obvious pleasure to his 26-year friendship with Bill Hunter and a 33-year association with Norman Wakefield (Willis 1971; 1973). The Willis archive in the Library at the Herbarium includes, as just one example, 20 years of correspondence with Keith Rogers.

Club members may have been 'amateurs' but there was a ready acceptance of the expertise among them. Of Carl Walter, it was noted that 'no one did better work at the time in our Field Naturalists Club than our friend Walter, who named for everyone' and who 'from his long experience in the field, was often consulted' (Allen 1989; Anon 1907). Flora Campbell was referred to as 'our mycologist' and when on excursions spent as much time identifying fungi for other members as she did collecting for herself (Anon 1885). Herbarium staff readily acknowledged the expertise of Club members and their willingness to share their knowledge. Herbarium botanist Frank Morris paid tribute to Alfred Tadgell, who 'constantly inspired and taught "beginners" by his lectures, writings and leadership of excursions to near and far distant areas' (Morris 1949). Nor were the Herbarium staff too proud to accept help in their official duties from Club members whose acquaintance with particular plant groups was greater that their own. Thus Richard Bastow was asked by Ewart to assist in identifying mosses, Bill Nicholls not infrequently undertook orchid identifications for the Herbarium, and Norman Wakefield helped Jim Willis in the preparation of his *Handbook* by preparing draft keys for several of the more difficult groups (Ewart to R. Bastow 2 April 1908, RBGM archives, MSS 399b, f.219; Willis 1973).

Many enjoyable camp-outs

Field work was another aspect of Herbarium work where belonging to this community of botanists proved invaluable. Observation in the field was one of the primary objectives of the Club (Halley 1885), and it was an aspect of herbarium work that for many years was almost impossible to achieve with the limited resources available. Ewart came to the job of Government Botanist as an experienced plant pathologist but not a plant taxonomist. For him, field work was a vital means by which he could gain first-hand experience of a flora of which he knew practically nothing and with which he needed to become acquainted very quickly if he was to be credible as Government Botanist. However with his teaching commitments, the only time he could make field trips was during the University vacation.

In addition, as public servants, Herbarium staff were obliged to follow the Public Service regulations. Under these regulations permission was needed from a higher level than the Government Botanist for official work to be undertaken other than at one's normal place of business. Even Mueller had to obtain permission to travel out of Melbourne. One of Ewart's first field trips was an official visit to Wilsons Promontory. This was partly in his capacity as the Club's representative on the Committee of Management of the Wilsons Promontory National Park, and partly because the Minister had been persuaded to sanction a botanical survey of the Park as Herbarium business (Ewart *et al* 1909). A trip to the Ovens Valley to inspect the spread of the weed St Johns Wort afforded Ewart and Audas a rare opportunity to combine Department of Agriculture business with collecting for the Herbarium (Ewart and Audas 1910). These trips were, however, the exception rather than the rule. Occasionally opportunities for field work came from unexpected sources. In 1947 Jim Willis was invited to participate in an expedition being arranged by Russell Grimwade. A group of scientists from different disciplines would travel by bus from Port Lincoln in South Australia westward to Perth. Ministerial approval for Willis to join this group as botanist was sought and refused. As Willis recounts the story, Grimwade then 'interviewed' the Premier and Willis was able to board the bus (Jim Willis interviewed by Darren Watson 22 July 1994, RBGM archives, MSS 499.2). (Fig. 2) Approvals were clearly not easy to obtain.

Staff were usually left in the position of having to use weekends and vacations to undertake the field work that combined the interests of the Herbarium and themselves. James Audas was one staff member who loved going bush, and he invariably used his leave for this purpose. Club members were entertained with the accounts of his many holiday excursions published in *The Victorian Naturalist*. These reports, and the specimens Audas collected, give an invaluable picture of the flora before the further encroachment of settlement or agriculture (see for example Audas 1911, 1920). Jim Willis was particularly appreciative of the opportunities offered by Club excursions. He talked warmly of spending weekends and holidays on 'joint family outings' and of 'many enjoyable camp-outs' in the company of various of his friends in the Club (Willis 1973). (Fig. 2) When Margaret Corrick first joined the Herbarium staff her task was to incorporate some thousands of Willis specimens into the collections. She estimated that most of these specimens were collected on Club excursions (M Corrick 2005 pers. comm. 19 May).

Collections

One of the most important aspects of the close association between the Herbarium and the Club was the accession to the Herbarium collections of so many specimens from so many Club members. Reference has already been made to Jacob Halley's remarks about the readiness of members to donate plant specimens to the Herbarium and their general understanding that the Herbarium collections were available for all to consult and would be looked after as a resource for all. The fact that staff participated so genuinely and generously in the life of the Club undoubtedly encouraged people to lodge specimens. For many there was a personal connection with Herbarium staff, with strong friendships being forged. It is not an exaggeration here to single out Jim Willis as being particularly influential in encouraging the botanical pursuits of other Club members.

Specimens came to the Herbarium in a variety of ways. Alfred Ewart was aware very early on that there were private collections of specimens belonging to Club members that would be valuable acquisitions for the Herbarium. For a total expenditure of £102 Ewart purchased the 10 000 specimens of Felix Reader's herbarium which was particularly rich in mosses and the plants of north-western Victoria, Carl Walter's herbarium of approximately 3000 specimens, and about 5000 lichens collected by Francis Wilson (Cohn 2005). Ewart was particularly pleased to receive the bequest of Alfred Howitt's *Eucalyptus* collections. Not only was Howitt an acknowledged expert on this genus, but there were still many of what Ewart termed 'knotty points' to be resolved relating to this group of plants (Ewart to M. Howitt 8 April 1908, RBGM archives, MSS 399b, f. 239). Other Club members who bequeathed their collections (and in some cases notebooks) to the Herbarium included Richard Bastow (over 1000 bryophytes), Thomas Hart (whose collections also included a full set of William Hunter's specimens), and Herbert Williamson (Austin Bastow to Ewart 25 May 1920, RBGM archives, MSS 318; Willis 1960). The value of these specimens can be seen from the interest expressed by the Director of the Royal Botanic Gardens, Kew, in obtaining Williamson's herbarium for Kew (Arthur Hill to Ewart 12 March 1931 and Ewart to Hill 14 April 1931, RBGK archives, PRO2VIC3).

Other Club members whose specimens are in the Herbarium include Francis Barnard, St Eloy D'Alton, James Stirling, Daniel Sullivan, Charles Sutton, Edward Pescott, Frederick Pitcher, Alfred Tadgell, Henry Tisdall, Hermann Rupp, Edith Coleman, Gustav Weindorfer and his wife Kate, and Flora Campbell, who was acknowledged by the Queensland Government Botanist Frederick Bailey as one who had 'perhaps exceeded all others' in the collection and elucidation of Victorian fungi (Bailey 1892). Norman Wakefield donated many specimens to the Herbarium, including the vouchers and types from his articles in *The Victorian Naturalist* (Aston 1980). Jean Galbraith spent much time in the Herbarium while working on her book *Wildflowers of Victoria* (1950) and on occasion, in order to make the most of her limited time in Melbourne, she spent the night in the Herbarium on the couch reputed to have belonged to Ferdinand Mueller. Other Club members whose collections came to the Herbarium include Bill Hunter, Keith Rogers and Bill Nicholls who gave both his collections and his orchid paintings to the Herbarium.

What this represents for the Herbarium is a comprehensive coverage of well-prepared and labelled Victorian material collected by people who had built up a very considerable knowledge of the Victorian flora. Much of this material was collected in the period after the great collection-building efforts of Ferdinand Mueller and particularly in the middle decades of the Herbarium's history, the 1920s-1940s, when it was not possible for herbarium staff to make significant field collections. Without the contributions made by these people the Herbarium would have very little material collected during the 50 or so years after Mueller's death. Also significant is that much of this material was collected by people who were expert in specific groups of plants or had devoted their efforts to particular regions of the State. Thus the Herbarium has good material from Gippsland thanks to the efforts of Bill Hunter, Bill Nicholls, Alfred Howitt, James Stirling, Henry Tisdall and Keith Rogers, and from western Victoria thanks to Felix Reader, St Eloy D'Alton, and Daniel Sullivan. Richard Bastow, John Bracebridge Wilson and Francis Wilson were working on the lower plants when no-one else was interested in them. And there were the orchid collections of Nicholls, Coleman, Pescott and Wakefield. This is by no means an exhaustive list of the Club members whose specimens now form part of the Herbarium collections.

Centre of reference

Another aspect of the relationship between Herbarium and Club to consider is the leadership of botanical activities in Victoria. While Mueller was alive there is little question that he was seen as the focus of botanical research and collecting, but

Fig. 2. Jim Willis (top right) with Club members and their families on the Club excursion to Lake Mountain on the Australia Day weekend, 1948. (Reproduced with permission from the Archives of the Royal Botanic Gardens Melbourne.)

what after that? Ewart when he arrived was impressed by what he saw as a lack of direction in Victorian botanical affairs and this was partly behind his early determination to play a prominent role within the Club (Cohn 2005). He was determined to make the Herbarium once again the centre of reference for botany in Victoria. As a member of the Club he was in an ideal position to tap into the extensive botanical knowledge that resided in members of the Club. He wanted both to harness that knowledge and lead the community of botanists. The first plank of his campaign was to encourage the use of up-to-date botanical names as determined by the Herbarium botanists. Here he met with qualified success: Francis Barnard's declaration of support for Mueller's standards has already been noted. Ewart was more successful in his chairmanship of the Plant Names Committee. Most members of this Committee were so as either Club members or Herbarium staff. The diligent work of the Committee resulted in a series of articles published in the *Journal of the Department of Agriculture of Victoria* between 1911 and 1916 listing the recommended common names for the flowering plants of Victoria and, in 1923, the publication by the Club of the *Census of the plants of Victoria*. Most Herbarium staff served on the Committee at some stage, including the revived Committee of the 1930s-40s. This was a highly successful collaboration between the Club and the Herbarium.

During the years when Ewart was Government Botanist, 1906-21, the Herbarium did provide some leadership of botany in Victoria. In the period after 1921 this was not the case. Ewart's four successors as Government Botanist also held the office of Director of the Botanic Gardens. They were, in order, William Laidlaw, Frederick Rae, Alex Jessep and Dick Pescott. Their interests and inclinations lay more towards that side of their work involving the Botanic Gardens than the study of the native flora that was inherent in the work of the Herbarium under their control. Jessep and Pescott, while not engaging in the work of the Herbarium, were nevertheless assiduous in their efforts to improve conditions at the Herbarium. Between them they were responsible for the renaissance in the Herbarium's fortunes. However, it was difficult for Herbarium staff to lead botany in Victoria when they were so few in number, when there was no Government direction, and when the Herbarium's senior officer, while concerned with management of the Herbarium, did not participate in its research or related activities. There was certainly a perception that the Club took up the baton during these years. As Jim Willis said, the 'Club was largely responsible for any botanical work done in Victoria. They always had a reputation for good sound botanical work by amateur people' (Jim Willis interviewed by Darren Watson, 22 July 1994, RBGM archives, MSS 499.2). Willis joined the Herbarium staff in 1939 and this marked the beginning of the rebuilding of the Herbarium staff numbers. It was due in no small part to Willis that the Herbarium regained its position at the centre of botanical activities in Victoria.

A major reason for the Club taking a leading role in Victorian botany was the publication of its journal. Up to 1960 the overwhelming majority of botanical papers published in Victoria were in *The Victorian Naturalist*. Willis made a half-joking remark about Ewart stealing material from the *The Victorian Naturalist* for the *Proceedings of the Royal Society of Victoria* (Willis 1950). However, this does not stand scrutiny. An inspection of the *Proceedings* reveals relatively few botanical papers. Much of the material published in the *Proceedings* by Ewart with colleagues and students as co-authors are about Northern Territory rather than Victorian plants. What Jim's remark shows, however, is that *The Victorian Naturalist* was viewed as vital for the publication of botanical information. Among the more prolific writers in *The Victorian Naturalist* were Norman Wakefield (62 botanical papers), Bert Williamson (45), Edward Pescott (36), Bill Nicholls (118), Hermann Rupp (71). Of the Herbarium staff Willis wrote 107 botanical articles, Audas 13, Ewart 22, and Morris 22. It could be said that Herbarium staff published here because there was nowhere else. Rather, the existence of *The Victorian Naturalist* provided the encouragement to put information that was lacking from other quarters into print .

The close union between the National Herbarium of Victoria and the Field Naturalists Club of Victoria has proved mutually beneficial to both organisations over the 125 years that the Club has been in existence. In the community of naturalists that was the Club, the Herbarium staff found colleagues who shared their interest in the native flora of Victoria and whose expertise was of value to the Herbarium. Many Herbarium staff have been active participants in Club activities. The association between the two organisations proved particularly important to the Herbarium during the middle period of its history, when it had few staff and resources were minimal, and the Government required little beyond curation of the collections and the provision of an identification service for the public. Club excursions provided Herbarium staff with opportunities for field work that were rare in their official duties. Of particular significance are the many Victorian specimens collected by Club members and lodged in the Herbarium. The fruitful collaboration between the Herbarium and the Club still continues with the highly successful 'Fungimap', a project to map the distribution of fungi, which is based at the Herbarium and involves the observational skills and input from many field naturalists (Grey and Grey 2005; May 2004).

Abbreviations

FNCV – Field Naturalists Club of Victoria
RBGK – Royal Botanic Gardens, Kew
RBGM – Royal Botanic Gardens Melbourne

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'If it is not against the rules' Women in the FNCV 1880-1980

Sheila Houghton

Abstract
The Field Naturalists Club of Victoria never had a rule barring women. It welcomed them, electing two women to the committee in 1885. Forty-three years passed before another woman served on the Committee, and it was not until 1947 that the Club had its first female President. Women played a significant part in the Club's activities, notably in supporting the Wildflower Exhibitions. The Club attracted both professional women and amateur naturalists, some of whom became recognised experts in their chosen field. This paper presents a selection of the 2213 women elected between 1881 and 1980, who both contributed to the knowledge of natural history, and played a vital part in the history of the FNCV. (*The Victorian Naturalist* **122** (6), 2005, 290-306)

Introduction

In July 1881 the Hon FS Dobson LLD, MLC was surprised, but honoured, to read in the newspaper that he had been elected a member of the Field Naturalists Club of Victoria (FNCV). He wrote to thank the Club for being 'good enough' to elect him, adding that he hoped to join Club excursions during the summer, and to bring Mrs Dobson with him 'if that is not against the rules' (Dobson 1881). Henrietta Louisa Dobson was the first woman to be elected to the Field Naturalists Club of Victoria on 12 September 1881 (Fig. 1). It was possibly as much her desire to join an excursion as his that she should do so. Born Henrietta Louisa Sharland in New Norfolk in 1853, Henrietta came from a prominent Tasmanian family whose interests may well have included natural history, since her nephew, Michael Sharland, became an ornithologist, nature writer to *The Mercury* (Hobart) and sometime President of the Tasmanian Field Naturalists Club.

It has been suggested that the FNCV agreed to accept a woman member because they wanted the prestige of having Frank Stanley Dobson on their members' roll (Taylor 1991). But the Club never evinced any objection to women joining, and before Mrs Dobson appeared on the scene there was the mysterious Miss Guilfoyle (who may have been a sister of WR Guilfoyle, the Director of the Melbourne Botanic Gardens), who exhibited tropical fish on several occasions during 1881, and again at the Annual Conversazione in 1882, though she was never elected a member (anon 1881, 1882).

In a letter written on 30 May 1881 to Hugh Paterson, who was struggling to establish the Naturalists Field Club of New South Wales, Dudley Best, the FNCV's Secretary, offered some good advice: 'try to inveigle a few ladies to join ... and take my word you will now have plenty of fellows' – the objective observation of a confirmed bachelor (Best 1881). The Rev. JJ Halley, in his Presidential address in April 1885, took a moral approach. He welcomed those whom he termed their 'sisters of science' in the Club, 23 of them at the time, and declared that 'the happy home is

Fig. 1. Henrietta Dobson (on extreme right), photographed with members of her family in the 1890s. (Courtesy of Archives Office of Tasmania [NS1337/39])

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certainly the intelligent home', where intelligent mothers and sisters would 'add something to the common stock of thought and knowledge'. This influence would assist the popularisation of science, while offering an alternative to the popularity of sport. Optimistically (and in the event somewhat unrealistically), he hoped that 'it will be our privilege, before many years have passed, to listen to this annual address delivered by one of the sisterhood of our guild' (Halley 1885). The flamboyant Augustus Forbes Leith, in his letter of resignation before returning to England in 1887, was more enthusiastic. He had 'hailed with delight the time when ladies first joined the Club' for he 'failed to see that there was any life in it until they came to the front'. He embellished these comments by saying that he considered that 'Woman had done more for Natural Science than ever Man did', adding that 'one good drawing is worth fifty pages of descriptive manuscript' (Leith 1887).

In the first century of the Club 2213 women were elected. The meticulous keeping of records during the first 60 years of the Club's history enables us to trace the emergence of women members. In the first 25 years, 168 women and girls were elected, of whom 40 were still members in 1905, including the 16 juniors who were elected that year. This represented 14.8% of the membership, which had grown to 19% by the end of the First World War. In 1940 the women accounted for 33.7% of the membership. The scarcity of membership lists after this date until 1983 makes it impossible to gauge whether this percentage was maintained. There was a big increase in the number of women elected during and just after World War II: 20 in 1941, 34 in 1943, 40 in 1944 and 51 in 1946. 1107 women were elected between 1955 and 1980, but of these we have no way of telling how many remained members for any considerable length of time, and this figure also includes women who dropped out and then were re-elected at a later date, sometimes more than once. We know nothing about the majority of these women, beyond the basic facts of their name, address, marital status and the date of their election to the Club. An analysis of the addresses indicates that initially members came from the inner suburbs of Melbourne, such as South Yarra, Toorak and Kew, but gradually they were drawn from further afield, mainly from the eastern or south-eastern suburbs. A small percentage were country members, often teachers in state schools who moved to different areas. Some of those who lived permanently in the country remained members of the FNCV after local clubs were formed in their area.

The Victorian Naturalist, however, provides much information, which gives some insight into who these women were, and their interests. The practice, maintained until the 1960s, of publishing who nominated and seconded the election of a member may give some clue as to that person's particular interest, especially in the early years, though as the Club expanded this became more of a formality, with the nominee not being personally known to the proposer. More helpful is the practice, during the 1960s, of publishing a new member's interests. But the most valuable resource of all is the reports of meetings, which were given in great detail up until the 1960s. There is no evidence that women were involved in the campaign for the reservation of Wilsons Promontory in 1898, but we can trace later a growing concern amongst them for the preservation of the environment: for example, in Grace Nokes supporting a motion to preserve native flora in 1924, Winifred Waddell's concern for the preservation of native plants in the 1940s, and in 1964 when Mrs Emilie Bennett drew the Club's attention to the destruction being caused by bulldozers in the Heytesbury and Lower Glenelg areas, and also in Patricia Carolan's concern for the Howqua River area. Reports of ordinary meetings contained details of discussions, in which women sometimes took part, so that we know, for instance, that in 1920 Calphurnia Currie was concerned about the content of meetings and the level of assistance given to country members, and that when in 1942 the Club was discussing the possible effect of blackout restrictions on their evening meetings Royena Chisholm suggested that the lady members gather on the steps of the Emily McPherson College, of which she was Principal, and proceed together for safety to the meetings, then held at the Royal Society of Victoria.

Correspondence mentioned in ordinary meeting reports has not survived. Amongst the letters held in the Club's archives are requests from women about to travel interstate or overseas for letters of introduction to naturalists or natural history clubs in the places to which they were going. Others ask for help in the identification of specimens, for information about the Club, or deal with details about their upcoming talks or exhibits, or give thanks for letters of condolence on the loss of a relative. In 1931 Calphurnia Currie wrote letters of sympathy to the Club on the loss of HB Williamson and AE Rodda, and there are also tributes from women who had received much help and instruction from outstanding members.

Contribution to the Club is not confined to whether a person held office, and this is particularly true of the women members, especially in the first 60 years of the Club's existence. The part they played in the Wildflower Exhibitions is a case in point. They were very supportive here, at first in what might be called a female role, serving refreshments, selling flowers, arranging the entertaiment, but very soon they were involved in the natural history displays, in the Microscopical, the Orchid and Plant Identification Sections, and in assisting at or taking charge of tables devoted to the flora of the various States. Usually their contribution was personally acknowledged, but sometimes one can only infer their involvement from general thanks in the Annual Report. Some women were regular exhibitors at meetings, others only occasionally; some gave talks, led excursions and reported on them, held minor but important offices such as Exhibition Steward at meetings, or Library Assistants when the Groups were established. The amount of information available for an individual varies enormously, but even an occasional reference indicates that she was supporting the Club. In every decade at least one woman member emerges who played a significant part in the Club's history, or became well-known in wider natural history circles. These are the women who have been chosen as the subject of this paper, along with a few others of whom we have only a glimpse (but one which reveals a variety of involvement).

1880-1920

Henrietta Dobson was the only woman member for nearly two years until the election of Flora Campbell and two other women in 1883. Flora Campbell was the woman who in many ways in the first twenty-five years exemplified the purposes for which the Club had been founded, the self-taught amateur who became an expert in her field. Flora Mary Campbell was born in Tasmania in 1845. She was elected to the Club in 1883, when she was living in South Yarra, and in 1888 she married William Martin, so became better known by her married name. Her special interest was in fungi, about which very little was known at the time. But Flora Martin knew what she was doing, and significantly the collection of fungi which she exhibited at a Club meeting in June 1883 was reported as being 'mostly named' (Anon 1883). In 1886 she contributed a paper on edible fungi, and pointed out that 10 species usually regarded as poisonous were quite safe to eat if they were young and fresh (Campbell 1886). Members of the Club remained cautious and somewhat sceptical, and their opinions were not exactly altered after an excursion to Olinda Creek, where, at her instigation, they collected and cooked the Beefsteak Fungus *Fistulina hepatica*. They were unable to eat it because it was too old (Anon 1885).

Flora Martin sent many specimens to the Royal Botanic Gardens, Kew, England, including the first fruiting specimen of 'Blackfellow's Bread' *Polyporus mylittae*, which established the nature of the fungus that had puzzled botanists for years. She contributed specimens which MC Cooke included in his *Handbook of Australian Fungi*, a presentation copy of which was amongst her books found after her death in 1923, signed by the author over his photograph 'In kindly remembrance of the good offices of Mrs Flora Martin in advancing this work in the colonies, and in securing its official recognition, my thanks are ever due' (Pitcher 1925).

Flora Martin corresponded with botanists overseas, and did not hesitate to take issue with Baron von Mueller over plant classification. In particular she corresponded with FM Bailey, the Queensland Government Botanist, and sent him specimens, which particularly annoyed the Baron. In a very heated letter to FGA Barnard in 1885 she quotes from a letter from Bailey about a Dr Lucas, who 'without the least knowledge of the Queensland flora pays a flying visit' to northern parts 'gathers naturalized weeds or strays from gardens and hands them to the Baron as Australian plants, and he without consulting me publishes them as indigenous'. (TP Lucas, an original member of the FNCV, had moved to Brisbane for his health). She continues: 'The paper on fungi is most misleading, but I can't write about [it]. I am so indignant.' She had visited Queensland herself briefly, in company with JE Tenison-Woods, who also commented on the spread of introduced plants (Campbell 1885).

Flora and her husband moved to a farm in Drouin in 1892 and this increased her interest in pathogenic fungi. She had already, in 1887, given a paper at a Club meeting, on 'Vegetable Pathology' and exhibited 400 specimens of diseased plants (Campbell 1887). She was interested in the economic aspects of plants, and in 1895 read another paper to the Club, intriguingly entitled 'A Ramble Amongst Fertilizers', mainly about weeds (Martin 1895), and she put forward ideas about aerating the soil and compost that would gladden Peter Cundall's heart. In 1890 she was the first woman to present a paper to the Australasian Association for the Advancement of Science conference in Melbourne, on 'Diseases of Plants' (Anon 1890a).

There was a big upsurge in enrolments during 1884, which was in no small part due to the efforts of Dr Dobson. In his presidential address in 1884 (Dobson 1884a), he stated his belief that botany was a suitable study for ladies, an idea shared by the Reverend William Woolls, of Sydney, elected an Honorary member of the FNCV in 1883, who wrote in a letter to the *Sydney Morning Herald* 'Botany ... is particularly fitted to attract the attention of the fair sex' (Woolls n.d.). With this in mind, Dr Dobson, who was a somewhat reluctant President, was an energetic recruiter of female members. In 1884 he proposed almost all the Simson ladies for election. Robert Simson was a pastoralist and had been a member of the Legislative Council for the Western District in the 1870s. He had married Catherine Officer (Hone 1976), who had a renowned garden at their home in Toorak, and was 'a great student of botany' (Dobson 1884b). Elected in 1884, she remained a member until 1893, though curiously her recorded input to the Club consisted of exhibits of snakes and rats, apart from an initial contribution of Queensland plants. Her sister-in-law, Margaret, Mrs John Simson, elected at the same time, and followed by all her daughters in 1885, became a loyal member until her death in 1922. Along with Henrietta Dobson she was elected to the FNCV Committee in 1885.

Their election may have been something of a token gesture, because Mrs Dobson did not attend any Committee meetings, and Mrs Simson only one in September 1885, but neither did many of the male Committee members, often only the chief office-bearers being present, a kind of executive sub-committee. (FGA Barnard did not include them when he drew up his chart of officer-bearers from 1880-1901 to present to the Club on its 21st anniversary). Mrs Simson's presence at the September meeting may well have been related to the impending Wildflower Show, held in October 1885 for the first time. There are references in later years to the Ladies Committee, and to the Wildflower Show sub-committee, which in 1890 contained four women, Kate Coghill, Mary Halley, Miss AE Roberts and Susannah Cochrane (Anon 1890b). There is no doubt that the women played a significant and continuing part in these events. In the 1930s the Shell Company provided an exhibit each year, and there are letters of thanks to Mrs Florence Ellen Barrett (known as 'Effie'), the wife of Charles Barrett, and her committee, for managing their exhibit. Women from different parts of Victoria, and interstate, many of them not members of the FNCV, regularly contributed exhibits of native flowers from their local areas, until the passing of the Wildflower Protection Act in 1930 prohibited the picking of native flowers in Victoria. Miss Nethercote, elected in 1911, was the convenor of the Ladies Committee in 1917 (Anon 1917), and she was passionate about the Grampians flora, going to considerable lengths to organise the collection and transport of exhibits. She and Miss Rollo, elected in 1904, took part in the discussion before the 1918 Show (anon 1918), which led to an effort to make the display more systematic, and gradually specialist tables, such as the Orchid Section, presided over by Edith Coleman and her daughter Dorothy for nearly twenty years, became a regular feature, together with a Plant Classification table, in the care of HB Williamson, assisted by Jean Galbraith. Mrs Jane Edmondson, a member from 1901 for 52 years, looked after the Flower Stall and the making up of buttonholes and bouquets for sale, while Hilda Gabriel was in charge of the refreshments for several years in the 1920s. The Microscopical Section was often in the charge of women.

Gertrude Nethercote was a very energetic and enthusiastic member of the Club, and was complimented by the President in 1916 on her successful efforts to increase the membership and interests of the Club. In January 1919 she took a party of girls camping at Wilsons Promontory, and gave a detailed talk to the Club on their experiences, illustrated by lantern slides. They camped at Darby River, fished successfully at Tongue Point, swam in the river, and undertook a three-day trek to Sealers Cove. She also provided some useful hints on how to keep bread from going mouldy on an extended trip (Nethercote 1920). They adopted a young koala, that Miss Nethercote received a permit to keep, which was present at the meeting and gave 'an occasional grunt of satisfaction on hearing the voice of its mistress' (anon 1919). What Gertrude Nethercote did is not known, but it is probable that she was a schoolteacher. The reason for her resignation in 1934 is unknown, but her services were sufficiently valued for the Secretary to write urging her to reconsider her decision (Colliver 1934). Financial pressures may have been the cause. Three years later, her father, Charles Nethercote, who had been elected in 1915, is recorded as paying the subscription for himself and his daughter (Nethercote 1937), but there is no record of her involvement after 1934.

Augustus Forbes Leith would probably have approved of the election in 1889 of Miss Susannah Cochrane. At the January 1890 monthly meeting she exhibited paintings of 25 species of Victorian orchids, and thereafter she exhibited paintings regularly at meetings, Annual Conversaziones and Wildflower Shows until 1911. She disappears from the records after that, until 1937 when she wrote to the Club offering back copies of *The Victorian Naturalist* for sale (Cochrane 1937). She died in 1941.

Another, somewhat better-known, painter was Amy Vardy Fuller. She was elected to the Club in 1914, and became a Life member in 1925. Born in Geelong in 1869, she made her debut as a singer in Melbourne in 1889. Her musical talents were put to good use in 1916 when she organised the vocal and instrumental programme for the Wildflower Show. As a painter she was self-taught, and, as she confessed in a talk to the Club in 1915, she 'knew but little of the science of botany', but finding while living with relatives in South Africa that pressing the local flowers was unsatisfactory she decided to try painting them. She had painted 325 South African specimens, 165 Western Australian flowers, and was proceeding to Victorian and New South Wales specimens, enlisting the assistance of botanists to name them (Fuller 1915). Although not possessing the same botanical accuracy as Ellis Rowan's, Amy Fuller's paintings were considered sufficiently significant for the Royal Botanic Gardens, Kew, England, to purchase 102 of them, featuring flowers represented there only by pressed specimens. It was, she said, a wrench to part with them, and she would have been dismayed to know that when Jim Willis tried to locate them in 1958 he could find no record of them! (Willis 1958). Amy Fuller was the convenor of the Ladies Committee for the 1918 Wildflower Show, and her paintings were regularly displayed at shows until 1931. When she died in 1944 she left 230 paintings to the Club (FNCV Minutes 1944).

The reasons why women joined the Club are not always easy to determine, but there was in the early days a certain cachet in being a member of the FNCV, and it is possible that some of the daughters who were elected (and no doubt their mothers) saw it also as an opportunity to survey the marriage field as well as the heathlands or seashore. Several marriages did take place.

Una, daughter of the Reverend JJ Halley, the Club's third president, married George Coghill, and founded a field naturalist dynasty (Carey 2004 pers. comm. 28 September) (Fig. 2). She disappeared from the membership list for thirty years before being re-elected when George Coghill became President, but she was very much around in the intervening years, going on camp-outs and assisting at Wildflower Shows. FGA Barnard, one of the original members, editor of *The Victorian Naturalist* for 32 years, and an indefatigable historian of the Club, married Mary, the daughter of Henry Watts, another original member. Anna McHaffie, of the Phillip Island family with a keen interest in natural history, married Alfred Hardy, who later worked for the Forestry Commission and was President in 1918-1920.

The marriage that was to have a lasting effect on Tasmanian history and conservation was that between Kate Cowle and Gustav Weindorfer. Kate was born in Devonport and after her parents' deaths travelled with her sisters Laura and Carrie to Melbourne, where she met Alfred Hardy. Discovering her botanical interests, he encouraged her to join the Club. She and Laura were elected in 1902, with Carrie joining a year later. Kate became an active member, and her botanical knowledge was employed in supplying lists of plants observed on Club excursions. She exhibited a collection of dried Victorian plants at the Annual Conversazione in 1905, and was co-leader of a junior excursion to Sandringham, a popular place for botanical investigation. Gustav Weindorfer, who had been elected in November 1901, encouraged and helped her to classify her plant collection, and they also shared an interest in music. Kate's biographer considered it a meeting of kindred spirits that brought out the latent abilities in both of them. Kate had settled into a single academic life, and Weindorfer was restless and thinking of returning to his native Austria and his profession as an estate manager. Kate's family were strongly opposed to the marriage because of the Austro-German connection, but Kate was an independent woman, who at 42 knew her own mind, and her decision was to have a significant, though largely unrecognised, consequence. They were married on 1 February 1906, and spent their five-week honeymoon on Mt. Roland collecting and classifying plant species. And it was from there that Weindorfer first saw Cradle Valley, a sight that brought back memories of his homeland, and he remained enthralled by it for the rest of his life. Kate was the first woman known to climb Cradle Mountain. Together they built the famous Waldheim Chalet, which was ready to receive their first paying guests by the end of 1912. Kate spent time at the mountain, either in short visits, or for several months, during which she cooked for the guests, and took parties on less arduous bushwalks than those conducted by Weindorfer. Sadly after 1914 her health began to deteriorate, and she died on 29 April 1916 (Schnackenberg 1994).

Fig. 2. Enid Una Coghill, pictured in later life. (Courtesy of Elspeth Carey.)

A Life member

Mary Bage, wife of Edward Bage, was elected in 1884, and became the Club's first female Life member. She occasionally exhibited specimens at meetings, but her role was more concerned with the social niceties. At a monthly meeting in 1900 she moved that the FNCV forward congratulations to Professor Baldwin Spencer on his nomination to become a Fellow of the Royal Society (London), and again in 1904 when he was created a Knight of the Order of St. Michael and St. George. In the same year she invited members, after the examination of exhibits at the ordinary meeting in September, to partake of light refreshments in celebration of her 21 years as a member. In 1920 she was the promoter of the 40th anniversary meeting of the Club, again providing refreshments. But she was also concerned with other matters: in 1911 she suggested that the Club contribute to the Mawson Antarctic Exploration Fund, providing £1 for the purpose (the Club subscribed £5); in 1925 she raised the question of whether cars should be admitted to Sherbrooke National Park, and nearer home she gave her opinion on whether unbound issues of periodicals in the library should be lent, although we don't know what her position was!

Professional Women

While some of the women members in the first 25 years of the Club's existence had an amateur, or transient, interest in natural history, there was a good proportion of professional women: Leonora Little, the first woman science graduate from Melbourne University (BSc. 1893), was elected to the Club in the same year; Ada Lambert, who graduated in 1895, and became a science teacher, elected as Mrs a' Beckett, in 1916 with one of her sons; Jean White, (DSc. 1909) who later conducted the first major study of the problem of prickly pear in Queensland, elected in 1905; and Georgina Sweet, who graduated in 1896, and had a distinguished university career, (DSc. 1904) was elected in 1891. Some of these memberships were short-lived, but Georgina Sweet was re-elected in 1911. (Leonora Little married in 1894, later moving to Western Australia).

The exception was Freda Bage, elected in 1894 at the age of 11. She came from a scientific family who had a keen interest in the Club. Her father, Edward Bage, a partner in Felton, Grimwade and Co., the wholesale druggists, was one of the Club's original members. Elected in 1880, he became a Life member with his wife, Mary, in 1884, and was the Club's Treasurer in 1886-1887. Freda, who graduated from Melbourne University with a M.Sc. in 1907, was a life-long member for a total of 76 years, even though she moved to Brisbane when she was appointed Principal of Womens College at Queensland University in 1914. Prior to that she had been a regular exhibitor at the Club's Wildflower Shows. In 1905 and again in 1908 in the Microscopical Section she demonstrated the development of chick embryos, assisted firstly by Jean White, and then by Gwynneth Buchanan (elected 1917) who became lecturer in Zoology at Melbourne University in 1921. Freda took part in the Club's camp-outs at Wilsons Promontory at Christmas 1912, together with Janet Raff, and again in 1913. She became President of Brisbane Field Naturalists Club in 1915, and sent exhibits of Queensland flora to the FNCV Wildflower Shows on numerous occasions. In 1917 she wrote saying how much she enjoyed receiving *The Victorian Naturalist* each month (Bage 1917), and when she was in Melbourne she attended meetings of the Club. She was elected an Honorary member in 1945.

Over the years the FNCV counted amongst its members other distinguished women scientists, such as Dr Ethel McLennan, the mycologist and plant pathologist, and Dr Isabel Cookson, the paleobotanist who became a pioneer of Australian palynology. As recent BSc. graduates they were both elected in 1916, but their membership appears to have been fairly brief. Cookson, however, gave two lectures, one in 1929 on 'Ancient Plants' and the other to the Microscopical Group in 1961 on her branch of palaeontology. Ethel McLennan, who became Associate Professor of Botany at Melbourne University, popularly known as 'Doctor Mac', was re-elected to the Club in 1937, but before that in the 1930s she had hosted Club excursions to the University Botany Department, and joined Jim Willis in leading excursions in search of fungi, as well as contributing articles on fungi to *The Victorian Naturalist* (McLennan 1932a, b, c).

The first woman to play an active role in the administration of the Club was Janet Raff, who was elected in 1909 and remained a member for 64 years, becoming an Honorary Member in 1949. She was a graduate of Melbourne University, where for many years she was a senior demonstrator and lecturer in agricultural entomology. Janet Raff is generally regarded as being the first woman to be elected to the Committee of the Club (the Council after 1950), a position she held from 1928-1933.

Unlike Mrs Dobson and Mrs Simson in the 1880s she attended meetings regularly. She was also a frequent exhibitor at monthly meetings, mainly of entomological specimens, including in 1931 a *Cactoblastis* moth bred from eggs collected from Prickly Pear at Roma, Queensland, and its characteristic egg-stick. She went on several Christmas camp-outs, led excursions to Black Rock for shore life, and to Kew Lagoons for pond life, and contributed articles and excursion reports to *The Victorian Naturalist* between 1912 and 1956. In 1938 the Club selected her to represent them at the Australian and New Zealand Association for the Advancement of Science (ANZAAS) Conference. Four other women went as Club delegates to ANZAAS conferences: Dr Margaret Chattaway attended the 1956, 1958 and 1959 conferences; Miss RS Chisholm in 1961; Dr L Myfanwy Beadnell in 1962; and Miss EL Forster in 1965.

Amateur Naturalists

Each decade produced several women who remained members for many years and contributed significantly to the life of the Club, with an increasing number emerging as the 20th century progressed. One of these was Calphurnia Currie, known as 'Ferny', who was elected in 1917, when she was living in Fitzroy. By 1919 she had returned to Lardner, the family property near Drouin. She was a frequent exhibitor, though not always in person, reported on the flora and fauna in her district, and led Club excursions to the area. In 1932 she sent a vivid account of a local bushfire. At a meeting in 1920 she took part in a discussion about making meetings more popular, and urged that country members should be given more help, especially in the naming of specimens, a plea that was echoed by other country members from time to time. Ferny contributed articles to *The Victorian Naturalist* from 1918 until 1952, and also had articles published in *Emu*. Grace Nokes was elected in 1918, and remained a member until her death in 1945. Her particular interests were botany and ornithology, and she was an early supporter of the need for the protection of native flora, and the conservation of significant areas.

If many members were neither professional women nor knowledgeable amateurs, willing to give talks or display specimens, they tended to contribute the skills they had. Such a person was Dorothy Philpott, who in 1918 qualified as a shorthand writer, and offered to take the minutes at the monthly meetings, an offer no doubt gratefully accepted. Another handy person was Helen Bailey, elected in 1929, who was reprimanded in 1934 for breaching the Wildflower Protection Act by picking orchids. She pleaded ignorance, but by way of atonement offered to type lists of protected plants to be distributed to members. She produced 600 copies of the wildflower protection article and lists of flowers, refusing reinbursement.

Junior Members

The original rules of the FNCV did not include a membership category for juniors. In 1886 children under the age of 16 were admitted as juniors. The annual subscription for adults was 15/-, for Juniors 5/-. Another amendment to the rules in 1904 introduced the category of Associate member between the ages of 16 and 20, who paid 5/-. The Junior subscription was reduced to 1/-. The Junior category was removed in 1927, but a further modification of the Associate category crept in (it doesn't ever seem to have been formulated) according to Eulalie Brewster, who was elected in 1944 at the age of 18, when she discovered that had she been male she could have been elected at 16! (Brewster n.d.). This paternalistic distinction disappeared when the Club was incorporated in 1950, when the Associate category was abolished, and the Junior category was reinstated for persons under 18, although the establishment of Junior Clubs largely catered for them.

In the early days of the Club the younger members tended to be the children of members, but by 1892 when the FNCV offered prizes for natural history other young people were involved, many of whom were not members. An increasing number of female members were teachers in both private and state schools, and would have encouraged their pupils to join the Club as an extension of nature study, introduced into the curriculum as part of the 'new education' in the early 20th century. There was a big upsurge in junior elections after 1904, perhaps in part because of the reduced subscription. In January 1905 four girls came from Moonee Ponds State School, another four from the newly-established Government Continuation School, and in November and December another 19 were elected, when it would appear that almost the entire female junior population living in Droop Street, Footscray was enrolled. From then until 1913, 51 juniors were elected, including another big contingent from Footscray in October 1909, all nominated by a Miss Gillbanks, who had herself been elected in April that year. Interestingly, no further female juniors were elected after 1913, although the Junior category existed for another 14 years.

Most of the female junior memberships appear to have been of short duration, but some interesting names occur, such as Lucy Bryce, elected in 1908 aged 11, who went on to have a very distinguished career as a hæmatologist, and founded the Blood Bank during World War II (Verso 1979). One junior who did rejoin the Club was Bertha Keartland, daughter of George Keartland, who had been a member since 1886. Bertha was a junior member from 1905-1907, and has the distinction of being the first junior to contribute to an ordinary meeting, with a nature note about a young Bronze Cuckoo that she had observed being fed by Superb Warblers and Yellow-rumped Tits. She attended Teachers Training College and taught at the new high schools in Bendigo and Rutherglen before going to Melbourne University in 1916, the year she rejoined the Club. She graduated with an MSc. in 1922, studied at the Domestic School in Toronto, where she researched the vitamin content of grain, and was awarded an MA. Back in Melbourne she became one of the foundation staff of Emily MacPherson College in 1927. After her retirement in 1933 she returned to teaching nature study (Kelly 1993).

1920s to 1940s

Royena Strathy Chisholm, another life-long member, was elected in 1918. She became Principal of Emily MacPherson College in 1924, and was a supportive member of the Club, with a concern for the preservation of records and collections. At a meeting in 1919 she exhibited photographs of the Club's excursion to King Island in 1887; and she asked Dr Hugo Flecker, a former member of the Club, founder of the North Queensland Naturalists Club and the person after whom the Cairns Botanic Gardens are named, when he visited the Club in 1945, whether FP Dodd's insect collection still existed. A few months later she asked whether the Club had any control over how its donation to the Royal Botanic Gardens, Kew, England was to be spent; and in 1946 whether it was true that a spring existed near the Shrine of Remembrance. (Stan Colliver said he thought Charles French had once mentioned collecting water for his billy tea there). When she died in 1970 Royena Chisholm left a bequest to the Club.

The early 1920s saw the election of two women who made substantial contributions to the knowledge of natural history, Edith Coleman and Jean Galbraith. Edith Coleman's daughter, Dorothy, had been elected as an Associate member in 1914, but it was not until September 1922 that Edith was elected, giving a paper on orchids the same evening. This was subsequently published in *The Victorian Naturalist* (Coleman 1922), the first of her 35 articles and notes on a variety of topics to appear in the journal. She was a great nature lover, but orchids dominated, and it was her discovery of the pollination mechanism of the genus *Cryptostylis* that created the most interest both here and overseas. Together with Dorothy, who often provided line-drawings to illustrate her mother's articles, Edith presided over the Orchid Section of the Club's Wildflower Exhibition for many years. In 1926 she proposed the establishment of an Orchid Research Section in the Club, through which she was able to encourage other enthusiasts. The garden that she created at her Blackburn home was not far from where the Club now has its headquarters, a fitting conjunction. Edith Coleman was the first woman to receive the Australian Natural History Medallion in 1949. Her prolific writings are dealt with in another symposium paper in this issue. Illness prevented Edith Coleman from active participation in Club affairs in her later years, and she died in 1951.

In 1922, aged 16, Jean Galbraith made the momentous decision to visit the FNCV Wildflower Exhibition. Her enthusiasm and curiosity attracted the attention of HB Williamson, long-time FNCV member and noted amateur botanist. He offered to identify any plant specimens that she liked to collect and send to him. Thus began the correspondence that turned Jean's love of plants into a passion, based on sound instruction, which continued until Williamson's death in January 1931. In the May following his death Jean offered to collect Australian specimens for the Royal Botanic Gardens, Kew, England, as Williamson had done for many years, and the offer was accepted.

Jean was elected to the Club in 1923, and each year she assisted Williamson on the Plant Classification table at the Wildflower Exhibition, later taking charge of this herself. Through the Club Jean met Edith Coleman, who became a close friend and mentor. Jean was elected an Honorary member in 1959, and in 1964 the Club presented her with an FNCV microscope, designed by Dan McInnes and WC Woollard, to assist her in her work. In 1950 she published *Wildflowers of Victoria*, with two later editions in 1955 and 1967. They were superseded in 1977 by her *Field guide to the wildflowers of south-east Australia*, many an amateur botanist's *vade-mecum*. The famed garden at Tyers, in Gippsland, created by Jean and her parents, was immortalised in *Garden in a valley*, published in 1939 and reprinted in 1985. A prolific writer, Jean Galbraith was well-known to gardeners through her articles in *The Australian garden lover*, from 1926-1976 under the name 'Correa', and from 1985-1992 in *The Age* newspaper, Melbourne. Her contributions to *The Victorian Naturalist* from 1926-1980 included 48 much-valued articles on Australian wattles. Her last article was 'Botanists and the FNCV – the first 30 years', the talk she gave at the Centenary meeting of the FNCV in 1980 (Galbraith 1980). Jean was a foundation member of the Latrobe Valley Field Naturalists Club and the Society for Growing Australian Plants (now Australian Plant Society), and an Honorary member of the Victorian National Parks Association and the Native Plants Preservation Society. In 1970 Jean Galbraith became the second woman to be awarded the Australian Natural History Medallion. When she died in 1999, aged 92, Jean had been a dedicated member of the FNCV for 76 years.

Another important woman in natural history circles became a member in 1926. Margaret Louise Wigan, who became President of the Bird Observers Club from 1932-1934, was the first woman president of any natural history society in Australia. As well as being an ornithologist she had wide interests in natural history, showing a great variety of exhibits at FNCV meetings, from a *Cordyceps* collected at the Easter camp-out in the Otways in 1928 to *Grevillea rosmarinifolia* from the hedge at Ivanhoe Grammar, where she was Matron, to the black land snail. (CJ Gabriel said that this snail was of particular interest being bright scarlet in Gippsland and the Dandenongs, but light grey in the Otways (Gabriel 1940)). It has now been established that these are two different species of *Victaphanta* (Smith and Kershaw 1979). Margaret travelled extensively, to North Queensland with an introduction from the Club to Dr Flecker in Cairns, to Adelaide and to England and Europe. After a visit to Kew Gardens in 1931 she wrote to the Club to convey their desire for a new collection of Victorian flora. At the Wildflower Show in 1926 she assisted at the Queensland and South Australian tables, and was jointly in charge, with AS Chalk, of the Ornithological Section of the 1948 Nature Show (as it was called by then). Her contributions to *The Victorian Naturalist* between 1927 and 1951 were mostly articles on birds, or excursion reports. Margaret Wigan was a member of the FNCV Committee from 1948 to 1953. By the time she became an Honorary Member in 1962 she was unable to attend meetings, so the President, Dan McInnes, and a number of her friends visited her home to present the certificate. It was an occasion of much amusing reminiscence (Garnet 1962). Margaret Wigan died in 1970 at the age of 94, yet another member who had followed the example of Charles French by living to a great age.

Blanche Miller, also an ornithologist, was elected, together with her husband, Victor, in 1924. They both put much time, energy and money into the Club, although Blanche never held any office. She declined to be on the sub-committee established in 1936 to introduce new members, but was nevertheless keen to encourage people, especially juniors, to join. She was interested in the history of the Club, and her 'Early years of *The Victorian Naturalist*' was published in the journal (Miller 1934). At the AGM in 1935 she gave a talk on past Annual Meetings, which caused the President to suggest that she might like to continue FGA Barnard's History of the Club. Apparently Blanche did not take up this suggestion, but at the Club's Diamond Jubilee meeting in 1940 she gave a paper on 'The Club's Activities – Past, Present and Future', that was not published. She was made an Honorary Member in 1937, and after she died in 1948 a *Eucalyptus leucoxylon* was planted in her memory on Vernon Davey's property at Toolern Vale, the site of the Royal Australasian Ornithologists Union's first observatory, where the Club had held bird observing excursions.

The early 1930s saw the election of two women who were to have a profound effect on the Club. They were May Salau, nee Vale, elected in 1931, and Eudora Freame, elected in 1932 (Fig. 3). May Vale was born in Heathcote and grew up on a farm. She trained as a teacher, and met her husband-to-be, Fred Salau, at one of her postings. He later ran a nursery at Clarinda, in south-east Melbourne, and gatherings at their home became a kind of mirror of those at Charles French's home in the 1870s. Stan Colliver had been elected at the same meeting as May Salau, and soon afterwards 'The Gang' was formed, consisting of amateurs and professionals who met at either the Salau or Colliver homes every two months to further their interests. This was undoubtedly the forerunner to the formation of the Geology and Botany Groups within the Club in 1945. May was a frequent exhibitor at Geology Group meetings, and a long-time member of the Nature Show committee in the 1960s under the leadership of Dan McInnes. She had a very professional approach to the mounting of exhibits for the shows, and according to Tom Sault she was frequently heard telling helpers that 'near enough is not good enough'. May Salau died in 1990 at the age of 95 (Sault 1991).

Fig. 3. Margaret Eudora Freame (FNCV Archives)

Margaret Eudora Freame was elected along with her husband in July 1932. Marine biology and entomology were her particular interests, and she was responsible, with AJ Swaby, for the establishment of this Special Interest Group in 1947. She and her husband JJ (we have no names) led many excursions to Altona and Mornington, and the gleanings from these trips were regularly exhibited at meetings. From 1932 to 1963 scarcely a meeting went by when she did not exhibit some specimen of marine life, and over the same period she wrote articles and notes for *The Victorian Naturalist*. Mrs Freame was a great supporter of the Hawthorn Junior Field Naturalists Club, founded in 1942, being Secretary-Treasurer from 1943 to 1958, and Vice-President in 1948-49. She was made an Honorary member of the FNCV in 1950 for her services to the Hawthorn Junior Field Naturalists Club. As a member of the Nature Show committee she assisted with the Marine Biology section, and in 1948 helped with the Club's exhibit at the Royal Show. Eudora Freame was elected to the FNCV committee in 1945, and became Vice-President in 1948. After she died in 1968 her marine collection was purchased by the Rosebud Aquarium and Museum.

Post World War II

After 65 years of the Club's existence women began to be elected to the Committee on a regular basis. Ina Watson was the first woman President of the FNCV in 1947-48. An ornithologist, she was a member of the RAOU of which she became Vice-president in 1966, and of the Bird Observers Club, in which she held almost every office, including President. She had also been President of the Leach Memorial Club. From 1950 until 1962 she worked with Roy Wheeler in the Altona Salt Works Survey, studying the life history of the silver gull, and co-authored their report on the work. This survey became the catalyst for the foundation of the Victorian Ornithological Research Group, of which she was an original member.

On a visit to England in 1949 she went to the bird sanctuary on Skokholm Island, Wales, where she learnt the technique of bird-banding. Ina was one of the first bird banders registered with CSIRO. She gave talks to the FNCV on these travels and also on her visit to Central Australia with the RAOU in 1953.

Ina Watson was a noted nature photographer, and 19 of her photographs are included in the National Photographic Index of Birds. She was also an accomplished landscape artist, and an exhibition of her oil paintings was held in the Hamilton Gallery in 1971. Ina contributed articles to *The Victorian Naturalist* from 1944 to 1961, and numerous articles were published in *Emu, Walkabout* and *The Bird Lover*. She wrote two books for children, *Silvertail, the story of a Lyrebird*, which was included in the gift of books to the Queen for her children in 1954, and *Larry the seagull* (Watson 1971a).

The late 1940s was a period when the Club was undergoing changes, and Ina Watson was involved in the preliminary stages of preparing for the incorporation of the FNCV, which took place in 1950. She was one of the three people concerned over the method of adjudication and the duration of nominations for the Australian Natural History Medallion, which led to the revision of the rules in 1947 (Watson *et al.* 1947). She was a member of the Award Committee of the Medallion from 1964-1966, and again in 1967-1968.

Ina Watson was educated at Essendon High School, and was an Associate of the Australian Institute of Accountants, and of the Public Relations Institute. For 27 years she was managing secretary of the Melbourne Radiological Clinic, and then spent ten years as Information Officer in the Department of Fisheries and Wildlife (Watson 1971b). In 1967 she moved to Portland to live with her sister. Ina Watson died in 1992, aged 83.

Another woman who made a considerable impact on the Club was Winifred Waddell (Fig. 4). She was elected in 1947, and was passionate about the preservation of native flora. She founded the Native Plants Preservation Group of the Club. The conservation of areas of floral significance required money, and Winifred Waddell's idea was that there should be Associates to the Group, who paid a separate subscription, and/or made donations for the specific purpose of conservation. This did not fit within the constitution drawn up at incorporation, so she set up the Native Plants Preservation Society as a separate entity. The FNCV Committee had recorded that the Club's conservation work was being done through Miss Waddell, and praised her efforts (FNCV Minutes 1952). Winifred Waddell was awarded the Australian Natural History Medallion in 1964 for services to botany and conserva-

Fig. 4. Winifred Waddell (Reproduced with permission from the archives of the Royal Botanic Gardens Melbourne)

tion, which she said she valued as much as the MBE awarded in the same year (Atkins 1966). In the early 1960s she wrote nature articles for *The Junior Age* which Jean Galbraith edited into *Wildflower diary*, as a tribute to Winifred, after she died in 1972.

Dr Margaret Chattaway migrated to Australia with her mother, in 1946, to take up a position in the Forest Products Division of CSIR, later CSIRO. She had led a colourful life previously. Born in 1899 in Oxford, where her father was Professor of Chemistry, she attended St Hugh's College, and obtained her doctorate in wood anatomy. She worked in Italy and then was appointed to a fellowship at Yale University. During WWII she joined the army as a driver, and later was promoted as a Junior Commander in the Army Education Department.

While she was working at CSIR, her boss, Dr Dadswell, with whom she had corresponded during the war, knowing Margaret's great love of the bush, ensured that she had a lot of field work, and she fell in love with Australia. She did not become an Australian citizen until her 90th birthday, when she said she was a little ashamed that she had delayed so long. She celebrated the occasion by taking a joy-ride in a helicopter. In later life she lost her sight, but this did not stop her. She joined the Association of the Blind, of which she became a Life Governor, and bearing in mind the advice given her that 'You have to learn to see through your fingers', she attended the Association's Vision Resource Centre and learned many handcrafts, including woodwork (Janes 2000; *The Age* 19 September 1989).

Elected to the Club in 1946, Margaret Chattaway became Vice-President and Assistant Editor of *The Victorian Naturalist* in 1951-1952, and President in 1952-1953. Her lectures included accounts of Club excursions to Bendigo and Central Australia, aspects of British flora, and a report on her visit to New Zealand for the ANZAAS conference in Dunedin in 1956. In 1950 she organised a Symposium on Wood for the Club assisted by colleagues from CSIRO. At a time when conservation action was gathering momentum in Victoria in the 1940s and 50s she contributed information about the preservation of National Monuments in Britain. She was a contributor to *The Victorian Naturalist* from 1951-1964, but appears to have had no direct connection with the Club after that time, which may have coincided with the onset of her blindness, but during the 20 years of her active involvement she made a significant contribution to the Club. In 1980 she attended the Centenary meeting, and was photographed with the President and the seven other ex-Presidents who were there. She died in 1997 at the age of 98, following what seems to be something of a characteristic of field nats, of both sexes.

Just a year after Margaret Chattaway joined the Club, another woman who was to make an enormous contribution to the Club was elected in December 1947. She was Marie Allender, who in 1955 was elected Club Excursion Secretary, a position she held for the next 35 years. As an office-bearer she became a member of Council and she remained so for a further five years after relinquishing the position of Excursion Secretary. In 1964 she was made an Honorary member, when tribute was made to her cheerfulness and efficiency in organising excursions, and to the fact that she devoted a good part of her life to the Club. This, of course, was to continue, and 25 years on she was presented with a Club badge, engraved '30 years service', and a silver platter inscribed 'For outstanding service. FNCV 1985'.

The excursions Marie organised ranged far and wide, to most parts of Victoria, to Western Australia, New South Wales, Norfolk Island, and Queensland, and in 1972 to New Zealand. Mackenzie coaches became an integral part of Club life. In 1967 Marie was given the management of the finances for excursions, and when the Club resumed responsibility for them after ten years, Marie presented it with a bank balance of $4000 (McInnes 1995).

In 1957 Marie was appointed as a technical assistant at the Herbarium, where she worked until her retirement in 1980. The FNCV held all its meetings there, but there was no means of direct contact, so for many years Marie acted as a focal point for the Club, her private phone number being the contact, and this was used not only in the organising of excursions, but to field a great number of enquiries of all kinds. If Marie was unable to answer the questions herself she put callers in touch with people who could. She was Secretary of the Botany Group from 1957-1963. Her name is commemorated in *Olearia allenderae*, a plant named after her by Jim Willis, Herbarium colleague and fellow FNCV member, after she discovered this new species on Wilsons Promontory, in 1964 (Grey *et al.*1998).

Sadly Marie died in 1995 just as the Club was negotiating the purchase of the hall at Blackburn, which has given the FNCV the central point that Marie had so generously provided for many years.

Margery Lester, known as Madge, was elected in 1953. In the course of her long association with the Club she was Assistant Librarian, Assistant Secretary, Minute Secretary at General meetings, Club reporter, and Editor of *The Victorian Naturalist* from March 1976 to February 1977, and again for the special Centenary issue, (*TVN* 97 no.3;1980). She was President of the Botany Group in 1963-1964, and the Group's syllabus planner in 1961-1962. She also ran the Club's bookstall for a time, and in 1970 was enrolled as an adult member of the Hawthorn Junior Field Naturalists Club.

Madge came into the Club as an interested amateur, and in her organised and meticulous way she set about acquiring knowledge in most fields of natural history. Botany was her speciality, and she became a frequent speaker at Botany Group meetings, illustrating her talks with slides and drawings. These talks were always informative, as a glance at the programmes show: the plant kingdom; the difference between spores and seeds as methods of botanical regeneration; introduction to conifers (the Botany Group's exhibit for the 1964 Nature Show); wheat rust; leaves and photosynthesis, etc. In 1959 she gave a talk on banksias, illustrated with her own slides of all the Victorian species from the Little Desert to East Gippsland. Typical of Madge and her methods was the talk she gave to the Botany group in December 1965. It had the slightly ambiguous title of 'Rot', which she presented as 'odd Christmas fare, consisting of "flummery" and a "meat course"'. The 'flummery' was a story of an imaginary country where dead trees lay feet thick because the agents of decomposition were on strike. The 'meat course' dealt with the importance of fungi in decomposition. Back to the 'flummery' where all was well, because the fungi were back on the job, the old trees had been disposed of, and new ones were growing in their place (anon 1962).

Madge was a skilled and patient photographer. Her series of slides on the emergence of a cicada taken during one evening was so popular that she exhibited them three times at meetings during 1960. The Club now has these slides, along with many of Madge's papers.

At a General meeting in October 1957 during a discussion on the recent Prahran Nature Show Madge suggested that members should be given 18 months in which to prepare for a major show, so that the Groups would be able to participate. This might have been just a sensible idea, but it suggests that the Prahran Show had not come up to Madge's high standards. Madge was a commercial artist and she put much time and effort into the Nature Shows, making models, and providing diagrams, illustrations, signs and posters. For one show she produced a striking poster of a kangaroo with a pouch full of wildflowers.

During her editorship of *The Victorian Naturalist* two special Coast issues were published. Madge believed in provoking discussion, which an article of hers on the koala in one issue produced (*TVN* 95:35:1978). When the Club library was relocated to the back of the Herbarium hall Madge spent three days a week for five years classifying and cataloguing the stock, labelling shelves and generally making the library a useful resource. This gave her an intimate knowledge of the bookstock, so when before she died she gave her private library to the Club, she included strict instructions about which books were to be put in the library, the rest being offered for sale to members, which raised $400 for the Club (Allender 1988). The FNCV benefitted even more after Madge died in 1988, from a bequest of over $30,000, with directions that further monies were to come to the Club after the death of her sister (Lester 1988). Discussions about the Club's buying its own premises had gone on for many years. Madge would have been pleased to know that she had assisted so materially in making this possible.

During the 1960s there was a sharp decline in the number of women prepared to serve on Council, and when they did it was in Assistant positions. In the mid-1970s Margaret Corrick emerged, as Secretary to the Botany Group, and the Club's Assistant Secretary from 1973-1975, then as Vice-President in 1975-1976, and finally as President in 1976-1978. But during the whole of her Presidency Margaret operated without a Secretary, and for part of that time she was on the Editorial Committee of *The Victorian Naturalist* as well. In addition she was Secretary to the General Committee of the Australian Natural History Medallion from 1973-1980, and has been the FNCV representative on this committee since 1980.

Margaret Corrick, at the end of the FNCV's first century, is comparable in many ways to Flora Martin at the beginning: amateurs who became experts in their field, benefitting in the way the founders of the Club intended. Margaret was born in Hobart into a nature-loving family. She and her parents and her two sisters were all members of the Tasmanian Field Naturalists Club, and when they moved to Western Victoria in 1962 they were active members of the Casterton and later the Hamilton Field Naturalists Clubs. Margaret's enthusiasm for native plants was inspired by the flora of the Grampians, and fuelled by the campaign for the conservation of the Little Desert and the Lower Glenelg area. The local flora was almost completely unknown to her, and there were few books available, but mentors were at hand: Arthur Swaby, Lionel Elmore, Fred Davies, and most particularly Cliff Beauglehole. In 1965 Margaret was elected a member of the FNCV (Corrick 2003).

Margaret worked as a bank clerk, but in 1975 she was appointed a Technical Officer at the Herbarium, a position she held until her retirement in 1985. When she was presented with her Honorary membership certificate in 2005 she said she had gained much from her membership of the Club, and that it had contributed to her being employed by the Herbarium.

Margaret Corrick became an authority on the genus *Pultenaea* and wrote 24 articles on the bush-peas of Victoria for *The Victorian Naturalist* to which she has been a regular contributor from 1976. She provided the section on *Pultenaea* in the *Flora of Victoria* (1996), and has co-authored two books with Bruce Fuhrer *Wildflowers of southern Western Australia* (1996) and *Wildflowers of Victoria* (2000), and assisted him in the preparation of *A field guide to Australian fungi* (2005).

There is no doubt the FNCV owes much to Margaret Corrick. She came to the fore when membership was dropping, and was prepared to work hard to keep going the many activities of the Club, not only the general administration and the regular monthly meetings, but also *The Victorian Naturalist* and the Australian Natural History Medallion. The women who supported her as Council members were Marie Allender and Madge Lester. A hopeful sign for the Club was the election to the Council of Wendy Clark in 1975, and Susan Beattie in 1977. They were part of a group of people who graduated from the Hawthorn Juniors in the mid 1970s. They came not only with natural history knowledge, but also with some experience of administration.

Conclusion

Who were the women who joined the FNCV in the first century of its existence? Generalisations are always risky, but the women may be classified into four loose categories. There are those for whom natural history was a passion, whose work in their chosen field led them to become well-known beyond a Club which provided them with interaction with other naturalists, for example Flora Martin, Jean Galbraith and Edith Coleman. A second category contains women for whom the Club provided a focus for their interests, who were prepared to support it by accepting office, or taking part regularly in its activities, like Eudora Freame, Marie Allender and Madge Lester. The vast majority would probably fit into the third category, those for whom natural history was a hobby. For these the Club provided a venue in which to meet like-minded people, to learn from experts or more knowledgable people in various fields, and to enjoy the companionship of field excursions. A further category may be identified of those whose membership was short-lived. This could include professional scientists who had other claims on their time, though they may have maintained a connection with the Club; or women who just came along to see what was on offer and decided it was not for them. The women chosen for this paper fall mainly into one of the first two categories. Margaret Corrick is an exception. She not only became a practising botanist, the author of several books, but also gave unstintingly of her time and energy to the Club. It may also be noted that when people disappeared from the records, and this applies to the men as well as the women, many remained members for many years. The Club created a bond beyond the purpose for which it was originally founded.

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The FNCV's new century woman

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Abstract
Since 1981 women have had an active role in management. They hold key positions as office bearers and also make a large contribution to the running of the Club's everyday activities. Women members today are well-educated, may hold a higher degree, particularly in the natural sciences, and join the FNCV in their own right. Interest often began in childhood although membership may not start until after retirement. Botany is a prime but not exclusive interest. Women also take an active part in naturalist and conservation activities outside the Club, publish on related subjects both in *The Victorian Naturalist* and elsewhere. Women gain personal satisfaction from membership of the FNCV. (*The Victorian Naturalist* **122** (6), 2005, 306-311)

In 1881 membership of women in the FNCV began with the first tentative inquiry, 'if it is not against the rules', by the newly-elected Hon FS Dobson. This paper is about women members' continuing participation in the Club's activities.

By the beginning of the FNCV's second century, 1981, women were established as office-bearers in positions of power, you might say, having gradually infiltrated the male domain. Apart from 1885-1886, when there were two women, Mrs FS Dobson and Mrs John Simson, on the Committee (now Council), there were no others for more than 40 years when Janet W Raff was elected, in 1928, and stayed for five years. It took 67 years until the Club had a woman President. In the Club's first 100 years of existence, there were only three women presidents, Ina Watson, Margaret Chattaway and Margaret Corrick.

The 'new' FNCV century started well, with the election in 1981 of the fourth woman president and the youngest president to that date–Wendy Clark. She has also entered the FNCV hall of fame, joining Baldwin Spencer, JA Kershaw and J Ros Garnet in having been President twice, her second term from October 2001 until 2004, and she outranks them in the number of years served as President, nearly seven years to their four. She was also Secretary for three years, from 1978-1981, the end of a long apprenticeship leading up to the top job. Wendy came up from the Hawthorn Juniors, which she joined in 1966 at the age of 12. She became Treasurer of the Juniors in 1971 and was President for three years from 1975. She came to the senior club via the mammal survey and field survey groups in 1972, and was Chair of the mammal survey group for three years from 1977, the year she joined the Council of the FNCV. Wendy's interests are wide-ranging. At general meetings she might report on how she has been caring for three baby Ring-tailed Possums, or exhibit a Tawny Frogmouth that she has had stored in her freezer, or give a talk entitled 'Eat or be eaten' on a favourite topic, spiders. She is currently a member of Council.

In the last 25 years, there have always been women on Council and they have filled vital executive positions such as secretary, treasurer and editor (and their various assistants). Although women Presidents have continued to be thin on the ground, most of the key office-bearers today are women–President (Karen Muscat), one of two Vice-Presidents (Dr Melanie Archer), Treasurer (Barbara Burns), two out of three Editors (Anne Morton and Dr Maria Gibson), Librarian

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(Sheila Houghton), joint Newsletter Editor (Joan Broadberry). There have also been many female special group secretaries, representatives on Council and other office-bearers. Noteworthy examples include Maria Belvedere (Marketing/Publicity/Membership Officer 1998-2000), Win Bennet (Botany Group), Sally Bewsher (Fauna Survey Group), Felicity Garde (Membership Officer 1993-2000, Fauna Survey Group), Yvonne Gray (Assistant Treasurer 1985-1986, Treasurer 1986-1989), Karen George (Secretary 2003-2005), Joan Harry (Council Member 1994-1995, Botany Group 1991-1994), Sophie Small (Fauna Survey Group), Jenny Wilson (Council Member 1995-2000, Conservation Co-ordinator).

As well, the women have been there in the background, working in the office, collating the newsletter, cleaning the toilet, weeding the garden, making cups of tea or even providing home-made soup at special functions. Women often lead excursions, especially special interest group excursions, and they are frequently the ones who write the reports of outings and meetings. They do a lot of the work in keeping the Club running smoothly and in documenting its day-to-day natural history activities. Without them, much important information would not be shared and might be lost.

Many of them have made an outstanding contribution to the Club during the past 25 years. Sheila Houghton goes out to Blackburn from Gisborne every Tuesday, to attend to the library and the archives. She has so many facts about club history at her fingertips that she is a valuable resource in her own right. She has been Acting President, Vice-President, Secretary, Secretary of the Natural History Medallion Committee and, of course, Librarian. When she became Secretary of the Club in 1982, she immediately reorganized the filing system and then saw that the membership records were transferred to a computer system. Then, when the library had to be removed from the National Herbarium to the 'Tin Shed' behind the Astronomer's House, Sheila was right there, rescuing many documents from oblivion, as she was there again when the Club moved to Blackburn. She made sure that the floor was strengthened to take the weight of the present compactus. She had previously overseen the sale of unwanted books, netting the Club $42 000. She has a genuine interest in natural history, being especially interested in fungi, often bringing specimens to meetings. She has become the Club Archivist, is compiling an index to some of the archives, including biographical material on members, and has written some profiles of office-bearers for an Honour Book, which is kept in the library. She has written papers on the Club's history, as well as obituaries and the history of the Natural History Medallion and profiled many Medallion winners. She has also indexed (2004) *The Southern Science Record and Magazine of Natural History* 1881-1883, which was the forerunner of *The Victorian Naturalist*. Her latest not inconsiderable effort has been with the booklet *Leaves from our History* (2005), assisted by Gary Presland. In 1996 the Club awarded Sheila an Honorary Life Membership in recognition of her services spanning 24 years, valuable work which she has continued for another nine years and will no doubt continue just as energetically into the future.

What is the typical FNCV woman of today like? I am basing my picture to a large extent on the results of a questionnaire that Sheila Houghton sent out in 2003 in preparation for the Club's 125th anniversary symposium in 2005. Sheila sent out 115 questionnaires and received 61 replies, which, together with information gleaned from *Field Nats News* and *The Victorian Naturalist*, provided a series of snapshots of women members and their involvement in the Club.

The questionnaire shows that today's Club woman is well educated, probably holds a degree, maybe a higher degree, which is in the natural sciences, particularly in biological fields or horticulture, or in librarianship or teaching. Many are professional working women; some joined the Club after retiring when they hoped to be able to indulge more fully their interest in the natural world, an interest which had often started in childhood.

Gretna Weste, for instance, had attended field naturalist meetings and nature shows as a child. She first visited Wilson's Promontory at age five, when she and her brother slept in an old tank. In 1957 when she took her own children walking there, it poured day and night and the horizontal rain blew 'quite large fish' which landed all around them. She became a professional botanist at the University of Melbourne, her specific interest being the destructive Cinnamon Fungus *Phytophthora cinnamomi*, which causes large areas of bush to die off. She discovered the fungus, a soil pathogen, at Wilson's Promontory in 1970 and with her students has monitored the epidemic ever since, sharing her results with Park rangers. As a Field Nat she has led excursions, presented talks and written reports and papers, including an update on the Cinnamon Fungus in the Wilson's Promontory Centenary Issue of *The Victorian Naturalist*.

Margaret Dacy spent her 1920s childhood in the mallee, where, as she puts it, 'the wildflowers, when they arrived, were extravagantly appreciated'. In later life she went on to write and illustrate a book on orchids and she still paints flowers in watercolour.

Annabel Carle was brought up in England 'in a horticultural family that spoke the Latin names of plants'. When she retired in 2002 she immediately applied for and won an Earthwatch Community Fellowship for work in the Coorong, which led her to reassess her 25-year-old involvement with the FNCV, resolving to become more active from then on.

Women today make up roughly 40% of the total FNCV membership. About half of them are married or in a relationship but in most cases they did not join the club together with their partners or because of a family connection These women are members in their own right and have made their own mark in the club.

What are their specific fields of interest today? Number one interest still tends to be botany, which had a resurgence in the 1980s. At that time Margaret Potter had become a member of the club. It was plants that drew her to the FNCV when she retired after many years as a chemistry teacher. She became secretary and inspirational leader of the Botany Group, a position she held for five years, and was a member of the Council in the mid-80s and the Club's Publicity Officer and Membership Secretary. She co-ordinated the Club's participation in the Maranoa Gardens Festival in 1991.

Hilary Weatherhead, a member of Council from 1980-1984 and of the editorial committee in 1982, led many and varied botany excursions, to look at seaweeds at Black Rock or ferns and mosses at Warburton, and gave many talks on a wide range of plant communities.

A number of women, like Linden Gillbank, are especially interested in the history of Australian botany and of the Club, and have contributed to special historical issues of *The Victorian Naturalist*. Linden has documented Ferdinand von Mueller's wanderings and achievements. Sara Maroske has also written historical articles, one of them being the involvement of von Mueller in the use of the now discredited introduced Marram Grass *Ammophila arenaria* as a dune stabilizer on the coast of south-west Victoria.

Women's interests range far wider than the pretty plants and fungi. Mammal surveys are popular (and this includes an interest in bats, for which we can probably thank Lindy Lumsden), as well as birds, geology, entomology, and a growing awareness of ecology.

Cecily Falkingham is a true all-round naturalist. She firmly believes that the wonder of personal discovery is always much more exciting than reading facts from books. She is the sort of person who, when fruit bats arrive in her garden at 11 p.m., will stay up watching and recording their actions until two o'clock in the morning. She has done much to popularise natural history both outside and within the Club. She was Naturalist in Residence in 1995 and her writings in *The Victorian Naturalist* reveal her inquiring mind. She has also been involved in the Timelines Australia Project and local conservation issues.

Joan Broadberry keeps a nature diary and her curiosity about such things as a paper nautilus shell found on the 90-mile beach in Gippsland has been shared with us in articles illustrated with her photographs. Her *Diary of the Saunders Casemoth* (1999) includes a description of the caterpillar constructing a silken ladder to help it climb the slippery side of an Esky where she was keeping it under observation.

In the past 25 years women have continued to contribute to *The Victorian Naturalist*, though they are still not as well represented as their male counterparts. They are more likely to write 'contributions' and 'naturalist notes' than research reports and often provide book reviews. Their editorial input has been very high, with Robyn Watson, Pat Grey, Merilyn Grey, Anne Morton and Maria Gibson as editors and others in supporting roles.

Many FNCV women members have published articles in other journals both in their areas of professional expertise and in the wider field of what is loosely called natural history. Some are authors of more substantial books–Kathie Strickland on Mornington Peninsula plants (1992-1994), Beth Gott on aboriginal plant use (1991), Jane Calder on the Grampians (1987), to mention just a few. Pat Grey, with husband Ed, has worked tirelessly in the cause of fungi over many years, culminating in their recently published book, *Fungi Down Under, the Fungimap Guide to Australian Fungi* (2005).

Among the talented and multiskilled New Century Women we include photographers such as Wendy Clark and Ilma Dunn. Ilma's collection of 5000 photos is housed at the Royal Botanic Gardens and has been used in Viridans CD-Roms and the NRE Flora Information Service. Ilma once presented a memorable slide show of alpine plants, set to music. Then there are painters like Ruth Jackson, whose picture of Common Correa *Correa reflexa* was used to update the Club's emblem in 2004.

Dorothy Mahler is a great worker, not only as Excursion Secretary and Tour Organiser for 11 years, from 1987-1998 (including a trip to Mungo and Mootwingee in 1995), but also as an excursion leader, a speaker at meetings, a newsletter collator and above all as a report writer. She represents the indispensable 'backroom girls', not on Council, but essential to the Club.

There are many energetic and dedicated women members who are also active outside the FNCV as members of other Field Naturalists groups or Friends' Groups, the Bird Observers Club of Australia, National Parks Association, the Society for Growing Australian Plants, Birds Australia and committees of management of many local reserves which they have worked hard to create or preserve.

Dr Elizabeth Turner was a club member for 30 years until her death in 1999, and a Council member from June 1981 till October 1982. During the 1980s she was Secretary of the Victorian Field Naturalists Clubs Association (now SEANA). She also spoke to general meetings of her travels and wrote for *The Victorian Naturalist*, using her medical knowledge to write on 'Preventive marsupial pediatrics' and 'Botany in the service of medicine'. Marie Allender used to heave a sigh of relief on excursions when doctor Elizabeth turned up.

Stefanie Rennick worked on conservation issues on the Mornington Peninsula, saving Greens Bush as part of the process. With Ilma Dunn she produced a field guide to the Mornington Peninsula.

Karma Hastwell contributed 2596 survey sheets during five years of the Australian Bird Count, from 1989 to 1994. That works out to 10 each week. She was in her 70s at the time of the survey.

Helen Aston is perhaps best known for her work outside the FNCV, although she has made a great contribution within the Club, which she joined in 1991 after she 'officially' retired from her work at the Herbarium where she was employed for 34 years. She has been guest speaker at general and Botany Group meetings, led excursions, and written papers for *The Victorian Naturalist*. She was awarded the Natural History Medallion in 1979, and has served on both the Award Committee and the General Committee of the Medallion. She has a great love of birds and has taken part in numerous surveys. Her *Aquatic Plants of Australia* (1973) has become a classic; she has made a major contribution to the *Flora of Australia* (1982-2004), co-authored *A Bird Atlas of the Melbourne Region* (1978) and written many, many articles on plants, birds and her numerous travels. She has also had a plant genus *Astonia* and a species *Cardamine astoniae* (an uncommon perennial herb of alpine areas) named after her.

Country members become interested in finding out about the plants and animals with which they are unfamiliar when they move to a new area after marriage. Ellen Lyndon, who joined the FNCV in 1943 and after the war moved with her husband to Leongatha, discovered the plants in the local Crown reserves and was determined to save them. Rain and gales did not stop her. Her motto was 'Get out and face up to the weather and the day will improve'. One particular interest was the Butterfly Orchid *Sarcochilus australis*, which grew in Foster's Gully near Yinnar. Lyndon Clearing in Morwell National Park is named after her in recognition of her efforts towards its declaration as a National Park. She was awarded the Order of Australia in 1988 for her work in natural history conservation. She continued to write for *The Victorian Naturalist* almost up to the time of her death in 2000. Her last article was on the Corroboree Frog *Pseudophryne corroboree*; her first, almost 50 years earlier, was on the flowering of Blackwood *Acacia melanoxylon*.

The questionnaires were, with a few exceptions, sent only to women who were members before the start of the 21st century. There was a decline in new women members during the 1980s, but this has been remedied, especially since the Club acquired its own premises in 1996 and we still have many women joining, 2002 being a bumper year. The most notable 'new' member is of course our President, Karen Muscat, who like so many before her was willing to step into a vacancy. She has brought creative and management skills to the job and a youthful enthusiasm that is so valuable in such a long-established organisation as the Field Naturalists Club of Victoria.

We were sorry to lose Natalie Smith who joined in 1996 but died after a long battle with cancer in 2002, at the age of 28. She had been a Council member and Conservation Co-ordinator and worked actively for the club.

Sapphire McMullan-Fisher and Sharon Morley, both young women, were initially somewhat hesitant about joining an unknown bunch of 'oldies' for a weekend in the bush, and for a while they had to take a big breath when arriving at meetings. Soon, however, Sapphire could feel she was part of a big community. Sharon went on to become a member of Council and organized the 2004 Cryptogamic Extravaganza.

We found that many of the women who responded to the questionnaire thought they had been members of the Club for several years longer than was the fact. Once you have joined, you feel you have been part of it for a long time. That is one of the great benefits to all members, not only women.

There are 43 women in the Club today who were elected during the FNCV's first century and of these, eight have been members for more than 50 years. Eulalie Brewster is our longest serving woman at the present moment, with 61 years' association with the Club. When she joined she was 18 years old, but was too young to be a full member and had to be content with Associate Membership. Women had to be 21, although boys were apparently men at age 18. However, she was still only 20 when she married a Gippsland dairy farmer on 5 April 1947, and nine days later she became a full Country Member. She was a foundation member of the Latrobe Valley Field Naturalists Club and writes that she still assists the Victorian Wader Study Group with netting and banding activities when they visit Inverloch.

Joan Forster, now 88 years of age, has been a member for 60 years. Writing in response to the questionnaire, Joan mentioned many field naturalist women who had influenced her and enriched her life. She, like many others, especially remembered Laura White, who was a Club member from 1955-1990 and an inspirational botany teacher in the field. 'I can still hear her voice in my mind when I look at plants which she named so patiently for us from her extensive knowledge.' Joan wrote. She continued: 'My association with the Club and its members has been important to me, increasing knowledge, forming friendships and giving me experiences which expanded my love of the natural world. It has motivated me to take part with groups that work to preserve our indigenous natural world and knowledge and enthusiasm to share with the children who have been part of my life for fifty years'.

In the first century or the 'new' century, being a woman member of the Field Naturalists Club of Victoria brings its own rewards.

Acknowledgement
I want to thank Sheila Houghton, especially, for providing me with so much help and advice for this paper–lists of members, office-hearers, dates, and of course the questionnaires. This paper has been prepared from information taken from them and from *Field Nats News* and *The Victorian Naturalist* covering the years 1981-2005.

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Marine studies and the FNCV

Brian J Smith[1]

Abstract
The FNCV has only recently included the Marine Research Group amongst its special focus groups. Unlike many of the other groups, the Marine Research Group existed as a separate entity prior to its amalgamation with the Club. As the Marine Research Group of Victoria, and before that the Marine Studies Group and the Underwater Research Group of Victoria, many of its members carried out much valuable and wide-ranging research into diverse aspects of marine studies in Victoria. They were closely associated with Museum Victoria and themselves built on a rich history of marine observations and specimen collecting, stretching back to the earliest days of settlement in this part of the nation. (*The Victorian Naturalist*, **122** (6), 2005, 311-314)

Introduction

The marine environment has always attracted those interested in the natural world. In Australia, over three quarters of the human population live within 50 km of the sea, and from the earliest days of European settlement a beach culture and 'holidays by the sea' have been an important part of everyday life. Many of these casual encounters have blossomed into a life-long interest in marine studies that have added significantly to our knowledge of this diverse biotic region.

Early Days

From its inception, the FNCV has had members interested in the marine environment. Some were professional scientists and academics who combined their scholarship and leadership with an infectious enthusiasm for natural history. These included McCoy, Spencer and Dendy who established the early ethos of enquiry, observation, recording and collecting. Arthur Dendy was the consummate biologist. Before he came to Australia he was employed for a while in the British Museum of Natural History where he worked on the Challenger Expedition sponge collection. Brought to Melbourne by Baldwin Spencer as Lecturer in Biology at the University, he became an active member of both the FNCV (Smith 1980) and the Royal Society in the 1880s and '90s. He made a major contribution to the early study of our marine fauna, participating in the marine survey of the southern

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part of Port Phillip run by Bracebridge Wilson and sponsored by the Royal Society, and describing the complex sponge communities at Port Phillip Heads (Smith 1981a).

Of equal significance in the development of the Club was the presence of the gifted and dedicated amateurs who made valuable contributions in describing and recording our fauna. A good example is William Bale, one of the foundation members of the Club, who was an amateur microscopist. Bale first published on microscope techniques but then took up the study of hydroids and became a world authority on this group. He was commissioned to compile a catalogue of the Australian Hydroid Zoophytes by the Australian Museum and later was asked to work on the hydroids collected by the FIS *Endeavour*. In all, he described over 130 new taxa in 23 publications (Smith and Watson 1969). Other examples were the shell collectors John Gatliff and Charles Gabriel, who turned their hobby into a serious study that resulted in many new discoveries and publications (Smith and Black 1969; Smith 1981b; Smith 1981c).

When the Club formed a series of special interest groups, such as Botany, Geology and several others, after the Second World War, one of these was Marine Biology. In 1949, this was modified to the Marine Biology and Entomology Group, which persisted as an active group until 1981, when it was discontinued due to the loss of several active members.

URG and MSG - Port Phillip and Western Port

In this same period those interested in active marine studies were gravitating towards the National Museum in Melbourne with its comprehensive reference collections and library and an active and knowledgeable Curator of Molluscs, J Hope Macpherson (later Hope Black) (Fig. 1). Hope published *Marine Molluscs of Victoria*, the definitive text on the Victorian marine mollusc fauna, with CJ Gabriel (Macpherson and Gabriel 1962). With full descriptions of all the major species and a complete listing of all the species then known to have been recorded from Victoria, this was both a checklist and a field guide. It contained almost 500 illustrations, which were exquisitely executed line drawings by George Browning. These made the book so easy to use that it still remains the reference of choice for those working with the southern Australian fauna, even 40 years after its publication. This text provided both the amateur collector and the professional scientist with an exceptional reference which greatly stimulated future work into our local marine biodiversity.

Hope represented the Museum in a joint research project with the then Fisheries and Wildlife Department, to carry out an ecological survey of Port Phillip Bay between 1957 and 1963. They were assisted by amateur divers from the Underwater Explorers Club and volunteers associated with the Mollusc section at the Museum. Extensive collections were made and the study resulted in a series of landmark papers on the various groups that make up the flora and fauna of the Bay, published in two volumes of the *Memoirs of the National Museum of Victoria* (vol. 27 in 1966 and vol. 32 in 1971).

In the late 1940s Hope made representations to the Museum to establish the Malacological Club of Victoria and allow it to meet in the Museum. Several years later some members wished to concentrate just on shells. They formed a separate group, the Malacological Society of Victoria, which later became the Malacological Society of Australasia. Others had a wider interest in marine biol-

Fig. 1. J Hope Black (née Macpherson), former Curator of Molluscs at the National Museum of Victoria.

ogy and they formed the Marine Study Group of Victoria (MSG), which held its inaugural meeting at the Museum on 4 February 1957. The Group held monthly meetings in the Museum, and field excursions to various marine localities to observe, study and collect specimens. After the Port Phillip Survey work was completed, other projects were undertaken. In 1964, a monthly newsletter, *Marine News*, was commenced for the information and interest of members.

In 1966, a sister group, the Underwater Research Group (URG), was formed from many of the divers in the Underwater Explorers Club who were interested mainly in study of marine life rather than in exploring wrecks or underwater fishing. A leader in this group was Jan Watson, who later became a specialist in the systematics of hydroids and an Associate of the Museum. Both the URG and the MSG decided to carry out separate but parallel survey work on Western Port. They both published reports on that work which included comprehensive species lists of their findings. Members of both groups started to work together on Museum workdays to process their Western Port collections and incorporate them into the reference collections. Several members became so interested in the projects that they became active in both groups. It was no great step from here to suggest that the two groups should form some sort of closer association.

MRG and the Coastal Atlas

After further discussion it was decided that the best solution would be for the two groups to amalgamate and form the Marine Research Group of Victoria (MRG), with some members who pursued their interest by diving and others who were bound mainly to the intertidal zone. The inaugural meeting of the new, enlarged group was held on 25 March 1980 in the Theatrette of the Museum. The Group held monthly meetings here, continued *Marine News* as the newsletter, held both diving and intertidal excursions and continued with the Museum work-days to identify and process the material they collected. Their two great fields of research were in area faunal surveys and broad scale species mapping. Field trips ranged widely along the whole Victorian coastline and even included visits to several of the Bass Strait islands. In particular, three projects stand out from this period.

Firstly, perhaps the most significant achievement during this period was a statewide project to map the distribution of the common intertidal animals. This involved visiting each of 207 reference areas in grid squares of 5 minutes (of latitude) x 5 minutes (of longitude) (9.3 x 7.2 km). A total of 254 species of common intertidal invertebrates was chosen. Each was figured and described in the publication and a statewide distribution map for each species produced. The field work was carried out between December 1979 and June 1984. All this resulted in a 168 page publication called *Coastal Invertebrates of Victoria: an atlas of selected species*. This was published in 1984 and sold over 2000 copies (Marine Research Group of Victoria 1984). Secondly, other projects undertaken by the Group included carrying out a survey of two proposed marina sites near San Remo in Western Port. Comprehensive species lists were compiled and a report sent to the State Government. This study resulted in the San Remo marine community being listed under the Victorian *Flora and Fauna Guarantee* Act, 1988 (O'Hara 1995). The most significant component of this community is the opisthobranch molluscs, investigated and described by Robert Burn, a member of both the MRG and the Malacological Society of Australasia. Thirdly, a mainly diving project was a survey of the benthic fauna of the channels at the southern end of Port Phillip. This was based on a similar survey of the area carried out by J Bracebridge Wilson and the Royal Society a century before.

Joining the FNCV

During the last decade of the 20th century plans were drawn up to move what was then the Museum of Victoria from Russell Street to a new building in Carlton Gardens. (It should be noted that the museum was originally called 'National Museum of Victoria', and became 'Museum of Victoria' when it was amalgamated with the Science Museum in 1985. It is now called 'Museum Victoria', of which the Melbourne Museum at Carlton Gardens is one campus). The move to the new premises involved two moves for the marine collections and staff: firstly to temporary quarters in Mollison Street, Abbotsford in 1998, and then to Carlton Gardens in 2000. During these moves, no space was available for a meeting room or storage for the Group's reference library or records. Museum work-days had to be curtailed and much of the connection between the Museum and the Group was lost through the upheaval of the move and change of staff at the Museum. The Group decided to look for a new home. Work-days were recommenced in 2001 and have continued uninterrupted since then, continuing the long and close relationship between the Group and the Museum.

Talks were commenced with the FNCV, and on 10 February 1997 a Special General Meeting was held to approve the dissolution of the MRG on the basis of its simultaneous merger into the FNCV. The Marine Research Group of Victoria was dissolved and the Marine Research Group of the FNCV was born. The speaker at this inaugural meeting was Hope Black, who is still active in the field of malacology and marine studies. Within the structure and procedures of the Club, the Marine Research Group is continuing with its general pattern of activities of monthly meetings, regular field-work towards specific research outcomes and an emphasis on both teaching and a concern for the marine environment.

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I would like to especially thank Clarrie Handreck, former President and the longest serving Secretary of the Group, for supplying much of the information used in this paper. Clarrie was the main compiler of an unpublished history of the Group (MSG/MRG of Victoria: 1957-1997). I would also like to thank Alan Monger, Joan Broadberry and other members of the Group, and Win Kershaw of Launceston, for the loan of photographs that I used in my presentation to the Symposium. I also thank Robin Wilson of Museum Victoria for his helpful suggestions which improved this manuscript.

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The Junior Group excursion to Kentbruck Heath, Glenelg River area, in the early 1970s.

The Junior Group: 62 years of encouraging young naturalists

Wendy Clark[1]

Abstract

Early in the history of the FNCV it was recognized that junior membership should be encouraged. The first group dedicated to junior naturalists was formed in Hawthorn in 1943. In the following years the club florished and operated essentially independently. The existing Junior Club became a part of the main FNCV in 2002, thus returning to the fold after 59 years. (*The Victorian Naturalist*, **122** (6), 2005, 315-318)

A few years ago the Melbourne Junior Field Naturalists Club finally returned to its parent body and became a group of the Field Naturalists Club of Victoria (FNCV) rather than a separate club in its own right. The how and why is a fascinating story, and it starts right back in 1883.

Early in the Club's existence, members of the FNCV recognised the need and desirability of providing for junior naturalists as well as adults. In 1883 they attempted this with a low subscription for juniors of 5/-. However, this had little success. In 1904 they followed it up with an even lower rate for under 18-year-olds of 1/-, and monthly excursions were organised particularly for juniors. Separate meetings were sometimes held and approaches were made to youth organisations. This resulted in a third of the FNCV membership in 1905 being under 21 years of age (the majority of these were under 18). This arrangement was successful for many years but the practice gradually lost favour and was discontinued in 1914.

The next time an attempt to cater for juniors was addressed was in 1941, when a concerted effort was made to set up branches, the first one being at Hawthorn. In conjunction with the Hawthorn Library, a lot of effort went into promoting the idea of the club. A show was arranged in the library for one month, and a book was there for people to sign if they were interested in joining a Junior Naturalist Club. Many hundreds of names and addresses were obtained. This resulted in the formation of the club, to be called the Junior Field Naturalists Club (Hawthorn Branch), and its inaugural meeting was held on 27 August 1943. Mr SR Mitchell was president, Mrs ME Freame was Secretary/Treasurer and Mr Reeves was Lanternist. The librarian, Mrs Carbines, was to act as a liaison officer between the Club and the Hawthorn Council, which was very supportive and allowed meetings to be held in the Hawthorn Town Hall.

Demonstration evenings were a feature of early meetings, with up to four FNCV members showing techniques of collecting and preserving in various branches of natural history. Indeed, whenever such meetings have been scheduled, even in recent times, they have always proved popular. Excursions were now back on the agenda, with the first being 'Rocks of the Hawthorn District' at Studley Park. To keep up the momentum another Nature Exhibit was prepared in the Hawthorn Library. Attendance at these early meetings fluctuated and efforts were made to encourage the Boy Scouts and Girl Guides of the district to attend. This was successful for a while. In August 1944 the Club celebrated its first birthday, and after the lecture the Juniors all enjoyed a piece of cake baked specially for the occasion. This practice of celebrating the Club's birthday still continues today. Currently, because of a younger age group, we have a dress-up theme concerning some aspect of natural history, and have games such as 'bat moth' and 'guess the animal', as well as a birthday supper and cake.

Growing stronger

The Club went from strength to strength, reaching a peak in the years 1948–1951 when attendances at meetings were always above 50 and sometimes over 100. Unfortunately excursions were not recorded during this time, though we know that

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there were some joint trips with the FNCV. A feature of the '40s and '50s was the Nature Shows and associated Exhibits organised by the FNCV. The Hawthorn Junior Exhibits at the FNCV shows held at the Hawthorn Town Hall were among the best. In 1951 the Hawthorn Juniors organised their own show in the Hawthorn Town Hall, preparing all the exhibits themselves. They also had exhibits at the Children's Exhibition in the Melbourne Town Hall and the Exhibition Buildings in 1946 and 1947 respectively.

The years 1954–58

These years were a time of low membership, when the efforts of a few FNCV members kept the Junior Club going. After an unsuccessful excursion to Seaholme in May 1954, no further excursions were held until 1958. Activities seemed to be restricted to the monthly meetings. At this stage Mrs M Freame retired as Secretary/Treasurer after 15 years in office.

The years 1958–1962

Under the leadership of Mr P Fisch as Secretary/Treasurer and Mr Dickens as President, the club stabilised its membership of around 12–24 (though attendances at meetings were somewhat higher). Mr Fisch reintroduced excursions and they once more became a regular feature of Club activities.

1962: the year of change

After the sudden death of Mr Fisch and the retirement of Mr Dickens, who was in his 90s, Dan McInnes, the outgoing President of the FNCV, took over the presidency of the Club. Miss E Wallace, Chief Librarian at Hawthorn, became Secretary/Treasurer. This change was of great significance for the Club because for the first time there was a break with the previous organisation, as Mr McInnes had attended only one meeting prior to his taking office.

Mr McInnes began by encouraging members to take a greater part in the Club's organisation. He saw that starting a Club newsletter was a way to expand, and Tim Shaw, a member of the Juniors, became the first editor. With the assistance of his friend Barry Cooper, Tim published the first newsletter, consisting of a single duplicated sheet, in September 1962.

Newsletters and publications

In 1963 the Newsletter was called *The Hawthorn Branch* and extended to four pages. Tim Shaw was in charge of all publications at this stage, and oversaw the publication of a booklet titled *How To (Methods of Preparing and Setting Natural History Specimens)* and *The Hawthorn Branch* (a re-edited collection of 1963 newsletters). In August 1965, a Publications Committee was formed to organise all publications. In 1965 Paul Gahan altered the whole format of the newsletter and it was renamed *The Junior Naturalist*, which it is still called today.

A large number of additional publications have been produced, including *Preserving Marine Specimens* by Leigh Windsor; *The Collection and Preservation of Insect Specimens* by Dennis Walsh; and the *Observation and Collection Record Book* by Paul Gahan. A feature of the newsletter and publications since 1965 has been the large number of members involved.

In 1965 an agreement was made with the FNCV librarian, Mr Peter Kelly, for books to be borrowed by Junior members. They could have them for a period of two months.

Nature shows

Mr McInnes, who was also the organiser of the FNCV Nature Shows in the Lower Melbourne Town Hall each September, arranged for the Juniors to have an exhibit titled 'How to Polish a Rock Pebble'. This show and subsequent ones were to prove instrumental in bolstering membership. By June 1962 membership had already passed the 40 mark.

The foregoing text is a brief summary derived from Cooper (1968).

Growth of the Club

The club now went from strength to strength under the inspirational leadership of 'Mr Mac' as he liked to be called. More and more the Juniors began taking an important part in the running of the organisation. A Council was formed, with those over the age of 12 years being eligible to be invited to become Councilors. In fact, these junior Councillors now took on every role except President until the early '70s.

The Nature Shows and the Newsletter played a vital role in increasing membership, which rose during this period to a peak of 170 members, with attendances at meetings averaging over 100.

An awesome club

Some of my memories of this time are of meetings in the Hawthorn Town Hall, with around 120 people attending. The reptile boys were a bit on the rebellious side and it wasn't unknown to have a lizard race at the back of the hall. One such event was with a Frilled Lizard. For keen naturalists, this was an awesome time. The Club provided an outlet for these teenagers and younger kids to mix with people who thought the same way as they did, to learn more on subjects they were passionate about and to get involved in running the Club. There was no other place in those days that provided this outlet; few if any TV wildlife shows, and little travelling to wild places, let alone with people who could teach them about what they were seeing.

Excursions and camps

Excursions were now held every month and were usually well attended, with many interesting places being visited. Sometimes travel was by train to places such as Hurstbridge, but usually we all met at the Hawthorn Town Hall and those without transport were allocated spaces in the available cars. In those years it was a terrific system as the majority of the members were teenagers and were able to come along without parents; consequently they didn't have transport.

In 1971 the first Easter Camp was arranged. This was destined to become a feature of the Club's activities, with some members in the future vying for the position of having attended the most Easter camps without a break. It has become so popular that even some parents came along after their kids had grown up and stopped coming.

The first camp was to the Little Desert, in those days an almost mystical place for teenagers who were unlikely to be able to get there. We hired a bus, which was easily filled, and during the trip up, Council members gave a series of talks on features we passed on the way. We went on bush walks, nature rambles and had campfire discussions and singalongs. On Easter Sunday morning we woke to find that the Easter Bunny (now the Easter Bilby) had visited us all during the night.

Another feature of those early camps was the fun of having to push the bus when it got bogged. Our bus company, McKenzies, always issued us with an old bus that could be taken on dirt tracks, and a driver who was comfortable camping. They were fun times for the bus driver as well!

The first Junior President

In 1971 Mr McInnes felt that it was time to hand the Presidency over to a Junior member. The Council at this time was strong, with a reasonable number of older teenagers and several members in their early to mid twenties. Michael Coulthard was elected as our first Junior President in November of that year. He ran the club using the same structure that Mr McInnes had established, and the club continued to flourish. The members of Council themselves were forming strong bonds with each other, which is essential for the smooth running of a club such as this. To nurture these bonds Council camps were arranged to explore new places. The Club went from strength to strength, the members developing a fierce pride in the fact that their Club was run without any parents on the Council. In reality they did help in the background by supporting their kids with the jobs they took home.

Over the next twenty years the Club continued in the same vein, with the presidents and other councillors growing up in the Club and learning the ropes from the other members. All subsequent presidents were Juniors who grew up in the club.

We had several different meeting halls after the Hawthorn Town Hall started charging rent that we could not afford. We met in a church hall in Hawthorn, at Preshil School Hall, at Balwyn Primary School and eventually in the FNCV Hall from 1996. With so many changes of location, The Hawthorn Junior Field Naturalists Club changed its name to the Melbourne Junior Field Naturalists Club in 1996.

During these strong years the Juniors were involved in helping set up Black Rock, Pascoe Vale, Montmorency and the Preston Junior FNCs. Montmorency Junior FNC ceased to be just a junior club and became a club for all age groups, and the Pascoe Vale Club is now a general interest club rather than a Field Naturalists Club. All the other Junior Groups failed to survive.

While it is terrific to have the Juniors run their own club, there are a few downsides. Losing their contact with the Senior (FNCV) club is one. Initially several members of the FNCV would come to meetings with exhibits and pass on their knowledge. Over time the numbers dwindled till at present adult members are rarely seen unless they are speakers or parents. This, together with the current culture of being generally interested in everything, instead of picking a subject to learn in greater detail, resulted in fewer and fewer people having the knowledge to be able to impart–the knowledge that everyone craves to hear. Maybe at the 150th anniversary I will be able to give you the answer to this deepening problem.

Challenges of the future

Membership numbers have waxed and waned over the years, changing with the social attitudes, the charisma of the president at the time, the amount of promotion the club has done and other effects we haven't quantified. The average age of the Juniors has changed over the years too. In the early years the majority of the members were teenagers. This made it possible to have the Juniors run the club. We have just come through a long period of very young membership with the average age around 7 years. Rather than just the intensely interested person, families attend these meetings and excursions now. . Pitching the lectures and trips to young children results in it being hard to keep the older teenagers who are needed to run the club. Pressures of schoolwork and teenagers being employed on the weekends also make it hard to keep them working in the Club.

We are just starting to see the age group rising once more (perhaps the children in the surrounding suburbs are all growing up), and once again we have a Council of teenagers who have the ability to take on some of the roles, such as that of Editor.

During those years when there were almost no teenagers, Wendy Clark reluctantly (as she was now a parent) stepped in to help re-educate the councillors on the system of running the Club in the way that Dan McInnes had established so successfully. We are now starting to see the results of this as the teenagers are staying and taking over once more.

Insurance and returning to the fold

As all club organisers know, insurance issues changed the running of clubs. The cost for the Juniors to have their own Public Liability and Personal Accident cover was much more than could be afforded. Our solution was to become a sub-group of the FNCV and come under its insurance. This meant there was little change in the way the Club was run as we already met in its hall, used its library and acted as part of the FNCV anyhow. So finally in 2002, after 59 years, the Junior Club returned to the Club from which it originated. Now the Club is called the Junior Group FNCV.

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Hawthorn Junior Field Nats president, Wendy Clark, at the camp at Lake Tyers, 1970.

From fungs to Fungimap: fungi and the FNCV

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Abstract
Prior to the formation of the Field Naturalists Club of Victoria, there was no organisation for those with an interest in Australian fungi, especially their natural history. From its first days, the FNCV provided a place of interaction for fungi enthusiasts, through the pages of *The Victorian Naturalist* and through meetings and excursions. The publication by Jim Willis in 1934 of a guide to Victorian agarics, and by Bruce Fuhrer in 1985 of a field guide to fungi, with copious coloured illustrations, were landmarks in enabling field naturalists to put names to fungi. The FNCV was involved with the publication of some editions of both books. Fungal forays have been held regularly since the 1930s, with Willis and Fuhrer leading many of them. The Fungimap scheme grew out of interest by the FNCV Botany Group in carrying out botanical surveys. Fungimap was nurtured by the FNCV, along with Royal Botanic Gardens Melbourne, leading to the establishment of a separate organisation in 2005. Recently, a fungal studies group of the Club has been formally established. (*The Victorian Naturalist* **122** (6), 2005, 319-326)

Background

At the time of the formation of the Field Naturalists Club of Victoria in the 1880s, there were a number of Australian naturalists with an interest in fungi. Mostly, this interest was manifested through the collection of specimens, which were sent for formal description to mycologists in Europe, such as Mordecai Cooke (associated with the Herbarium at Royal Botanic Gardens, Kew). Most of the collectors sent specimens via Ferdinand von Mueller, at the Melbourne Herbarium, who was the dominant Australian botanical figure in this period (May and Pascoe 1996). In fact it was Mueller who coined the word 'fung' (*Oxford English Dictionary*), which he introduced as the English equivalent of the Latin 'fungus', along with 'alg' for 'alga', in the same way that 'plant' was derived from 'planta'.

In visualising Mueller's network of relationships, Maroske (pers. comm.) uses the analogy of Mueller as the hub, with the collectors the spokes, but with little contact between the different collectors. Mueller himself was an inveterate collector of all plant groups, but his early attempts at collecting fungi, which began in his days in South Australia, produced rather poor specimens. Fleshy fungi, which can be beautifully coloured, often lose their colour on drying; and other features important for classification are also difficult to discern from dried material. Like other Australian fungi collectors, Mueller relied on European experts for the naming of his collections, and was advised to accompany dried material with notes and paintings of the fresh specimens. Mueller, who was no artist, encouraged collectors to prepare paintings. Marie Wehl (one of Mueller's nieces) in South Australia, and Flora Campbell (Mrs Martin), Charles French Jr and Henry Tisdall in Victoria were among a number of fungi collectors who produced numerous accurate watercolours of their collections (May 1990; May and Pascoe 1996).

It was not until the early decades of the 20th Century that taxonomic work on larger fungi was undertaken in Australia, commencing with the activities of John Cleland and Edmund Cheel. For the microfungi, which include important crop pathogens such as rust fungi, local efforts commenced somewhat earlier with the appointment of Daniel McAlpine as Vegetable Pathologist in the Department of Agriculture in 1890. McAlpine had arrived in Melbourne in 1884, and initially taught at the University of Melbourne. He published not only on pests of exotic crops, but also described many fungi from native plants (May and Pascoe 1996).

As to the natural history of the fungi collected in the 19th century, occasional interesting snippets of information can be gleaned from letters accompanying the batches of specimens, such as Mueller's perceptive observations on the fungus-eat-

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ing habits of potoroos (Hilton 1980). However, descriptions of new species were almost always confined to the morphology, and rarely noted even the habitat, let alone other aspects of the ecology of the fungi.

Fungs and the FNCV (1880-1930)

The formation of the FNCV immediately provided a meeting place for those with an interest in fungi. Mueller was one of the founding members of the Club, and many other early members exhibited or wrote on fungi, including Flora Campbell, who was referred to as 'our mycologist' (Anon. 1885), McAlpine, Tisdall, Felix Reader and Henry Watts. From the very first volumes of *The Victorian Naturalist* there are references to fungi (or fungs) being exhibited at meetings of the Club, or spotted on excursions. An example is the 'Vermillion ... *Clavaria*' noted on the 1884 excursion to Frankston (French and Best 1884). The scope of member's activities is demonstrated by the 350 fungi specimens exhibited by Flora Campbell at the February 1886 meeting (*The Victorian Naturalist* 2: 138) and the 'close to a hundred distinct species' of fungi noted on the excursion to Lilydale in 1885 (Anon 1885). Interest in fungi was not confined to macrofungi, with various groups of microfungi featuring in exhibits and articles. Some reports began to deal with particular areas, such as Tisdall's (1885) paper on fungi 'east of Mount Baw Baw'.

There is no direct evidence of communication among those with a mycological interest, but the 'spokes' who radiated from Mueller's hub, and others drawn to the FNCV, had plenty of opportunities to share their mycological interests at meetings and on excursions, and also through the pages of *The Victorian Naturalist*. There was even mention of a 'Cryptogamic Botanical Section' (*The Victorian Naturalist* 4: 49-50), although nothing further seemed to eventuate in this regard.

McAlpine, as the only professional mycologist, kept members in touch with his latest projects, such as the preparation of a 'Systematic Census of Australian Fungi' (*The Victorian Naturalist* 10: 36). In addition, McAlpine published introductory articles for groups such as entomogenous fungi (McAlpine 1895). Tisdall also published articles with a didactic tone, such as 'Notes on the genus *Calocera*' (Tisdall 1894). Articles in *The Victorian Naturalist* also included important observations on the natural history of local fungi, such as the first report of the fruit-body of Native Bread (*Laccocephalum mylittae*), until then known only from the underground sclerotium (Tisdall 1886). Mueller's neologisms 'fung' and 'alg' rarely seem to have been taken up. Some of the few examples in print are in the pages of *The Victorian Naturalist*, such as the article by Tisdall (1890) on 'Victorian fungs new to science'.

In this period, *The Victorian Naturalist* included some calls for material from overseas mycologists such as Curtis Lloyd, a puffball specialist from Cincinnati, USA (*The Victorian Naturalist* 23: 28) and the German mycologist Hans Sydow (*The Victorian Naturalist* 23: 96). These led to direct contact between collectors and mycologists, without the need for a local intermediary like Mueller.

The results of activities of fungi collectors in the 19th century were brought together by Cooke in his *Handbook of Australian Fungi* (1892). Although this book contained a number of coloured plates, it seems not to have been much use in identifying fungi. The copy owned by Charles French Jr [collection of the author] is in pristine condition and seems rarely to have been opened. The trouble with Cooke's *Handbook* as an identification guide was that the author, having never seen any of the material in the field or fresh, was not in a position to explain the distinguishing characters. Even though he had at his disposal some excellent original watercolours, only one species per genus was illustrated in colour, and Cooke is known to have used some imagination in preparing plates from more sketchy original drawings (May 1990).

An example of the difficulty of putting names to fungi at this time is the blue *Mycena interrupta*, a common agaric of forest gullies, originally described from Tasmania by Berkeley (1859). Tisdall collected this and sent material to Cooke, who failed to recognise it, not surprisingly, as it is described as 'livid' in colour in the *Handbook*. Cooke incorrectly placed

Tisdall's collection in *Agaricus* subgenus *Leptonia,* despite its habit on wood (May 1990). The 'tiny exquisite blue agaric' was also incorrectly listed as *Agaricus* (*Leptonia*) in the report of the 1885 Club excursion to Lilydale (Anon. 1885).

In the first 50 years of the Club, fungi were well accepted as a subject of study for members, and the existence of the FNCV would have been a boon for those with mycological interests. However, the lack of workable field guides would have been a problem for those with a nascent interest in fungi.

Fungi guides and forays (1931-1990)

In an article which occupied most of the April 1934 issue of *The Victorian Naturalist*, James ('Jim') Willis presented a key and succinct descriptions of 70 species of gilled fungi. The article was accompanied by several colour plates, from illustrations by Malcolm Howie (Jim's brother-in-law), which were readily recognisable as some of the common fungi of forests near Melbourne. Willis had a great knack for expressing the key qualities of each species, so as to facilitate recognition in the field, and also included novel information about the habitats of the various fungi.

A more technical *Handbook* to the larger fungi of South Australia appeared soon after (Cleland 1934-1935). Willis immediately revised his article, taking up a number of the new names introduced by Cleland (Willis 1935). His 1934 paper was then published in book form by the FNCV, as *Victorian Fungi* in 1941. The popularity of this guide can be gauged by the fact that it was reprinted (as *Victorian Toadstools and Mushrooms*) in 1950, 1957 and 1963.

The appearance of Willis's (1934) article on gilled fungi had an immediate effect in enabling identification of the commoner and more distinctive larger fungi. Charles Barrett wrote: '[this] fine paper ... has already turned the thoughts of many ... to Fungi, and lured us to trails through a Fairyland .. of flowerless plants' (Barrett 1934).

Willis originally became interested in fungi during his studies at the Victorian School of Forestry, Creswick, and at the time of his initial publications on fungi was employed by the Forests Commission of Victoria. He later joined the staff of the National Herbarium, where he worked until his retirement in 1972 (May1996). Although his duties at the National Herbarium mainly concerned the flowering plants, Willis maintained a life-long interest in fungi. He relished being in the field, and on excursions he was always happy to share his knowledge with fellow naturalists.

From the 1930s there were frequent notes on fungi in the pages of *The Victorian Naturalist*, often from the pen of Willis, and including documentation of the spread of Fly Agaric *Amanita muscaria* (e.g. Coleman 1945). From the 1930s photography was a valuable adjunct to fungal studies, and some members contributed fungal portraits (e.g. Lyndon 1969). However, the only colour illustrations available were the few plates by Howie in *Toadstools and Mushrooms of Victoria*, and a few plates in Cleland (1934-35).

In 1968, the FNCV was associated with the publication by AH and AW Reed of *Flowers and Plants of Victoria* (Cochrane, Fuhrer, Rotherham and Willis, 1968). This book included numerous excellent colour photographs, many by Bruce Fuhrer, among which were a few fungi. The advent of cheaper colour photography and printing led to the appearance of well-illustrated field guides to various animal and plant groups. Fuhrer was a pioneer in high quality photography of cryptogams, including fungi, which need special techniques due to their often small size, and growth in shaded places. He produced images for a loose-leaf guide to Australian fungi (Cole, Fuhrer and Holland, 1978) and published *A Field Companion to Australian Fungi* in 1985, which was reprinted by the FNCV in 1993. Fuhrer has a vast knowledge of cryptogams, and his photographs always show the key characters necessary for identification. Like Willis, he has been an active member of the FNCV, has led many forays and been a frequent speaker at Club meetings.

In most years during the decades from 1930 to 1990, fungal forays were included in the Club's excursions. From the 1940s, forays were excursions of the Botany Discussion Group (later Botany Group), but often there were also forays as General

Excursions. Jim Willis and Bruce Fuhrer led many of these. The publications on fungi by Willis (1934) and Fuhrer (1985), each ground-breaking in its own way, ensured that a wide audience was able to profit from the authors' enthusiasm for and knowledge of fungi.

Fungi surveys and Fungimap (1991-present)

In the early 1990s, there was some discussion about ways to invigorate the FNCV Botany Group. Excursions were still reasonably well-attended, but it was felt that survey-based activities, rather than mere rambles, might be a way of attracting new (and younger) members, following the example of the popular Mammal Survey Group activities. A Botany Research and Survey Task Force (also called the Botany Research Group), was set up in early 1994, largely through the efforts of John Julian (FNCV Vice-President). By the end of the year, the survey group had merged with the Botany Group, but its brief existence did provide an impetus to alter the scope of the Botany Group's activities.

Also, around this time, it was becoming apparent that the collections held at the National Herbarium of Victoria (MEL) were completely inadequate to assess the distribution and conservation status of Victorian fungi. In fact, for macrofungi, there were only 4.2 collections on average per species held in the Herbarium, and 80% of species were represented by less than five collections (May and Avram 1997). Therefore, it was not possible to distinguish common but poorly-collected species from any rare species that might need special attention regarding their conservation.

Between 1994 and 1996, John Julian organised regular surveys of the fungi of Wattle Park, in association with the Friends of Wattle Park (Schleiger 1994; Julian, 1994; Eichler 1995; McPherson 1997). This pioneering survey of urban fungi produced about 500 collections, which were described and photographed after the morning's foraying, thus teaching participants about the characters important for fungus identification (even if many of the specimens were not able to be identified on the day). These collections were lodged at MEL, but unfortunately remain un-accessioned. A similar fate has befallen numerous collections from regular fungi forays to the Kinglake East block formerly owned by the FNCV, and Club expeditions to Mt Buffalo and Wilson's Promontory (May 1998). This material will be of great value, especially for establishing detailed inventories of all the fungi from particular localities, but requires intensive work on curation and identification before it can be accessioned and analysed. An indication of the scope of projects that involve large-scale collecting of specimens is that the current Perth Urban Bushland Fungi Project has a budget of more than $300,000 (CALM 2004).

In June 1995, I presented a proposal for a mapping scheme for Australian fungi to a meeting of the Botany Group, arguing that there was an urgent need for better information on the distribution and ecology of Australian fungi, especially to allow informed decisions about the conservation of fungi (May 1995). A significant feature of the proposed scheme was that it would not involve collection of specimens (which would overwhelm resources at the Herbarium), but rather sight records of readily recognisable species would be collated. Eight such species were initially proposed, including such distinctive species as Pixie's Parasol *Mycena interrupta* and Fly Agaric *Amanita muscaria*.

Batches of records soon arrived, at first from FNCV members, but eventually from recorders in all states. A number of participants, particularly those in rural and regional areas, had been pursuing an interest in fungi for many years in relative isolation, and relished the opportunity to contribute records and later to attend workshops and conferences. In 1996 a colour leaflet with pictures of the eight target species was produced, along with an 'FNCV Fungi Kit' which included a guide to making collections, and a checklist of fungi illustrated in field guides. The following year the list of target species was extended to 50 (all illustrated in Fuhrer's *A Field Companion to Australian Fungi*). By 1998, more than 1600 records had been received, with some individual species represented by more than 100 records (Schleiger, 1998). A further 50 target species were added in 1999. Currently, the Fungimap database contains more than 20,000 records of the target and other fungi species.

The fruit bodies of fleshy fungi are very sporadic in appearance, reliant on suitable rain, which is very variable from year to year. Observations from Fungimap recorders across Australia have produced significant extensions to distributions, and also considerably fleshed out existing distributions based on the often meagre sets of herbarium specimens. Collection of the Fungimap data by means other than a network of volunteer recorders would have taken enormous time and resources, because to see fungi, you really do have to be in the right place at the right time.

As well as enabling production of detailed maps. Fungimap data confirmed the rarity of a number of species, including *Hypocreopsis* sp. 'Nyora', now listed under the *Flora and Fauna Guarantee Act*, and records have been provided to the Australian Heritage Commission to assist in identification of biodiversity hotspots. Another project undertaken by Fungimap was the collection of dung samples from across Australia for Ann Bell (Lower Hutt, N.Z.) who was undertaking a study of the fungi that grow on dung. This led to the discovery of a number of new species (Bell and Mahoney 2001).

Fungimap was formally supported by the FNCV (from 1996) and also by RBG Melbourne, but the scheme had no other official status. From 1999 Regional Coordinators were appointed in most states: Bettye Rees (NSW), Heino Lepp (ACT), Pam Catcheside (SA), Katrina Syme (WA) and David Ratkowsky, followed by Sapphire McMullan-Fisher and then Sarah Lloyd (Tasmania). Initially John Julian was the Executive Officer, and then a Fungimap Co-ordinator was employed by RBG Melbourne (Katy Sommerville, followed by Gudrun Evans and Cassia Read). Representatives of the Regional Co-ordinators formed a Steering Committee, along with the Fungimap Co-ordinator and the Convenor, Tom May (RBG Melbourne, and one-time FNCV President). Notably, several of the Regional-Co-ordinators also served on the committees of interstate field naturalists groups.

Several FNCV members have had significant roles in Fungimap administration and communication. John Julian's zest and flair for organisation resulted in the establishment of *Fungimap Newsletter* and success in securing grants, such as from the Sydney Myer Foundation and The Ian Potter Foundation. In 1997, Michael McBain created an extensive website, which for some years resided on a server in the back room of his Fairfield residence, with the somewhat mysterious URL <http://calcite.apana.org.au/fungimap>. In 2001, Ian Bell produced an innovative CD-ROM guide to the target species, of which numerous copies have been sold (Fungimap 2001). Production of the CD-ROM led to the FNCV receiving a National Community-Link Volunteer Award. *Fungi Down Under: the Fungimap Guide to Australian Fungi* was published in 2005, written by Pat and Ed Grey, with editing and production assistance from Leon Costermans. This landmark book, the first Australian field guide to fungi to include detailed maps, has colour illustrations and detailed text for all 100 target species.

Communication with recorders was initially entirely through the website and the *Fungimap Newsletter*. The *Newsletter* has evolved considerably since its commencement in 1996, and some recent issues (20 and 23) now include high quality colour images. Issue 118 (2) of *The Victorian Naturalist* also included colour photographs of some of the rarer and more unusual target species, with the cover image a magnificent portrait of *Entoloma virescens* by Ilma Dunn. The first national Fungimap conference was held in 2001 in Denmark, Western Australia, with more than 100 participants, and further successful conferences have been held at Rawson, Victoria (2003) and Gowrie Park, Tasmania (2005). A variety of fungi identification workshops have been organised by Regional Co-ordinators and in association with the FNCV.

In the acknowledgments pages of *Fungi Down Under* more than 80 people are listed as being directly involved in the production of the book and in donating images. This exemplifies the very strong volunteer culture that has been a significant feature of Fungimap (and indeed the FNCV). Many aspects of the scheme have been maintained almost entirely by dedicated volunteers, particularly the entry of records into the Fungimap database.

A few weeks before the symposium celebrating the FNCV's 125th anniversary, a meeting to incorporate Fungimap was held during the 3rd Fungimap Conference, in Tasmania. The aims of the new organisation are to promote the conservation, study and appreciation of Australian fungi in the natural environment, with the mapping scheme remaining a major focus.

The combined support of the FNCV and RBG Melbourne was crucial in the genesis and development of Fungimap. Both organisations provided administrative support, and RBG Melbourne continues to host the Fungimap office. It would have been difficult to start up a new organisation from scratch, and in any case it was not at all apparent in 1995 that Fungimap would grow to the point where that would become necessary. With hindsight, Fungimap is a clear demonstration that once there is a rationale for data collection and sufficient supporting information, there is a great deal of latent interest even for seemingly less popular groups of organisms such as fungi.

FNCV Fungi Group (2004-present)

By 2003, the events pages of *Fungimap Newsletter* listed activities organised by various groups around Australia with fungi as their focus, including Sydney Fungal Studies Group (founded in the early 1980s), Fungal Studies Group of the Field Naturalists Society of South Australia (founded 2001), Fungi Lovers Adventure Group (from 2003, based in northern Tasmania) and Perth Urban Bushland Fungi project (commenced 2004). Perhaps because of the involvement of the FNCV in supporting Fungimap, there had not been earlier moves to set up a formal fungi group within the FNCV, although annual Botany Group fungus forays continued during the 1990s, and many active Fungimap recorders were also FNCV members.

In Victoria, at the instigation of Ed and Pat Grey, a formal special interest group was set up in 2004, called the FNCV Fungi Group. The Group already has an active program of fortnightly forays during the fungus season, and also meets regularly for identification sessions following forays. Detailed reports of forays have been published in *Field Nats News*. Some members are becoming very proficient in photography (particularly with digital cameras), and there is a growing interest in microscopy, which is vital for identification, especially once one strays beyond common and distinctive species.

A mutually beneficial relationship with Royal Botanic Gardens Melbourne is developing, with RBG mycologists providing identification and advice, and the Fungi Group lodging selected well-annotated specimens of novel and interesting species at the National Herbarium of Victoria.

The FNCV Fungi Group compiled results of their 2004 season as a CD-ROM, on which are more than 380 images of 62 more or less readily recognisable species, accessed through a simple but effective viewing window (FNCV Fungi Group 2005). This method of compiling and presenting images provides an inexpensive way of building up an electronic library of the best images from each season, and can be readily expanded from one year to the next, by adding further images and also additional species as they are encountered and identified.

Conclusion

It is true that for the FNCV, especially as revealed through the pages of *The Victorian Naturalist*, fungi are not as prevalent a topic as flowers or mammals (Archer this issue). However, the study and appreciation of fungi is a thread which runs through the activities and publications of the Field Naturalists Club of Victoria throughout its 125 year history. There have been periods of greater or lesser activity fungus-wise, but two factors contribute to the persistence of an interest in fungi.

Firstly, the 'field' part of the Field Naturalists Club provides something that is essential for the enthusiast of native fungi, which are often ephemeral, and fade and decay readily once picked. The appreciation of fungi in the natural environment on such a regular basis as the FNCV forays is not something offered by many other organisations.

Secondly, the Club has always been a meeting ground (whether at talks or in the field) for persons deeply interested in various natural history subjects, but at the same time, a welcome venue for beginners. The wonder of the neophyte mixes happily with the pleasure of old-hands in conveying their knowledge. However the various contrasts of amateur/professional, expert/beginner and scientist/naturalist might be defined and perceived, on the whole, persons of all these descriptions have been happily accommodated in the life of the Club.

Speaking personally, what attracted me to the Club in the first place was the opportunity to observe fungi in the field with a group of people with such evident enthusiasm and knowledge.

The excitement of the fungi hunt is marvellously captured by Willis (1934):

> With the approach of winter ... the fungus enthusiast becomes excited - there are dreams of past trophies and pleasant anticipations of finds to be made. Once you have discovered a rare species and your interest is fairly captivated, it is amazing how the fungus fever will grow; every patch of bush ... is ... rich in possibilities ... Perhaps the greatest thrill in hunting Australian fungi is the knowledge that few others have been in the field, that very little is known about our fungi, and that any specimen may prove an addition to the list of species already recorded.

The Club culture as a meeting place for sharing knowledge with an emphasis on the field is no doubt something that has contributed in large part to the longevity and success of the FNCV in general, particularly when mixed across the various sorts of animals, plants and geological features that are to be encountered in Victoria. Even on excursions with fungi as the focus, there will be a forayer glancing upwards at the sound of a bird call, or tapping on a stone tor as others cast their eyes downwards in pursuit of fungi; and not at all unlikely that an identification for a slug or a beetle can be proffered by someone in the group. It is to be hoped that this happy mix continues for many years to come. Much certainly remains to be discovered about the natural history of our fungi.

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Australian Natural History Medallion

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Abstract

Since 1940, the Australian Natural History Medallion has been awarded anually. The Field Naturalists Club of Victoria played a central role in the inception of the award, and has continued to be centrally involved in the process. The form of the Medallion has changed twice in its 65-year history. (*The Victorian Naturalist* **122** (6), 2005, 326-330)

In 1987 a history of the Australian Natural History Medallion was written (Houghton 1987) to assemble as much material as could be gathered, particularly from FNCV minutes, after the destruction of the ANHM minute book and all current correspondence and dossiers. All previous winners are mentioned somewhere in the History with photographs of some selected for significant reasons such as the first Medallionist, the first in each of the States, and the first to receive the new Medallion in 1981. That history of the medallion is the best source for details about many of the winners and much of the administrative background.

Background

John Moir wrote to the Secretary of the FNCV in March 1939 saying, in part: 'In several countries it is the custom for societies formed to protect flora and fauna to mark, in some manner, their appreciation of some person's signal service in that direction by awarding them a medallion.' He was a member of the Bread and Cheese Club which had been formed to foster the knowledge of the Australian arts and to cultivate an Australian sentiment. Moir had written to six other clubs: Gould League, Royal Australasian Ornithologists Union, Mitcham FNC, Wattle League, Bird Observers Club and the Bread and Cheese Club.

The FNCV was asked to convene a meeting of these clubs and they sent invitations to a further ten organisations including the Royal Society of Victoria (Table 1). The meeting was held on 5 June 1939 and agreed on a set of Rules, the purpose of which has not changed in substance to this day. Significant changes were made in 1947 when a fixed period of nomination was set at three years instead of one, with the option of renominating a successful candidate (previously it had been a 'once only' chance which the Award Committee considered was unfair to worthy nominees). Also, at that time, a four-year term was established for members of the Award Committee. Previously it had been appointed annually by the General Committee from its own members.

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Table 1. The second list of invitees to the inaugural meeting

Australian Forest League (Victorian Branch)
Chief Inspector of Fisheries and Game
Federation of Victorian Walking Clubs
Entomological Society of Victoria
Victorian Advisory Council for Flora and Fauna
Royal Society of Victoria
Royal Zoological and Acclimatisation Society of Victoria
McCoy Society
Microscopical Society of Victoria
Melbourne Women's Walking Club

The first medallion was awarded in 1940 to Alec Chisholm who had a wide interest in natural history with a particular interest in ornithology. It has been awarded every year since then–a total of 65.

Current Structure

The current situation is shown in Fig. 1. The main difference from those early days is the number of clubs or societies that are invited to appoint representatives to the General Committee or make nominations for the Medallion; it has grown from the original seventeen to about ninety.

The essence of the Medallion is the natural history societies which manage it and make the nominations. Two of these have special roles:

The President of the Royal Society of Victoria is an ex officio member of the committee which assesses the dossiers and decides on the winner each year. That Society may also have a representative on the General Committee and that role seems to fall on the shoulders of its president as well.

Under the Rules of the Medallion the FNCV has certain responsibilities:

- funding, design and procurement of the Medallion
- appointment of the Secretary
- hosting the Medallion presentation
- having its president chair the General Committee

To ease the financial burden on the FNCV a Trust Fund was set up in 1975 to receive donations from Member Societies and individuals. Ideally the fund should be endowed to a level at which it is self-funding but the structure of the Medallion administration does not allow it to seek support from philanthropic organisations.

The FNCV also offers in-kind support by providing:

- Banking and accounting
- Stationery
- Archiving
- Committee meeting venue

However, there is no reporting relationship from the General Committee or its Secretary to the FNCV.

The General Committee comprises representatives of natural history societies (nine at the moment) and is charged with:

- appointment of the Award Committee
- consideration of applications to be represented on the General Committee
- amending the Rules, and
- any other purpose which may be necessary.

From time to time the General Committee has had to remind the FNCV of its independence and there is one example quoted in the History:

> But the General Committee still ordered its own affairs and an enquiry about the Medallion rules from the F.N.C.V. secretary in 1957 brought the terse rejoinder from the General Committee secretary 'the F.N.C.V. has nothing to do with making or altering Medallion rules, except as it acts through its representatives. (Houghton 1987).

Even though the Medallion is a national award, there is obviously a strong Victorian influence because of the involvement of the FNCV and the necessity of managing it from Melbourne, which precludes interstate societies from attending Committee meetings unless they appoint a Victorian resident as their representative.

Winner Profile

An analysis of the Medallion winners over the 65 years may indicate if there are any biases due to the Melbourne-centred management.

The first characteristic is obviously gender. The first woman to win the Award was Edith Coleman in 1949, the tenth award to be made. To date only 12 women (18%) have received the Medallion. They conform to a nineteenth century view of women's natural history pursuits–botany, ornithology and a lone entomologist.

Some Medallion winners have had multiple and diverse interests so the number of

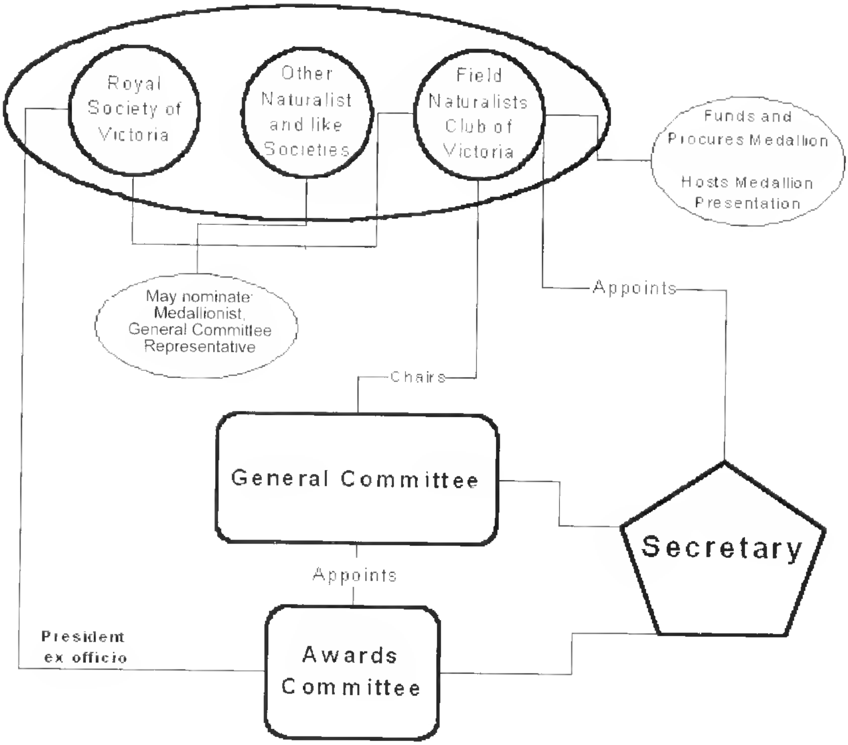

Fig. 1. Structure and roles for management of the Medallion

disciplines represented in Table 2 is greater than the number of Medallions awarded. Botany (28%) and Ornithology (29%) are far and away the subjects most represented, with all of the others having a similar proportion to each other.

There is no doubt that Victoria (55%) is over-represented when we consider the population of each State (Table 3). With the remainder, also on a population basis, South Australia is possibly more successful.

There are about 90 clubs and societies on the mailing list and each of them is eligible to nominate a representative to the General Committee and/or to nominate someone for the Medallion. Victoria (40%) is, again, grossly over-represented (Table 3). This is not deliberate but probably arises from better local knowledge and access to address lists of clubs that are in some way affiliated with the FNCV. There seems to be some sort of correlation when we compare Medallion winners by State with Nominating Societies by State. Some people might argue that as most Victorian societies are small, they are unlikely to make nominations. However, this argument does not explain the fact that most recipients are Victorian and the highest number of nominating societies come from Victoria.

To investigate this a little more deeply I have taken the data for the last eighteen years (1987–2004), that is, since the history was published, to show us more recent trends.

In percentage terms women have fared a little better, increasing from 12% to 22%.

If anything, botanists and ornithologists have increased their dominance of the Medallion (both at 35%) at the expense of anthropologists and earth scientists. More than half of the Medallions have been won by Victorians and the percentage is a little

Table 2. Medallions by Discipline (%). Other comprises conchology, ecology, herpetology, ichthyology. (As some Medallion winners have had multiple interests the number of disciplines represented is greater than the number of Medallions awarded).

	1940-2004	1987-2004
Anthropology	6	0
Botany	28	35
Education	7	4
Earth Science	7	0
Entomology	8	9
Mammalogy	6	9
Ornithology	29	35
Other	9	8

Table 3. Medallion Winners and Societies by State (%). Societies are those to which invitations are sent to nominate a person for the Award

	Winners 1940-2004	Winners 1987-2004	Society mailing list 2004
ACT	1.5	6	3.3
NSW	12.3	0	13.2
QLD	7.7	17	12.1
SA	10.8	6	12.1
NT	0	0	2.2
TAS	4.6	10	11
VIC	55.4	55	39.6
WA	7.7	6	6.6

Table 4. Successful Nominating Societies between 1987 and 2004. Number of Medallions.

Victoria	Australian Plants Society (Victoria)	2
	Bird Observers Club of Australia	2
	Field Naturalists Club of Victoria	2
	Victorian Ornithologists Research Group	2
	Entomological Society of Victoria	1
	Gould League of Victoria	1
Queensland	Entomological Society of Queensland	1
	Queensland Field Naturalists Club	1
Tasmania	Launceston Field Naturalists Club	2
ACT	Canberra Ornithologists Group	1
South Australia	Royal Society of South Australia	1
Western Australia	Western Australian Naturalists Club	1

Table 5 Number of Nominations each year (1999-2004). * indicates successful nominating societies.

	1999	2000	2001	2002	2003	2004
Launceston Field Naturalists Club*	**N**					
Wildlife Preservation Society of Australia	N	N				
The Queensland Naturalists Club*	**N**	N				
Geelong Field Naturalists Club	N	N				
Field Naturalists Society of South Australia	N	N				
Field Naturalists Club of Victoria*	**N**	N	N			
Western Australian Naturalists Club	N	N	N			
Entomological Society of Queensland	N	N	N			
Entomological Society of Victoria*		N	N	N		
Australian Plant Society (Victoria)		N	N	N		
Bird Observers Club of Australia			N	N	N	
Gould League of Victoria			N	N	N	
Field Naturalists Society of South Australia				N	N	N
The Queensland Naturalists Club					N	N
Canberra Ornithologists Club*					N	N
The Wetland Centre					N	N
Victorian Ornithological Research Group*					N	
Angair–Anglesey Aireys Inlet Society						N
Total Number of Nominations	8	9	7	5	7	5

higher in this later period with South Australia and New South Wales falling.

Both in the short and the long term botanists and ornithologists from Victoria have dominated the Australian Natural History Medallion. It is hard to believe that it is because Victoria breeds the best naturalists.

Part of the explanation lies in the fact that a small group of Victorian societies have been very active and very successful in promoting their members (Table 4). Four of them demonstrate their commitment by also serving on the General Committee.

To see if there is a lack of competition we can look at the nominations for the last six years (Table 5). The number of candidates has never been less than five candidates, and has been as high as nine. However, there are not a lot of additional nominating Societies to those that have been successful previously. Our catchment area is small and that is probably the main reason for our low national exposure.

A National Award

The General Committee has a desire for the Medallion to be truly seen as a national award. We have been patently unsuccessful in attracting press coverage even when we have had Vice-Regal patronage to present the Award.

Banksia and Eureka Awards and other environmental awards are better known through the media exposure they generate. We seem to have retained a very staid image, as do many field naturalist activities (whether it is true or not). The vasculum and butterfly net are still seen to be our symbols. That rather pleases me personally but it does not help in today's world.

The General Committee, and the Societies which its members represent, have before them the task of broadening the list of nominations and encouraging specific high-class candidates–and not just from their own Societies.

There is still a place for the Australian Natural History Medallion but we must work a little harder to maintain its prestige and status.

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Information subsequent to 1987 was obtained from the files of the Secretary of the ANHM General Committee: all but the most recent years of these are contained within the FNCV Archives. *The Victorian Naturalist* contains articles on many of the later Medallion winners, describing their natural history achievements.

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SGAP, Swaby and the FNCV

John Walter*

Abstract

Arthur Swaby was both a major player in the formation of the Society for Growing Australian Plants and an active member of the Field Naturlaists Club of Victoria. Swaby also wrote for the magazine *Your Garden*, which was instrumental in the formation of the SGAP. Other FNCV members who played a crucial role in these developments include Ivo Hammet and Ernest Lord. (*The Victorian Naturalist* **122** (6), 2005, 330-335)

I should preface this paper with a few comments regarding the structure of the Society for Growing Australian Plants. The Society was founded in Victoria as a single national society with the intention that regional groups be formed based on climate and vegetation. These regional groups quickly became state-based groups with each State taking on its own name and managing its own affairs. A percentage of the membership fee collected by each state body is forwarded to a national body, known as the Association of Societies for Growing Australian Plants (ASGAP). In recent years there has been a trend to 'modernise' the name of the State Societies to 'Australian Plants Society' to reflect the wider interests of the membership and reduce the formality of the name. In this paper, I am dealing with the formation of the original Society, and will therefore refer to the Society by its original acronym SGAP.

If you ask a member of SGAP who founded the Society, the odds are they will not know. Those that do know something of the formation will mention some fellow called Swaby and perhaps suggest that 'he wrote for *Your Garden*'.

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They are correct in that Swaby did write for the popular gardening magazine *Your Garden* but the roots of the foundation of SGAP go back many years before that magazine was first published. While Swaby is the recognized 'founder', there are many other members of the FNCV who played important roles in its formation, and the very existence of the FNCV provided a forum for the sharing of the ideas which led to SGAP.

Arthur James Swaby was born at Benalla in Victoria on 14 July 1887 to William Swaby and Ellen (née Bain). William was a foreman at the local flour mill[1] who made visits to the bush on his bicycle, sometimes with young Arthur as pillion passenger.[2] Arthur's formal education began at Benalla Primary School where he also taught as a monitor when only 14 years old. He gained the Diploma of Education at Melbourne Teachers College and subsequently spent his whole working life as a teacher, specializing in science subjects. He taught at several country schools including Yea until 1913, then taught successively at Essendon, Coburg and University High Schools before moving to Horsham High School in 1921.[3]

While at Horsham, Arthur met with Harold Smith (1877-1955), a local sawmiller, and the two made several excursions into the Black Ranges and the Grampians. Arthur could not afford a motor vehicle on his teaching salary but he was soon borrowing Harold's car for additional explorations of the district, including the Little Desert. As the friendship between the men grew, Harold and Arthur struck an agreement to build a cabin where they had access to their beloved wildflowers. Harold supplied the timber from his nearby mill and Arthur, having previously built the family home in Horsham, supplied the labour. Soon a cabin was erected close to the bridge in the area now known as Smiths Camping Ground near the outflow of Lake Wartook. The Swaby family regularly used this cabin in the holiday season even after they moved to Hampton at the end of 1927.[4] Harold Smith joined the FNCV in October 1927, around the time he discovered the Mt Byron Bush Pea, *Pultenaea patellifolia*. This discovery and communication with the FNCV led to the visit in 1930 by Herbert Williamson, then the FNCV's leading botanist who was researching the genus *Pultenaea*. Swaby also returned for this excursion into the Black Range.[6]

Swaby was Science Master at Hampton High School in 1928 and joined the FNCV on July 9 1928.[7] He became involved in the Club's Wildflower Show in his first year as a member and for many years afterwards was the show's chief organiser. Arthur Swaby was appointed to the position of Assistant Secretary and Assistant Librarian when Herbert Williamson died early in 1931.[8] The initial position was to support the Honorary Secretary, Mr Rodda, but the sudden death of Mr Rodda on 16 August 1931 threw Swaby into the position of Honorary Secretary. Swaby was in regular attendance at the meetings and usually brought along a specimen or two. Jim Willis wrote in his unpublished obituary of Swaby that:

> For years it was unusual for a monthly meeting of the F.N.C.V. to pass without some meaningful exhibit by Swaby, and the range of material presented (geological, plant, insect, mollusc, microscopical) attested the wide knowledge of the exhibitor. All his specimens were neatly labelled, with explanatory notes, for he always contended that no exhibit was worthwhile unless the viewer could easily grasp its significance – in fact, that the label was just as important as the rock, fern or cocoon it accompanied.[9]

Swaby had his differences with the FNCV Council but managed to serve as both Vice President and President in subsequent years as well as serving on a number of the Club's advisory committees, including the Heathland Flora Reserve Sub-Committee and the Maranoa Gardens Advisory Committee. Joining Swaby on the Maranoa Gardens Advisory Committee in 1947 were two men who would also play a large part in the formation of SGAP, Ivo Hammet and Ernest E Lord.[10]

Ivo Charles Hammet (1896-1975) had a lifelong interest in books. The knowledge therein had a lasting impact on his life as his daughter Irma Chelmsworth recalled in a letter to Esma Salkin in 1981. Salkin's summary of the letter records:

> [his] motivation to grow native plants was stimulated by reports in journals of early

> exploration, papers etc., in his renowned library of Australiana. Of particular interest were the accurate and detailed observations of the French exploration. After reading these documents he had an intense desire to save the remaining flora and made many trips to the Little Desert collecting plants. In the twenties and thirties any one growing native plants was considered odd, because the fine foliage of natives was in direct contrast to the heavy foliage of plants normally grown.[11]

Hammet joined the FNCV on 8 September 1930[12] and was on the Council from 1940 to 1948, taking on the role of President during the year 1944-45. His Presidential Address was titled 'Preserving our Flora' and the minutes record that Hammet was:

> basing his remarks on his own experience in propagating Australian Flora in his Ivanhoe garden. He stressed the fact that as the native flora disappears so do the birds and insects, and in many cases erosion takes place. He instanced cases of the Wattle dying out at Wattle Glen, and the disappearance of the Sandringham flora. The only way to prevent the total disappearance of many of our native plants is by the cultivation of them in home gardens, and already a move in this direction has taken place with a number of our native species being offered for sale by nurserymen. This list should be increased, as more becomes known of their growth habits from experiments made under cultivation.[13]

Ernest Edward Lord (1899-1970) is perhaps best known for his book *Shrubs and Trees for Australian Gardens* (1948). He joined the FNCV on 8 February 1932[14] and no doubt quickly became acquainted with Swaby. Lord was elected to the committee of the FNCV in 1942 and served continuously until 1954, first as Treasurer, and later as President for two terms. In both his Presidential Addresses he tried to prepare the FNCV for the future he saw for Australia with rapid increases in population and increased pressure on the environment. The following extract from his June 1951 address records his views clearly.

> Let us for a moment look at Australia's 150 years' record from the viewpoint of Natural History. ... Wholesale forest destruction to clear land for grazing and cropping and for timber supplies, with until just recently, no thought whatever of replanting or provision against erosion. ... We are short of electric power, short of gas, short of coal, short of water in a dry season. Above all, Australia has one desperate need: population. ...
>
> What does all this mean when added up? It means that every bit of country that can possibly be made to produce food, clothing and housing requirements must be opened up.
>
> How are we concerned as field naturalists? As individuals, if we are honest with ourselves, very little. So long as we can get an outing in the bushlands that remain, and collect a bit of whatever we are interested in to add to our own personal knowledge on these things, we are content. What does it matter to us individually if 1000 acres have been lopped off a national park for tobacco culture; if the Mallee Fowl or a rare Boronia have become extinct? ...
>
> But as a Club we have a very real concern in such matters. And a club is no more than the sum of its members. If we evade or neglect such responsibilities we have no right to be a Naturalists' Club. ... The period of discovery and description of new species is tapering off – for Victoria at any rate – and the period of the great battle for preservation of what natural history remains is rapidly becoming the supremely important duty of every truly Australian organization.[15]

Swaby had long been expressing his love for the Australian landscape and his understanding of the need for its conservation. In an undated letter believed to have been written in the late 1930s to support Mr Hyam's effort to establish the Council for the Preservation of National Monuments as an influential body, Swaby states that

> Our Association [Council for the Preservation of National Monuments] regards Australia not merely as the soil on which our passing generation is planted to wrest from it as much as possible while we can; but as a going and growing concern in which soil and people are related and interdependent, continuous through the ages and capable of rising to height of which few dream today. While we must cultivate a spirit of tolerance and cooperation toward other lands and peoples, it is imperative that we do nothing to check the grow-

ing pride in our community and its distinctive possessions. …

The dedication of national monuments – natural and historic – is not for our benefit alone. We have to think of the coming generation and to teach them to think of the future. We must set apart objects and places typical of the early days of each locality – something tangible round which community interest may cluster. Every settlement has something distinctive. Some localities have priceless features.

What we, as an association, should do is to fix upon as many of these features as possible and cultivate in the present and rising generations a habit of regarding these things as ours to enjoy and hand on unimpaired – those magnificent red gums along the river or creek, … those bulokes, wattles, or mallee in that lane, … the spring gold of the bank yonder, the wonderful freshness of that hill of broom in the Mallee in January, … the lookout rocks, the fern gully.

As a people we have been too much bent on destruction. In the race to put every acre under cultivation, we have forgotten that man does not live by bread alone. We are singularly blind to the beauty of the countryside and the intrinsic interest therein.[16]

In 1946, another letter from Swaby to the FNCV Council attracted the following response in the minutes:

The Committee endorsed Mr. Swaby's view that some reasonably large and representative area of the Bayside Heathlands should be permanently reserved and that a section of the reservation be maintained in an Australian Garden which would form an adjunct to the Melbourne Botanic Gardens. In the event of a suitable and sufficiently large area of the Sandringham Heathlands being unobtainable (a not unlikely possibility in view of the closely settled nature of the area …) the Government should be persuaded to examine the practicability of reserving some large tract of heathland in the Frankston, Cranbourne – Piercedale (sic) triangle.[17]

While Swaby was not alone in his opinion, he was in communication with the Trustees of the Maud Gibson Trust via the trust advisory committee members John S Turner of Melbourne University Botany Department and Sir Russell Grimwade. Turner was a member of the FNCV and Grimwade was made an honorary member in 1953. Soon afterwards the Trust was committed to the creation of such an annexe and began looking for land in that region.[18]

According to Willis, Swaby was instrumental in establishing the Botany Discussion Group in 1946 and was its first chairman; presenting a series of lectures in elemental botany to the group members.[19] In 1947 soon after he was elected Vice President of the Club he was involved in the formation of the Marine Biology Group where he lectured on elemental biology.[20] It was the formation of yet another group in 1947 that concerns us. The President announced in October 1947 that the FNCV had decided to form a group of those members interested in the cultivation of our Native Plants. Interested members were invited to leave their names with Miss Adams and the resulting list included Mr Hammet, Mr Seaton, Mr Lord, Mr AJ Swaby, Mr J Ros Garnet, Mr and Mrs P Fisch and Mr Schubert.[21] It was this group, known as the Wildflower Garden Section, which became the nucleus of the Society for Growing Australian Plants when it was formed 10 years later.[22]

One of its members, John Stoker 'Jack' Seaton (1906-1982) began growing a few natives in the 1930's. He told Esma Salkin that:

Ivo Hammet and Bert Hargraves were interested in them then. We weren't growing many. We were regarded as cranks. On holidays to South Australia I visited Kangaroo Island and made many trips to Adelaide where I visited Payne's garden in Torrensville and visited the Burdett garden at Basket Range. The Burdett garden was terraced on a hill and was one of the best wildflower gardens in Australia in the 1930's.[23]

Seaton joined the FNCV in 1946[24] and immediately became a regular contributor to the specimens produced at meetings.

In December 1947 the first issue of *Your Garden* was published with Ernest Lord as the founding Editor. This issue contained a number of articles by FNCV members, including an article on the culture of native shrubs by George Althofer,[25] another on the culture of native orchids by J Ros Garnett and the first of a series of articles titled 'Simple Studies in Plant Life' written by 'AJS' who was, of course, Arthur James Swaby. Over the next two years *Your Garden* carried 14 articles by Swaby, 13 by Althofer as well as several by Garnet. In January 1950 Lord was replaced as Editor and Swaby, Althofer and the others soon disappeared from its pages, however, Lord had made the name Swaby known to the publishers who would soon call on Swaby for a much larger role in the magazine.

Meanwhile the Maud Gibson Trust employed Seaton in 1948 as a correspondent to enable contact with amateur gardeners growing native plants. Russell Grimwade had successfully argued that the Trust employ a professional plant breeder to work on the culture and improvement of native flora. The plan was for Seaton to gather seeds and plant material from the amateur growers and Schubert's Nursery was engaged to begin the propagation. They would then be grown in trial plots in the Observatory Grounds next to the Botanic Gardens with the ultimate aim of establishing Australian Wildflowers in public and private gardens. While this proposal suited the objectives of the Wildflower Garden Section, it proved to be short-lived due to the lack of propagation material.[26]

Swaby made a return to the pages of *Your Garden* in the June 1954 issue with his series of articles titled 'Know Your Natives' which ran for 6 years. In this first article Swaby notes that '*the possibility of forming some association of growers is worth considering*'.[27] The idea of an association quickly caught on, and the foundation meeting of the 'Australian Growers of Australians' was held on 12 March 1957. Perhaps inspired by the success of J Ros Garnet and Winifred Waddell in taking committee's of the FNCV to the wider world, Swaby ensured that the executive of the new association were all from the Wildflower Garden Section of the FNCV with Hammet as President, Seaton and Schubert as Vice Presidents, Miss Butchart as Treasurer and Mr. Pow as Secretary.[28] Garnet and Lord were both very active members and Mrs Fisch soon took on the role of Newsletter Editor, although the bulk of the membership of 451 was made up of readers of *Your Garden*.

The name was soon changed from Australian Growers of Australians to the Society for Growing Australian Plants, but not before some amusing correspondence between Swaby and Professor John Turner from Melbourne University Botany Department. Turner commented that while AGA was a good abbreviation the full title could almost apply to any Australian parent.[29] Swaby replied that 'Parentage and Stock Breeding had also occurred to him as possible interpretations and it would be a mixup if the idea of eugenics or test tube babies got abroad. In fact it would be nearly as bad as suspecting the very modest Field Naturalists of nudism.'[30]

SGAP went on to become the largest Horticultural Society in Australia with over 9000 members, but along the way it lost its founder who resigned in 1962, a disappointed man. Why would anybody be disappointed with what could only be described as a resounding success? The answer is simple when you come to know Arthur Swaby. He sought to create a small dedicated scientific research organisation whose aim was to bring more native species into cultivation in order to save them from destruction. He believed that instead he got a garden club only interested in growing the same old things.[31] Many years later the Study Groups formed within SGAP would become extremely successful at achieving Swaby's goal, and some individual members have been outstanding for their work in bringing native species into cultivation, but that is another story.

Arthur Swaby was made an Honorary Life Member of the FNCV in 1968 after 40 years of continuous membership,[32] and reluctantly accepted an Honorary Life Membership at the insistence of the SGAP Committee when his resignation became known.[33] He died on 20 October 1979 at the age of 92. Finally, it is perhaps worth noting that the SGAP Victoria *Newsletter* published a mere 80 words detailing the death of its founder Arthur Swaby[34], while *The Victorian Naturalist* carried a 1200 word obituary written by Ros Garnet[35]. Jim Willis wrote, but never published, a further tribute of 1500 words.[36] The national body ASGAP, however, does recognise Arthur James Swaby at its bi-annual conferences where the keynote address is titled the 'A J

Swaby Memorial Address'. Perhaps the membership of SGAP will have a greater appreciation of their founder and the role played by the FNCV in their society's formation, after the publication of a comprehensive history during their upcoming 50th anniversary in 2007.

Notes

[1] Interview of Bernard Swaby (grandson of Arthur Swaby) by John Walter (Feb 2004)
[2] Interview of Les Swaby (son of Arthur Swaby) by Esma Salkin (1979)
[3] Willis, JH (1979, unpublished) *A tribute to Arthur James Swaby (1887-1979)*. Royal Botanic Gardens Melbourne archives, MSS 316
[4] Bernard Swaby, *op.cit.*
[5] FNCV Membership records
[6] JH Willis, *op.cit.*
[7] FNCV Membership records
[8] Letter from Mr. Rodda to Arthur Swaby 25/2/1931 advising his appointment. Copy in FNCV File 047-034
[9] JH Willis, *op.cit.*
[10] Minutes FNCV Committee Meeting 29/4/1947
[11] Summary of correspondence by Irma Chelmsworth to Esma Salkin. Salkin, Esma (1981) *Know your Natives – The Native Garden Movement in Melbourne from the 1920's to 1960's*. (BA thesis Monash University)
[12] FNCV Membership records
[13] Minutes FNCV Annual General Meeting 11 June 1945
[14] FNCV Membership records
[15] Transcript of Presidential Address delivered June 1951 by EE Lord, reprinted in the *The Victorian Naturalist* **68**, 1951, 41-42
[16] Undated letter from Arthur Swaby to Mr Hyam, FNCV Hyam File
[17] Minutes FNCV Committee Meeting 27 August 1947
[18] Twigg, K. (1996) *A Vision Shared – The Maud Gibson Trust 1945-1995* (South Yarra: Maud Gibson Trust) p.41
[19] JH Willis, op.cit.
[20] 68th FNCV Annual Report reprinted in *The Victorian Naturalist* **65**, 1948, 54
[21] Minutes FNCV Committee Meeting 13 October 1947
[22] Readers should not confuse the Wildflower Garden Section with the Wildflower Preservation Group which was established by Winifred Waddell two years later in 1949 and led to the formation of the Native Plants Preservation Society in 1952.
[23] Interview of Jack Seaton by Esma Salkin (July 1980) William Burdett was a member of the FNCV and contributed each year to the Club's shows. Frederick Cyril Payne later established a nursery and display garden at Athelstone in Adelaide in South Australia. This garden was later incorporated into the Black Hill Conservation Park.
[24] FNCV Membership records
[25] George Althofer established Nindethana Nursery near Wellington in NSW in 1938 and later founded Burrendong Arboretum.
[26] Maud Gibson Trust Committee Minutes in Twigg *op. cit.* pp. 37-38.
[27] *Your Garden - Know Your Natives* June 1954, 4
[28] Minutes of the Inaugural Meeting of the Australian Growers of Australians, Australian Plants Society (SGAP Vic) archives
[29] Letter from JS Turner to AJ Swaby 4 March 1957, University of Melbourne Archives Turner Collection Box 25B File TURN00231
[30] Letter from AJ Swaby to JS Turner 7 March 1957 University of Melbourne Archives Turner Collection Box 25B File TURN00231
[31] Letter from Arthur Swaby to Enid Bowman, Secretary of SGAP 10/9/1962, Australian Plants Society (SGAP Vic) archives
[32] Records of General Meeting 8 July 1968, reprinted in *The Victorian Naturalist*, **85** (1968), 238-239.
[33] Letters dated 15 March 1963 and 19 March 1963 from AJ Swaby to Sister Bowman, Secretary of SGAP South East Region
[34] SGAP Victoria *Newsletter* – Dec 1979, p 5
[35] Obituary of AJ Swaby by J Ros Garnet – *The Victorian Naturalist* **97** (1980), 33-34
[36] JH Willis, op.cit.

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The organising Committee for the History Symposium. Left to right: Mimi Pohl, Anne Morton, Sheila Houghton, Gary Presland, Alan Yen.

The FNCV and the VNPA

Malcolm Calder[1]

Abstract

The Field Naturalists Club of Victoria became the 'parent' body of a number of other groups, including the Victorian National Parks Association (VNPA). Beginning in the latter part of the 19th century there was a popular movement to reserve areas of particular natural value. In Victoria members of FNCV were particularly active in this movement, leading to the formation of VNPA in 1953.
(*The Victorian Naturalist* **122** (6), 2005, 336-339)

Introduction

In the beginning there was the Field Naturalists Club of Victoria (FNCV). Today, along with the FNCV, there are many organisations covering the interests of natural history, fauna and flora, conservation and environment, field studies, geology and landscape, intertidal and marine biology, and so on.

The FNCV has been the nurturing parent of many of the more specialised societies and organisations now thriving in Victoria. In this short paper, I look at the role of the FNCV in the establishment of community interests in National Parks and the formation of the Victorian National Parks Association.

To do this I am going to follow, fairly superficially, three historical threads that have been running in parallel or intertwined with the thread of the history of the FNCV. The first of these threads is the global history of the National Park movement. The second is the thread of the biological/earth/ecological sciences. The third thread is the socio/political/economic thread of the State of Victoria.

Global History of National Parks

The concept of National Parks arose in America with the creation of Yellowstone (1872) and Yosemite (1890) National Parks (Nash 1990). Much earlier, in the 1860s, groves of Redwoods had been reserved in the Yosemite Valley as a nature reserve - the first legislated reserve dedicated to the protection of a native species in the wild. This was the 'New World', a pioneering community, where people and governments recognised the value of grand nature and the natural environment. The motivation for these foundation national parks was very human centred. It was recognised that they had both a recreational and spiritual value to the people; visitation would be uplifting and would benefit the people. The areas were permanently reserved to ensure their perpetual survival as a national icon for future generations to enjoy. The notion of environmental conservation was not a major factor.

At this time Australia was another pioneering community, converting a natural 'wilderness' to create a productive agricultural economy. In the 1860s the earliest signs of public concern over the rapid advance of land clearing were being expressed. In 1865 *The Argus* in Melbourne reported:

> Over and over again we have urged that steps should be taken to protect our forest lands, not only because extravagance will lead to scarcity, but also because the local climate will be affected in all those places where the forests are removed. In protecting the forests ... we prevent waste of soil, we conserve the natural streams, and it is not improbable that we prevent decrease in rainfall.

(This is a message we still need to hear).

There was no real concern here about nature conservation, but a distinct self-interest in protecting resources of timber and soil, and concern for the potential climatic effect of forest clearing.

With time, the notion of National Parks reserved for human recreation and spiritual experience moved also to the recognition of these areas as vital for the protection of nature. More and more they became areas for nature conservation, habitat protection, education and research as well as recreation. This was especially so in the parts of the world where European settlement was advancing–the USA, Australia, Southern Africa, Canada and, later, South America. In Europe, including Great Britain, there was limited opportunity for the creation of

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large tracts of public land as National Parks. As a consequence, National Parks in Europe are largely areas of special landscape quality where planning and management strive to retain both traditional and conservative forms of land management.

In Victoria the first area declared a National Park was the volcanic cone of Tower Hill, initially reserved in 1866 but given National Park status in 1892 (Frankenberg 1971). In essence it was a game reserve and the local Acclimatisation Society introduced goats, jungle-fowl and rabbits. 1882 saw the reservation of Fern Tree Gully as a Recreational Reserve, while Wilson's Promontory and Mount Buffalo were reserved in 1898 and declared National Parks in 1905 (Gillbank 1998; Houghton 1998). Clearly, the last two decades of the nineteenth century was an active period in the development of National Parks in Victoria and coincides with the formation and early influence of the young Field Naturalists Club of Victoria.

Today our National Parks have dramatically increased in area and number, and have a diversity of functions including nature conservation, environmental protection, education and research and passive recreation. Management comes under the broad responsibility of Parks Victoria under policies established by the Director of National Parks within the Department of Sustainability and Environment.

From the formation of the FNCV in 1880 through to the first decade of the 20th century, members were extremely active in promoting the concept of National Parks as a means of protecting the natural environment and providing opportunities for people to experience and understand the plants and animals of Australia. Senior members of the FNCV such as JB Gregory and AHS Lucas, along with influential academics and administrators, had the necessary connections into government to advance the cause of National Parks. The FNCV was the primary advocate. As we will see, circumstances between 1910 and 1945 did not provide for nature conservation and National Parks to be high on the State agenda.

Biological/Earth/Ecological sciences thread

At the time of the establishment of the FNCV, the scientific world in Australia was very much taken up with discovering the great diversity of the plants and animals that occupied this land, as well as describing the geology. Gold fever was subsiding and the great depression of the 'nineties was imminent. Both professional and amateur scientists were active and interested in their new environment, and recognised the need for a recreational and rewarding outlet for the study of nature and the documentation of their discoveries. So the FNCV was formed.

Biological sciences at the time were very much at the descriptive stage here, responding to the unusual nature of our flora and fauna and the great interest from overseas in what was being discovered. There seemed to be so many unusual and unlikely species to be discovered. Collecting, describing and cataloguing was the *modus operandi* and many new and important discoveries were made by members of the FNCV.

Internationally, the biological sciences were moving from the descriptive phase to the more analytical aspects of plant and animal form and function. But most significantly, the early years of the 20th century saw the growth of the science of ecology. Out of this grew the recognition of the interdependence of plants and animals and their associations in distinct communities. Plant and animal species existed within complex habitats and together made up complex communities. This science of ecology had its foundation in the United States, although it has been argued that its roots are European (Carpenter 1938). Once founded, however, the science spread rapidly to other parts of the world.

By the 1930s and '40s, Australian biologists, foresters and agriculturalists had embraced the new science of ecology. The concept of the ecosystem emerged as an ecological entity involving the plants and animals growing in an area as well as the soil, the base rock formation and the climate within which they existed. The ecosystem brings together all these elements and recognises the interdependence of species within it. Recognising ecosystems and communities provides an objective basis for recognising the fundamental units within National Parks. Looking through the contents pages of *The Victorian Naturalist* it is clear that the members of the FNCV, led by Philip Crosbie Morrison, embraced the relatively new science of ecology, recognising the significance of community and habitat and the need to protect these if biological conservation was to be effective. Ecology became the foundation of natural history and strengthened the case for National Parks.

Socio/Political/Economic thread

In this section I will be very brief, since I have no authority or qualification to deal with it in any depth. Nonetheless, it is interesting to consider the aspects of local and world events as they impact on the natural history movement in Victoria. Furthermore, history shows that decisions regarding National Parks are made by governments only when there is strong community pressure, and that community pressure is influenced by the overall wellbeing of the population.

Through its history, Victoria has experienced periods of economic depression and economic prosperity. Victorians have been involved in several overseas conflicts, particularly World War I and World War II. There have been governments with varying views on rural development and environmental protection, with different policies on land and water management, with different views on public and private expenditure. Against this background of change, the FNCV and others with interests in natural history and environment have had to operate generally as a hobby interest carried out in the evenings and at weekends.

It seems to this writer that such hobby interests are very sensitive to variations in the social, political and especially the economic environment of the day. The history of the FNCV seems to support this conclusion, as does the evidence provided by the establishment of National Parks in Victoria. It can be seen that the periods of greatest activity in the efforts which culminated in the establishment of the first National Parks were in the 1880s and '90s and the early decades of the 20th century. The period before World War I and between the Wars was a period of little activity for establishing National Parks. Our minds were concerned with other things.

During World War II, Crosbie Morrison, Ros Garnet and the Council of the FNCV were very active in developing the case for more habitat conservation in National Parks. From 1945 through to 1952/1953 they worked at all levels of government and the community to build a powerful case for National Parks. Their view was that the greatest impact would be achieved with the establishment of a National Parks Association and a National Parks Authority. Both Morrison and Garnet held executive positions in the FNCV during these years and were the strongest supporters of the formation of the Victorian National Parks Association to act as a strong advocate and lobbyist for National Parks in Victoria.

FNCV and VNPA

Gillbank (2005) has provided a general timetable of the actions that occurred within the FNCV, leading ultimately to the reservation of land as National Park:

1) Ramble with collection and documentation
2) Talk and exhibits at a Club meeting
3) Publication in *The Victorian Naturalist*
4) An organised club survey
5) A public meeting
6) Letters and deputation to Government Ministers
7) Reservation

The history of National Park reservation in Victoria certainly supports this timetable and I will quickly follow this chronology. But the formation of the VNPA mark II is rather more complex.

Our story starts in 1936 when the FNCV formed its 'National Monuments and National Parks' sub-committee. At this time there was strong recognition of the importance of habitat protection for the survival of species. FNCV member Crosbie Morrison and J Ros Garnet, among others were publicly active in raising the need for greater effort for National Parks. They worked in close association with the Victorian Advisory Council for Flora and Fauna to lobby for the cause.

However, the 1939 fires and the advent of World War II intervened. In 1944 the FNCV was one of 37 organisations supporting the foundation of the 'Save the Forests Campaign' and eventually the Natural Resources Conservation League.

In June 1946 the FNCV convened a conference attended by representatives of many conservation-minded organisations all expressing grave concern about the failure of current management in National Parks. Crosbie Morrison was elected Chairman of the Conference, which continued to develop its case for a number of years. The Conference was reconvened in 1948 and adopted a report seeking the creation of a permanent, adequately funded Authority, responsible for the management of all National Parks, with power to recommend acquisition of any new areas that should be reserved. In early 1949 a deputation to the Victorian Government, lead by Morrison and Garnet, presented 'National Parks Plan for Victoria' (Hyam, *et al.* 1949). Later, this standing Committee had a meeting with the Premier TT Holloway and members of his cabinet. In 1951, the State Government endorsed many of the recommendations but there followed several years of political turmoil in the State and several changes of Government. Eventually, in 1957, a National Parks Act establishing a National Parks Authority was passed. Crosbie Morrison was appointed the first Director of National Parks (Pizzey, 1992).

In 1952 the VNPA was established, essentially to represent and carry forward the views and the functions of the 1946 Conference. Morrison was the first President and Garnet the Secretary. This new body was launched in the Lower Melbourne Town Hall on July 23 1953 (Garnet 1953). So another child of the FNCV was born, with strong parental blessing and support. The rest is, as they say, history.

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Junior field naturalists finding Graptolites, May 2004. Photo: Wendy Clark.

Changes in the content of *The Victorian Naturalist* between 1884 and 2004

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Abstract

A survey was made of changes in the content of *The Victorian Naturalist* between 1884 and 2004. Every second odd volume was censused and articles were divided into categories according to the purpose for which they were written, the approach that the author took, and their topic. Several main factors appeared to alter journal content over time: the development of ecology and conservation biology as scientific disciplines; editorial influence; and the appearance and disappearance of prolific authors. Special issues also created content peaks in their subject areas, and the birth and senescence of other local natural history publications may have had some bearing on content changes. The effects of the two World Wars appeared to be minimal. (*The Victorian Naturalist* **122** (6) 2005, 340-348)

Introduction

The content of any scientific journal is influenced by prevailing social and academic conditions. Interactions between science and culture cause shifts in theoretical paradigms, allow development of new equipment and techniques, and can modify community values. These factors inevitably are expressed in science writing, and temporal changes therefore will occur in the form, approach and tenor of journal articles. *The Victorian Naturalist* makes a particularly interesting subject for a 'time slice' study of its contents. It has been published since 1884, accepts a broad range of contributions based around the theme of natural history, and has always featured an eclectic mixture of professional and amateur contributions.

Variation in the ratio of amateur and professional contributions over *The Victorian Naturalist*'s history may be one factor influencing content changes. Usually, amateur scientific writing is not as compliant with academic conventions as that of professionals, nor is it as likely to be influenced by scholarly fads and schools of thought. If there have been changes in the relative numbers of professional and amateur articles, this stylistic difference could be manifested by changes in the approach taken by authors to natural history study and the purposes for which they write articles. But this pattern would probably be difficult to distil from publication trend data because there is considerable crossover between amateur and professional scientific contributions. This is especially true of scientific writing produced in the early 20th century, before the modern growth in occupational specialisation.

The influence of individuals or small groups may have produced significant changes over time in the content of *The Victorian Naturalist*. One way this could occur is through the influence of the editor or editorial committee (Sheila Houghton, pers. comm.). An editor's vision for the journal potentially shapes the type of material either solicited or accepted from contributors. For example, Norman Wakefield (editor 1953–1957, 1958–1964) wished to make *The Victorian Naturalist* a more informal publication containing a greater number of general interest articles (Houghton and Presland 2005).

The content of *The Victorian Naturalist* may have been influenced over time by the birth and senescence of other natural history publications. Local publications that have overlapped with *The Victorian Naturalist* on a broad range of topics include: *Transactions and Proceedings of the Royal Society of Victoria* (1865–1888), which became *Proceedings of the Royal Society of Victoria* (1889–present); *Wild Life* (1938–1954); *Emu* (1901–present); *Australian Journal of Zoology* (1953–present); *Australian Journal of Botany* (1953–present); *Muelleria* (1955–present); *Australian Journal of Entomology* (1962–present, formerly *Journal of the Entomological Society of Australia*); *Austral Ecology* (1976–present, formerly *Australian Journal of Ecology*); *Wildlife*

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Research[*] (1977–present); and *Australian Systematic Botany* (1988–present).

Changes in the group potentially contributing to *The Victorian Naturalist* can also alter its contents over time. Death, recruitment and retirement are demographic processes affecting the output of all disciplines. Some naturalists also entered the defence forces during World War I (1914–1918) and World War II (1939–1945), which could have reduced content during the wars in one or more subject areas, or created a number of overseas and northern Australian correspondents placing their natural history observations in *The Victorian Naturalist* (e.g. Lothian 1944; Givens 1945).

There are likely to be effects on the content of *The Victorian Naturalist* resulting from scientific developments in conservation biology and ecology. First, an increase should be seen in articles concerned with these subjects from around the 1960s onwards when these disciplines developed a more tangible identity and following. Many statistical and quantitative survey techniques have developed alongside ecology, so an increase could be expected in articles that test hypotheses and use quantitative methods to describe results.

This study was performed to examine the influence that various scientific and social factors may have had on the content of *The Victorian Naturalist* between 1884 and 2004. In particular, the effect of demographics among individual contributors, editorial approach, rival publications, war, and development in the fields of ecology and conservation biology were examined.

Methods

Every second odd volume was censused (e.g. Vol 1, 5, 9 ... 121) and articles were identified as eligible or ineligible for consideration by this study according to a list of criteria.

Eligible items were:

- Original observations and research.
- Reviews of known information on particular subjects.
- Instruction on technical subjects, such as taxidermy.
- Descriptions of collecting trips, naturalists' vacations, or observations made whilst away from home for another reason (e.g. defence force service).
- Reprinted articles from other publications (these appeared so occasionally that they could not skew results, and reprints were also considered representative of content, although they had appeared elsewhere).
- Spoken papers delivered before the FNCV, if these comprised a paper rather than a summary of a speech given by the author or another person.

Ineligible items were:

- FNCV excursion reports (these were excluded because they are numerous and usually touch superficially on a wide variety of subjects. This could overwhelm some of the more subtle trends).
- Summaries of speeches given at the FNCV, or elsewhere.
- Presidential reports, meeting reports, SIG reports, exhibition reports, Conversaziones, and other proceedings of the FNCV, or other society.
- Book reviews.
- Letters or questions to the editor, editorials.
- Obituaries.
- Submissions to government.

There was no minimum length requirement for articles. Each part of a series of articles or each part of a continued article was treated as a separate item because each part often focused on a different subject matter. Institutional affiliations (including honorary appointments), author surnames, and number of pages per volume were recorded from eligible articles.

Categories of eligible articles

Eligible articles were categorised at each of three levels, although they were listed in multiple categories if they fulfilled the requirements of more than one purpose, approach or topic. Categories are listed below:

Category level 1: Purpose

- Non club trip (article based on a collecting trip, scientific expedition, naturalist's vacation, or defence force service).
- History (historical people, scientific disciplines, events and places).
- Technical (instructions and methodology on animal husbandry, plant cultivation,

[*] First published as *CSIRO Wildlife Research* and formerly known as *Australian Wildlife Research*

preservation / collection of specimens, conservation methodology).
- Scientific exposition (research, observation, scientific policy discussion).

Category level 2: Approach
- Natural history (reviews of current knowledge, distribution records, behavioural or cultural observations, original research that is largely qualitative and not subject to statistical analysis, experimental design, or hypothesis testing).
- Hypothesis testing, survey and analysis (research that is usually largely quantitative, and incorporates an experimental or survey design, or chemical analysis).
- Description (policy discussion, historical narrative).
- Taxonomy, systematics and morphology (descriptions of new species, taxonomic relationships, morphological data).
- Mixed approach (work that takes more than one of the approaches listed above).

Category level 3: Topic
- Vascular plants.
- Non-vascular plants.
- Fungi.
- Birds.
- Mammals.
- Anthropology.
- Geology.
- Microscopy.
- Insects.
- Spiders.
- Molluscs.
- Crustacea.
- Other invertebrates.
- Ecology.
- Conservation.
- Plant palaeontology.
- Vertebrate palaeontology.
- Invertebrate palaeontology.
- Reptiles.
- Amphibians.
- Fish.
- History (people, places, events, excluding history of scientific disciplines – these articles are in the topic area of their discipline).
- Mixed (more than one topic listed above).
- Other (topic not listed above).

Analysis

For every volume censused, the number of eligible articles in each category was converted to a percentage of the total eligible articles in the volume. These percentages were then plotted against year of publication. The number of pages in each volume, the number of eligible articles in each volume, and the percentage of eligible articles where at least one author was associated with an institution also were plotted against year of publication.

Results and Discussion

The trends over time for all variables examined usually showed no pattern, and caution must therefore be used in interpreting the results. This is especially true because no statistical hypothesis testing was done, and analyses are therefore subjective.

The dimensions of *The Victorian Naturalist* have remained reasonably constant over its history, which made it possible to compare the number of pages and articles over time. The page number varied considerably between volumes (mean = 240, SE ± 12; Fig. 1). There appears to have been an overall increase over time in the number of pages, although the number of eligible articles has fluctuated between 13 and 97, and shows little apparent increase over time (mean = 45, SE ± 3; Fig. 1). There are no apparent wartime effects on either the number of pages or the number of eligible articles.

Articles where at least one author had an institutional affiliation increased over time (Fig. 2). This is a crude way of measuring the ratio of professional to amateur input, and must be interpreted cautiously because many of the earlier authors with institutional affiliations did not always record them (e.g. Ferdinand von Mueller, David Fleay), and it was only possible to count professional addresses for authors whose affiliations were well known. Today, professional bodies are far more strict about ensuring that their address is recorded on work produced under their auspices. It is also possible that the small size of the scientific community in the first part of the 20th century allowed workers to assume that others would know their affiliations.

Category level 1: Purpose

Scientific expositions have always accounted for over 50% of eligible articles. But there are two steep drops in the percentage of scientific expositions that corre-

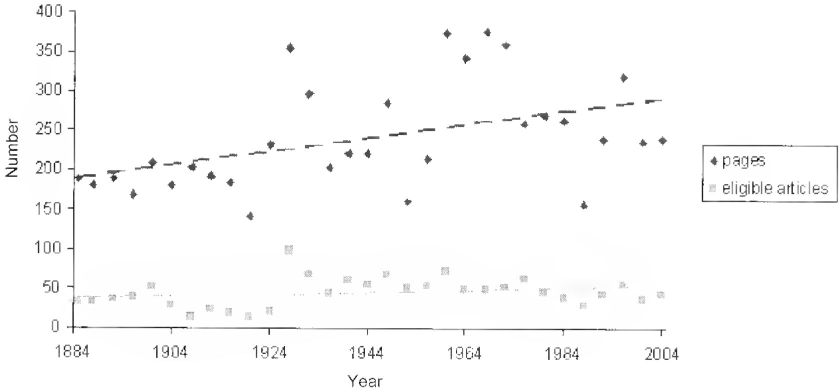

Fig. 1. Variation over time within *The Victorian Naturalist* in page numbers per volume and articles eligible for consideration in this study.

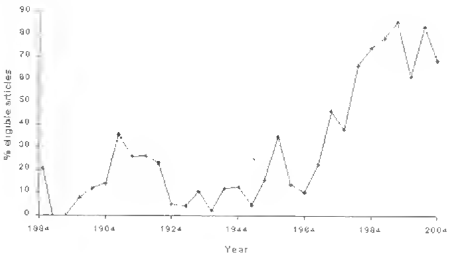

Fig. 2. Percentage of eligible articles in censused volumes of *The Victorian Naturalist* where at least one author was associated with an institution.

spond with peaks in the percentage of eligible articles written for other purposes. The first was a peak of 45% in the number of non-club trips in 1924, and the second was a peak of 42% in the number of history articles in 1996 because of the Vol. 113(4) special issue of *The Victorian Naturalist* on Baron von Mueller. Articles describing non-club trips were the subject of between 6 and 45% of eligible articles until 1924, when there was a drastic decline in this category. The category has since constituted less than 10% of articles in subsequent years.

Technical articles have accounted for less than 10% of eligible articles throughout most of *The Victorian Naturalist*'s history. However, there was a peak in technical articles of 10-14% between 1960 and 1968. These were mainly concerned with microscopy, and are likely to have been prompted by the incorporation of the Microscopical Society of Victoria into the FNCV (c. 1960). There was a further sharp peak of 26% in technical articles during 1992 because of a special issue Vol. 109 (4) on vegetation corridors in Victoria. This contained many articles describing the methodology employed in various conservation programs.

Category level 2: Approach

There was a sharp drop in articles using a taxonomic, systematic and/or morphological approach during Wakefield's editorship (Fig. 3), perhaps due partly to his belief that other journals catered for the needs of professional scientists (Houghton and Presland 2005). A selection of local professional botany and zoology journals were founded around this time and, along with *The Proceedings of the Royal Society of Victoria*, may have been the recipients of any redirected taxonomic work. Most articles that took a mixed approach were primarily taxonomic, systematic and/or morphological, but also incorporated some natural history observations (e.g. species distribution or plant habitat observations). This may be why the mixed approach trendline sometimes follows approximately that of taxonomic contributions (Fig. 3).

Natural history has always been the predominant approach taken by authors in *The Victorian Naturalist*. The percentage of natural history articles has fluctuated

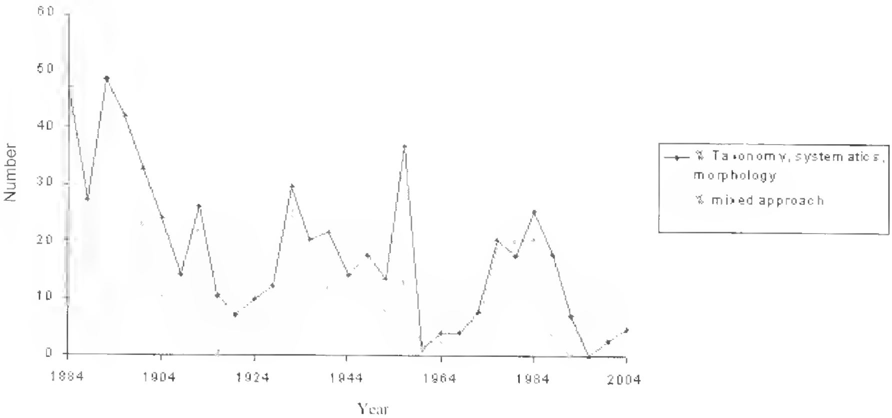

Fig. 3. Percentage of eligible articles in each censused volume of *The Victorian Naturalist* taking a taxonomic, systematic and/or morphological approach; or a mixed approach.

between 51 and 100% over time, but some trends emerge (Fig. 4). Articles using a natural history approach comprised more than 75% of eligible articles between 1900 and 1952, and again between 1964 and 1976. This is interesting given that natural history contributions fell to less than 75% of eligible articles during Wakefield's time as editor, and then increased again when he relinquished the position.

Wakefield aimed to popularise *The Victorian Naturalist*, but he may have done this partly by increasing the number of descriptive rather than natural history articles. There is a peak in descriptive articles between about 1960 and 1968 (Fig. 4), which encompassed part of Wakefield's period as editor and also the tenure of Dick Hudson, and part of Griff Ward's time in the position. The peak in descriptive articles was inflated by a series of narrative pieces on national parks and monuments by J. Ros Garnet, and a series on the origin of generic names of the Victorian flora by James Baines. The series of technical microscopy articles that appeared in the 1960s balanced the increase in descriptive articles, but as already discussed, this is likely to have been produced by the incorporation of the Microscopical Society of Victoria into the FNCV.

There was another apparent downturn in the percentage of natural history articles that began around 1980, and this downward trend continued until 1996, when the descriptive (history) articles in the von Mueller special issue displaced a particularly large volume of material in other categories. The natural history trendline has been erratic since then (Fig. 4). The initial downturn in natural history articles appears to coincide with the increase in hypothesis testing, survey and analysis articles that began during the editorship of Rob Wallis (1979-1983).

Wallis did not specifically intend to increase the number of 'hypothesis testing' articles published, but he believes that the increase may have resulted from his college lecturer's position. He was Head of Biology at Victoria College (a position held previously by Norman Wakefield), and he encouraged the students to publish their third-year research projects. *The Victorian Naturalist* provided an ideal outlet for the data, and also those of Monash University students. It is possible that a 'snowball effect' then occurred because others saw the increasing number of research reports appearing in the journal, and were encouraged to submit their own (Professor Rob Wallis, pers. comm.).

Category level 3: Topic

There has been a marked rise in the appearance of conservation and ecology articles since the late 1960s (Fig. 5). Articles focusing on more than one topic

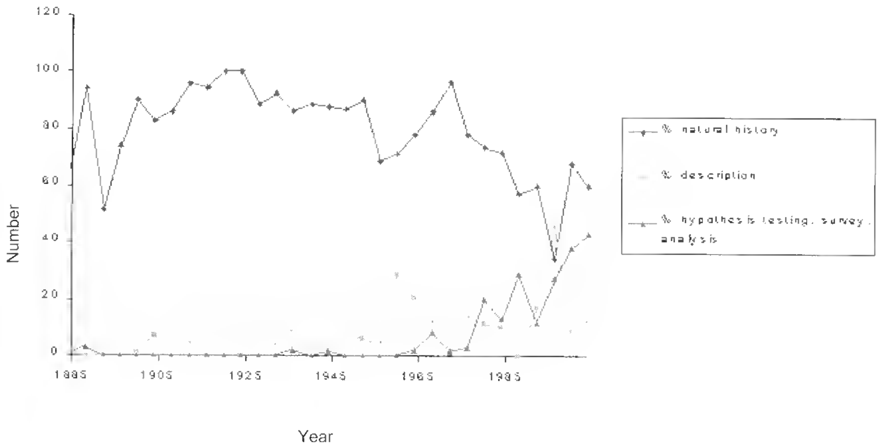

Fig. 4. Percentage of eligible articles in each censused volume of *The Victorian Naturalist* taking a hypothesis testing, survey or analytical approach; a natural history approach; or a descriptive approach.

have also increased alongside conservation biology and ecology contributions (Fig. 5), which may be because both of these fields usually deal with multiple taxa, and because many conservation articles involve an ecological study. The increase in ecology and conservation papers was probably due mainly to the increasing popularity and professional recognition of these disciplines, and after 1980, due mainly to the contributions of university student projects.

The percentage of articles about vascular plants has always been high (range 14-50%), which may be partially due to the advantages for local naturalists of botany as a study subject (Helen Cohn, pers. comm.). Rewarding field sites can be accessed relatively easily by the urban biologist, and field surveys can minimise requirements for collecting and curating samples. There may have been a slight decline in vascular plant articles since around 1960 (Fig. 6). The trend is erratic (and always has been), but if this represents a true decline, it may be due to an upsurge in other topics, or the advent of botanical journals, such as *Muelleria*. It may also be partly due to the death or retirement of some prolific contributors on vascular plants (e.g. James Willis, Jean Galbraith). Non-vascular plants and fungi always comprised less than 10% of eligible articles in *The Victorian Naturalist*, although this could change in coming years due to the activities of the recently-formed Fungi Special Interest Group.

Between 1896 and 1900 over 40% of eligible articles were about birds, but there was a fall in articles on this topic after 1900 (Fig. 7), which may have coincided with the 1901 founding of *Emu*. There was another peak in bird articles (35%) in 1952 (Fig.7), possibly due to the editorship of the ornithologist Ina Watson (editor 1951-1952). Alec Chisholm was editor between 1939 and 1948, which corresponded with another peak of bird articles (32%) in 1944 (Fig. 7). Several of the articles contributing to these peaks were written by the editors, but the majority were by a variety of other authors (e.g. Edith Coleman, Tom Tregellas). It is difficult to determine whether editorial policy or invitations to fellow ornithologists caused this, or whether the enthusiasm of ornithologists active in the club at the time simply inspired others to publish on this topic.

Mammalogy has had a moderate degree of popularity since 1884 (typically less than 20% of articles), although there appears to have been an increase in this popularity since about 1960 when consistently more than 20% of articles have addressed this topic (Fig. 7). There have been several major contributors of mam-

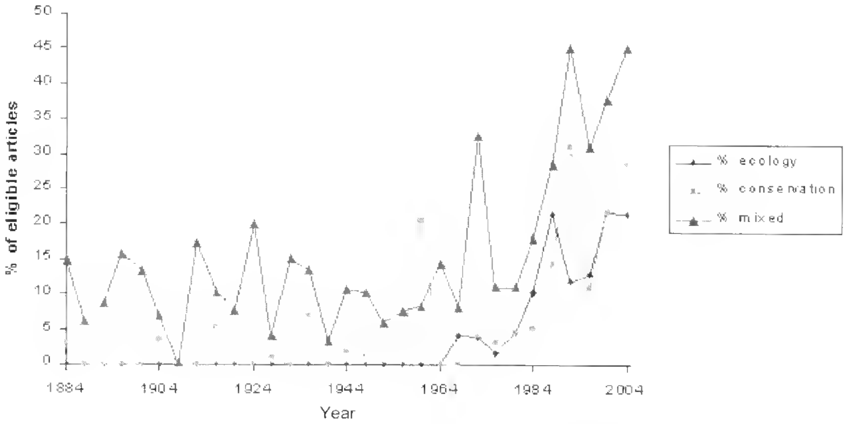

Fig. 5. Percentage of eligible articles in censused volumes of *The Victorian Naturalist* in the topic categories of ecology and conservation biology, and in mixed topic categories.

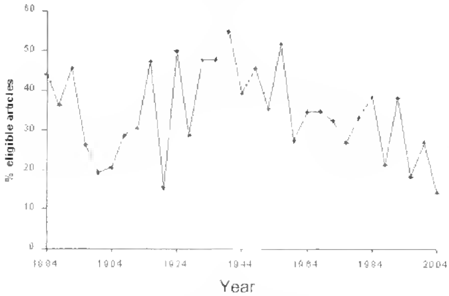

Fig. 6. Percentage of eligible articles in censused volumes of *The Victorian Naturalist* in the topic category of vascular plants.

malogy articles to *The Victorian Naturalist* over its history, although no single author seems to have been responsible for peaks in popularity of the topic. David Fleay (Healesville Sanctuary) was prolific between about the late 1920s to the late 1960s, and John Seebeck contributed many articles between the late 1960s and around 2000. Many of the mammalogy contributions have been received from universities, and the increase is probably due largely to publication of student projects from Deakin University, Monash University, LaTrobe University and The University of Melbourne.

The peak of 6–18% in microscopy articles that occurred between 1956 and 1968 has already been discussed in context of the incorporation of the Microscopical Society of Victoria into the FNCV. The percentage of articles on this topic has been less than 6% at all other times. Daniel McInnes and CS and GJ Middleton were the predominant contributors on microscopy; McInnes published between 1956 and 1961, and the Middletons published between 1959 and 1967.

Geology and anthropology have never featured heavily as topics in *The Victorian Naturalist*. There has never been more than 10% of eligible articles on geology in any volume, and while many authors have contributed one or two articles on this topic, only Edmund Gill (National Museum, Melbourne) could be considered prolific, due to the numerous pieces he published between 1938 and 1975. Anthropology contributions have also been relatively low, and are consistently less than 10% of eligible articles. There was a peak of 8% for anthropology articles in 1928, most of which were written by Alfred Kenyon. This was probably connected with the Prehistoric Club formed in Kenyon's home in 1927, which became the Ethnological Section of the FNCV (although it did not flourish). Gill also contributed some anthropology articles, although Aldo Massola (National Museum, Melbourne) was the most prolific: he published over 40 anthropology articles between 1956 and 1974.

Invertebrate, vertebrate and plant palaeontology have usually comprised less than 10% of eligible articles in *The*

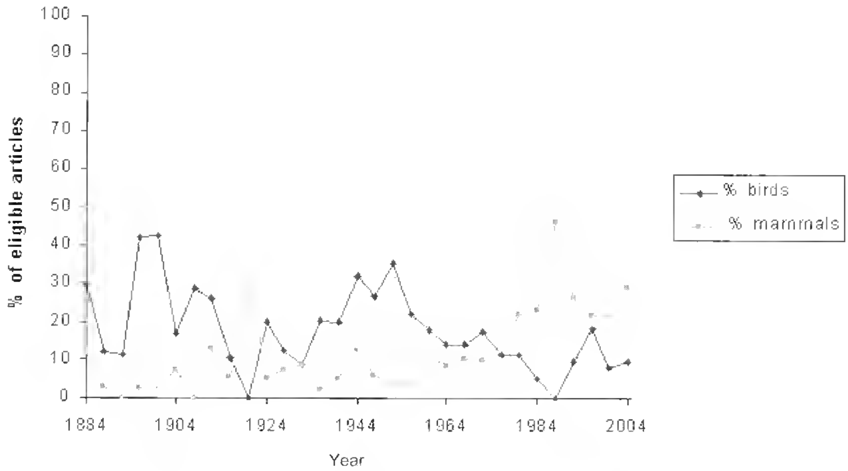

Fig. 7. Percentage of eligible articles in censused volumes of *The Victorian Naturalist* in the topic categories of birds and mammals.

Victorian Naturalist. The isolated peaks in this discipline are due to the activity of individuals: Stanley Colliver (Geology Department, University of Queensland) produced the 1936 peak (9%) in invertebrate palaeontology articles, and Frederick Chapman's work resulted in a 1920 peak of 15% in plant palaeontology articles.

The Victorian Naturalist has always contained a variable percentage of articles on insects (Fig. 8) and spiders. Content on insects appears to have declined erratically since the 1930s (Fig. 8), but there have typically been less than 5% of eligible articles per volume written about spiders. Entomology contributions have been received from a variety of authors, some of them eminent entomologists (e.g. Alec Burns and Artis Neboiss, both past entomology curators in the National Museum, Melbourne). Surprisingly, neither Charles French Senior nor Junior (both Victorian Government entomologists) contributed many entomology articles to *The Victorian Naturalist*, although both contributed many articles to the journal. French Snr published little entomological work other than his five-part series *Handbook of the Destructive Insects of Victoria* (1891–1911). The majority of papers contributed to *The Victorian Naturalist* by French Jnr and Snr were botanical (Baines 1976), possibly because much of French Snr's early training was in horticulture (Marks 1991).

The most prolific contributor of entomological articles to *The Victorian Naturalist* was the amateur hymenopterist Tarlton Rayment, who wrote over 80 papers, mainly about entomology. The professional commercial artist produced beautiful illustrations to accompany his largely taxonomic and behavioural work. There is a suggestion that he had trouble publishing some of his work in other journals because their editors considered his style too 'whimsical' (Marks 1991). *The Victorian Naturalist* is therefore likely to have provided a suitable outlet for Rayment's unconventional writing.

Papers on crustaceans and other invertebrates, reptiles, amphibians and fish have usually comprised less than 10% of eligible articles per volume. Molluscs have also largely followed this pattern, although there was a peak of 12-14% between 1972 and 1976. This was largely due to the contributions of Brian Smith (National Museum, Melbourne), and to a special issue 93 (6) on the Coast.

Articles on historical topics usually comprised less than 10% of eligible articles in *The Victorian Naturalist*. But 40% of articles were on history in the 1996 commemorative von Mueller issue. 'Other' topics, that do not fit into any other topic category, have consistently represented 7-20% of articles since 1988, although there were usually less than 10% before that time.

This may reflect a new diversity in *The Victorian Naturalist*. 'Other' topics have included X-rays of Australian fauna (Fergus 1936) and the therapeutic value of natural science (Davies 1960).

Acknowledgements

Thanks to Alan Yen who had the initial idea to do a retrospective survey on the content of *The Victorian Naturalist*. Thanks also to Sheila Houghton and Rob Wallis for so kindly helping me to explain several of the trends.

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Evolution of *Field Nats News*: a tribute to our volunteers

Noel Schleiger[1]

Abstract

The *Field Nats News* began in 1990, as a means of more quickly providing information to members of the FNCVabout excursions, and other future events. Since then it has evolved to include a wide range of material, some of which would previously have been published in *The Victorian Naturalist*. Publication of *Field Nats News* is a testament to the wonderful work of volunteers. (*The Victorian Naturalist* **122** (6) 2005,348-350)

How it started

From 1884 to 1990 all of the FNCV's meeting and excursion notices were published in *The Victorian Naturalist*. Unfortunately, there were dificulties associated with this arrangement. Circulation of *The Victorian Naturalist* was delayed and the six monthly calendar of future events did not appear in time to advertise events. These were crucial factors affecting attendance at meetings and excursions as people either did not know about the events or were left with insufficient time to organise their timetables! Therefore, during Dr Arthur Farnworth's presidency, it was decided to publish a newsletter which was seen as a panacea for 'difficulties in relation to communication and co-ordination'.

The first newsletter of the FNCV was published in November 1990, under the presidency of Dr Arthur Farnworth. It was edited by Noel Schleiger and typed by Dorothy Mahler. Issue No. 1 consisted of a single A3 sheet constituting four A4 pages.

As a result of the success of this first edition, it was decided to produce a bi-monthly publication. It was soon obvious that one A3 sheet was not enough and by May/June of 1991 (Issue No. 4) we expanded to two A3 sheets (8 pages) and by Issue No. 6 (Sept/Oct) there were three A3 sheets (12 pages). Up to this stage, Dorothy Mahler was typing up and laying out material in her spare time at her work place and then delivering it to 'Pink Panther', located nearby, to print the 500+ copies required at the time. This arrangement continued until the Dec 92/Jan 93 issue, when Rod Barker took over the layout of the newsletter.

Collation was a problem. Initially, Dorothy and Noel worked alone. It took them three nights from about 8-11 pm working 'flat out'. Enid and Arthur Farnworth and Ed and Pat Grey joined Dorothy and Noel to help with the larger newsletters and work was completed in one night at Noel's home in Montmorency.

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The Fauna Survey Group also helped with collation occasionally in those early days with Russell Thompson, Ray Gibson and others joining the group at Montmorency. Prior to the initiation of the FNCV newsletter, the Fauna Survey Group had their own newsletter. As the FNCV newsletter grew in size, the Fauna Survey Group decided to amalgamate their newsletter with that of the FNCV. The newsletter was then issued every third Tuesday of the month as the Fauna Survey Group had done.

The newsletter evolves

Dr Malcolm Calder was President at the time of the June/July 1993 Issue (No. 16). During his presidency, Issue No. 21 contained 20 pages, a record which still stands. That issue contained a 7½ page report on a talk by Bob King (Department Minerals and Energy) about Victorian Building Stones.

A further 3.5 pages were devoted to 'Gold Mining in Australia', while the remainder, by Ilma Dunn and Arthur Thies, covered Botany excursions.

Rod Barker of Boronia Heights Secondary College was the layout operator from February/March 1993 (No. 14). This involved Noel driving from Montmorency to Boronia twice a month, firstly to leave the typing (on disc) that Dorothy had done and then to pick up the printed copy a week later. Rod Barker continued until May 1994.

By August 1994, Malcolm moved that the newsletter be produced monthly. This resulted in smaller issues from August 1994 to April 1995. Malcolm began a 'President's Report' in August 1994 (No. 24), when the newsletter changed its name to *Field Nats News* (*FNN*).

John Julian commenced as layout operator in August 1994, with *FNN* 24, the birth of the *FNN* as we know it today. He used the 'box layout' for important reports or for coming events.

Newsletter layout

Much experimentation occurred with the layout of the newsletter by different teams before a standard format was adopted. John Julian introduced the style which evolved into that of the current newsletter. FNN 24 (August 1994) had a two column page format, was much more compact and allowed the inclusion of more material.

By July 1995, with Rob Wallis as President and the advent of Publisher 2, the newsletter layout was changed to three columns per page. The size expanded to two A3 sheets, producing eight A4 pages. The Calendar of Events was put on the back page for convenience. This meant that when the newsletter was opened the calendar was the first part to be seen, and it was often the first item of interest for members - what talks, what excursions, and where!

FNN 34 (July 1995) was the first issue to have a Table of Contents on the front page. One year later, *FNN* 45 (July 1996) canvassed members for help with the layout of the newsletter at our present location in Blackburn. The Diary of Events then went to page 2 instead of the back page. *FNN* 46 was the first issue to acknowledge help by volunteers towards the newsletter production. Joan Broadberry and Brigid Vaughan joined the layout team and subsequent issues greatly benefited from their services.

Keith Marshall joined the layout team to produce *FNN* 48 (August 1996) and Ann Williamson joined the typing team for *FNN* 51 (November 1996).

By July 1997, the Field Nats Bookshop was set up and *FNN* 57 published the first catalogue of books for sale to members. Keith edited *FNN* 58, 59, and 60. By *FNN* 63 (March 1998) the work of the collation team was being acknowledged.

With two layout teams in operation, it was possible to lighten the workload in producing the *FNN*. Keith and his team alternated with Noel and his team depending on availability. This system worked well from *FNN* 73 to FNN 116 when availability and membership changed.

Since *FNN* 117 (January 2003) Joan Broadberry and Noel Schleiger, with the help of Bob Barron, have been co-editors of the newsletter. Unfortunately, in the last few months Bob has had to discontinue because of health reasons. His expertise with computer technology will be greatly missed, and he is wished well with his recovery.

The size of both the layout and the collation teams over the years 1995-2005 has oscillated between 7 and 19. When the team membership falls below 10, it is difficult to have the newsletters collated and addressed for delivery to the Blackburn Post Office by the due time.

What is in the newsletter?

Since November 1990, the newsletter has gradually taken on some items formerly published in *The Victorian Naturalist*, in addition to Calendar of Events, e.g. excursion reports. Reports of talks and field excursions organised by the FNCV and the now numerous Special Interest Groups were comprehensively recorded in FNN, although it is regretted that, of the six FNCV tours organised during this same period (being to Binna Burra Qld, northern Tasmania, Grampians Vic, Kangaroo Island SA, Mildura/Broken Hill, and Mt Kosciusko NSW), only one of these tours, to Mildura/Broken Hill in 1995, was written up in detail. In fact, this tour, called 'The Big Trip', was serialised over five newsletters! Other topics now included are the President's Report, minutes of general FNCV Council matters, conservation issues, nature notes and letters to the editor, punctuated by special announcements of workshops and other events, and advertisements. Advertisements on behalf of outside bodies help to minimise the cost of production of FNN. *The Victorian Naturalist* now concentrates on scientific reports and nature notes. Probably there are items in FNN which should be in *The Victorian Naturalist*.

How many volunteers?

Right from the outset, the newsletter would not have been possible without the volunteers to write it, lay it out for the printer, and then collate and label it for posting.

It takes at least nine authors to write the various sections of FNN. It takes at least two and often five to lay out the newsletter ready for printing and two more to check it, which is usually done in a rush. Under ideal conditions, at least twelve people are needed to collate the newsletter and label it, on the third Tuesday of the month.

So, every month 25 to 30 volunteers are involved in the production of FNN.

Sincere thanks to all who have contributed in the past and, hopefully, will continue successfully in the future. Throughout the years, the administrative officers, Felicity Garde, Maria Belvedere, Ann Williamson and now Mimi Pohl, have been helpful and supportive with 'stop press' news as well as the layout.

Since 1990, the membership of the club has doubled and, hopefully, the development of FNN has contributed to this. The way the newsletter has evolved has contributed to the growth and success of the various Special Interest Groups, and makes one realise that the FNN is essential to the efficient functioning of the FNCV.

Received 30 July 2005; accepted 3 November 2005

Dorothy Mahler and Denis Meltzer, as Excursion Secretaries for many years, advertised excursions in the *Field Nats News*

The Kershaw Dynasty

J Hope Black (Macpherson)[1]

Abstract
The Kershaw family had a long and active involvement with both the Field Naturalists Club of Victoria and natural history within the museum world. Beginning with the arrival of William in Victoria in 1849 and ending with the death of Ronald in 2003, the Kershaw dynasty has had enduring and important impacts on the study of the natural sciences in Victoria and Tasmania. (*The Victorian Naturalist* **122** (6), 2005, 351-357)

The death of Ronald Calder Kershaw in March 2003 brought to an end a dynasty of four generations of Kershaws associated with the Field Naturalists Club of Victoria and Museum Victoria. The dynasty dates back to William Kershaw who arrived in Victoria with his family in 1849, aged 29.

William Kershaw was born at Ryecroft, West Yorkshire in 1820, the eldest son of David Kershaw and his wife Hannah. The family worked as weavers and, as far as we know, William was also a weaver but had developed an interest in natural history, particularly entomology. It seems likely that their decision to migrate was the result of the industrial revolution that was causing unemployment and unrest throughout England.

William Kershaw married Hannah Lamb in 1840 and they had a number of children by the time they migrated, paying their passage on the *Ann Milne*. None of these children survived to adulthood except their fourth child, David, born at Keighly, West Yorkshire in 1846. The first recorded birth to the couple in Victoria was in 1855.

William's interest in natural history continued after he arrived in Victoria and his private collection (see below), acquired by the Museum in 1940, shows he started collecting very soon after he arrived in Melbourne. According to family history Kershaw, lured by gold, spent some time at Ballarat, but by 1854 he was back in Melbourne. He and Henry Edwards, the actor and entomologist who had arrived in Victoria in 1853, very quickly became known to each other and began making joint excursions to collect local Lepidoptera. These they showed to Professor McCoy who was so impressed with the young men's collection that in 1856 he bought it for the Museum and this collection formed the foundation of the Museum's very extensive and now world-wide Entomological collection. At some time in the past, this material was incorporated into the general collection and now can only be identified by checking individual specimens. McCoy also proposed them for membership of the Philosophical Institute of Victoria (Royal Society of Victoria from 1860) which had been established in 1854, and they were announced to the monthly meeting on 19 March 1856. Four months later McCoy read a paper to the institute 'On the Formation of Museums in Victoria'. McCoy wrote:

> Victorian insects have been scarcely touched by Government collectors but I have secured for the University a fine series as a commencement selection from the beautiful and extensive collections of Victorian insects made by Mr. H. Edwards and Mr. Kershaw for their own use.

Henry Edwards (1827-1891) was born in Ross-on-Wye, Herefordshire, younger son of Thomas Edwards of Brook House. He early developed the twin interests of acting and natural history. As well as being an early member of the Royal Society of Victoria, to which he continued his membership until his death, he joined the Field Naturalists Club and attended meetings when he visited Melbourne in 1889.

Unfortunately history is silent on how William supported his growing family for the next ten years, except that he did own several properties in the Collingwood area from which he would have had income. His address, recorded by the Royal Society of Victoria in 1859 and 1860, was 142 Johnston Street, Collingwood. He must have continued his contact with McCoy because in 1860, '61 and '62 McCoy purchased further material from him, consist-

[1]22 Kurrajong Street, Hastings Vic. 3915

ing of over a thousand Lepidoptera and three hundred Coleoptera.

In 1864 McCoy employed William as assistant to John Leadbeater, the taxidermist, and he was soon appointed second taxidermist. So far, it has not been possible to establish whether he had had some training in taxidermy in England but Henry Edwards was known to be a capable taxidermist and would have passed on his knowledge to his collecting companion. Working with the very skilled Leadbeater would have honed his skills also, and fitted him to be appointed second taxidermist. Incidentally, John Leadbeater joined the FNCV in September 1881 and a relative, Thomas Leadbeater, who had been appointed assistant taxidermist in 1882, joined the FNCV in October 1882.

The largest task undertaken by the taxidermists was the articulation of the skeleton of an adult Black Right whale, 90 feet long, which had been washed up at Jan Juc, Victoria and went on display at the rear of the Museum at the University of Melbourne in 1868. Pescott[1] gives the credit for preparing and mounting it to Kershaw, while Rasmussen[2] credits it to Leadbeater. From my own experience of working at the Museum where manpower was at a premium, I have no doubt that both men would have been involved. When the Museum was moved to Russell Street in 1901 the skeleton was set up in the courtyard between the Swanston Street and Russell Street buildings. Lack of protection from the weather finally caused its deterioration and it was subsequently removed and destroyed.

William's position as taxidermist did not prevent him pursuing his other interest of entomology and he became well known among those of the community interested in natural history. When the FNCV was formed in 1880 he was an original member. Although he did not attend the inaugural meeting, his sons David (1846-1883) and William Henry Briggs (1859-1949) did.

Next to Professor McCoy, Kershaw was the most enduring contributor to the development of the National Museum of Victoria (now Museum Victoria). In spite of the heavy workload required of him, William, as a senior staff member under McCoy, undertook collecting trips around Melbourne and the Mornington Peninsula that resulted in a number of echinoderms, crustaceans and molluscs being added to the Museum collections. He also visited central and eastern Gippsland where he collected, amongst other items, the large land snail *Pygmipanda atomata kershawi* (Brazier 1871) from the Snowy River area, east of Bairnsdale.

In spite of efforts by McCoy to retain his services, William was retired in 1891; he died in 1899. Even in retirement he continued his interest in the institution to which he had given such dedicated service. Over the years, McCoy acknowledged receipt of many donations of specimens from William Kershaw. In 1940 Kershaw's entomological collection was purchased by the Museum, having been offered by his son James. This was an extensive collection mainly of Lepidoptera (10 005 specimens including some moth type specimens) and Coleoptera (12 100 specimens). Also included was some historical material collected as early as 1849, soon after Kershaw arrived in Victoria, and retained by him when he and Henry Edwards sold a portion of their joint collection to McCoy.

William's wife Hannah died in 1860 and in 1865 he married Elizabeth Boyd (1838-1907) at St Kilda. Their first child, Mary Hannah, was born at Fitzroy in 1865 and was followed by seven other children, including two sons who lived to adulthood.

In 1883 McCoy employed William's son, James Andrew (1866-1946) as assistant taxidermist (Fig. 1). In 1890 he was appointed taxidermist to replace his father who retired a year later. The position would have been as senior taxidermist since Leadbeater had died in 1888. In checking records we find that William Kershaw in later life was referred to as entomologist, and James as taxidermist until his appointment as Curator in 1899. However, designating titles that suggest a person had a particular area of duty is erroneous, as all staff at the time needed to be multi-skilled.

On the death of McCoy in 1899, Professor Baldwin Spencer was appointed Honorary Director. With McCoy's resistance removed, the government of the day moved quickly to relocate the Museum to the Public Library site, between Swanston and Russell Streets. Much of the organising and execution of this move fell to James Kershaw as the senior staff member.

At Spencer's instigation James was made Curator of the zoological collections. This gave Spencer more freedom from administrative duties, allowing him to pursue his ethnological studies in Central Australia.

Spencer was an Honorary Director with many other commitments, so the day-to-day running of the Museum fell to James Kershaw. This included creating exhibitions, and the additional space at Russell Street enabled him to expand the exhibits. Thus he was able to prepare a series of table cases showing representatives of Recent shells found round the Victorian coast. Each specimen was labelled with its scientific name and where it was found. These cases were very popular with the public as people could bring their specimens to the Museum, compare them with those exhibited in the cases, and so identify and name them. Another popular exhibit, set up by Frederick Chapman, appointed Palaeontologist in 1902, was a similar set of cases displaying specimens from the various Miocene fossil beds around Melbourne and regularly visited by collectors. Both these exhibits remained popular until the early 1940s when they were removed to make way for more innovative modern exhibits, much to the sorrow of many local collectors.

The increased space available on completion of a Russell Street frontage enabled expansion of the exhibition galleries. Australian mammals and birds could be adequately displayed in the upper gallery, above the Russell Street frontage; this space became known as the Spencer Hall. Once again, planning and much of the hands-on execution fell to James Kershaw. These displays included several that depicted larger, better known species such as lyrebird, Brolga, Black Swan and albatross in their natural habitat.

In 1910, James Kershaw visited King Island, following the report of fossil bones there, to look for evidence of extinct animals. He found evidence of wombats and emus. As a result of this excursion Spencer and Kershaw wrote two articles for the *Memoir* series of the Museum.

Fig. 1. James Andrew Kershaw, 1866-1946

The wealthy pastoralist HL White of Belltrees, near Scone in NSW, was a keen ornithologist who was putting together a representative collection of Australian birds and eggs; because of this, he was very much involved with the Royal Australasian Ornithologists Union. This latter connection led him to arrange that his field collectors should send insects and spiders, obtained as a sideline during their bird collecting, to the Museum. This arrangement provided substantial additions to the Museum's collections from the Northern Territory and north Queensland. Kershaw extended this contact by interesting White in the requirements of the Ornithology collection and suggested he might donate duplicate material to the Museum. This was strongly supported by Major (later Dr) JA Leach, the Lecturer in Nature Study at the Education Department. Later, Kershaw was able to persuade White to donate his collection of skins and eggs to the Museum. It arrived there in the charge of White's curator, Sydney W Jackson, on 4 August 1927, and White continued to add to it until his death later that year.

In 1928 the Federal Government appointed a three-man committee to report on the feasibility of establishing a National Museum in Canberra. The personnel were Dr ACD Rivett, Chief Executive Officer, Commonwealth Council for Scientific and

Industrial Research (later CSIRO) Chairman, Dr Charles Anderson, Director Australian Museum, Sydney, and James A Kershaw, (later Director, National Museum, Victoria). The recommendation was positive but it was many years before the Museum was established.

Baldwin Spencer had many other interests and was frequently absent, so for many years Kershaw had been, to all intents, the Director of the Museum. Thus it was fitting that on Spencer's retirement in December 1928 Kershaw should be appointed Director, a position he occupied until his own retirement in 1932, when he was appointed the first honorary curator.

It was Kershaw who, following the American example, planned a notable innovation and improvement to Museum exhibitions, the first of the Dioramas or habitat groups. These large exhibits consisted of a realistically-painted background with a three-dimensional foreground occupied by a small group of animals. The lion group was completed in 1929 and the polar bear group in 1930. The Australian War Memorial artist, Louis McCubbin, was lent to the Museum to paint the background, and Charles Brazenor, at that time the taxidermist and later Curator of mammals, carried out the work of mounting the animals and arranging the foreground.

As early as 1904, Kershaw had observed the common eel and wrote about a colour variation. This work was concurrent with observations made in northern Europe by the Danish zoologist Professor Johannes Schmidt who, like Kershaw, had noted that eels living in fresh water had not been found carrying spawn. Schmidt received a grant from the Carlsberg foundation and was able to carry out research from which he concluded, although he did not observe spawning, that the European species breed in the Sargasso Sea off Bermuda. Kershaw (1911) described in some detail juvenile eel (elvers) migration in Victoria, known as 'eel-fares'. Later workers have been able to establish that eels seen in Australian waters breed in the Coral Sea, to the north-east of Australia.

James Kershaw was also a keen collector and was able to venture further afield than his father had done. Although his specific interest was entomology he did not neglect the rest of the animal kingdom. He was a member of the party that visited the Bass Strait islands with the Royal Australasian Ornithologists Union in 1908. He again visited the islands in 1909. He visited the Barrier Reef with Dr William Macgillivray of Broken Hill and his son in 1913. They worked their way up the coast by boat from Cooktown to Lloyd Island where they obtained supplies, then proceeded by small cutter to Claudia River on the coast. From there they penetrated upstream for some miles, where they established a camp and made substantial collections (Kershaw 1914 and 1915). In 1921 Kershaw travelled across the continent on the transcontinental railway to Ooldea in South Australia, to collect zoological, botanical and ethnological specimens. This resulted in many specimens being added to the Museum and Herbarium collections.

Like other members of the Kershaw family, he was active in the FNCV from 1883, and a member from 1888. He served in a number of capacities: as a Committee member for over 30 years, Secretary in 1901-1903 and again in 1908, President in 1913-1915 and again in 1931-1933.

Beginning in 1894, he was responsible for the publication of 69 papers of various lengths, (Kershaw RC 1948, 1949), most of which appeared in *The Victorian Naturalist*. There were 16 on entomology, 13 on fish, seven on mammals, four on snakes, three on birds. In additon a further four were published in *Emu*. He seemed to ignore the invertebrates apart from insects though he did write notes on Paper Nautilus. This may have been because there were a number of capable people collecting and writing on a number of phyla, such as Arthur Dendy on sponges, William Bale on hydroids, Joseph Gabriel on hydroids and GB Pritchard, JH Gatliff and Charles Gabriel on molluscs. James participated in many club excursions and was responsible for writing notes on day excursions and camp-outs such as that on the Buffalo mountains and several on Wilsons Promontory. He was concerned with preservation of landscape as well as flora and fauna, and was a foundation member of the National Parks Association founded in 1908 in association with the reservation of Wilson's Promontory as a national park. It had been reserved in 1898 but without any formal arrangement for its management.

Professor Baldwin Spencer had a broad interest in the conservation of the Australian environment and particularly in the preservation of its fauna and he saw the need for an authoritative influential body to advise the Victorian government. He suggested that a committee should be set up consisting of representatives from Victoria's Royal Society, FNCV, Royal Australasian Ornithologists Union, Fish Protection Society, Anglers Club, National Museum and the Zoological Gardens. Later he suggested that the Royal Geological Society of Australasia should be included and that a conference of delegates should be held. An important outcome of this meeting was a deputation to the Minister of Land for the setting up of a Committee of Management for Wilson's Promontory. This was approved and proclaimed on 18 August 1908. At the first meeting on 22 September, Baldwin Spencer was appointed Chairman and James Kershaw was Honorary Secretary, a position he occupied until his death in 1946.[3]

James Kershaw was elected a member of the Royal Society of Victoria in 1900 and was a Councillor from 1902 to 1935. He was President in 1918-19, Honorary Secretary 1920-23, Honorary Librarian 1924-5, and a Trustee from 1922 until his death. He was a Fellow of the Royal Entomological Society of London and a corresponding member of the Zoological Society of London. At the January 1935 Melbourne meeting of the Australian and New Zealand Association for the Advancement of Science he was elected Vice-President of the Zoological Section.

James married Elsie Charlotte Brown in 1889 and they had three sons. She died at Windsor in 1930 and he on 16 February 1946.

William Kershaw's other two surviving sons were also interested in natural history and contributed specimens to the Museum collections. William Henry Briggs Kershaw, a landscape gardener, collected insects and molluscs, particularly land shells. Following his death the Museum received his shell collection. He had made several other donations during his lifetime.

Thomas Kershaw (1867-1942) was employed by McCoy as assistant entomologist in 1896 and resigned in 1904, probably because he wanted to pursue his other interests as farmer, artist and explorer. He made collections in New South Wales and Victoria, which he donated to the Museum.

James Kershaw's eldest son was Harold Edgar (1890-1962) born at Windsor, Victoria. He was not formally engaged in natural history studies, his occupation being as a soldier, in commerce and as a farmer. However, in his youth he was a member of the FNCV, and it was there he met his future wife, Jessie Elizabeth Kelly (1888-1976) at the end of World War I. She was also a keen naturalist and supported her husband's and later her son's interest in natural history. The family lived at Windsor with James Kershaw, who by this time was a widower, so they became involved with his interests, particularly the FNCV and the National Museum. Harold became a collector and followed his father's interest in entomology. But he also retained a broad interest in natural history that included molluscs and fossils. Some of his material ended up in the collections of both his father and son, and a few specimens in those of the Museum of Victoria.

There are also a few items in the Museum collections donated by Harold's younger brother Leslie Norman (1892-1940) but nothing from the youngest brother Cyril Boyd (1904-1948), as far as I have been able to ascertain.

Harold's son Ronald Calder Kershaw, along with his two sisters, were members and active participants in the FNCV in the early 1940s. It was here that his sister Elsie Mary (1922-) met her future husband, Wilfred Habgood Joske. He was not himself a collector but inherited a collection of Thursday Island shells from his father, Adolf Joske, who had collected them when stationed there about 1917. Part of this collection he retained but part he passed on to his brother-in-law Ronald Kershaw.

Ronald was born on 7 December 1920 at Malvern, Victoria, and died in Launceston, Tasmania on 15 March 2003 (Fig. 2). He grew up under the influence of his grandfather so that his greatest interest was natural history. From an early age he enjoyed spending time in the bush with his father collecting insects, spiders, snails and whatever wildlife came to hand. On leaving school he studied accountancy but it was soon interrupted by service with the Australian Imperial Forces in the Middle East and New Guinea. When duties allowed, his recreation was study and collecting of wildlife wherever he found himself.

In 1947 he met his future wife Winifred Mary Bull, who had served in the WAAF during the war, and they married in 1948. They moved to northern Tasmania, where they farmed at Clarence Point on the West Tamar for a number of years. During this time they had two daughters. Later he was employed by the Tasmanian State Government in the Agronomy Division at the Department of Agriculture Laboratories, at Mount Pleasant. He retired in 1978. He continued his personal involvement in the collection and study of molluscs, particularly land snails, and he wrote a number of papers as the result of his studies. His first four papers on the family Charopidae were published between 1954 and 1956 in *The Victorian Naturalist*. These were followed by papers in the *Journal of the Malacological Society of Australia* and *Records of the Queen Victoria Museum*. He also collaborated with Brian Smith in two major publications on land and freshwater molluscs.

Ron Kershaw was a member of that dying breed, the amateur naturalist. His health was impaired by his war service and on discharge from the AIF he moved to Tasmania for an outdoor life. Since it was necessary to earn a living throughout his whole life, his scientific work was carried out in his spare time.

His appointment as the first Associate, and later the first Research Associate, at the Queen Victoria Museum in Launceston meant that he had a working relationship. However, the Museum was closed at night, at the only time he had for his molluscan work until after his retirement. Unfortunately, by then his health was already deteriorating.

To appreciate his contribution it is necessary to understand the isolation of his position in Tasmania in the latter half of the last century. Computers were relatively rare and the Internet was not yet available. There were no co-workers locally to bridge the gap, so Ron Kershaw assembled an extensive reference library and corresponded with researchers within Australia and as far away as Sweden, New Zealand, France and USA.

Fig. 2. Ronald Calder Kershaw, 1920-2003

Until the advent of the electron microscope and, through the efforts of Brian Smith at the Queen Victoria Museum, he was able to access these facilities, and did his own photography and produced his own papers for publication. At weekends and on holidays he collected throughout Tasmania and curated his collection. The occasional visits of shell collectors from interstate or New Zealand and of visiting scientists helped to alleviate the isolation.

Ron Kershaw had been a member of the FNCV since his youth and he was also a member of the Royal Society of Tasmania, Tasmanian Field Naturalists Club, and the Malacological Society of Australasia. On the occasion of Ron's retirement from the Society, John Stanisic of the Queensland Museum noted Ron's 40 years of membership, his contribution to malacology, and his published bibliography. He was an Honorary Associate in Invertebrate Zoology, Museum Victoria, and Honorary Associate in Malacology, Queen Victoria Museum. As an acknowledged authority in Tasmania on malacology, he was invited to write the article on WL May for the *Australian Dictionary of Biography*.

He was always willing to help students and local collectors. They were encouraged to reach their potential and make their contribution to the knowledge of Tasmanian fauna, particularly land mollusca, which had been neglected in the past.

Ron was involved in the activities of the local community but his interests spread much wider, including areas such as Aboriginal land rights, conservation and the environment.

Over the course of his life he had made large natural history collections, in particular of Recent and fossil molluscs, and had also built up a very fine library of natural history books and reprints. Before his death, the whole collection was acquired by the Queen Victoria Museum. under the Commonwealth Grants Scheme. Ron Kershaw's research was greatly helped by his wife Win, particularly when it came to accessing information from French and German publications, as she was able to translate them.

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Notes

[1]Pescott (1954) *Collections of a Century*, 67
[2]Rasmussen (2001) *A Museum for the People*, 56-7
[3]Pescott (1983) *Australian Dictionary of Biography*. 104-105

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From cabinets of curiosities to black boxes: the future of the Field Naturalists Club of Victoria

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Abstract
Field naturalists have contributed to our understanding of the natural world through their observing, collecting, identification and storage of objects that interest them. They have been able to achieve this task more successfully using increasingly complex technologies in their endeavours. Today, some of the 'black box' technologies have reached beyond the interest and understanding of most naturalists: will these technologies result in the demise of the traditional naturalist and end the Field Naturalists Club of Victoria? In reality, the FNCV has expertise that is essential, and its long-term future is bright if it can maintain a balanced membership on the basis of age, amateurs and professionals. (*The Victorian Naturalist* **122** (6) 2005, 358-366)

Introduction

In celebrating the achievements of the Field Naturalists Club of Victoria (FNCV) over its 125 year history, it is opportune to speculate about where the Club will be at its 150th or 200th year. Such speculation is difficult because it is easy to suggest where the Club is going based on its current activities, but unforeseen external factors can have profound influences (both positive and negative) on what actually happens.

In this paper, I will briefly outline some historical developments in science – both technical and theoretical – to see how they have influenced the way in which naturalists, and consequently the FNCV, have fared. This is reflected in the title of this paper. The 'cabinets of curiosities' refers to the importance of specimens for the naturalist; specimens are the objects that capture the curiosity of the collector. Many naturalists assembled a collection of objects, from potpourris of interesting unrelated objects (ranging from the common to the bizarre) to systematic collections of particular groups of rocks, plants or animals. These amateur collections formed the basis of many of the world's major natural history collections (museums and herbaria), which in turn are a legacy for future study. The 'black boxes' refer to technological and intellectual advances that have influenced both naturalists and science. The ways in which they work may, at times, be of little or no interest to the average amateur naturalist; the results are of primary interest. The main question here is whether some of these black box advances are so specialised that they could permanently deter interest by naturalists in the future.

By definition, 'naturalists' are people who indulge in natural history activities. Martin *et al.* (1996) provide two formal definitions of 'natural history': (1) 'The study of living organisms in their natural habitats' and (2) 'The study of all natural phenomena.' The first definition immediately confines the study to the field (more akin to 'field naturalists') and implies that laboratory studies are precluded. The second definition is very broad and is more akin the Club motto, 'Understanding Our Natural World.' What constitutes 'natural history' has changed over time, and a detailed discussion is beyond the scope of this paper; a more detailed discussion is found in Griffiths (1996).

It would also be inappropriate for me to discuss the origins of 'naturalists' as we define them today. That is a subject tackled by others (Allen 1978; Griffiths 1996; Jenkins 1978), although I would note that it is a subject for which information is readily available only for Europe, North America, and Australia. I wonder whether there is a strong tradition in natural history in other societies such as in Asia and the Middle East. Jenkins (1978) notes interests in keeping and observing wild animals as far back as 3500 BC in Egypt and 3000 BC in China. In traditional hunter-gatherer societies, an acute awareness of natural history was probably essential for survival, and the thought of studying nature for nature's sake

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may have been an alien concept. No doubt similar examples could be found for other aspects of natural history such as geology, palaeontology and astronomy.

In western science, there was originally an overlap between naturalist activities and biology; the latter was not a distinct tertiary discipline until late in the 19th century. Naturalists were interested in collecting, classifying and naming species, and there were two types: field naturalists who were primarily observers of living organisms in their natural environment, and cabinet naturalists who collected trophies (although many could be classified into both categories) (Griffiths 1996). The discipline of natural history arose out of the amateur tradition, but with technological advances, natural history separated from science with the emergence of biology as a separate, more laboratory-based, discipline (Finney 1993). Natural history was considered more the domain of the non-academic, and naturalists were often relegated to lower class citizenship because some 'scientists' claimed that, compared to post-Darwinian biology, natural history lacked a scientific basis.

This demarcation between natural history, as practised by amateurs, and academic science may have been more blurred in Victoria. Societies that catered to the more professional members of society were established in Victoria in the 19th century, natural history was initially part of the Philosophical societies that became the Royal Societies (Willis 1980). Some State-based societies were formed for specialist disciplines; some, such as the Geological Society of Victoria, still operate: some have become national societies, while others have either closed down (e.g. Acclimatisation Society of Victoria) or been incorporated into existing societies. The FNCV arose as an alternative to the more socially exclusive Royal Society of Victoria and the Royal Zoological and Acclimatisation Society of Victoria. It concentrated on field studies as opposed to laboratory studies (Evans 1982). The FNCV attempted to popularise science. While conservative in some aspects (the FNCV opposed evolution and black-balled potential members who supported it in the 1880s), it was interested in conservation (calling to save forest treasures in 1887) and interested in Australian flora and fauna (as opposed to the Acclimatisation Society of Victoria) (Evans 1982). Many of the early members were office workers, and FNCV activities provided a weekend activity for them (Evans 1982).

However, compared to many other naturalist clubs, the FNCV has some very important characteristics that have enabled its survival:

(1) It has a long history of amateur naturalists interacting with scientists. Even though the interests of field naturalist clubs began to differ from the more experimental approach of the universities, the FNCV was really an amalgamation of amateurs and professionals (Finney 1993). For example, professional Museum staff (such as Baldwin Spencer and James Kershaw) enjoyed a long association with collectors from the FNCV (Rasmussen 2001). The then National Museum of Victoria even put on a major exhibition of Australian Aboriginal art under the auspices of the Trustees acting on advice from the FNCV members Charles Barrett and AS Kenyon (Rasmussen 2001). The FNCV had a significant influence on the biological endeavours of Baldwin Spencer (Professor of Biology at the University of Melbourne and Director of the National Museum of Victoria). Trained in the UK, and arriving in Melbourne in 1887 to work under McCoy, Spencer joined the FNCV in August 1887 and had two terms as President. Spencer's participation in FNCV trips enabled him to collect specimens and convinced him of the unique nature of the Australian environment; his FNCV excursion in September 1887 initiated his interest in earthworms, including the Giant Gippsland Earthworm. A three week FNCV excursion to King Island in 1887 had a profound influence on him because he was the only academic among 26 naturalists (Mulvaney and Calaby 1985).

(2) The long-running journal of the Club, *The Victorian Naturalist*. The material published in *The Victorian Naturalist* was more like that published in the professional journals such as the *Proceedings of the Royal Society of Victoria*. However, its first issue emphasised the main object of the Club in its introduction:

> Field work has been the main object of the Society, and the enlarged cabinets, and the exhibits at meetings testify to the activity of members in this direction, while the number of careful observers of Nature in the colony has been greatly magnified.[1]

The black boxes

I want to briefly outline eight factors that have had profound effects on natural history, and in turn, on field naturalists. These factors have, in most cases, benefited naturalists and broadened the boundaries of their endeavours. Yet some of these factors have either led to a drift away from active participation in field naturalist activities or moved natural history to a level of specialisation that is not of interest to the average naturalist.

The eight factors that I want to discuss are: (1) the microscope, (2) mechanical transport, (3) printing, (4) the camera, (5) the atom, (6) evolution and ecology, (7) computers, and (8) DNA technology. There are certainly other factors, and many will disagree with my selection; the list is more illustrative than definitive.

(1) The microscope opened up a new dimension for naturalists in that it enabled them to see details beyond the power of the naked eye and to gain an understanding of the structure of objects (both physical and biological). However, the advent of the electron microscope may have alienated some naturalists.

(2) Mechanical transport gave naturalists greater mobility and accessibility (both on land and across seas and continents), but on the downside it led to development of other interests that resulted in environmental change (greater access to marine and land-based resources and establishment of international tourist resorts).

(3) Printing resulted in better recording and dissemination of information to a wider audience.

(4) The camera (still and movie) has had an incredible impact for improved communication and education, and has stimulated interest in natural history and conservation. It also enables recording of natural history objects without the need to always collect specimens. While television now provides a broad mixture of programs that range from drama, comedies, quiz shows, documentaries to junk reality programmes, the original quality reality programmes were probably natural history ones. The development of cinematography has had two negative influences on naturalists: (1) Infotainment: natural history programmes aimed at a market rather than on fact (e.g. the emphasis on the spectacular predatory mammals), and (2) the evolution of the couch potato.

(5) Atomic theory allowed a greater understanding of the basis of biology and geology and also resulted in biological research with a greater emphasis on biochemistry and physiology.

(6) The theory of evolution and the rise of ecology as a discipline provided a framework to understand how and why plants and animals are where they are, and a way of assessing changes in conservation status of plants and animals. The theory of evolution changed the way plants and animals are identified and classified. Ecology has provided a better framework for understanding the natural world and the relationships between geology, flora and fauna. In conjunction with mathematics and modern computers, evolution and ecology have seen a dramatic rise in application of mathematical modelling which in most cases is relevant, but at times is a poor excuse for the paucity of empirical data on which to base decisions.

(7) Computers have resulted in an exponential rise in data and image storage and transfer technology. This has been of great benefit to naturalists, although one negative may be that nerds have turned to computer games and chat rooms instead of natural history!

(8) The rise of DNA technology has provided us with a better understanding of the basis of life and genetics. It could be argued that with rapid advances in DNA technology the objects of study have become secondary to the technology. There is a generation of graduate biologists who have less understanding of whole organism biology and the natural world, and see natural history as a series of DNA sequences. There is a danger that DNA technology could see the rapid loss of traditional skills: whole organism biology, traditional taxonomy, traditional herbarium and museum collections, and a science that thinks that it

is so smart that it can identify which individuals within a species need to be saved if the species is not to become extinct.

An example of where there is a divergence between naturalist interests and modern scientific endeavours is the study of the Giant Gippsland Earthworm *Megascolides australis*. This is an example of an endemic species whose recorded scientific history is closely aligned with the FNCV or its members. It was described by a President of the FNCV (McCoy 1878), and members of the FNCV who researched the Giant Gippsland Earthworm and published in other journals or books include McCoy (1878), Spencer (1888a, 1888b), Bage (1909), Barrett (1931, 1935, 1938, 1941a, 1941b, 1942a, 1942b, 1954), Watson (1947) and Yen *et al.* (1990). Members of the FNCV who published articles on *M. australis* in *The Victorian Naturalist* include Goudie (1904), Barrett (1929, 1930), Anonymous (1931), Colliver (1944), Stewart (1946), Eve (1974), Smith (1974), Smith and Peterson (1982) and Van Praagh *et al.* (1989). These studies have used many of the factors listed above.

I am currently involved in a research project on translocation of the Giant Gippsland Earthworm, and one component of this project is to identify genetic markers to track the success of the translocation. In an email I received from one of the geneticists in this project (Dr David Runciman, Genetics Department, La Trobe University) he stated:

> Standard universal primers prove to be no good for this species but one of my cockroach-specific primers coupled with a universal primer (mtD11) was able to amplify very weak bands at 40°C annealing temp. I excised these, re-amplified and sequenced and got excellent sequence for six individuals. Four identical haplotypes plus two others differing by 3 & 4 bp with no evidence of numts (no stop codons), all from ~540 bp from the middle of COI. Am now waiting on *Megascolides*-specific primers I designed from the alignment of these to arrive. Very small sample size but interesting that we already have three haplotypes from just six samples.

While this finding (that a potential genetic marker has been found in the Giant Gippsland Earthworm) is important, the technology and terminology involved is well beyond the interest of many amateur naturalists (and many scientists). The question is whether technology will become so advanced that naturalists will become irrelevant in the future.

The future of natural history

Has technology advanced to the point where it could become irrelevant to the interests of the average amateur naturalist? Or more importantly, will it make the naturalist obsolete? The answer is simply 'no.' Naturalists will continue their activities as long as there is nature to be observed. In the centuries ahead of us, the 'nature' may not necessarily constitute the same environments that exist today; these may be systems that have eventuated as a result of human exploitation of the planet.

There are several reasons why naturalists will still be relevant in the future:

(1) Loss of expertise and knowledge

The future of the FNCV is closely tied to the future of natural history. In Britain, a House of Lords Select Committee reported a gloomy picture of Britain's chronic shortage of skilled naturalists and taxonomists, leading to a decline in field identification skills among both amateur and professional naturalists (Gates 2003). This is partly a result of the increased funding available for biotechnology and biomedicine, and a generation of tertiary biology students may graduate with inadequate exposure to the natural world. The report also noted that the average age of amateurs is rising, and these are the people who contribute to national bird, butterfly and plant surveys. Field work at schools is minimal because of time-tabling pressures and fear of litigation from possible accidents. In Britain, 80% of pupils under 16 never do any field work, and two-thirds of A-level biology students do one day or less. The camera has replaced the collecting jar, and the programmes produced are generally exciting and spectacular films of hard to get to places, and field work in the local park pales into insignificance. The reduced interest in the 'cabinets of curiosities' could mean that there will be less specimen collecting and loss of associated skills (e.g. specimen preparation) and collections for future generations.

In the past, nature studies in schools often led to a future interest in natural history. The United Kingdom experienced a reduction in nature studies in schools, and it was found that many teachers did not feel confident about identifying plants and animals; this led to the establishment of the Field Studies Council and AIDGAP (Tilling 1987). AIDGAP involved a programme of publishing identification guides and running identification courses. In Australia, the same situation exists and there are even fewer identification guides available. This is a serious situation in view of the uniqueness of the Australian environment. The danger is that globalisation of knowledge could lead to future teaching of natural history based on non-Australian information.

(2) The need to study at the organism/object level

The trend of moving from studying the whole organism to the molecular level is seeing a new type of graduate biologist one that may be a master of technology but with inadequate skills to identify plants and animals. Combined with the way tertiary institutions have cut back courses (field work, field techniques, plant and animal identification), this has resulted in a vacuum that good naturalists can fill.

(3) Need for live observations

In his autobiography, Sir David Attenborough (2002) wrote:

> Zoology had changed since I was a student at Cambridge. Then the science had seemed to me to be largely laboratory-bound. We were taught about the anatomy of animals and peered into the entrails of crayfish, dogfish and rats. We sat in lecture theatres while the complexities of animal classification were explained and illustrated with skeletons and stuffed skins. We heard about painstaking experiments designed to find out whether pigeons could count and how quickly rats could learn to run the correct way through mazes. But there was no suggestion that we might ultimately, as qualified zoologists, watch elephants in Africa or crouch in a hide in the depths of a tropical forest watching some rare bird at its nest. That was what naturalists did. Not scientists. .

(4) Inadequate resources to inventory lesser known groups of plants and animals

In a continent where much remains to be discovered and where the scientific community is quite small, there will always be a role for amateurs and volunteer groups to either assist with inventories or undertake their own work. The FNCV has a history of such activities that range from smaller scaled surveys (as currently undertaken by the Flora, Fauna Survey, Terrestrial Invertebrates and Marine Research Groups) or larger longer-term projects (such as Fungimap).

Where to for the Field Naturalists Club of Victoria?

While I believe that there will be an important role for the naturalist in the future, it is necessary to distinguish between the activities of individual naturalists and the activities of the FNCV. In the Centenary year of the FNCV, Willis (1980) outlined the main activities of the Club: meetings, excursions, publication of *The Victorian Naturalist* and other publications, specialist groups, branches, shows and exhibitions, and maintenance of FNCV property.

In the future, the FNCV could play an extremely valuable role in science and conservation by fulfilling the following objectives:

- Encourage whole organism/ object field observations;
- Teach field and some laboratory techniques;
- Educate and promote future naturalists amongst teachers, schools and the public;
- Maintain a successful mixture of professional and amateur members; and
- Continue publication of *The Victorian Naturalist*.

These broad objectives need to be assessed in the scientific, activities and operational aspects of the FNCV.

Scientific directions

The FNCV has to consider its future scientific directions without losing amateur interest. This could involve:

(1) Adopting and adapting new scientific technologies where appropriate. Naturalists have readily adopted computers, digital cameras, GPS units and other technologies to enhance their naturalist outputs. Naturalists need to be aware of utilising

new technologies for collecting or recording plants and animals, even to the extent of collecting DNA samples.

(2) Special Interest Groups (SIGs) have changed over the years, but those involving botany and vertebrate fauna will probably always be active in some form. There will be new disciplines that arise out of the current Groups, such as the recent rise in the fungi SIG and the establishment of the bat SIG. These groups will assist science and conservation by filling the gaps: early FNCV members saw their role as providing a valuable contribution to scientific knowledge by collecting natural history specimens (Watkins 1984). While vertebrates and vascular plants can usually be identified in the field now or samples taken without harming the object of study (e.g. using hair tubes for mammals), some of the lesser known groups such as fungi, bryophytes and invertebrates still need to be collected.

(3) New areas where FNCV members could become involved include protecting the native flora and fauna from exotic plant and animal incursions (biosecurity). While the study of native Australian flora and fauna is the primary objective, knowledge of overseas fauna is useful to discover unwanted invasives.

(4) One issue that the FNCV has to keep in mind is how academic it should be. The formation of kindred organisations such as the Bird Observers Club, Australian Plants Society, Victorian National Parks Association and Fungimap out of the FNCV may have affected membership in the short term, but the separation of more specialist groups may have reinforced the more generalist nature of the FNCV. The FNCV has been fortunate in that many leading scientists have been active members (Pescott 1940) and the Club has maintained a valuable mixture of amateurs and professionals. An example of where a naturalist society has gone the other way is the American Society of Naturalists, established in 1883. The purpose of that Society is to advance and diffuse knowledge of organic evolution and other broad biological principles so as to enhance the conceptual unification of the biological sciences, which is much more scientific than the purpose of the FNCV. The American Society of Naturalists publishes a well-respected scientific journal, *American Naturalist*, and two examples of recent titles are 'Alternative life-history pathways' and the elasticity of stochastic matrix models', and 'The opportunity for canalization and the evolution of genetic networks', both of which would be considered as too esoteric for amateur naturalists.

Activities

While the FNCV provides facilities and assistance for its members, it is the activities that keep the Club in the spotlight. Some activities will not change, but the way they are run may change.

(1) Meetings, whether general or special meetings of the FNCV or meetings of the SIGs, will be a major activity because they provide the forum for members to meet. The problem is that only a small proportion of members attend meetings, and certainly few rural members manage to attend. In the future, the FNCV should consider teleconferencing meetings to regional areas – this would be an opportunity for regional members to at least hear guest speakers. As many regional naturalist clubs are facing closure because of falling membership, perhaps the FNCV can at least provide teleconferenced meetings to some of these clubs.

(2) The Special Interest Groups will continue, but some groups will wind up or amalgamate with other SIGs, while new groups will start. Some societies may decide to join the FNCV, as the Marine Research Group has done.

(3) Excursions will continue. These can be one day excursions or camps. Most excursions are run by a SIG and concentrate on the area of interest of that SIG. The FNCV could consider trying to have excursions with more than one SIG involved, and perhaps look at field projects with longer term objectives (such as monitoring the effects of climate change on flora and fauna). Occasional expeditions to areas in the remoter parts of Victoria or to other parts of Australia could also be part of the FNCV excursion programme.

(4) The value of the FNCV in addressing skill shortages in nature studies could be highlighted by the Club running workshops (or even short courses) on elements

of natural history (techniques, identification). These could target the general public, older (university and TAFE) students, and teachers.

(5) Publications will be an important part of the FNCV. Besides *The Victorian Naturalist*, the Club occasionally publishes books. It could consider consolidating future books into a series of field guides or naturalist handbooks. In the UK, a non-profit group of scientists called the Company of Biologists writes the Naturalists' Handbook Series to assist investigators to make novel discoveries about local plants and animals. The titles range from individual groups of animals (e.g. Grasshoppers, Common ground beetles) to microhabitat (e.g. Insects on nettles, Animals under logs and stones, Animals on seaweed).

Operation

While scientific directions are important for the future of the FNCV, it is often the operational aspects that ensure their success or failure. For most of its 125 years, the FNCV has operated on voluntary participation by members. Only in the last few years has the FNCV employed a part-time administrator. This was partly due to the need to assist maintaining the FNCV's own offices in Blackburn, but also to help with the increased range of activities now associated with the Club.

(1) The FNCV now has had more corporate, financial and legal obligations imposed on its operations. Like so many other voluntary organisations, the FNCV has been caught up in the ever increasing burden of insurance premiums. This adds to the realisation that the FNCV now has to be accountable for any of its activities in case of accidents and possible subsequent litigation. Many members join the FNCV for the social activities that it can provide – and rightly so. Unfortunately society is forcing them to face issues that affect the running of the Club: privacy laws, intellectual property rights, corporation laws, duty of care, and the GST! The SIGs collect information on excursions, and little thought has been given to intellectual property rights. These property rights belong to the FNCV and the Club has a scientific responsibility to ensure that the information is used properly.

(2) The Club took a major step in 1994 by purchasing the Blackburn offices. It now needs to consider that in order to grow (and increased membership is essential for survival of the Club), does the FNCV need to be run more like a business and employ more staff, each with specific roles to assist members with those corporate responsibilities listed earlier? One only needs to look at other kindred groups to see that some employ several full time staff members.

(3) The move to Blackburn had an enormous effect on the demographics of Club membership. Blackburn was chosen because it represented the centre of distribution of members in the metropolitan area. It is probable that the loss of meetings in the city has seen a drop in attendance by members in the western and northern suburbs and an increase in members from the eastern suburbs. Already there are space limitations in the Blackburn offices, and in the next few years, the FNCV will have to consider whether to renovate or to move. If Blackburn property values escalate, the option is for the FNCV to sell, and one possibility is to set up a field station away from the city and hold meetings in the city. This is not a new idea in Australia; the Launceston Field Naturalists Club has a 50 ha field centre with accommodation.

(4) The internet has changed the way in which we communicate. While a majority of FNCV members currently prefer hard copies of the *Field Nats News* rather than the electronic version, it is likely that the proportion requiring the electronic version will rise. An active and up-to-date FNCV website could be the most efficient means (both in time and costs) of communication within the FNCV and also with the public. Even though electronic publishing has its value, it is important that *The Victorian Naturalist* continue as a hard copy journal because it exemplifies the scientific standing of the FNCV. It may be possible that past issues of the journal could be accessed on the internet in the future.

(5) Whatever eventuates in the future with how the FNCV operates, one factor will not change: the need for members.

The mean age of naturalists in Victoria is increasing. For the FNCV to survive, it first needs more members, and it also needs a diversity of members: amateurs, professionals, male, female, young, old. The FNCV immediately needs to target two groups: youth (school and tertiary aged) and the early retiree baby boomers, to boost numbers. Another section is different ethnic groups; natural history has been predominantly an Anglo Saxon tradition (Europe and North America). Does the tradition exist, although maybe in different forms, in Asia, Africa, South America, or the Middle East? Can we encourage more migrants (and their descendants) from these regions to join the FNCV? The FNCV membership is relatively static at the moment, but any significant decline in membership could cause problems for the long-term viability of the Club.

Conclusions

Field naturalists are a diverse and robust group of curious individuals whose skills are essential if we are to achieve the objectives of the FNCV: 'To stimulate interest in natural history and to preserve and protect Australian flora and fauna.' In 1950, Ern Lord predicted that there would be a greater need for conservation in view of the then social pressure for more development and larger Australian population (predicting a population of 50 million by 2000). He predicted that the naturalists 'studying birds and wildflowers' needed to formulate a long-term conservation policy. This required paid officers, a city office, and branch offices, and was only achievable with financial backing. Lord (1950) stated that

> ... this cannot be done without vision, organization and means. In the vast flood of a new population, the Field Naturalist of the future faces an almost frightening task – the task of guarding a national asset for a world to come. We have seen the destruction to our own time and the pace is accelerating. Are there men and women in this Club big enough to meet this future?'

While Lord was incorrect in his prediction of a population of 50 million in Australia by 2000, his call for long-term policy for conservation, and the call for members to meet the challenge still remain. There is a need for skilled naturalists, and it is up to the members of the FNCV to set future directions and objectives and to strive to achieve them while still enjoying nature and understanding our natural world.

Acknowledgements

The author wishes to thank David Runciman and Mike Westerman (Genetics Department, La Trobe University) for their input, and to the former for allowing me to quote the email message – I hope you do not take my comments about DNA technology in the wrong way! I also wish to thank Beth Gott, Sheila Houghton and Gary Presland for their interesting insights.

Note

[1] Introduction in *The Victorian Naturalist* **1** (1), 1884.

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Natural observations: the artists of Frederick McCoy's zoology of Victoria

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Abstract
In the production of his *Prodromus* of the Zoology of Victoria, Frederick McCoy was greatly assisted by three men of remarkable artistic ability. Each of these artists–Ludwig Becker, Arthur Bartholomew, and John James Wild–was remarkable in his own way, and contributed uniquely to the *Prodromus*. Their constributions are considered briefly here. (*The Victorian Naturalist* **122** (6), 2005, 366-375)

When Ludwig Becker went fishing at the mouth of the Yarra Yarra in October 1855 he was searching for weedfish, a cryptic species adapted to life in the varying environmental conditions of a temperate estuary.

If the German naturalist and artist were to have looked up he would have seen a substantial flotilla at anchor, with men rowing to shore in smaller boats stacked to the gunnels, passengers ready for disembarkation. At the Railway Pier, a mile to the south, more sweating men and straining horses were loading freight on the new train for delivery to warehouses over the recently constructed Sandridge Bridge. There on the northern bank of the river, Melbourne was still growing, stretching to meet the demand for goods from the goldfields. The scene was similar two miles away at Williamstown on the western side of Hobson's Bay. But for that moment, Becker's concentration was fixed on a small net with which he hoped to catch female weedfish heavy with young.

After untangling the fish he took some measurements, noting the sex of the animal before making a detailed sketch (Fig.1). He then dissected the females, counting the embryos, carefully noting their stage of development. His observations were soon presented to the Philosophical Institute, in a paper *On a Viviparous Fish from Hobson's Bay* (Becker 1855-6), and were therefore among the earliest contributions from the emergent scientific community in the young colony of Victoria.

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The men, who would go on to pursue and promote science in Victoria, came together at the Philosophical Institute to share their findings, debate new ideas and to shape up to each other in the tussle to control nascent colonial institutions. The Transactions of the Society provided an important forum where some of the brightest minds hoped to contribute to the colony and establish their reputations by contributing articles.

Frederick McCoy, a well-groomed and ambitious Irishman, had just been appointed as the first professor of Natural History at the University of Melbourne. He soon joined the Philosophical Institute and wasted no time in cementing his place amongst his peers. By all accounts Frederick McCoy was a genial but nonetheless formidable opponent. In 1856 he famously commandeered the museum's collection from its original home at the Assay Office in Latrobe Street, and hauled it to the University at Carlton where it remained until the end of the century. McCoy's audacity paid off, and in 1858, he was appointed Director of the National Museum, a position he would hold until his death in 1899. It was from this solid base that McCoy set out to describe the zoology of Victoria and its adjacent waters.

McCoy's vision, forged in Britain at the end of the enlightenment, demanded that he assemble, describe and illustrate all the animals of Victoria, 'as opportunity arose' (McCoy 1878-1885). This ambition was, in retrospect, naïve, as southern Australia continues to yield new discoveries by the year. McCoy's approach to collection and documentation was *ad hoc* as he rarely travelled to the field.

By the time of the inception of the Field Naturalists Club of Victoria in 1880, McCoy was anchored at the University, busily overseeing a laboratory, lecture room, museum, and working on his publications. McCoy's appointment as the first President of the Field Naturalists Club of Victoria, a society dedicated to making observations in the field, is tinged with irony, as his Australian career was as a laboratory-based scientist. McCoy clearly saw his role as an honorary one, conferring prestige on the club by his association and that of the institutions he represented, but rarely attending its meetings (Houghton 2001).

The specimens that McCoy assembled at his museum and had illustrated by his artists were gathered from a range of sources. It appears that some specimens, such as the 'Two-pronged Toad-fish' were collected by McCoy himself as he rambled near his home at Brighton Beach (McCoy 1886-90). More often, correspondents in the country sent animals to the laboratory to be identified. Other specimens were acquired from regular suppliers, such as Mr. Percy Jenkins, a fishmonger of Swanston Street (Bennett 2002).

With the benefit of hindsight McCoy's approach to collection now seems to mirror the colonisation process. The Professor /Museum Director sitting at the centre, (think London) and material sent to him from the hinterland for identification and incorporation into the canon of knowledge under his control.

McCoy's focus was taxonomic, and he generally described individual species without careful analysis of their environmental niche and usually without focused consideration of their relationship to other similar species from Australia. McCoy subscribed to a belief in 'centres of creation' espoused by Louis Agassiz (Butcher 2001) in which God created an assemblage of creatures for each geographic zone of the world. There is no doubt that McCoy saw the uniqueness of Australia's fauna as conforming to the theories of Agassiz, this belief being further strengthened by his examination of the continuity in Australia's fossil record (Clode 2005 pers. comm.).

Agassiz, like McCoy, travelled from Europe to the New World and established a great museum in roughly the same period. In 1859 Agassiz opened a Museum of Comparative Zoology at Harvard. When Charles Darwin's ideas exploded on to the scientific scene in 1859, McCoy did not see the need to adjust his understanding of the 'the species question', a stubbornness that masked the evolutionary significance of the Australian fauna, which he studied so fiercely. Both McCoy in Australia and Agassiz in North America were now at the heart of science on their respective continents, where they remained hostile to theories of evolution and biogeography being championed by Darwin, Wallace and Huxley.

McCoy's determination did, however, propel him to commission the illustration of 1000 living species over the last four decades of the 19th Century. The resulting legacy is a fine collection of images, produced by a succession of artists. McCoy's brief to the artists appears to have been to create life-sized images (wherever possible), for morphological exactness and for taxonomic clarity. Rarely was there any environmental, atmospheric or behavioural data recorded. The images are particularly spartan when compared to the dramatic compositions of John James Audubon or even the reconstructed habitats that animate the albums of John Gould (1845-1863 and 1865).

The archive of images commissioned by McCoy remained stored for many decades under the stairwell of McCoy Hall in the Museum at 328 Swanston Street. Concealed within its pages are invaluable records and incidental observations of the Victorian fauna on the cusp of ecological upheaval. Annotations by the artists, as well as the observations of James Kershaw (the taxidermist and keen entomologist) and McCoy himself, are made in pencil on the margins of their original sketches. A fresh examination of these works can now reveal surprising biological information as well as providing a historical lens on the process of science as it emerged in the highly charged atmosphere of colonial Melbourne.

Many of these images were eventually published as lithographs in the two weighty volumes of the *Prodromus of the Zoology of Victoria* (McCoy 1878-1885; 1886-1890). They appeared with detailed descriptions, and were often accompanied by McCoy's arcane but often amusing anecdotes. During the same period McCoy also produced the accompanying *Prodromus of the Palaeontology of Victoria* (1874-82) in which significant fossils finds were similarly described and illustrated (Darragh 2001). For all their eccentricity these twin publications remain the most significant publishing accomplishments of the Museum, noted as much for their scope as for the beauty and technological sophistication of the images they contain.

On completion of the first volume, McCoy outlined his rationale:

> The geological and botanical investigations have approached completion, and their publication is far advanced, it has been decided to commence the publication of the branch completing the subject, namely, that of zoology or the indigenous members of the different classes of the animal kingdom.
>
> As the Fauna is not so well known as the Flora, it is a necessary preliminary to the publication to have a large number of drawings made, as opportunity arose, from living or fresh examples of species of reptiles, fish, and the lower animals, which lose their natural appearance shortly after death, and the true characters of many of which were consequently unknown, as they had only been described from preserved specimens.[1]

McCoy followed a well-established European precedent when he sought out artists to make detailed illustrations of the animals that came under his gaze. In the forty years that he occupied the joint posts of Professor at the University and Director of the Museum he commissioned six highly talented artists and draftsmen to provide the illustrations to accompany his descriptions. He claimed, 'The originals [specimens] of all the Figures are in the National Museum Melbourne.'(McCoy 1878-1885; 1886-1890)

We will focus on the work of just three of these artists, Ludwig Becker, Arthur Bartholomew and John James Wild. These are the artists who made the most significant contribution to McCoy's *Prodromus of the Zoology of Victoria*. Their efforts encompassed the length of McCoy's grand project from its conception in the late 1850s to its demise in the early 1890s.

Ludwig Becker

Ludwig Becker was born in Offenbach-on-Mainnear. Darmstadt, Germany on 5 September 1808. He had trained as an illustrator and contributed to the scientific publications of his mentor Johann Kaup. He later studied lithography under Peter Vogel and went on to be the court painter to the Arch Duke of Hesse-Darmstadt (Kerr 1992).

Becker came to Launceston via England and Rio de Janeiro in 1851, and immediately impressed Lady Denison who labelled him 'one of those universal

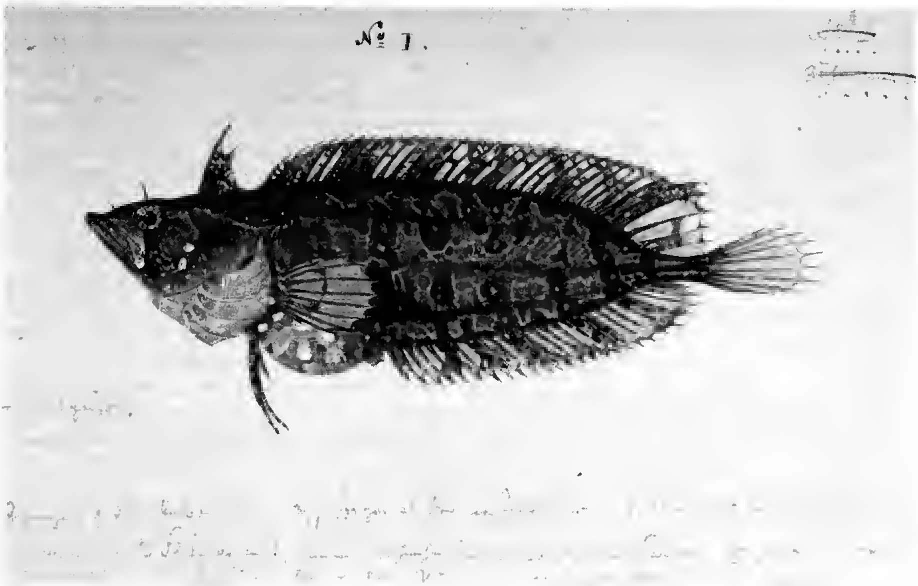

Fig. 1. Becker's drawing of a Weedfish *Heteroclinus tristis*. Source: Museum Victoria/Artist:Ludwig Becker

Geniuses who can do anything; is a good naturalist, geologist & draws, paints and plays and sings'.[2] An appealing personality and a peripatetic thinker, Becker was influenced by the ideas of Alexander Humboldt, who had instructed artists to draw *en plein air* to capture 'a certain physiogamy of nature particular to each region of the earth' (Heathcote 2001).

Becker came to Victoria in 1852, and was caught in the rush to the Bendigo goldfields where he tried his hand at mining but, more significantly, produced a small body of work which captured the moment of excitement as well as the displacement of the original inhabitants of the area (Tipping 1978; 1979).

On moving to Melbourne Becker contributed to the emergent intellectual and cultural life of the city. He exhibited his Bendigo works, designed medals and certificates, and was a founding member of the Philosophical Institute, the Victorian Society of Artists and an active participant in the Melbourne German Club (Kerr 1992).

Perpetually anxious about money, Becker appears to have tried his hand at a broad range of tasks. He published *Men of Victoria*, wrote and illustrated in cartoon style 'An Australian Song', created special events, illustrated scientific papers and publications, as well as joining expeditions into the Victorian hinterland with other notable German-speaking intellectuals such as Neumayer, Von Guerard and Blandowski (Tipping 1979; 1984). As a highly skilled miniaturist Becker had the capacity to enter into the minutiae of the scenes and animals he depicted. His drawings are often accompanied by annotations in an attractive and expansive script, and his language is always visually charged.

It is likely that Becker's illustrations, such as that of the weedfish published in the transactions of the Philosophical Institute of Victoria (Becker 1855-6), prompted McCoy to consider the artist's potential contribution to his own more ambitious project to illustrate the zoology of Victoria. In 1858 he engaged Becker to create lithographs at a rate of £10 per plate (Becker 1858). Some of the animals, such as the Australian Fur Seal and the Death Adder, appear to have been collected by Becker himself, while the Polyzoa, over which he had protracted and very agitated correspondence with McCoy, was apparently a more direct commission (Becker 1859).

Becker seems to have been persistently exasperated by McCoy's tardy payment. In contrast McCoy appears to have held Becker in high regard, referring to him posthumously as 'the late clever observer and artist'.[3]

Becker's enthusiasm led him to join the ill-fated Burke and Wills expedition to the north of Australia. Exhausted and suffering from scurvy, his death from dysentery in Bulloo, southwest Queensland, appears attributable to Bourke's enmity and poor leadership. His record of the journey stands as perhaps the greatest visual record of an expedition to inland Australia, his premature death robbing Australia of one of its most inspired colonial artists.

As well as the sketches and lithographic proofs commissioned for the Museum, there is a small collection of fish and fossil studies by Becker that came to the Museum collection, which together provide a rich insight into Becker's previously neglected zoological observations.

Arthur Bartholomew

Arthur Bartholomew, son of Thomas Bartholomew, a decorator, was born in Bruton, Somersetshire, in 1834 (Public Record Office Victoria 1909). He arrived in Victoria in December 1852 on the *Oriental* (Public Record Office Victoria). Soon afterwards, he sailed to Tasmania where he met and married Eliza Ann Nicholls (Archives Office Tasmania 1856). They had two children, Christianna and Adelina, in quick succession before returning to Melbourne for Arthur to take up the position that would define his professional career (Archives Office Tasmania).

In September 1859 Bartholomew was appointed Attendant to McCoy, in the department of Natural History at the newly opened Melbourne University (Melbourne University Archives). For six months Bartholomew attended McCoy in lectures and assisted in the laboratory. In 1860 this role expanded to take advantage of Bartholomew's artistic ability. Obviously McCoy saw Bartholomew's potential for the ambitious projects that lay ahead.

Bartholomew began both a zoological and geology series for McCoy, which would form the basis of the *Prodromus of Zoology of Victoria* and the *Prodromus of Palaeontology of Victoria*. During the following four decades he illustrated in detail more than 700 living animals and an as yet undocumented number of palaeontological specimens. Along with his duties as McCoy's assistant in the lecture room and laboratory, Bartholomew also transferred many of his own drawings and those of other artists on to stone for the production of lithographs.

Bartholomew was both methodical and systematic in his approach, his work characterised by a fastidious attention to detail and a remarkable technical facility. He mastered the application of successive water colour glazes to build richness and depth into his colour, while using layers of varnish to give the leathery chrysalis of Lepidoptera a remarkable three dimensionality (Fig. 2).

It appears that most, if not all, of his illustrations were completed in the laboratory where he was at the mercy of McCoy for the range and quality of the specimens that were brought to him. The highlights of his oeuvre are his exquisite watercolour studies of insects, and his notes on the metamorphoses of the animals indicate that it was his responsibility to nurture them in the laboratory. These images reveal an almost unimaginable level of detail, comparable to such masters of scientific illustration as Ferdinand Bauer and Jean Charles Werner.

His images of larger animals, brought dead to the university, are equally well observed but do not have the animation of the smaller studies. It appears for instance that some of the specimens brought to him by Mr. Jenkins, the fishmonger, were not exactly fresh. Typically Bartholomew would prepare a precise pencil sketch of each fish, complete with diagnostic details and a geometric analysis of the scale pattern. He then rendered a watercolour that together with the pencil sketch would be used to guide the lithographic process. His image of a sardine provides insight into the level of detail required to translate laboratory observations successfully into the printed plates.

This systematic program of recording continued for 40 years, and the resulting illustrations stand as testament to an otherwise neglected career. His relationship with McCoy was long and familiar, as this anecdote from a former student illustrates, 'One of McCoy's jokes was to address the students, "Gentlemen, we will now look at the strange reptile, Bartholomew!" This last in a curious falsetto voice as he half turned himself around to summon [him].'[4] Regardless of his obvious submissive position, Bartholomew faithfully attended McCoy through the ups and downs of the Museum, the Department and their personal lives. Less than a year after McCoy's death Bartholomew chose to retire from the Natural History Department at the University (Melbourne University Archive 1900). He continued occasionally illustrating for the Museum until his death at age 75 in 1909, when after a year of ill health he passed away at his home in Newry Street, North Fitzroy (Public Records Office Victoria 1909).

John James Wild

John James Wild was born Jean Jacques Wild in Zurich, Switzerland in 1824. He taught languages in Belfast, Ireland, where he met his wife Elizabeth Ellen Mullin.[5] Wild was appointed to the position of artist and secretary to Charles Wyville Thomson, leader of the *Challenger* expedition 1872-76 (Rice 2000). The *Challenger* explored all the world's oceans, in what was the first global project to investigate deep sea life. This expedition, more than any other project, established the discipline of oceanography as a collaborative and interdisciplinary science.

Wild's most significant contribution to the many volumes associated with the *Challenger* expedition is *Thalassa; an essay on the depth, temperature and currents of the ocean... with charts and diagrams by the author* (Wild 1877a), for which he was awarded an honorary doctorate from the University of Zurich. Wild also published an illustrated popular account of his travels titled *At Anchor* (Wild 1877b), in which he described Melbourne and produced engravings of Port Philip Heads and the Mountain Ash forests.

With these impressive achievements behind him, Wild must have been brimming with confidence when he immigrated to Melbourne in 1881. Curiously he was unsuccessful in finding a position fitting his formidable expertise, and was forced to apply, unsuccessfully, for academic work in New Zealand. In Melbourne he patched together a living, lecturing in modern languages and literature at Trinity College, as an examiner in French and German matriculation, and as a secretary and an artist (State Library Victoria 91/111). Frederick McCoy, no doubt recognising Wild's potential to elevate the scientific sophistication in his own publications, soon engaged him to create lithographs of both terrestrial and marine animals.

Wild had a deep appreciation for geometric patterns in nature, and it is in the depiction of animals such as Echinoderms, whose bodies are radially symmetrical, that he excels (Fig. 3). His depiction of marine invertebrates are generally more convincing than those of the higher forms, especially where he is tempted to place reptiles or mammals in semi-realistic tableaux. He was a parsimonious artist, characteristically drawing on both sides of a paper and taking particular care to fit as much information as he could on to the page. Some of his compositions now appear crowded, given our contemporary taste for white space.

As well as directing his highly disciplined mind towards detailed biological drawings, Wild was an accomplished lithographer. From drawings, transfers and proofs taken at successive states of the same image, it is apparent that Wild set out with a clear conception of the desired result. In contrast to Becker or Bartholomew he rarely worked his pencil images up in colour, rather waiting for a proof of the line work to complete a precise hand coloured image which would then act as a guide or 'pattern plate' for the master printer to complete. It is clear from instructions to the printer on his proofs that Wild possessed an unnerving capacity to plan for the colour separations that make his images the most technically sophisticated of those commissioned by McCoy for his *Prodromus of the Zoology of Victoria*.

Despite his considerable achievements in a range of disciplines Wild never gained a permanent post in Australia, consequently his most significant Australian legacy is the images he created for McCoy's *Prodromus*. His skills of observation under the microscope and high fidelity lithography were also recognised by Walter Baldwin Spencer, freshly appointed as

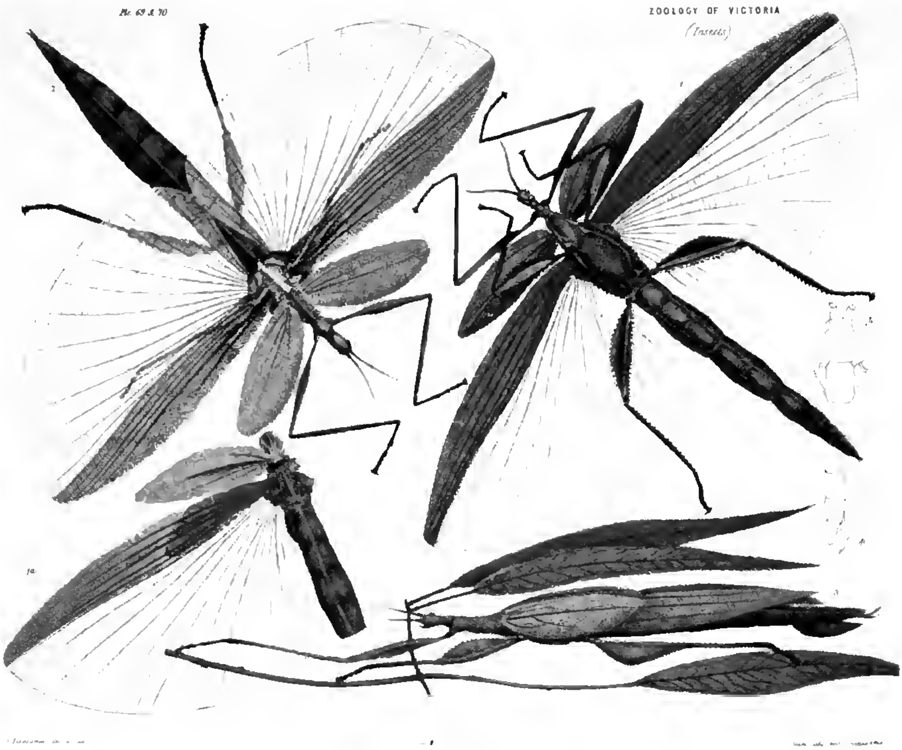

Fig. 2. Bartholomew's rendition of the Red Shouldered Phasma *Tropidoderus rhodomus*. Source: Museum Victoria / Artist: Arthur Bartholomew

Professor of Biology at Melbourne University. Spencer engaged Wild to illustrate an article for the *Proceedings of the Philosophical Society* in 1888.

In the same year Wild delivered the inaugural lecture on Anthropology at the Australasian Association for the Advancement of Science in Sydney, another interest he shared with the young Spencer who was to become the next Director of the National Museum.

Wild contributed to scientific societies in Melbourne at the end of the century, both as Assistant Secretary to RLJ Ellery at the Royal Society and as a contributor to the Royal Geographic Society of Australasia. John James Wild died largely unrecognised in Australia in 1900.

Epilogue

In 1878 McCoy, proudly and for the first time, described the Giant Gippsland Earthworm *Megascolides australis* in Decade One of the *Prodromus*. His description was accompanied by a two-colour lithograph by Arthur Bartholomew. The worm had turned by 1888, when Spencer revised McCoy's description of the species in *Transactions of the Royal Society of Victoria* (Spencer 1888). Together with Wild, he assembled detailed and sophisticated images of the worm. These lithographs presented a new level of analysis, unprecedented in the *Prodromus*, made possible by microscopy and clinical dissection to reveal in great detail the vascular and digestive systems of the animal. McCoy's magpie-like collection habits and rudimentary descriptions appear amateur by comparison to this new work lavishly put out on large format.

Mulvaney and Calaby assert that in contrast to earlier biology in Victoria, Spencer 'set priorities and the work possessed theoretical value. Various species were selected because of their potential evolutionary significance or their biogeographical interest,

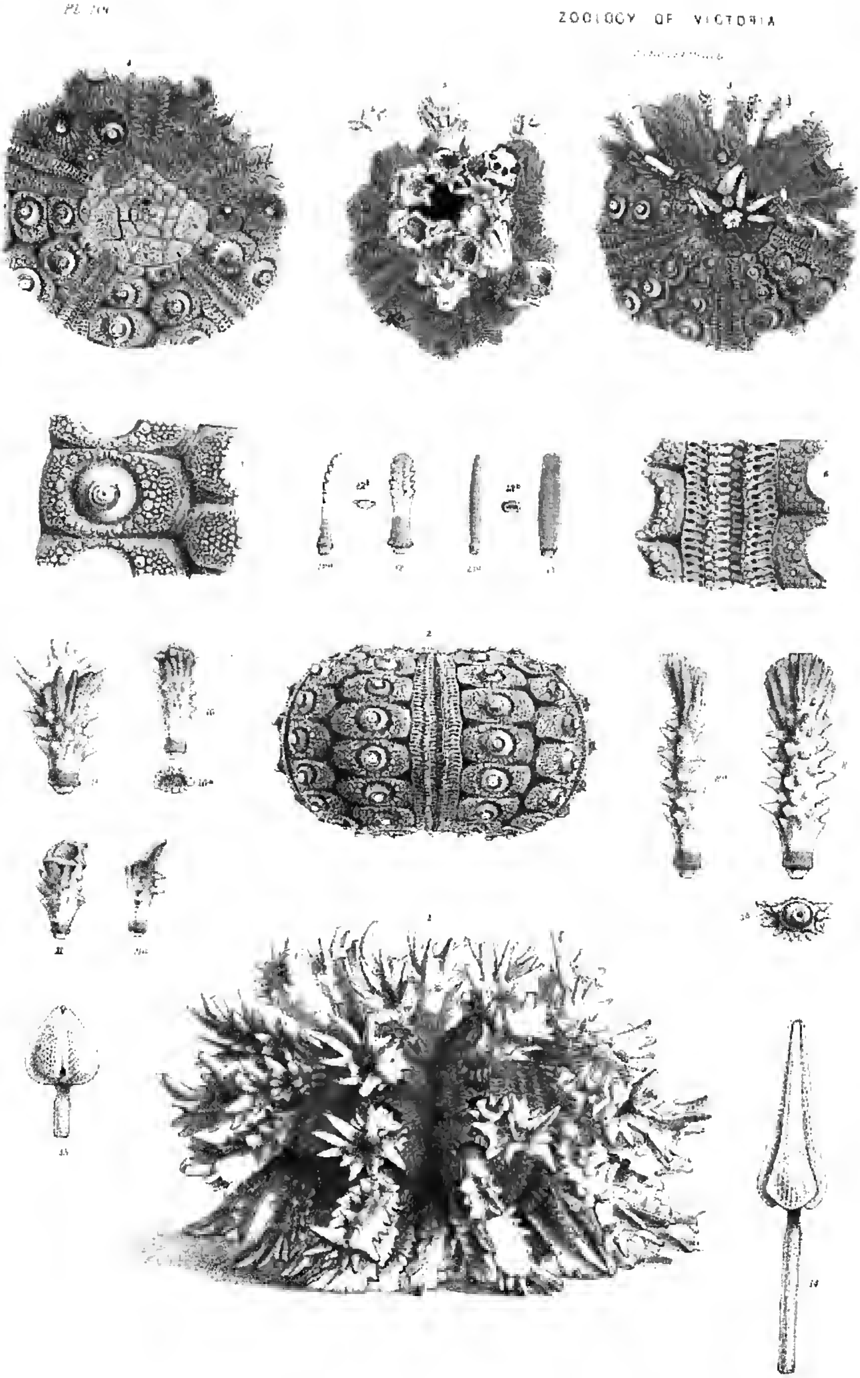

Fig. 3. Wild's drawings of *Goniocidaris tubaria* for McCoy's *Prodromus* of the Zoology of Victoria. Source: Museum Victoria/ Artist: John James Wild

and they were assessed within the conceptual framework of biological evolution'.[6]

Spencer's description of the anatomy of *Megascolides australis* exemplifies a new level of scientific rigor that came to characterise Australian science in the 20th century, a period when McCoy's *Prodromus* was largely relegated to a historical curiosity rather than a vital contribution to the scientific record.

Spencer had a much finer appreciation of the relationship between professional and amateur biologists (explored earlier in this volume by Linden Gillbank in her account of the history of the FNCV). Spencer's active participation with field naturalists clearly energised the club members, whereas we can only imagine that McCoy's pompous annual address must have filled them with dread.

Towards the end of his own life Spencer reflected on changes to the scientific landscape he had in fact fanned, sparing a melancholy thought for the intellectually simpler times that preceded his ascendancy to prominence in Australian Science.

> In study, field and laboratory scores of eager students relieved from the dead weight of the special creation theory, were working under the stimulus of an entirely new outlook on the world of life. It is difficult for the students of the present day to realize the excitement of those times when everything was new and stimulating and when further still, it was possible for one man to have a good all round knowledge of [...] the salient features of the different branches of Science.[7]

The principal artists of McCoy's grand project, Becker, Wild, and to a lesser extent Bartholomew, were just such men. They possessed a 'good all round knowledge of science' and were blessed with fine eyes and steady hands. Persistence and insatiable curiosity enabled them to empirically and on occasion poetically, describe the fauna they encountered in colonial Victoria.

McCoy's *Prodromus* created the opportunity for artists and lithographers with a passion for natural history to portray the fauna they encountered in their adopted land, but his intellectual framework constrained both their artistic expression and advances in scientific investigation. Nonetheless the archive of images that he assembled opened a window in to the practice of science in a period of vivid contestation.

Notes

[1] McCoy (1885) *Prodromus*, Vol 1, 1.
[2] Australian Encyclopaedia (1962) Ludwig Becker, 471.
[3] McCoy (1879) *Prodromus*, Vol. 1, 31.
[4] Lucas (1937) *A.H.S Lucas. His Own Story*, 140.
[5] Gibbney and Smith (1987). *A biographical register*. 343
[6] Mulvaney and Calaby (1985) '*So Much that is New*'. 97.
[7] Spencer (1927), cited in Mulvaney and Calaby (1985), *op. cit.* p. 97.

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From Woodlands to Field Naturalists – What an excursion!

Sue Wright[1]

Abstract
The Friends of Woodlands Historic Park, which began 23 years ago, were invited to dramatise the history of the Field Naturalists Club of Victoria for the 'Leaves from our History' symposium. This paper presents some background information about the Friends, and explains how the theme and content for the play 'A signal Service' came to be chosen. (*The Victorian Naturalist* **122** (6), 2005, 375-378)

Interpretive theatre has taken our show team (Friends of Woodlands Historic Park) travelling back through quite a few years and across quite a few kilometres. The most recent trip out of our home ground at Woodlands Historic Park was to the Herbarium, where we had the pleasure of joining the Victorian Field Naturalists celebrating 125 years of service. The response to our production of 'A Signal Service' was generous to say the least, and we were asked how and when we began this interesting time travelling. The story is an interesting tale and it illustrates another signal service – although of a much shorter nature than 125 years. Perhaps we should explain how we ended up on stage at Mueller Hall.

Our Friends Group began 23 years ago and we have always valued the diversity of our wonderful Park. From the earliest days we have successfully supported the natural environment of the grassy woodlands and the impressive built environment of the homestead. As you would expect, some of us feel more at home in one environment than the other, but we appreciate both, and we have a great admiration for the work in our dual 'worlds'. My own feeling is that the natural and built environments flow together in a continuum. I feel very privileged as we take the stories of one to interpret the heritage of the other. I'm proud to belong to a Friends Group that gives us the opportunity to conserve both.

Way back in 1997, our Friends Group faced a challenge. The Park system was in a state of change and re-orientation as a new management came into being. Woodlands had to change, as did a great many other Parks. We had always contributed to the Ranger-led visitor programs over Easter, but staff cutbacks and other constraints meant that there would be no program unless the Friends ran the program themselves. Phone calls went left and

[1]Friends of Woodlands Historic Park, Victorian Friends Network.

Mrs C French writes the *Argus* notice, which led to the formation of the FNCV, as portrayed in a play by the Friends of Woodlands Historic Park. Photograph: Wendy Clark

right and we thought we could support at least part of the program on our own. We decided to try a new idea and dramatise a piece of the homestead history as a theatre production at night. This meant that our volunteer efforts were spread over a wider time scale, and we evolved a presentation called 'Chaffey's Woodlands'. Looking back, it was unrehearsed, haphazardly presented and, even though the characters didn't have great costumes, the costumes certainly had character. At the end of Easter we looked at the results. There must have been something interesting in the show because there was an influx of people wanting another show. Somehow we had done something right.

To summarise, we were doing a show a month for the rest of the year and the story evolved each time we performed. We applied for a Council grant and were successful. We purchased light and sound equipment and costumes, and the bookings kept rolling in. Eight years later we're still in business. Interpretive theatre proved to be a brilliant way to create awareness of Woodlands and a very effective fundraiser for us. It was also a wonderful experience for the presenters. We revelled in the theatre process. It has remained an exhilarating experience for us, and we continue to be grateful to have the opportunities to write, produce and act our shows. In 1999 and 2001 we presented new shows. The repertoire was growing and so was our belief in the very powerful messages that interpretive historical dramas could deliver.

Woodlands continued to be our 'stage' until 2002 when I offered the show team to perform at the VNPA picnic to be held at Steiglitz Historic Park. There was some misgiving that a show in the Steiglitz Courthouse would be well received. The VNPA was more used to outdoor nature based activities. We took the risk. There were crowds at each performance and we've been regulars at the VNPA picnics ever since. This opened up the idea that we could travel venues as well as time. After the first effort at Steiglitz, we received an invitation to perform at the 2003 International Ranger Conference at Wilson's Promontory. This was a pretty tall order for the team from suburban Woodlands, but by then I had a few different interpretive experiences under my belt. It was a matter of applying the 'recipes' that had worked well before and trying not to be intimidated by the international audience.

I chose to interpret the beginning of the Field Naturalists 1905 Excursion to the Prom led by Alfred and Anna Hardy. To research them, and their excursion, I sought Sheila Houghton's excellent assistance and in a very short time I was initiated into the amazing world of the Field Naturalists. Our interpretation of their camp at Darby River was extremely well received. The only down side was that we performed for one day only and Anna and Alfred had such a brief interpretive rebirth.

After the Prom experience we continued with our interpretive theatre at Woodlands. We also performed at Point Nepean and at Point Cook. Then came 2005 and the indefatigable Sheila rang to invite us to do 'something' at the 125th Anniversary Symposium.

To try to encapsulate 125 years of wonderful history to be presented in three short acts requires signal inspiration and encouragement. Fortunately I had both, and somehow, some way, Anna and Alfred would come back to life. Once you bring characters to the stage they don't recede very easily.

The sheer wealth and diversity of the history of those 125 years meant that I had to be very focused finding the 'something'- otherwise we would all be sitting right through to the 130th Anniversary.

Ultimately, we decided on a theme of 'service' and after enormous discussion and selection chose early, middle and later episodes that hopefully define the initiative, inspiration and breadth of service to natural history and community awareness that the FNCV has performed so admirably. In interpretive theatre, you start from the message and then work backwards to the stories and the characters. Sheila was a goldmine of anecdotes and I had no trouble weaving her amazing oral and written stories to the theme.

The name 'A Signal Service' leapt out at me when I read the letter proposing the Natural History Medallion. Considering

A re-enactment by the Friends of Woodlands Historic Park of the FNCV packing up to move to its own premises in Blackburn. Photograph: Wendy Clark what we were interpreting, it was a natural choice for a title. Not surprisingly, Sheila inundated me with material and I bombarded her with a million questions, all of which she answered very patiently. I sincerely regret that so many wonderful anecdotes had to be put aside. Forgive me if your favourite FNCV episode or personality didn't come to light in this performance of 'A Signal Service'. As I said, I was constrained by time, certainly not by material.

I have to thank the theatre team from Woodlands – they are great interpreters and even greater friends. The stress levels were high as we all dealt with ultra busy lives having to fit in rehearsals, practise Latin names, find costumes and Pride of Erin music. There were times when we felt, perhaps, that we should have stayed safe within the confines of Woodlands. Then again there was the very happy feeling you get as you travel back to a time gone by, find a message and a wealth of characters begging to interpret a theme for today. It's like plunging into a treasure chest – you never know what treasure you'll find.

The single suggestion that Mrs. French wanted, just once, to have Sunday lunch on time, the beautiful letter about the fairy lights in war time New Guinea and the busy emotional packing up for new premises all stretched to great interpretive vehicles. The results were seen at the Hiustory Symposium on May 28th. We had the time of our lives and I was very glad that the recipe worked so well. Anna and Alfred had their small mention and I had a secret delight in the reference.

We are performing again at Woodlands and would welcome any of the FNCV members to join us. The reports of your 1911 and 1953 visits to Gellibrand Hill (part of Woodlands) has given us a wealth of new interpretive material, so the stories continue just as the efforts to preserve our diverse heritage continue. It occurs to me that if we find a story in every FNCV excursion we'll be needing an enormous supply of costumes, if nothing else.

It was a pleasure and privilege to join the FNCV for part of the 125th Anniversary. Celebrate a wonderful achievement and enjoy that celebration. If you would like another interpretive adventure, please ask us back. Once you bring characters to the interpretive stage they don't recede very easily. Anna and Alfred might be quiet for now, but look at all the others that are waiting!

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Junior naturalists checking for pondlife in a backwater on the Goulburn River, 2000. Photograph: Wendy Clark.

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In which is incorporated the Microscopical Society of Victoria

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Speakers on the second day of the History Symposium, May 2005. Back row, left to right:Nevil Amos, Malcolm Calder, John Kean, Gary Presland. Front row, left to right: Ian Endersby, John Walter, Alan Yen, Noel Schleiger, Ian Mansergh, Melanie Archer. Photograph: Wendy Clark.

The audience paying close attention to one of the speakers in a session on the second day of th History Symposium. Photograph: Wendy Clark.

The Victorian Naturalist

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From the Editors

This issue of *The Victorian Naturalist* contains one of the last of the presented papers from the History Symposium, too large for inclusion in the previous issue. Presented here, also, is Eric Bird's paper from the Symposium 'Digging in the Bay'. The slightly amended 'Guidelines for authors', are included and will be found at the end of the issue.

The Victorian Naturalist would not be successful without the enormous amount of time and effort given voluntarily by a large number of people who work behind the scenes.

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Front cover: Pauline Reilly, recipient of the Australian Natural History Medallion 2005. See Tribute on p. 47. Photograph by Jenny Porter

Back cover: Male (top) and female (bottom) Hardhead *Aythya australis*. See article on p. 38. Photographs by Geoffrey Dabb.

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Victoria's living Natural Capital–decline and replenishment 1800-2050 (Part 1)

Ian Mansergh*, Heather Anderson* and Nevil Amos*

Abstract

This paper examines Victoria's land-use history and the range of environmental, economic and social forces that resulted in the significant depletion of the state's natural assets. Historically, a succession of differing management practices has been applied to Victoria's natural assets, from Koori husbandry, through pastoralism to the more intensive agriculture of settlers. In the 20th century agronomy and technology further intensified and industrialised production across most landscapes. Land-use activities of one generation frequently caused management issues for the following generation, continuing a decline in the living natural capital. Environmental assets and processes were not considered and remained as external factors to economic production. Analysis suggests current and future drivers of land-use are changing and thus that future landscapes will change. There are therefore opportunities for the community to reverse some of the adverse effects of past practices. This increased knowledge, plus the affluence gained through past consumption of natural assets, should be used to replenish the living natural capital. (*The Victorian Naturalist* **123** (1), 2006, 4-28)

Introduction

In Part 1 of this paper we provide an overview of Victoria's land-use and environmental history.[1] This is done through:

1. constructing a simple framework through which to view land-use and ecological change;
2. analysis of various statistics in broad periods: Koori management, 1770-1850; 1851-1900; 1901-1939; 1940-1970, and 1971-2004;
3. observations and reflections of participants in our history.

Part 2 of the paper will provide an assessment of the prospects for replenishing some of Victoria's depleted living natural capital, and examine some of the future drivers of land-use change.

The present landscape condition is the expression of past natural events and management of the natural capital (Figs. 1 and 2). Economics, demography, environment, culture and public policy all have played a part in shaping Victoria's landscapes. From the 1840s, traditional Koori land management was replaced by an exploitative colonial view of the landscape. Early

Fig. 1. Victoria – Modelled Pre-1750 Landsat TM Satellite Image (DSE 2003)

*Department of Sustainability and Environment, PO Box 500, East Melbourne 3002

squatters were replaced by intensified land-uses and, in the 20th century, agronomic practices such as the use of fertilisers. The introduction of pesticides and herbicides led to the increasing industrialisation of agriculture and the rise of agribusiness. With a few notable exceptions, land and water use has been driven by commodity production (Wadham *et al.* 1957), and environmental assets and processes have not been treated as costs of, or benefits to, production. Generations after Major Thomas Mitchell's overly optimistic assessment of western Victoria as 'Australia Felix' (Mitchell 1838), we are now coming to terms with living in the driest inhabited continent (McKernan 2005).

By 1982 about 67% of Victoria had been transferred from the Crown to private ownership, making it the most alienated state in the Commonwealth (i.e. the greatest amount of land that has been transferred from the Crown to private ownership). At the same time, Victoria also has the greatest concentration of bioregions under high environmental stress (Fig. 3). Large segments of our biodiversity have been depleted and declines in ecosystem function and services are evident. Victoria's tree cover has been depleted by 62%, which is associated with the decline in other assets: threatened species, rivers and streams, wetlands and soils. Only 22% of river and stream length in Victoria is in good or excellent condition and many environmental indicators are predicted to worsen in the next decades as effects of past land-use become manifest (VCMC 2002).

The land-use activities of one generation frequently led to management issues for the following generation (Smith 2000), with a legacy of continuing decline in natural capital. Historic drivers of land-use are changing, creating novel opportunities, if not imperatives, to reverse historic trends and improve the condition of our future landscapes and natural capital. Positive changes are evident in our evolving use of public land, and indeed perceptions of all land and water use and management.

Framework for examining Living Natural Capital

Living natural capital is defined here as biodiversity assets and the processes they support and provide. Our native biodiversity is 'the variety of all native life forms ... the different plants, animals and micro-organisms, the genes they contain, and the ecosystems of which they form a part' (Commonwealth of Australia 1996). Economic and social capital are traditionally measured by growth (toward an unknown or undefined point), whereas natural capital is measured by its variance

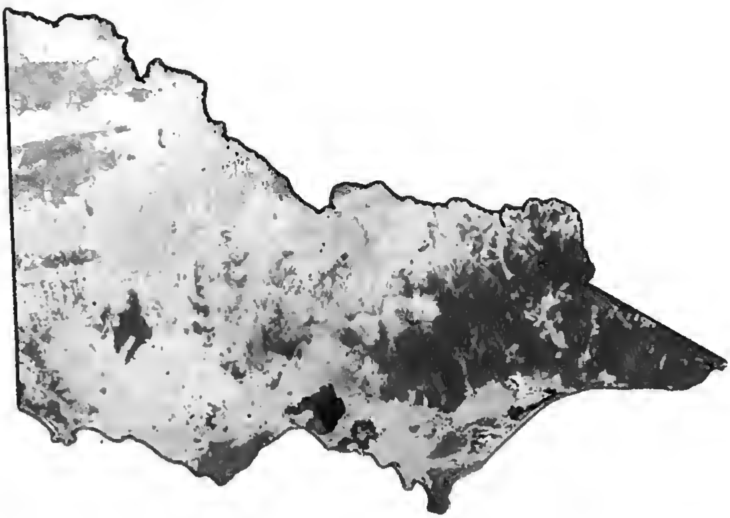

Fig. 2. Victoria - Landsat TM Satellite Image 2000. (DSE 2003)

from an ideal or benchmark. Thus there are fundamental differences in accounting for these asset types. Natural capital is finite – it cannot be increased beyond a 'natural' or benchmark value, but may be diminished through unsustainable use of natural resources or replenished through appropriate management. Some depletion of natural capital (e.g. extinction) is irreversible. Natural capital costs of economic and social development have been viewed traditionally as economic 'externalities' –costs that are not incorporated into the economic transaction (Herath 1998; see also Daly 1991).

Three perspectives are useful when examining living natural capital. The first is the natural capital expressed at a site (e.g. Fig. 4; Parkes *et al.* 2003). The second is the amalgamation of these effects at the landscape level (Fig. 5), which magnifies the ecological consequences of each site and may reach ecological thresholds (Radford *et al.* 2005). Removal or change in species composition (e.g. elimination of higher order predators) may affect ecosystem function. (See Mansergh *et al.* 2004 for a discussion in the context of alpine areas.) The third is the landscape-scale effects that are expressed elsewhere – either regionally (e.g. water in rivers and streams) or globally (e.g. atmospheric and climatic conditions). This paper concentrates on native vegetation as a high-order indicator of our natural capital, and relates this to other natural capital assets such as soil, water and associated biota.

Photosynthesis converts atmospheric CO_2 to organic carbon, which builds soil carbon and soil fertility–major elements in natural capital. When forests are converted to cultivated land, the natural living vegetation is lost immediately. Organic carbon reserves and nutrients continue to decline over decades (Fig. 8), although productivity can be increased using external inputs. Exotic animals grazing on natural vegetation will cause depletion of probably intermediate proportions, but changed fire and grazing regimes do affect ground cover species (McIntyre and Lavorel 1994). Clearing trees also changes the distribution of available microhabitats (water/light availability) tending to simplify understorey and ground cover. The removal of deep-rooted perennials affects groundwater and increases the risk of soil erosion, depending on topography and landscape.

Vegetation clearance and land-use change alters the original intact vegetation in a systematic manner: firstly to a variegated pattern of vegetation, then to fragmented vegetation, and finally to relict vegetation (Fig. 5; see Radford *et al.* 2004, 2005 for woodland birds). Recent debate and research suggests that there are ecological thresholds (reviewed in Huggett 2005)–points along a continuum of change (e.g. loss and fragmentation) at which a qualitative change takes place in the ecosystem, such as its ability to support a prior suite or richness of species. (See Soule *et al.* 2004 for a more complete discussion in relation to connectivity.)

A further issue is that of unequal representation of habitats in the landscape. Even subtle variations in the soil fertility, hydrology, etc. may affect the ability of an ecosystem to support populations of flora and fauna, particularly at a time of stress such as drought. (See, for example, Soderquist and Mac Nally 2000; Mac Nally *et al.* 2000). More productive sites would have been cleared first so all examples of a particular habitat could be lost even where much of the vegetation has been retained.

Victoria has a sound mapping base of our vegetation (Ecological Vegetation Classes [EVC]) and measurement of the extent of vegetation cover is periodically updated by remote sensing information (e.g. Gilbee 1999). As our understanding of the pattern and extent of habitat loss becomes clearer, the development of robust measurements for assessing changes in condition of natural capital will be critical in determining our starting point and success in restoration (Parkes *et al.* 2003) (Fig 4).

Koori land management

At the time of European settlement, the natural capital of Victoria had been influenced by Kooris for more than 40 000 years. This natural capital existed in a largely ancient isolated continent characterised by low nutrient soils and a high biodiversity. In the course of the long Koori management there were probably faunal extinctions (e.g. of the megafauna;

Roberts *et al.* 2001). Fire was a natural occurrence, but it was also an important management tool in the hands of Kooris. Its use probably played a large part in the spatial expression of Victoria's vegetation communities and their composition. The Koori population was spread across Victoria in accordance with their knowledge of the long-term and seasonal carrying capacity of the natural environment and their own technology (Smyth 1878; Lourandos 1997).

Koori life and land management in the 19th and early 20th centuries were recorded by contemporary Europeans (e.g. Smyth 1878; Howitt 1904), but modern research (e.g. Lourandos 1997) and recent Land Title Cases (Clarke v State of Victoria [2005] FCA 1795) have provided more detail and often different perspectives. In south-western Victoria, eel traps were used by people who were more sedentary than previously thought. Research following the 2003 fires in eastern Victoria suggests that there was an active occupation of the forested/alpine areas (Freslov *et al.* 2005). The landscape that Europeans exploited with new animals, technology and belief systems was a manifestation of both Koori management and the 'living natural capital' available in Victoria.

1771-1850: Koori - frontier

Squatters took up land in Victoria, from the 1830s onwards. Edward Henty settled illegally at Portland in late 1834; John Batman procured 243 000 ha around Port Phillip from the Kulin in 1835; the Omeo district and parts of Gippsland were taken up around the same time (Brodribb 1883; Prendergast 1968). Before Victoria was legally opened for settlement in 1836, there were about 180 Europeans and 25 000 sheep (Catrice unpubl.). Squatters in search of pasture came from Tasmania and, urged on by Mitchell's optimistic observations, south from New South Wales, to take up prime grazing land (Roberts 1935). This occupation was extremely rapid. By the 1850s most of Victoria except the Mallee and parts of Gippsland were available to the squatters (under a £10 licence) and there were more than six million sheep and about one million cattle (Powell and Duncan 1982; OCE 1992). Later licences were for the more inhospitable areas, such as the Wild Cattle Run (forests of South Gippsland) of over 100 000 acres and a 'carrying capacity' of 640 cattle, taken up in 1848 (South Gippsland Pioneers' Association 1966). Transport was overland (droving) and on water, and durable commodities such as wool and tallow provided exports and financial return.

Grazing sheep and cattle favoured the open grasslands and grassy woodlands (Prendergast 1968; Lunt *et al.* 1998). Access to permanent water became important and carrying capacity varied (Garder 1896; Smith 2000). Squatters exploited existing native vegetation (grasses and forbs) and landscapes (grasslands) previously husbanded by the Kooris, and converted natural capital into food and fibre. Some native species declined very rapidly; for example, Murnong or Yam Daisy, which had been a staple Koori food (Gott 1983). The selective grazing of the sheep and cattle must have caused local extinctions of ground-cover species and inhibited regeneration of others. Many local histories recorded the early disappearance of a range of plants and animals, and gradual changes in the structure of the vegetation through fire and ringbarking (e.g. Prendergast 1968).

In some areas the collapse of natural systems was already evident under the onslaught of introduced ungulates. In 1853 John Robertson, who had taken up land in the Wannon region in May 1840, observed:

> A rather strange thing is going on now. One day all the creeks and little watercourses were covered with a large tussocky grass, with other grasses and plants, to the middle of every watercourse but the Glenelg and Wannon, and in many places of these rivers; now that the only soil is getting trodden hard with stock, springs of salt water are bursting out in every hollow or watercourse, and as it trickles down the watercourse in summer, the strong tussocky grasses die before it, with all other. The clay is left perfectly bare in summer. The strong clay cracks; the winter rain washes out the clay; now most every little gully has a deep rut; when rain falls it runs off the hard ground, rushed down these ruts, runs into the larger creeks, and is carrying earth, trees, and all before it (quoted in Jones 1999).

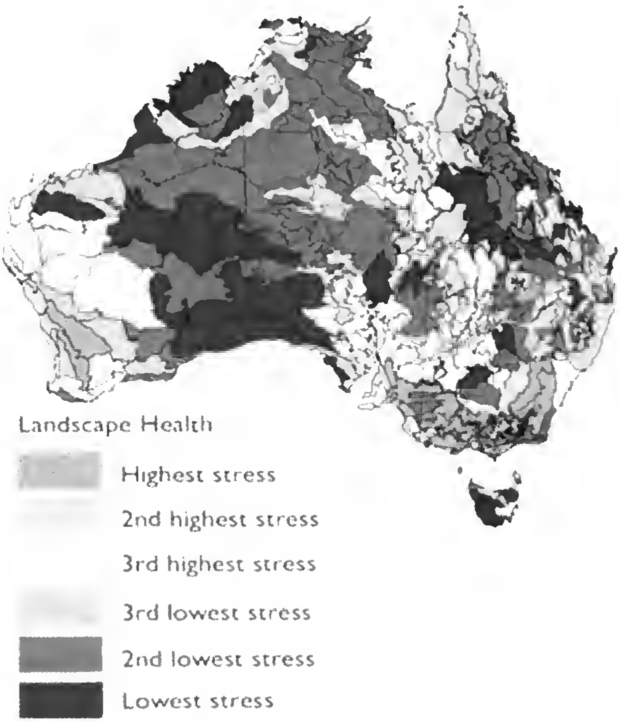

Fig. 3. Bioregional landscape stress for Australia (Source: NLWRA [2002a])

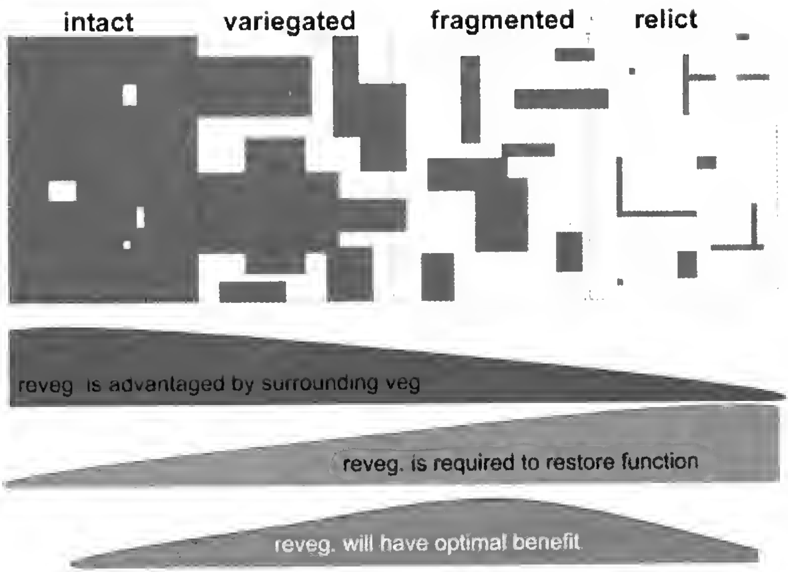

Fig. 5. Vegetation pattern in the landscape (after McIntyre and Hobbs 1999) and its effects on revegetation (D Parkes, pers. comm.).

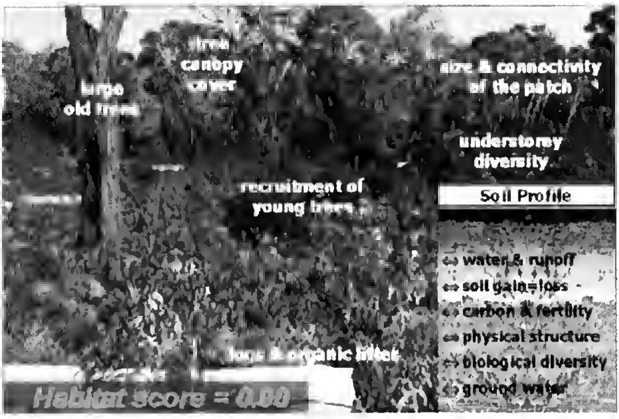

Fig. 4a.

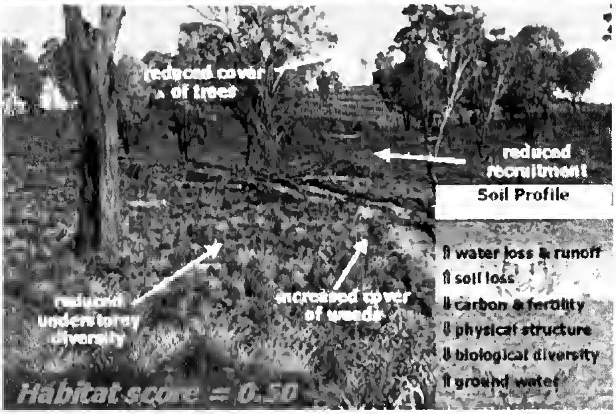

Fig. 4b

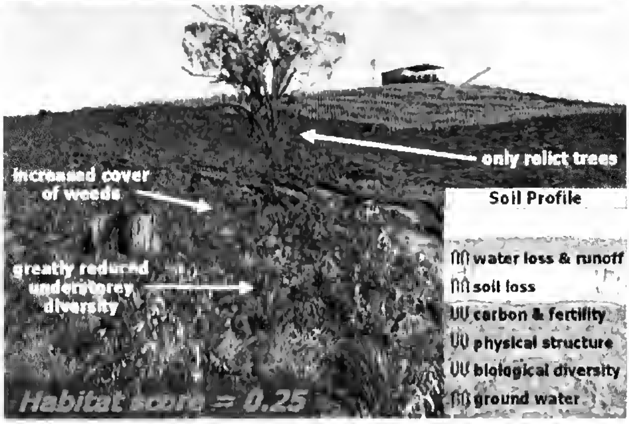

Fig. 4c

Fig. 4. The natural capital of vegetation and soil at three stages of landscape degradation (habitat score, see Parkes *et al.* 2003).

Fire was an important tool of the Kooris. Europeans used fire to create green pick for stock, although this was modified as fencing and closer settlement progressively restricted burning to 'the bush'. Of the uncleared Gippsland forests–probably tbe montane areas–Howitt (1891) observed that 'These annual bush fires [of Kurnai] tended to keep them open and to prevent the open country from becoming overgrown. In the same area (although varying in different forest types), dendrochronological studies indicate that fire became more frequent in the colonial period than under the Kooris (Banks 1989).

1851-1900: Colonial pioneers

The gold rush raised the population of Victoria from 77 345 in 1851 to 540 322 a decade later. Local landscapes, particularly streams, were radically changed in the search for alluvial gold. The need for durable beams in gold mines, wood for buildings, piers and railways, and timber for fuel (including for paddle steamers along the Murray River) drove timber harvesting in the Box-Ironbark and Red Gum forests and rapidly depleted many areas of mature native forest (NRCL 1957). By the end of the colonial period mining was still a major activity in more than 28% of the 729 Victorian townships, although some areas had been abandoned and natural regeneration was occurring.

During this period Koori land management was curtailed and negative attitudes and actions against the Kooris rapidly developed in the colonial population (Cannon 1982) and by 1861 the Koori population was estimated at only 16% of pre-settlement levels (Coutts 1982). Watson (1984) concluded that 'far from being inevitable, the destruction of the Kurnai (Gippsland region) society was gratuitous and grotesque'. (See also Leslie and Cowie 1978; Christie 1979). By 1886, after disease, resistance and dispossession, the Koori population had been reduced to about 6% of its pre-settlement level (800 people) (Christie 1979).

The concept of *terra nullius*–land unoccupied and thus free to be taken–emerged as the underlying paradigm of European settlement and allowed alienation to private property. From the 1860s, a series of Acts were passed for closer settlement requiring 'improvements' to the properties (Catrice unpubl.) and government surveyors 'squared' up the landscape for alienation and agriculture of the pioneers (Chappel 1966; Dingle 1984). Agrarian idealism was reinforced by Jeffersonian ideas of social democracy in which free, independent, small land-owning primary producers would form the basis of a new society. The Christian philosophy of subduing the earth, as expressed in Genesis 1: 28, also underpinned this view. A Scottish pioneer of the Monaro, John Dunmore Lang, envisaged future landscapes as valleys of Christian villages (Watson 1984, in Seddon 1994).

The change in land tenure was to have a profound effect across a range of Victorian environments (Bromley 1991). Closer settlement meant more labour available for intensive clearing, both of the preferred grassland and woodland environments and the higher-rainfall forested areas–the colony was to be 'Europeanised'. Native vegetation and species disappeared at the site and at the regional level prior to any detailed knowledge of their favoured habitats. For example, forest dependent Leadbeaters Possum *Gymnobelidus leadbeateri* is known from only a single record in south Gippsland (Bass River). The depletion of large areas of forests of south Gippsland and the western Strzelecki Ranges was rapid after being opened for settlement (1870s) when 90% of the work in the first 5-10 years was axe-work (South Gippsland Pioneers' Association 1966). In the Narracan region, dairy pastures (Adams 1978) were to dominate after the technique of ringbarking (a unique Australian invention) eliminated the tallest hardwood forest on Earth. The transition from pastoralism to intensive agriculture in this region eliminated native trees to create a new landscape 'that reminds one of the grassy hills and valleys of glorious Devon' (Western 1966).

Howitt (1891), an astute observer of nature, reflected on the interaction of land-use, soils, climate, insects and water on vegetation of the Gippsland Red Gum forest during this period:

> The long continued use of the country for pasturage, the trampling of the surface of the ground by stock, has greatly hardened the soil, so that rain formerly, in ... the 'normal state for Eucalyptus', soaked in, now runs off. In the course of successive droughty seasons, the soil of such places becomes thoroughly dry and hard, so that the red gum is deprived of much moisture which it otherwise would have in reserve. The trees are wanting in vigour and thus unable to withstand the attacks of insect pests.

The selective grazing of sheep and cattle would have inhibited regeneration of canopy and shrub layer, and properties were 'improved' by tree removal, changing the composition of the understorey. In some landscapes, such as the Gippsland Plains, lack of regeneration began in this era, leaving only senescent Red gums in the 1980s (Kile *et al.* 1980).

Pastoralism, based on native pastures, remained the primary land use (in terms of area) with increased clearing across the landscape in more closely settled areas. Licensed grazing of public land became a legitimate use for land not yet alienated. Many local towns quickly established Agricultural/Pastoral Societies to aid settlement and production, for example Port Fairy in 1853 (Earle 1975). However, there was little evidence of pasture improvement (Smith 2000). In 1900 only two tonnes of seed for improved pasture was produced in Australia (Smith 2000). Improvements such as fencing and buildings made fire less desirable, and the consequential change in fire regimes and greater herbage production may have increased organic matter (Smith 2000) and lowered soil pH. Over two thirds of the state (Figs. 6 and 7) was undergoing the degradation trend evident in the difference between Figs. 4a and 4b.

The fragility of the Australian environment to introduced plants and animals was unknown, and acclimatisation of exotic species was part of Europeanising the land. Two major vertebrate pests were released on some of the large squatting-derived properties, as on the Western Basalt Plains, and spread very rapidly–rabbits in 1859-1860 (Williams *et al.* 1995) and foxes around 1870 (Rolls 1969). Plants were also introduced, both consciously and inadvertently. Pastoralism also meant that native predators such as dingos, quolls and other species were persecuted and were to become regionally extinct.

Cropping, initially for feeding horses for transport, moved to wheat growing and was to become the second agricultural staple, particularly in the drier regions. The repeal of the English corn laws opened the largest global market for wheat and a new durable commodity that could be grown in the Antipodes (Wadham *et al.* 1957). In 1850 the area of cropping was negligible, but by 1860, 18 of the 37 counties had minor cropping (wheat) areas (13 of these < 5000 ha) concentrated in the south-western, central and north-eastern regions (OCE 1992). By 1880 the Wimmera, Mallee and Riverina had been 'opened up', and most of the one million hectares under wheat was north of the Divide (OCE 1992). The coppicing nature of mallee eucalypt meant that until the roots died or were removed, selectors faced substantial ongoing work (McKernan 2005). The invention of the stump jump plough and McKay's 'Sunshine' harvester, and the expansion of the railway network (which reached Swan Hill in 1890) facilitated land clearing, a requirement of closer settlement. On a 'good day' a bullock or horse team could clear 10 acres, and this was increased with the introduction in 1880 of traction engines, 2600 of which were used in the Mallee over several decades (Garder 1986). By 1900 the residual natural capital of the natural vegetation (in soils) was being depleted (Fig. 8)–the wheat yield per hectare had declined by more than 50% between 1870 and 1900 despite more land being 'opened up' (OCE 1992) (Fig. 9).

In the semi-arid Murray Mallee and Riverina, pastoralism, cropping and rabbits led to the loss of 10 of the 14 mammal species now extinct in Victoria–including rodents, bandicoots, dasyurids and macropods (Menkhorst 1995). One third of the semi-arid mammal fauna was to become extinct. Selective and excessive grazing by sheep and, subsequently, rabbits, utilisation of all fertile areas, and clearing for crops eliminated species and habitats. 'Regeneration of some trees and shrubs, notably Slender Cypress Pine *Callitris gracilis* subsp. *murrayensis*, has been a rare event ... following rabbit invasion' (Menkhorst 1995). Natural capital depletion includes both absolute loss and degradation in condition and processes in uncleared environments.

Major droughts occurred during the period (Keating 1992). The native biodiversity had evolved with periodic drought, but this was the first period where the flora and fauna had to survive in much reduced habitat with increased grazing pressure. Water, or lack of it, was emerging as a limiting factor of the Victorian environment for the trans-

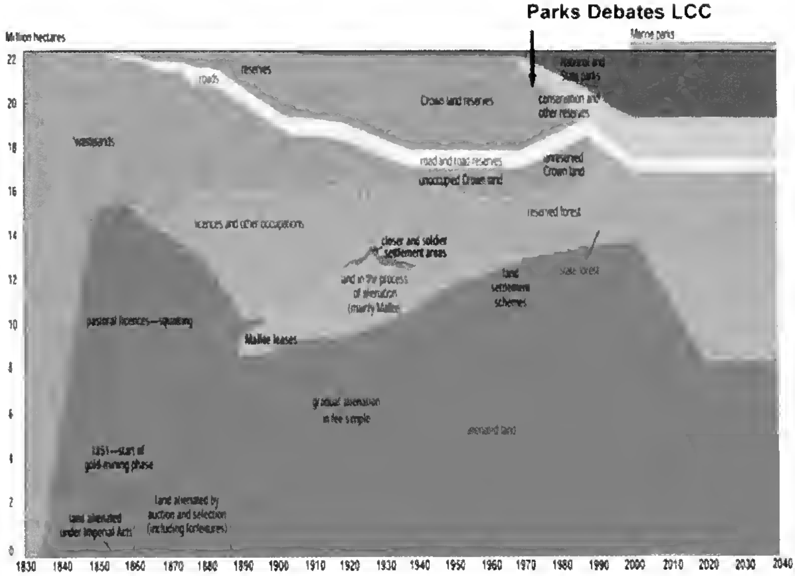

Fig. 6. Changes in land tenure and status in Victoria. (Adapted from: OCE 1992)

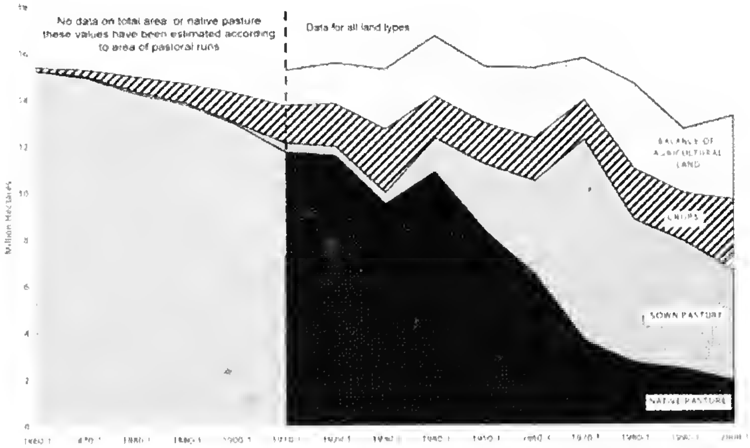

Fig. 7. Total area and proportion of crops, pastures and other uses of agricultural land in Victoria. Source: ABS Agriculture Commodity Survey, Australia (7113.0 and 7121.0), various years. Note: there was no ABS data available for the area of native pasture prior to 1910-11 or for the total area of agricultural land between 1860-61 and 1910-11. The dotted lines provide an extrapolation of these values.

planted agriculture. The socio-economic effects of the drought of the 1880s on the ill-prepared farmers (and their stock) were dramatic. When the Archbishop of Melbourne visited the drought stricken areas his spiritual advice was 'Don't pray for rain – dam it' (McKernan 2005). The extremity of the droughts and the slow realisation of their periodicity was to prompt a search for 'solutions'. As early as 1884, a New South Wales Royal Commission considered diverting the 'unlimited' water of the Snowy River to the Murrumbidgee (Miller 2005).

The high country would not be alienated, but instead licensed for summer grazing,

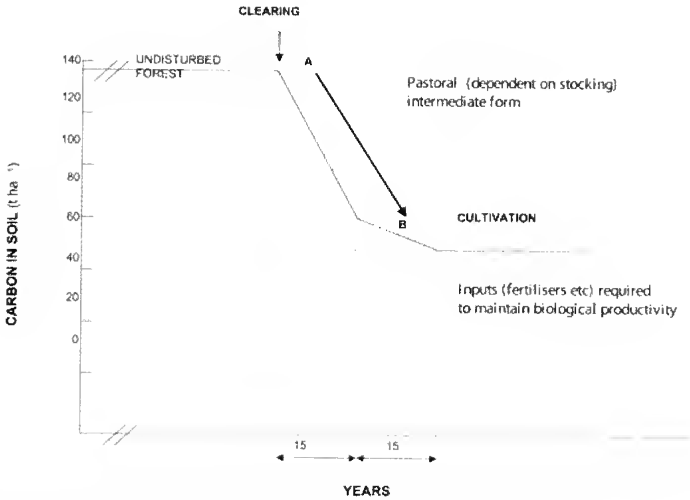

Fig. 8. Loss of soil carbon following clearing and cultivation. Adapted from Houghton *et al.* (1983) in Attiwill and Leeper (1987).

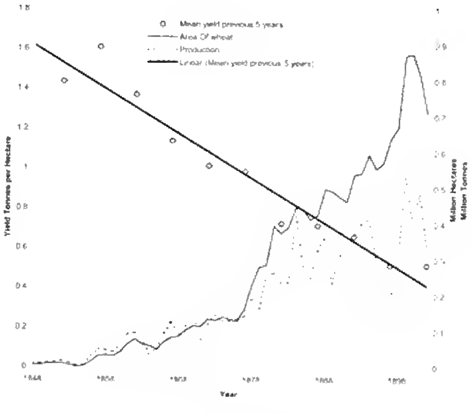

Fig. 9. Wheat production and yield in Victoria 1848-1901. Source: ABS Yearbook Victoria (1301.2), various years.

augmenting the viability of some of the small selectors and established squatters (Prendergast 1968) and providing drought refuge. Within the remaining Crown land estate the concept of reservation, for specific public purposes (forestry, parks, roads) developed. The need for long-term protection of forests for timber had emerged and Wilsons Promontory was reserved for a national park in 1898.

The policy of retaining unbroken Crown land frontages along the coast began as early as 1856 and was extended to inland rivers and water bodies (SRWSC 1983). The water frontages provided water for stock and prevented the squatters denying access (Cabena 1983). By the 1880s a legal framework for management was established. However, in 1903 private use was formalised by licensing to landholders. The opportunities of this far-sighted policy that could have protected our rivers and streams were squandered with 50% of frontage licensed and a further 20% illegally grazed (SRWSC 1983). There were dramatic consequences of this conversion for the degradation of riparian and in-stream habitats (SRWSC 1983).

By 1900 railway infrastructure was in place across Victoria, opening up new agricultural areas, particularly the northern cropping and dairy districts where refrigeration assisted getting product to markets. However, this was after many closer settlements failed. as the economic viability of the extent of land 'selected' depended on its inherent productivity over time, the frequency of drought, and the economics (e.g. depression of 1890s). The net land-use result was that most land suitable for agriculture had been alienated, and over half of the remaining public land (wasteland of Crown) licenced for grazing and other uses (Fig. 6).

'Native game' species declined rapidly around Melbourne from the 1860s (Wheelwright 1979) as it became a larger urban centre. Intensive horticulture in areas such as Geelong-Barrabool (Wynd 1992), the Yarra Valley and the Mornington Peninsula developed to supply Melbourne, and was accompanied by large-scale removal of native vegetation. By the 1890s, Victoria's urban-rural patterns and perhaps cultural perceptions of this divide (McKernan 2005) were largely set; Melbourne's population was 43% of the state's 1.14 million, with regional populations concentrated around the major goldfields (Powell and Duncan 1982). At that time Melbourne was at the forefront of innovation in water supply and sanitation, and its water supply catchments were closed – providing unique 'reference areas' for montane wet forest. After a typhoid epidemic killed 560 people in 1889, engineers designed an underground sewerage system that went to a 'sewage farm' (Werribee) that, while destroying natural swampland, would provide substantial habitat for a variety of waterbirds, particularly international migrants, up to the present day.

20th Century: 1901-1939-Federation, agrarianism and agronomy

After World War I (WW1), soldier settlements brought about major clearing of vegetation in the northern Mallee. The size of blocks proved to be uneconomical and of the 12 635 soldiers who settled there only half remained by 1934, (Priestly 1984, in OCE 1992). Most land was converted to cropping which, compared to grazing native pasture, eliminated natural vegetation at the site level (Figs 4, 8 and 10). The largest cropping areas were in the Wimmera-Mallee and Riverine Plains. The absence of deep-rooted trees and initial crop rotations induced severe soil erosion (OCE 1992) and major dust storms occurred in the semi-arid zone in the 1930s and 1940s (Garder 1986). Wind erosion, periodic plagues of the introduced House Mouse *Mus musculus* (e.g. in 1917) and rabbits affected both production and natural capital. The area under cropping in Victoria peaked in 1930 and 1931 at 3.7 million ha, with vegetation patterns in many of these landscapes becoming fragmented or relict (Fig. 5). Productivity increased with the adoption of fallowing, phosphate fertilisers and improved varieties (OCE 1992). However, many farms were not economically viable even with a level of government assistance (Wadham *et al.* 1957).

Throughout the period, small farmer pastoralism remained the most extensive land-use and continued to be based on clearing trees, and using native pastures with some pasture species introduced. In some intensively grazed (dairying) landscapes, native trees had been eliminated. For example, around Leongatha in 1918:

> '...there is ..., in many instances, a total absence of live timber in the paddocks, settlers having evidently been so intent upon clearing of the heavy timber ... that the benefits of trees as shelter belts was not perhaps fully appreciated' (Watkinson 1966).

Over the period, small owner-farmers were assisted with technical information derived from the emerging body of applied science. But biological information on managing the natural capital related, exclusively, to production. For example, *The Farmer's Handbook* (Department of Agriculture NSW 1946) had 30 pages devoted to clearing techniques.

In 1924, the Waite Institute was established in South Australia for the purposes of calling 'science to our aid' in agriculture. CSIR (later CSIRO) was established soon after, with the soil research division close to the Institute. Knowledge that had been acquired in the English grasslands (e.g. soil-plant relationships and the connection with productivity) was combined with local knowledge of the 'low productivity' of Australian soils (Harvey 2002). The first Director of the Institute, A Richards, expressed concern at the loss of native grasslands, but early work on native

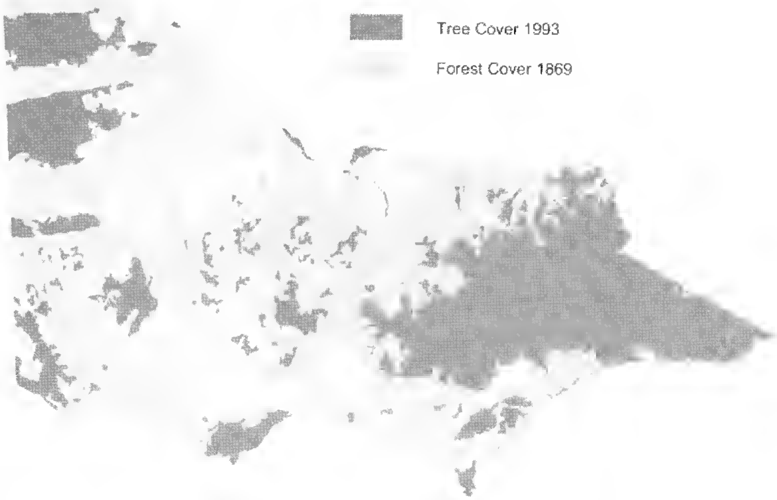

Fig. 10. Tree cover in Victoria 1869 (after Everatt and von Mueller) and 1993 (from Landsat TM) DSE Corporate GIS.

pastures, for example by Cashmore on *Danthonia* (Smith 2000), was largely abandoned when the productivity of exotic species such as perennial rye grass and nitrogen-fixing clovers became evident. With the application of phosphate and trace elements to different soil types, potential increased farm production and potential erosion mitigation became possible across a range of landscapes including new areas that were not previously arable. The Dry Sheep Equivalent became the unit of productivity in the Australian pastoral landscape, allowing comparisons of management systems.

In 1929 the Australian Government introduced a superphosphate subsidy to stimulate pasture development, and this became Australia's primary fertiliser. Widespread chemical use of fertilisers and pesticides came to underpin productivity in this period.

The record drought of 1902 came at the end of a seven-year period of aridity and nurtured concepts such as 'drought protection', culminating in the River Murray Waters Agreement of 1915 (Jacobs 1990). This agreement led to the establishment of storages such as the Hume Weir and a series of 26 locks along the Murray River (Fig. 11). The Long Lake water scheme channelled water over an area of 1600 km^2 north-west of Swan Hill (Garder 1986). The Hume Weir was completed in the late 1930s, beginning the large-scale regulation and storage of Murray River waters. Flood controls (levee banks) and irrigation would begin to affect the natural hydrological cycle, and consequently the health of adjacent riparian forests and ecosystems. The cost-effective landscape-scale engineering of the time involved open channels, creating very 'leaky' systems. Major droughts remained a recurring feature, and occurred in 1914, 1927, 1938 and 1940-41.

The effect of loss of deep-rooted perennials on a landscape scale became apparent, firstly in the soil erosion (Mallee dust storms), and then through rising water tables and increasing salinity in some landscapes. In the Cohuna district in 1901 salinisation emerged as a regional problem soon after irrigation commenced. The opening of Torrumbarry Weir in 1924 accelerated the problem, so that by the early 1930s salinisation seriously affected 300 000 ha in the Kerang region (Mackay 1990; Macumber 1990). Drainage projects were evoked. Barr Creek became and remains the largest single input of salt into the Murray system.

The remnant vegetation patterns in many agricultural landscapes were reduced to fragments or relicts (Fig. 5). Importantly, on public land that traversed these land-

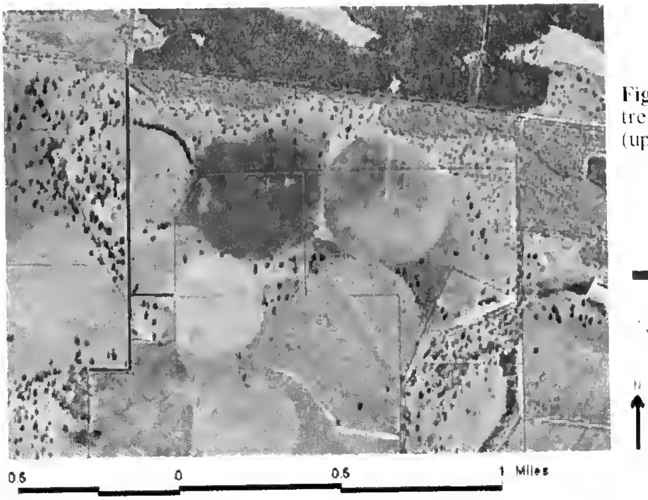

Fig. 13a. Pivot irrigation (centre) and blue gum plantation (upper).

Fig. 13b. Machinery crushing basalt rocks *in situ* in native pasture. Note the rock fences from past removal.

Fig. 13c. Stubble burning and elimination of mature Buloke/ redgum.

Fig. 13. Recent intensification of land use in SW Victoria. (Photos: (a) Greg Campbell; (b) Phil Perret; (c) Ian Mansergh).

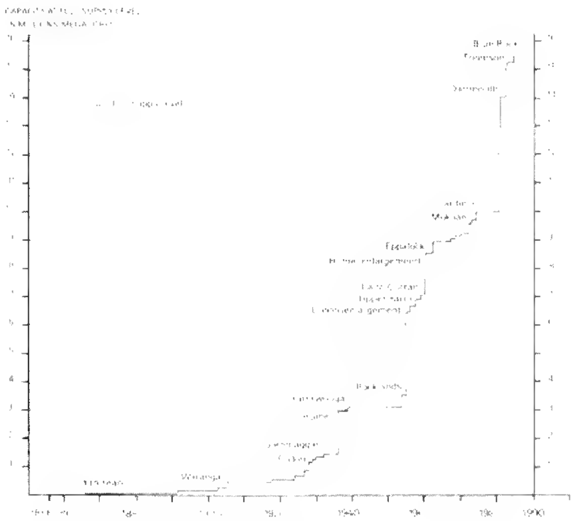

Fig. 11. Growth in volume of water storages in Victoria. (OCE 1992, after State Rivers and Water Supply Commission 1980).

scapes (such as stock routes, stream reserves, rail and road (including unused) reserves, along with other areas such as cemeteries and reserves), remnant vegetation was maintained as reservoirs of local native vegetation in the landscapes. Uncleared land and the 'wastelands of the Crown' supported the largest reservoirs of biodiversity (Fig. 6).

A State Forests Department was established in 1907 (Forests Commission of Victoria (FCV) in 1918) and gradually increased the area under its control with the forestry school at Creswick established in 1910. Log volume from state forests (1919-40) was about 80-100 M super feet p.a. (423.9 super feet = 1 cubic metre). Native vegetation cover increased in some areas under the auspices of forestry and a slow recovery of some aspects of natural capital probably occurred. There was virtually no virgin Box-Ironbark or River Red Gum forests of any extent, and adjacent Stringybark- Peppermint Gum forests had been 'mined' (FCV, in NRCL 1957). In the 1930s, the discovery enabling the use of short-fibre eucalypt wood for paper was to have a long-term effect on the management and use of forests. The APM Kraft pulp mill at Maryvale was built in 1939 to exploit the discovery, after the Victorian Wood Pulp Agreement Act 1936 guaranteed the supply of eucalypt pulp from state forest.

A variety of exotic softwood experimental plots were established, and Monterey Pine (*Pinus radiata*) was to emerge as the preferred softwood species. In 1924, the FCV established a 30 000 acre plantation at Anglesea (Wynd 1992) and about 50 000 acres of plantation in 'waste land' the Crown provided for employment during the Depression (NRCL 1957).

An emerging consciousness about the environment was articulated by the Australian Nature Association's support for the introduction of Arbor Day in Victorian state schools in 1904 and Wattle Day (1 September) in 1911. The Koala, *Phascolarctos cinereus*, near extinction in the 1920s, was able to recover largely because settlers in the 1890s had placed a population on French Island, which was the source of re-introductions over a 70 year period from 1923 (Menkhorst 1995). Late in the period, natural history became popularised. *Wildlife: Australian Nature Magazine* was first published in Melbourne in October 1938. A consciousness about the contrast between European and Koori world views was also to be artistically articulated during these times (Roberts 1986).

During this period Victorian Government agencies such as the FCV, Department of Agriculture, and State Rivers and Water Supply Commission began to assist in the

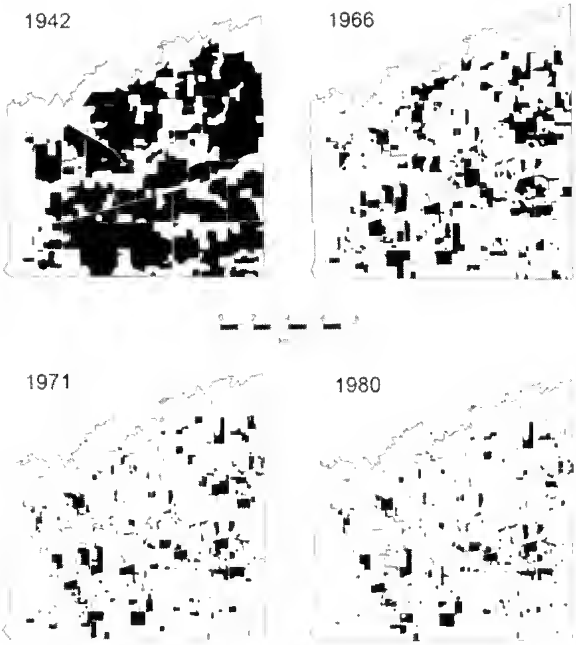

Fig. 12. Extent of forest vegetation (shaded) at Naringal in 1942, 1966, 1971 and 1980. Reproduced with permission from *Australian Wildlife Research* vol. 17: 325-347 (Bennett AF). Copyright CSIRO 1990. Published by CSIRO Publishing, Melbourne Australia *http://www.publish.csiro.au/journals/wr*.

resources (NRCL 1957). The period ended with the beginning of WW 2 and the 1939 bushfires that burnt approximately 6-8% (1.5 to 2 million ha) of Victoria, including approximately 20% of public land (DSE 2005). The conclusions of the subsequent Streeton Royal Commission were significant in public land management, particularly the use of fire. Reinforced by the grassland fires of 1943 that killed 51 people and 250 000 sheep, future efforts were to be directed to suppression (Arnold 1973).

1940-1970: Science for production and emerging problems

The Korean War helped to initiate a 'boom' in wool prices – 1950-51 wool earnt 18% of Australia's export income (Wadham *et al.* 1957). New land was cleared, and land uses changed. Use of Subterranean Clover and superphosphate (Sub and Super) techniques became widespread from the 1940s to 1950s (Smith 2000), resulting in a rapid decline in the area of native pasture (Fig. 7). This had a major effect on the grasslands and grassy woodlands of Victoria and set the Western Basalt Plains on a course to becoming the most endangered Australian ecosystem by the end of the 20th century, bringing associated declines of dependent species such as Eastern Barred Bandicoot *Perameles gunnii* and a suite of grassland plants. The fate of grasslands in Victoria is not unique; indeed, a parallel decline occurred in 20th century England because of the intensification of agriculture and the use of nitrogenous and other fertilisers (Harvey 2002). Compared to the previous period, depletion of natural capital had accelerated. Sub and Super was a mixed blessing: it 'stabilised' many landscapes but also gave the economic drive for additional clearing and elimination of native pasture, changing the biochemical make-up of the soil.

A public outcry prevented a large part of Wilsons Promontory from being cleared for 'marginal' farmland under the auspices of the Soldier Settlement Commission of Victoria (Marshall 1966). Native vegetation removal was concentrated in, but not restricted to, the Mallee where several of the issues following WW1 efforts were replicated. In the 1940s and 1950s, new techniques were established in some cropping landscapes, increasing productivity. A pasture phase (ley system) was included in the rotation; planting annual medics and

Subterranean Clover and stubble retention. This was aided by good seasons (OCE 1992). In 1947-48, 76% of wheat farms carried sheep which totalled 34% of the Victoria's total herd (Wadham *et al.* 1957). Productivity increased, becoming increasingly reliant on external inputs such as fossil fuels, fertilisers and pesticides.

Following WW2, transport, new machinery (bulldozers) and Sub and Super turned intact and variegated landscapes to relics (Fig. 5). Most of the landscape around Naringal (west of the Otways) was alienated prior to 1900 and finalised in the 1930s. Although logged of millable timber, parts of the area remained 'intact' up to the early 1940s but these had become relict by 1970 (Figs 5 and 12). The forest-dependent mammalian fauna became greatly restricted with many species declining in abundance (Bennett 1990). This clearing was replicated in many areas of Victoria, including smaller settlements such as Marlo in East Gippsland. A 1956-57 survey of 149 sheep farms between Benalla and Stawell (de Laine and Vasey 1961) found that scrub or timber and swamps constituted respectively only 2.5% and 0 5% of the farm area, with 94% being pasture (native and improved) and 2.5% crops. Native canopy was almost completely removed and moderate to severe erosion was observed on 45% of farms.

The drought of 1944-45 resulted in a decrease of 4 000 000 sheep and 200 000 cattle in Victoria (de Laine and Vasey 1961). This period saw a threefold increase in the water storage capacity, most of which was Murray River flow (Fig. 11). This opened up new areas to irrigation. Perhaps the symbol of the period, the tri-state Snowy Mountains Scheme was approved in July 1949 and completed in 1974. To satisfy the irrigation lobby, this diverted 99% of the upper Snowy River flows to the Murrumbidgee and Murray Rivers (Miller 2005). In 1967 the upper Snowy River flow stopped. The Kiewa Hydro Electric Scheme (the second-largest in mainland Australia) began in the late 1930s and was fully operational in 1961, creating dams and channels on the Bogong High Plains.

The fires of 1939 and the pulpwood obligations prompted intensive management of the mountain forest, and research (e.g. by DH Ashton and TM Cuningham) indicated that adequate regeneration required a heavy cut (clearfelling, later to be termed 'full sunlight regeneration') to create a seedbed (AATSE 1988). Even-aged forest management based on clearfelling became 'widely accepted in the 1960s and has remained the preferred method in many areas' (AATSE 1988). The forestry estate was consolidated and markets were strong, with housing booms in the 1950s and 1960s. By 1947 the log volume had risen to 260 million super feet p.a. (about 300% more than in the previous two decades) harvested from state forest, and to 460 million in 1957 (NRCL 1957). This rate of expansion was possible through the exploitation of new areas with new technology now including bulldozers and chainsaws. Between 1939 and 1957, 16 000 km of roads and tracks were constructed (NRCL 1957). Timber was an essential commodity for the war effort (Arnold 1973). The previously depleted Red Gum and Box-Ironbark forests were yielding a 'new crop' of valuable poles, fencing, fuel, etc. (NRCL 1957) and thus would not reach maturity for tree hollows –a resource upon which many of our fauna depend. In 1957, the FCV observed that, while production from private sources was bound to decrease, that from State Forests could be sustained and 'with the exception of sawn timbers, very greatly increased' (NRCL 1957). The future of forestry and what was to become the 'woodchip debate' was set.

At the beginning of the period, major land-use issues were clearly emerging in the agricultural landscapes. The Soil Conservation Authority was established in 1950, replacing the Soil Conservation Board. The Authority had jurisdiction over all land, whether public or private. In the public estate, the National Parks Act 1956 established the National Parks Authority, which oversaw a very small but significant estate (less than 1% of Victoria). These advances in public policy were to have a profound influence during the next period.

From 1959 Victoria led the way in wildlife conservation under A Dunbavin Butcher, Director of Fisheries and Wildlife. Until then, no land had been set aside and managed for wildlife (Marshall 1966). The introduction in 1959 of game licences (costing one pound per annum) prompted game management and importantly wetland protection. In the next seven years more than 100 000 acres of State Wildlife Reserves were created, both for wetlands (e.g. Kerang) and other environments (e.g. Rocky Range Reserve in the Snowy River for protecting Brush-tailed Rock-wallabies), and Serendip research station was established.

The publication of *Silent Spring* (Carson 1962) provided sobering evidence about the adverse ecological consequences of organo-chlorines and other chemicals on the environment and wildlife. In Australia there began an understanding of the importance of protecting the environment, from a local point of view, and constructing a record of what remained. This led to works such as *The Great Extermination* (Marshall 1966), and *Handbook of Victorian Plants* (Willis 1962, 1973), a work critical to the inventory of Victoria's natural capital.

1971-2004

In the 1980s, broad-scale alienation and conversion of native forest to pine plantations on public land ceased. Direct, large-scale 'consumption' of natural capital, typical of previous periods, declined in some sectors. Tree clearance, which had averaged 1150 km^2 p.a. for over 100 years (Gilbee 1999), was reduced to an average of 107 km^2 p.a. between 1972 and 1987 on private land–mainly used for irrigated farmland around Mildura and wheat cropping near Horsham (Woodgate and Black 1988). Native Vegetation Retention regulations were established in 1989, and reduced clearing to 2000-5000 ha p.a. in the first decade. By 2000, about 900 000 ha of native vegetation survived on private land. 'Net gain', where native vegetation removal was to be avoided, mitigated or offset, became a government policy objective from 1997 (The State of Victoria 1997).

In 1970 and 1971, the area under pasture in Victoria peaked at 12.3 million ha, including 1 million ha of former crop land (OCE 1992). The decline in wool prices induced more landscape change and intensification of agriculture (NLWRA 2001d). By the 1990s this was concentrated in western Victorian bioregions, already under high environmental stress (Fig. 3). Pastoral areas were converted to cropping and plantations; ley systems to cropping and irrigation/horticulture. Treed landscapes, native pasture and wetlands were converted under intensification processes such as laser levelling pivot irrigation, raised bed cropping, Blue Gum plantations, *in situ* basalt rock crushing and stubble burning (see Fig. 13 a,b,c). Combined, these endeavours covered hundreds of km^2. For example, the area of Blue Gum plantation in Victoria was very small in the early 1990s, yet 114 749 ha of hardwood plantations (predominantly Blue Gum) were planted between 1999 and 2001 (National Forest Inventory 2004).[2] In the south-west, a large proportion of the tree cover was in pine plantations (Gilbee 1999). Red Gum and Buloke 'pastoral' landscapes north of Horsham began to change as inappropriate stubble burning eliminated these trees (Fig. 13 a,b,c). The sustainability of these practices, where quality native vegetation removal is required, has been challenged in the planning system (Alexander 2005). Depending on location, such intensification has the potential to affect a suite of threatened species, such as the Red-Tailed Black-Cockatoo *Calyptorhynchus banksii graptogyne*, Regent Parrot *Polytelis anthopeplus monarchoides*, and Striped Legless Lizard *Delma impar*. The implementation of the policy and spirit of net gain (NRE 2002) should ensure that natural capital is not further degraded at the landscape and bioregional scales.

Increased chemical use, and progressively more expensive inputs (Fig. 14) was another trend in the further industrialisation of agriculture. 'Organic' farming arose as a partial response to this, and has been an expanding sector by area and value since the 1990s. The National Standard for Organic and Bio-Dynamic Produce requires landholders seeking certification as organic growers to develop, within five years, 5% of their property as treed areas, grassland or other reserves which are uncultivated and not intensively grazed. Recently, genetically modified (GM) crops are seen by some as the next agricultural advance. In Victoria, commer-

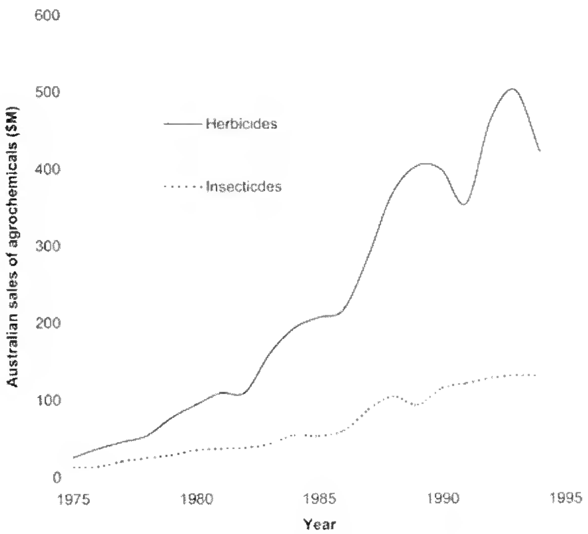

Fig. 14. Australian sales of Agrochemicals. (Herath 1998)

cial cultivation of GM canola is currently under a four year moratorium.

However, agricultural productivity increased over the century and had outpaced demand (Barr 2005). Farmers' terms of trade declined steadily from the early 1970s, the number of Victorian farms halved from the 1970s to the 1990s while their area doubled (OCE 1992). The era of the yeoman farmer was past its zenith and a family farm of one generation could not necessarily support the family of the next (see Barr 2005). The relative importance of agriculture to the Australian economy declined over the period,[3] yet about two thirds of Victoria had been historically alienated for agriculture and the sector consumed more than 77% of the water resources (DSE 2004). New socio-economic drivers of land-use change were emerging across Victoria, e.g. value of land (Fig. 15). The implications of these for natural capital will be discussed in Part 2 of this article.

The National Land and Water Resources Audit (NLWRA 2002b) concluded that

> Agricultural development has disturbed the rate and sometimes the direction of the ecological processes of natural landscapes. Some types of degradation (e.g. soil loss by erosion and dryland salinity) have long-term or irreversible consequences; other forms (e.g. leaching of nutrients, surface acidification) can be remedied with appropriate actions.[4]

As Smith (2000) observed, past advances in agronomy 'may well sow the seeds of their own ultimate decline (as successful Sub and Super has caused acidification)'. The environmental costs of native vegetation loss, altered flow regimes and water budgets, and changes in soil chemistry and structure, were being quantified at site, landscape and regional scales. The existing condition of many natural assets in both terrestrial and freshwater environments were poor, with future projections showing high risk of further deterioration (e.g. VCMC 2002; NLWRA 2001a-c). Modelling of groundwater hydrology indicated that Victoria may face a fivefold increase in the area affected by dryland salinity by 2050 (NLWRA 2001b). This is the legacy of excessive clearing of vegetation from recharge areas (Fig. 16). The area affected by soil acidity is projected to double over the same time frame (VCMC 2002). The amalgam of these assessments found Victoria with a very high concentration of bioregions under high environmental stress at the national level and these were all landscapes historically allocated to agriculture (Fig. 3; Table 1).

Table 1. Various parameters of land-use in states and territories of Australia. Native vegetation remaining in the intensive zone (Graetz *et al.* 1995) of Australia*; percentage area of freehold property **, parks and reserves +; and percentage of bioregions under high landscape stress ++. # = SAMLIV Project Team (2003); + = CAPAD (2002); ** = NLWRA (2001e); * = NLWRA (2001a)

State, Territory	Area native veg.remaining (km²) (%)*	Freehold	Crown leasehold	Public	Aboriginal & TSII	% area terrestrial protected areas (at 2002)	Number of bioregions in the high stress class
A C T	1 620 (69)	0%	38%	63%	0%	54.4	1
New South Wales	470 604 (67)	51%	39%	11%	0%	6.6	1
Northern Territory	186 629 (98)	0%	50%	10%	40%	4.8	
Queensland	772 452 (72)	36%	54%	7%	2%	4.1	2
South Australia	174 966 (64)	16%	43%	22%	19%	25.7	5
Tasmania	42 520 (80)	40%	0%	60%	0%	37.3	1
Victoria	84 541 (37)	68%	0%	32%	0%#	15.1	8
Western Australia	234 423 (56)	8%	36%	43%	13%	10.8	2
Australia (intensive zone)	1 967 754 (67)	21%	42%		23%	14%	20

The building of water impoundments was a major response to drought. However, damming of rivers affects flow regimes, one of the major determinants of the health of freshwater biodiversity (Koehn and O'Connor 1990). Major dam construction peaked during this period (focused on Murray River flow) and stopped in 1983 (Fig. 11), leaving the Ovens River the only substantial Victorian river flowing unregulated into the Murray. The Murray River's mouth in South Australia closed for the first time in 1981, and has required periodic dredging since 2003 to keep it open. The Murray-Darling Basin Commission capped water extraction in 1992 and rights to water became tradeable, on the assumption that the rights would migrate to the most economic use. The effects of the changing flow regime (seasonality, frequency, extent) and water extraction on the Murray, its biota and adjacent vegetation (e.g. Red Gum forests wetlands) has been dramatic (see Mackay and Eastburn 1990). The concept of environmental water and flows for all inland waters became an issue in the 1990s, and in 2003 commitments were made by government for an environmental flow of 21% to the iconic Snowy River (Miller 2005, see also part 2). Now, Lake Mokoan in north-east Victoria, which was built for irrigation in the late 1960s, is to be decommissioned and drained in 2007-2008 and the Winton wetlands are to be restored (DPC 2004). Water allocation, conservation and use remain key environmental issues as the finite nature of the resource is recognised.

Community awareness of environmental decline saw new programs developed in Victoria, a notable one being Landcare in 1986, which became a national program in 1989. Developed to help landholders combine their efforts to tackle environmental problems that directly affected productivity, such as rabbits and soil erosion, it evolved to become more holistic, including biodiversity conservation. The Land For Wildlife scheme was introduced to encourage and promote improved biodiversity stewardship across landholders' properties including habitat remnants. From an initial six properties (totalling 1055 ha) having 179 ha (17%) of retained wildlife habitat in 1981, the scheme now has 5936 properties

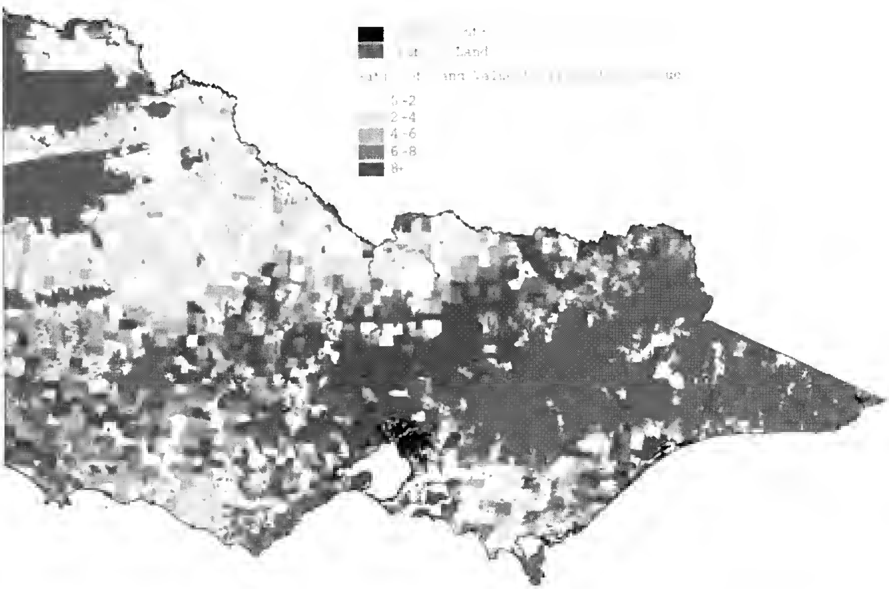

Fig. 15. Ratio of land value to agricultural value in Victoria (1997). Source: Barr and Karunaratne 2002

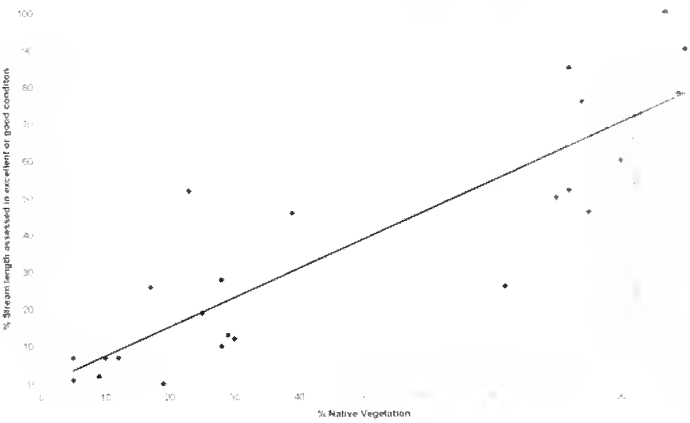

Fig. 16. The relationship between tree cover and stream condition.

(totalling 561 244 ha) of which 161 409 ha (29%) is being retained or restored as wildlife habitat (DSE Land For Wildlife Database, unpubl.). Trust for Nature, the oldest conservation land trust in Australia, has 30 000 ha of habitat and native vegetation permanently protected under covenants with 600 landholders (Di Lorenzo *et al.* 2005).

The rise and expression of a 'conservation ethic' is evident in the expansion of the parks estate. Public debate in the late 1960s and early 1970s concerning clearing the Little Desert for farming led to the establishment of the Land Conservation Council (LCC) to examine systematically the best uses of public land. Credence was given to uses that had been neglected in the past, such as national parks and wildlife conservation (LCC 1988). The LCC's process of developing a public report on the history and assets was to have profound and beneficial effects on the public estate. The LCC sponsored a range of systematic surveys of the flora and fauna that formed databases that are still expanding and being used today (e.g. The Victorian Department of Sustainability and Environment Flora Information System and Atlas of Victorian Wildlife). Over 25 years this unique Victorian innovation, and its successors the Environment Conservation Council (ECC) and Victorian Environment Assessment Council (VEAC), recommended a series of expansions to the conservation reserve system, resulting in a growth from 4% of the State's area in 1970 to over 16% in 2004. This growth was complemented by international reserve systems; for example, Victoria now has 10 Ramsar wetlands of international significance.

The rising community concerns and articulation about our natural heritage were promoted by a range of community-based organisations such as the FNCV, Bird Observer's Club of Australia and Victorian National Parks Association, and provided the LCC with information. Although the core of the reserve system was to be based on existing public land, other important initiatives such as the Roadside Conservation Committee sought to have biodiversity conservation incorporated into the management of other public land.

In the late 1960s, Greens Road was constructed into the Errinundra Plateau, and the last major area of Victorian virgin forest was made available to logging. Intensification of forestry (wood chipping, short rotations) on public land became a source of consistent national debate from the 1970s (see Rawlinson 1977). The community came to expect more from forests than commodities, and the conservation of forest-dependent flora and fauna, many of which were reliant on mature forest or tree hollows, became featured in the debates. Concepts such as the CAR (comprehensive, adequate and representative) reserve system (Commonwealth of Australia 1997) and the national Regional Forest Agreement processes arose from these debates. As part of a sustainable forests agenda, the Victorian Government announced in 2002 that it intended to reduce logging in the Otway State Forest by 25% and phase it out by 2008.

The value of applied science to agriculture, demonstrated in the prior period, saw the Department of Primary Industries establish 19 research centres across Victoria by 2002. However, in contrast to earlier periods there was an increase in the study and application of the 'new' sciences of ecology and conservation biology. One focus of this was threatened species and communities. The *Flora and Fauna Guarantee Act* 1988 (Vic.) and *Environmental Protection and Biodiversity Conservation Act 1999* (Commonwealth) sought, among other things, to list threatened species and communities and threatening processes.[5] Recovery actions prompted the development of new knowledge. Many of the listed threatening processes are the biological consequences of past land and water use and management.

This new knowledge led to a better understanding of species and ecosystems, and the need for a more holistic landscape approach and use of concepts, such as ecosystem services. Mistakes in the distant past might have been caused by 'ignorance', but increased knowledge means that present and future judgements must weigh a broader range of evidence that includes effects on biodiversity. Historically, Victoria has set trends in many aspects of land tenure and management. Compared to other States Victoria has: a high percentage of alienated land; a high level of clearing; a low level of leasehold land; a very low level of indigenous land management; a high level of public land dedicated to conservation; and a high percentage of stressed bioregions (Fig. 3; Table 1). Victoria has entered a 'maturing' phase in land-use and management that now recognises some natural capital assets. The International Panel on Climate Change (2001a, 2001b) concluded that 'Greenhouse Effect' climate change is happening at an unprecedented rate and anthropogenic causes are implicated. The predicted climate change threatens biodiversity assets and related ecosystem services at the global scale, with 15 to 37% of the world's species at risk of extinction (Thomas *et al.* 2004; for Victoria see Brereton *et al.* 1995). Adaptation to this novel threatening process will be the challenge of the present century and Victoria's natural capital will require additional protection and systematic replenishment in future.

Summary of Part 1

The history of land use in Victoria in the 19th century broadly follows patterns seen in North America, Canada and Argentina, and was a product of the colonialism of the time. Indigenous peoples were displaced and Europeans invaded the landscape, first as pastoralists and then as cultivators and 'owners'. The effects on natural capital were probably more rapid in Victoria because of the unique and isolated biodiversity, the climate (droughts), fragility of the soils, novelty of the exotics (ungulates, rabbits and foxes) and the spread of small farms encouraged after the gold rushes. This mode of production, augmented by agronomy and water engineering, would dominate the landscape for well over a century. Natural capital across many landscapes was converted to economic and social wealth. Lessons from this new landscape (drought, soil fragility) were slowly learnt and land management problems related to depletion of the natural capital–soil, air, water and biodiversity–progressively manifested themselves in the 19th and 20th centuries.

The rise of conservation on both public and private land expanded in the latter part of the 20th century. As we have gained a better understanding of our natural capital and landscape processes, sobering realities have become apparent. Some past landscape debt has already been incurred and is yet to be expressed. Even if all the active processes that have depleted our living natural capital could cease today, many of the degrading processes would continue for decades. But we are more mindful of this than ever before. The breadth and depth of these issues are enormous, as society aspires to reach an ecologically sustainable state. The historical imbalance between the triple bottom line elements of economy, society and environment is clear. In part 2 of this paper we will examine how the past trends might be reversed, and the balance somewhat restored.

Notes

[1]This paper is a modified version of a talk given at the FNCV 125th anniversary Symposium in May 2005. The arguments and evidence in this paper and other images were presented on that occasion. Reconstructed sequences of images were used to visualise an impression of historic changes at a statewide and landscape scale and the results of these changes in terms of on-site natural capital loss. Copies of the presentation (PDF format on CD), including images that could not be reproduced in this article, are available from the authors or FNCV.

[2]2003: Victorian plantations: Tree ownership - hardwood 154,650 ha (0.6% public) and softwood 211,961 (1% public); Land ownership - hardwood (public 6.7%) and softwood (53% public) (National Forest Inventory 2004)

[3]The gross value of Australian agricultural production as a proportion of total factor income was about 22% in 1975 but had declined to about 5% in 2004 (ABS).

[4]The national Standing Committee on Agriculture definition of 'sustainable agriculture' included 'adverse impacts on the natural resource base of agriculture and associated ecosystems are ameliorated, minimised or avoided' (cited in NLWRA 2001c).

[5]As of October 2005, 530 taxa, 36 communities and 36 potentially threatening processes had been listed under the Flora and Fauna Guarantee Act, and 198 Action Statements had been prepared.

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Editors' note

The tribute to Bary Dowling, published in *The Victorian Naturalist*, 122 (5) on pages 246-247, made no mention of Bary having spent part of his childhood in Ballarat. Because this experience was the subject of Bary's autobiography, *Mudeye*, it may be of some interest to readers.

Changes in vegetation structure and floristics under a powerline easement and implications for vegetation management

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Abstract

Utility corridors such as powerlines are widespread linear easements of highly modified vegetation which often fragment natural areas of conservation significance. Vegetation management along these easements is aimed at modifying vegetation structure by the removal of all tall shrubs and trees, which may have adverse impacts on flora and fauna diversity. Victoria's Bunyip State Park is bisected by a high voltage powerline easement which is managed by a four year slashing cycle. Repeated slashing has altered plant species composition and structure of the drier slope and ridge vegetation compared to unslashed adjacent Open Forest vegetation, but Wet Heath within the management zone has remained largely unmodified. At a broad level, plant species diversity in the easement is increased, and higher vegetation density has created small mammal habitat. The powerline easement did not appear to facilitate weed invasion. Vegetation management by repeated slashing has altered the vegetation, but does not appear to have had adverse conservation impacts on local plant and small mammal diversity. (*The Victorian Naturalist* **123** (1), 2006, 29-37)

Introduction

Utility corridors such as powerlines, gas pipelines and water pipelines are widespread linear easements, often encompassing a surprisingly large total land area (Knight *et al.* 1995) and, in some cases, representing an important component of the regional landscape (Hill *et al.* 1995). These corridors are usually highly modified strips of vegetation passing through tracts of little-modified native vegetation, and dissecting and internally fragmenting natural areas of conservation significance (Goldingay and Whelan 1997).

The most noticeable visual impact of these corridors is the loss of tree cover and the associated simplification of vegetation structure. Regular slashing to reduce biomass levels for fire safety (Chief Electrical Inspector 1999), and applications of herbicides to prevent regrowth entering the wire security zone (Hill *et al.* 1995) are major ongoing management practices. In these powerline easements, vegetation regrowth of shrubby seedlings and coppice from stumps and lignotubers is usually managed by repeated slashing, spraying with herbicides, or grading (Goosem 1997). Native vegetation may be completely replaced by exotic grasses or woody shrubs (Goosem and Marsh 1997), or previously forested areas converted to shrublands (Kroodsma 1982). This type of vegetation management is not unique to utility easements, and often occurs along other linear corridors such as road verges and firebreaks.

There are concerns that easements have a significant impact on conservation values by loss of habitat and biodiversity, and invasion of exotic species. Changes to the vegetation composition and structure can result in changes in native fauna (Goldingay and Whelan 1997). For example, where rainforest vegetation was converted to grassland, the small mammal community also changed from rainforest species to grassland specialists (Goosem and Marsh 1997). Avifaunal studies (e.g. Rich *et al.* 1994; Baker *et al.* 1998) suggest that utility easements may contribute to the decline of forest-interior bird species, and may contain a species-poor subset of the birds found in the surrounding forest. The new habitat type created by tree removal and corridor management facilitates invasion by non-forest bird species and exotic bird species. The role of easements in facilitating the penetration of dogs, cats and foxes into natural areas also has been investigated (Andrews 1990; Catling and Burt 1995; Lindenmeyer *et al.* 1994; Goldingay and Whelan 1997), and access roads and maintenance activities associated with easements may be a source of weed invasion (Parendes and Jones

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2000; Lonsdale and Lane 1994; Tyser and Worely 1992). However, the relatively dense ground cover promoted by slashing, and selective use of herbicide in some types of easement vegetation, appear to provide suitable habitat for small native mammals (Macreadie *et al.* 1998; Goldingay and Whelan 1997; Pearce 2003), and vegetation management has the potential to maintain, or even increase, uncommon habitat suitable for rare species.

This study aimed to investigate the effects of management of a powerline on native plant species composition and vegetation structure, and to comment on the conservation implications of current powerline management.

Study Site

Bunyip State Park, Victoria, covers 16 622 ha in the foothills of the Great Dividing Range, and is bisected by a 500 kV electricity transmission line running from the southeast to the northwest of the Park. This easement was established in 1962 and has been repeatedly slashed on a four year cycle (Macreadie *et al.* 1998).

The Park contains a variety of vegetation types ranging from Closed Forest and Mountain Ash-dominated Tall Open Forest, through Open Forest to Heathy Woodland and Wet Heathland (Parks Victoria 1998). The Park contains about 400 vascular plant species (Parks Victoria 1998). The section of the Park in which the study was carried out has Botanical Significance as it contains Wet Heathland, a rare vegetation community in Victoria, and a population of rare Swamp Bush-pea *Pultenaea glabra* (syn. *P. weindorferi*) (Fraser *et al.* 2004). The Heathy Woodland is also of Regional Significance (Parks Victoria 1998).

The study site was a section of the powerline easement between Peppermint Track and the Bunyip River aqueduct, and encompassed approximately 1.2 km of the easement in the south east of the Park. The powerline cuts through Open Forest and a vehicle access track follows the easement, which is dissected by a series of low ridges and Wet Heathland drainage lines (Fig. 1). These drainage lines create relatively continuous cover from one side of the easement to the other. Due to the topographic position of the drainage lines they are rarely, if ever, slashed during routine maintenance operations. This section of powerline was investigated by Macreadie *et al.* (1998).

The modified vegetation under the powerline contains a wide diversity of species and is a mix of open, heathy areas and grassy areas with emergent shrubs. The forest vegetation on either side of the ease-

Fig. 1. Powerline easement through Open Forest, Bunyip State Park. The vehicle access track runs the length of the easement, and the undulating low ridge – drainage line nature of the topography is visible.

ment at this location is mainly Mealy Stringybark *Eucalyptus cephalocarpa*-dominated Open Forest, with a heathy understorey containing several species of *Banksia*, *Hakea* and *Acacia*. The ground layer is dominated by Wiry Spear-grass *Stipa muelleri* and several sedge species. Open Forest dominated by *Eucalyptus obliqua* and *Eucalyptus radiata* also occurs along this section of the easement. Trees are absent from the drainage lines that run through the easement, and these drainage lines are dominated by Wet Heathland containing Prickly Tea-tree *Leptospermum continentale* and *Gahnia radula* or Scented Paperbark *Melaleuca squarrosa* with a dense understorey of Pouched Coral Fern *Gleichenia dicarpa*.

Methods

Square quadrats (25 m^2) were placed at 100 m intervals along the easement starting at Peppermint Track and ending approximately 1.2 km away at the Bunyip River Aqueduct. Ten quadrats were placed in the forest on each side of the easement, and ten in the easement, with five on either side of the access track. To minimize any edge effects, all quadrats in the easement were placed at least 10 m from the track, and quadrats in the forest were at least 10 m from the easement edge. Species presence, and cover, estimated using a modified Domin Cover Scale (Kershaw and Looney 1985), were recorded. Quadrat data were investigated for floristic patterns using both classification and ordination techniques (PATN analysis package, Belbin 1991), and species in each quadrat were clustered using the Bray-Curtis association measure with fusion using Wards method (Belbin 1991). Plant cover is displayed (Table 1) on a relative scale from 1 to 5. Plant nomenclature follows Walsh and Entwisle (1994).

Understorey structure to a height of 120 cm was determined using a graduated structure pole, along 20 m transects at each vegetation quadrat. The number of vegetation contacts in each 10 cm interval on the pole is converted to a percentage, and allows comparison of vegetation cover at horizontal intervals vertically through the understorey (Fig. 2).

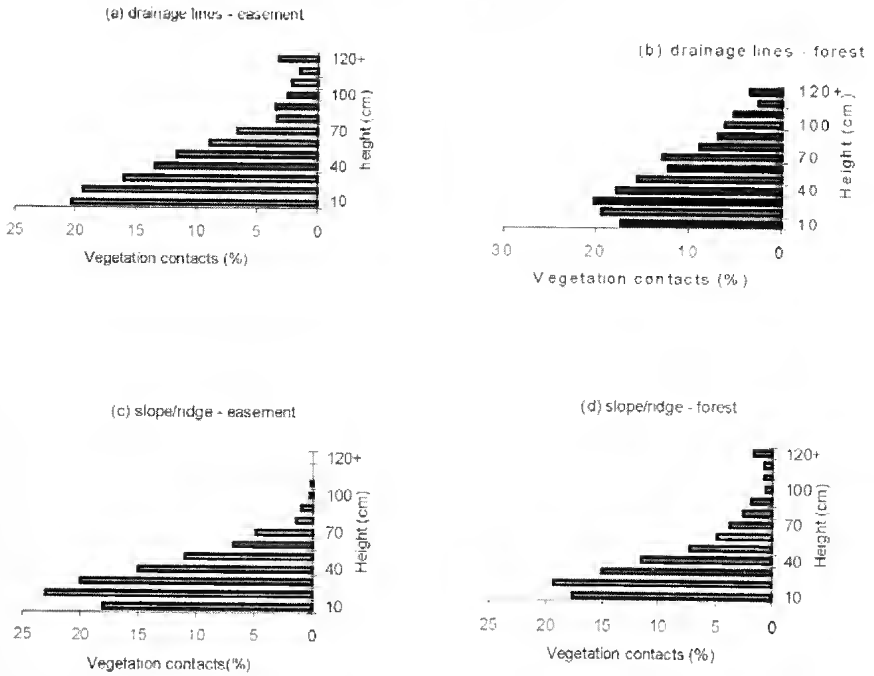

Fig. 2. Comparison of the understorey structure profiles for the powerline easement (a and c) and the surrounding Open Forest (b and d).

The structure data were pooled into four arbitrary strata (0–30 cm, 30–60 cm, 60–90 cm and 90–120 cm) for each of the four locations (easement slope/ridge, easement drainage lines, forest slope/ridge and forest drainage lines) and compared using two-way ANOVA. Data were examined for normality and homogeneity of variances, and the percentage data arcsine transformed for analysis. The differences between significant means were examined using Newman-Keuls multiple comparisons test.

Results

Vegetation structure

ANOVA results indicated a significant interaction between locations and structure ($F_{9,374} = 5.83$, $p < 0.001$). Newman-Keuls multiple comparisons tests showed that vegetation structure differed significantly ($p < 0.05$) in density in two strata for the slope/ridge locations in the easement compared with the slope/ridge locations in the surrounding forest (Fig. 2c and 2d). Vegetation density was not significantly different in the 0–30 cm or the 60–90 cm layers. In the easement, the vegetation layer between 30 and 60 cm was significantly more dense ($p < 0.05$) than in the forest, mostly due to a higher cover of grass, and vegetation was very sparse beyond 90 cm. In the forest, the vegetation structure was slightly more complex with a sparse layer of vegetation in the 90–120 cm stratum.

The structure of the vegetation in the drainage lines was similar regardless of whether the drainage lines were in the easement or in the surrounding forest (Fig. 2a, 2c and 2b, 2d). The only significant difference ($p < 0.05$) was slightly thicker vegetation between 60 and 90 cm in forest drainage lines compared with those in the easement.

The vegetation in the drainage lines is structurally different compared to the slope/ridge vegetation (e.g. Fig. 2a to 2d). Apart from the 0–30 cm layer, drainage line vegetation was generally thicker than the slope/ridge vegetation, especially in the taller strata (60–90 cm and 90–120 cm). This difference is due to the dense thickets of either *Leptospermum continentale* or *Melaleuca squarrosa*, with understories of *Gleichenia dicarpa*, *Ghania radula* or *Bauera rubioides* in the drainage lines. The slope/ridge vegetation comprised mainly low shrubs and *Stipa muelleri*.

Species composition and cover

Approximately 80 species were recorded, including 55 dicots, 14 monocots and 8 ferns. The only exotic species recorded in quadrats were *Cirsium vulgare* and *Hypochoeris radicata* and two unidentified herbs. *Erica lusitanica* and *Acacia longifolia* were infrequently observed growing in scattered locations adjacent to the access track.

The classification dendrogram (Fig. 3) indicated two primary vegetation types corresponding to drier vegetation from slope/ridge quadrats (Type 1) and vegetation from Wet Heath or drainage line quadrats (Type 2). Both these vegetation types could be subdivided into three variants, and each vegetation type was identified by high cover of a characteristic suite of species (Table 1).

Vegetation types

Vegetation Type 1: *Eucalyptus* Open Forest and derivatives

1a. *Eucalyptus* Open Forest: This *Eucalyptus cephalocarpa*-dominated Open Forest is widespread through the drier sections of Bunyip State Park, and may grade into Heathy Woodland. It is found on both sides of the easement on drier slope/ridge sites, and is the original forest type that occurred on the easement prior to modification.

1b. Originally *Eucalyptus* Open Forest of Type 1a. Although there is some regrowth of the canopy, the diversity of understorey shrubs is extremely low. This forest type is found in the easement along the forest edge, and results from slashing and partial regrowth following disturbance during the original powerline construction.

1c. *Stipa muelleri* grassland with emergent shrubs of *Acacia*, *Pultenaea*, *Epacris*, *Banksia*, *Dillwynia* and a dense cover of *Caustis flexuosa* and *Gahnia radula*. This is equivalent to the *Acacia–Banksia* type described by Macreadie *et al.* (1998), and is secondary grassland with stunted shrubs, formed by the removal of the *Eucalyptus* canopy of Type 1a and subsequent frequent slashing. This vegetation type is also characterized by a high incidence of bare ground. It was found only on slope/ridge sites within the easement.

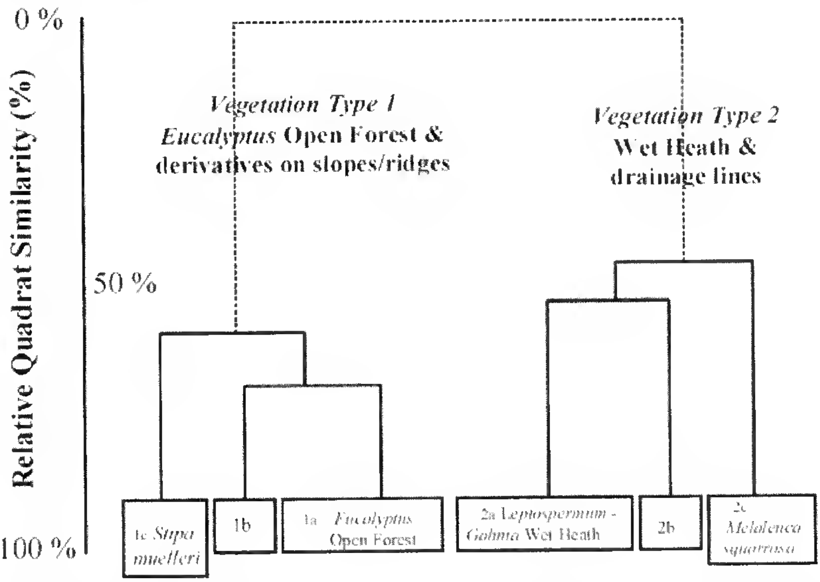

Fig. 3. Classification dendrogram showing the clustering of quadrats into two primary vegetation types – Eucalyptus Open Forest and derivative on slopes/ridges (Type 1) and Wet Heath and drainage lines (Type 2).

Vegetation Type 2: Wet Heath and drainage lines

2a. *Leptospermum continentale – Gahnia radula* Wet Heath: There is a high diversity of monocots such as *Tetraria capillaris* and *Baumea tetragona*. *Gleichenia dicarpa* is usually present, and *Stipa muelleri* is also abundant. It is found in wet sites and drainage lines in both the easement and forest. Most of the area covered by these drainage lines is too wet or inaccessible to slash.

2b. A variant of *Leptospermum continentale – Gahnia radula* Wet Heath: It is distinguished by a high cover of *Bauera rubioides* and the absence of most species found in Type 2a. There is a scatter of species not found in the other vegetation types, such as *Olearia ramulosa*. This vegetation type was the only one in which *Acaena novae-zelandiae* and *Cirsium vulgare* were found. It is found only in the less wet sections of drainage lines and wet sites in the easement where slashing is possible. It probably represents a more disturbed variant of Type 2a.

2c. *Melaleuca squarrosa* thickets: These thickets are characterized by an extremely dense *Gleichenia dicarpa* understorey. They are found in drainage lines in both the easement and forest. They are not slashed.

Discussion

Vegetation management along utility easements is aimed at modifying vegetation structure by the removal of tall shrubs and trees, and it might be expected that this management would result in habitat degradation and loss of diversity. However, the vegetation response to disturbance is dependent on the original vegetation type, and the individual management treatments used. Repeated slashing through dry sclerophyll forest in the Australian Capital Territory altered the vegetation structure by promoting eucalypt suckering and increasing the density of understorey vegetation compared with unslashed adjacent forest (Bell 1980). Vigorous suckering from stumps and roots is also reported after frequent slashing of powerline vegetation in North America (Luken *et al.* 1991), and suckering was controlled by herbicide applications. An easement through Queensland rainforest was converted to dense exotic grassland and patches of woody weeds (Goosem and Marsh 1997), and exotic grasslands and shrub-

Table 1. Floristic composition of vegetation types 1 and 2. Exotic species = *. Quadrats (n = 40) are displayed across the table, and the species present are listed vertically, with the values 1–5 representing relative cover. Plant nomenclature follows Walsh and Entwisle (1994).

Species	**Type 1c** ***Stipa***	**1b**	**1a** ***Eucalyptus***	**2a** **Wet Heath**	**2b**	**2c** ***Melaleuca***	
Leptospermum continentale	11	113	1 111	1211111111	1213		widspread
Gahnia radula	523111	211	1 11111111111	2413 51311	5235	21 3	species
Eucalyptus radiata		24	132 2	5			
Eucalyptus cephalocarpa			22121 2 21214				
Eucalytus obliqua			32				
Lycopodium deuterodensum			11				
Banksia spinulosa			1 11 1	5			species
Xanthorrhoea minor			 111	1			restricted
Banksia marginata			111 12				to original
Daviesia leptophylla			11 1				Open Forest
Lomatia ilicifolia			11 1 1	1		1	
Hakea nodosa			1				
Exocarpos cupressiformis			1				
Hakea teretifolia			1	1			
Gompholobium huegelii			1				
Tetratheca ciliata			1				
Stipa muelleri	535555	555	5555555555555	12 555 15	53		
Bare ground	52222		1	31 1			widespread
Acacia oxycedrus	1	121	1111	113		1	species
Acacia genistifolia	11111	11	1111 1 1	12 1 1	1		from all
Pultenaea gunnii	1211 1	11	111 1 111	1 111	1313		sites
Dampiera stricta	11	1 1	1	1			except the
Moss	111	111	1		1		wettest
Amperea xiphoclada	1	111	1111		11	1	sites
Pteridium esculentum		1 1	2		1	1	
Caustis flexuosa	5531 1		1111 1 1 11	1 111			
Monotoca scoparia	111		1 1				widespread
Lepidosperma laterale	1 1111		112 1 1				species,
Epacris impressa	111111		1 1	11 1 111			but missing
Dillwynia glaberrima	111111		1 1 1	1 111			from disturbed sites
Leptospermum myrsinoides	1 111		11	1 113			(1b) and
Acacia aculeatissima	1		1	1		1	wettest
Hovea linearis	1		11 11				sites
Hakea ulicina	1		1 1 2 11	1 1			(2b and 2c)
Hakea decurrens	11 1		111 111 111			1	
Eucalyptus seedlings	1111			1	1	1	
Goodenia lanata	1						
Acacia myrtifolia	11 1 1						
Lomandra longifolia	1 1			1			species
Viola cleistogamoides	1 1						mostly
Stylidium graminifolium	1			1			found in
Acacia brownii	1						frequently
Persoonia juniperina	1						slashed
Kunzea ericoides	11						sites
Acrotriche serrulata	1						
Hydrocotyle laxiflora	1	1					
Gonocarpus micranthus	11	1		111 1	1		
**Hypochoeris radicata*	1	1		1			
Bauera rubioides	12 1	2	1	131 5 1	2555	22	species
Tetraria capillaris				55 511135	1	1	of wetter
Baumea tetragona				5 1 1		12	sites
Tetrarrhena juncea			2	51		1 1	

Table 1 cont'd.

Species	Type 1c *Stipa*	1b	1a *Eucalyptus*	2a Wet Heath	2b	2c *Melaleuca*	
Leptocarpus tenax				1 1 1			species confined to Wet Heath (2a)
Pultenaea glabra				13 11			
Epacris gunnii				1			
Lobelia elata				11			
Selaginella uliginosa				11			
Lindsaea linearis		1		11			
Senecio minimus				1			
Euphorbia spp.				1			
Melaleuca squarrosa				131		111	wet sites with high cover of *Gleichenia*
Gleichenia dicarpa				111 5 1		5555	
Leptospermum lanigerum				1		1	
Epacris obtusifolia				1		1	
Restio tetraphyllus				1		1	
Empodisma minus				1 1		11	
Patersonia fragilis				12 1		1	
Acaena novae-zelandiae					32		uncommon species of wetter sites
**Cirsium vulgare*					11		
Cassytha glabella	1				11		
Cyathea australis		1			11		
Olearia ramulosa					1		
Olearia lirata					11		
Ozothamnus ferrugineus						1	uncommon species of wettest sites
Juncus pallidus						1	
Carex spp.						1	
Dicksonia antarctica						1	
Blechnum cartilagineum						1	
Blechnum nudum						1	

lands developed in easements through hardwood and softwood forests in Tennessee (Kroodsma 1982). In all these instances, the vegetation composition was considerably altered from that of the adjacent forest vegetation. In these examples, vegetation structure was similar with no emergent shrubs or trees and a more dense layer of grasses or grasses with low shrubs in the disturbed areas.

The response of the Open Forest along the Bunyip easement is generally consistent with this pattern of structural change. The drier sections of the easement have been converted to *Stipa muelleri* grassland with patchy low shrubby species, while the wetter drainage lines show little change between forest and easement.

Some changes in floristics were identified. The original *Eucalyptus* Open Forest (Type 1a) understorey is composed of a diversity of shrubby species, *Stipa muelleri*, and other monocot species typical of Victorian dry heathy Woodlands and Open Forests. Overall, the total numbers of species recorded in the *Eucalyptus* Open Forest (Type 1a) (35 species) and the modified vegetation of Type 1b (38 species) were very similar. Species other than the canopy eucalypts and *S. muelleri* rarely had cover values greater than 20% projective foliage cover.

However, a comparison of the composition of the original *Eucalyptus* Open Forest (Type 1a) and the *Stipa muelleri* grassland (Type 1c) showed a difference in the species present. Seven shrub species recorded in the Open Forest were not recorded in the *S. muelleri* grassland on the easement. These were shrubs with a serotinous seed store such as *Banksia spinulosa*, *Banksia marginata*, *Lomatia ilicifolia*, *Hakea nodosa* and *Hakea teretifolia*, and the ant-dispersed shrubs *Daviesia leptophylla*, *Gompholobium huegelii* and *Tetratheca ciliata*. Seeds dispersed by ants are typically dispersed about one metre, limiting species' ability to recolonise once eliminated. Also absent from the modified easement vegetation (Types 1b and 1c) were *Xanthorrhoea minor* and *Exocarpos cupressiformis*.

Substantial areas of bare ground occurred in the *Stipa muelleri* grassland. Caling (1998) found that a number of species of low-growing sedge and herb had higher cover in soil-disturbed, linear firebreaks compared with the surrounding vegetation. These bare areas may provide colonisation sites for species with clonal or rhizomatous growth mechanisms such as some ferns, herbs and ground covers, and are represented in the *Stipa muelleri* grassland by *Gonocarpus micranthus*, *Hydrocotyle laxiflora*, *Goodenia lanata*, *Viola cleistogamoides*, *Lomandra longifolia*, *Stylidium graminifolium*, *Selaginella uliginosa* and *Lindsaea linearis*. These species also may be responding to increased light. Five shrubby species recorded only in the *Stipa muelleri* grassland were *Acacia myrtifolia*, *Acacia brownii*, *Persoonia juniperina* and *Acrotriche serrulata*, and the shrubby colonizer *Kunzea ericoides*. The exotic *Hypochoeris radicata also* was present.

The floristic composition and structure of *Leptospermum continentale - Gahnia radula* Wet Heath (Type 2a) and *Melaleuca squarrosa* thickets (Type 2c) in the drainage lines showed little difference between the easement and the adjacent forest. The drainage lines are generally too wet to slash, and have no emergent trees to threaten the wire security zone. Only the more accessible and less wet drainage line edges near the access track appear to be regularly slashed, and it is here that the variant of *Leptospermum continentale - Gahnia radula* Wet Heath (Type 2b) with a few weedy species is found. The rare Swamp Bush-pea *Pultenaea glabra* (syn. *P. weindorferi*) is limited to these Wet Heath sites.

Although intact forest vegetation appears to be relatively resistant to weed invasion (Brothers and Spingarn 1992), roads and linear easements continue to be identified as potential invasion corridors for exotic weeds (Parendes and Jones 2000; Lonsdale and Lane 1994; Tyser and Worely 1992). For example, in heathland in the UK, weed invasion potential increased with the degree of edge disturbance (Angold 1997). The heathy understorey vegetation in this section of the Bunyip powerline easement was remarkably weed-free. This may be the result of the use of slashing and selective herbicides as easement management techniques, and avoidance of soil disturbing techniques such as grading. Weeds were recorded only in the easement. *Hypochoeris radicata*, *Cirsium vulgare* and two unidentified weedy species were recorded from quadrats, although Spanish heath *Erica lusitanica* and *Acacia longifolia* were growing along access roads.

Vegetation structural changes resulting from frequent slashing may disadvantage some small mammal species such as *Antechinus agilis*, but because vegetation density is the main factor contributing to habitat suitability for many small mammals (Monamy and Fox 2000), the *Stipa muelleri* (Type 1c) grassland in the easement provides quality habitat for species such as *Rattus fuscipes* (Macreadie *et al.* 1998; Pearce 2003).

Goldingay and Whelan (1997) suggested that small mammals would use dense vegetation and habitat linkages within easements, and this is supported by this study. The structural similarity of the Wet Heath (Types 2a and 2c) in the easement and the Open Forest enables this vegetation to be used as a link across the easement. Several mammal species have been trapped more frequently in Wet Heath vegetation compared to the surrounding slopes/ridge vegetation. These included the rare Broad-toothed Rat *Mastocomys fuscus*, Dusky Antechinus *Antechinus swainsonii* (Macreadie *et al.*1998), and Swamp Rat *Rattus lutreolus* (Macreadie *et al.* 1998; Pearce 2003). The frequency of occurrence of *Mastocomys fuscus* was highest in vegetation with high cover of *Bauera rubioides* (Macreadie *et al.* 1998). It appears from this study that slashing disturbance to Wet Heath (Type 2a) results in increased cover of *Bauera rubioides* (Type 2b) and it is likely that the slashing regime in this section of the powerline easement has increased suitable habitat for *Mastocomys fuscus*.

This study suggests that repeated slashing of vegetation has altered species composition compared with unslashed forest vegetation, though some vegetation communities within the defined management zone, such as Wet Heath, largely escape treatment and consequently show few changes to structure or composition. At a regional level, plant species diversity is not reduced, and at the local level, overall species diversity has increased as suitable establishment sites were created for non-forest plant species. Higher vegetation density in the easement also appears to create small mammal habitat, and the Wet Heath in drainage lines provides movement corridors across the easement. There was no indication that the powerline easement facilitated weed invasion. Vegetation management by repeated slashing and targeted herbicide application under the Bunyip State Park powerline easement at this location has altered the vegetation, but does not appear to have had adverse conservation impacts on local plant and small mammal diversity.

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Notes on diving behaviour of Hardhead *Aythya australis* in a sewage pond

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Abstract

Observations of the diving behaviour of Hardhead *Ayhtya australis* on a sewage pond were carried out over a two-day period. The length of the recovery period between dives did not influence the duration of the following dive, and likewise, the length of the recovery period was not influenced by the duration of the preceding dive. The length of dives and recovery periods varied significantly among individuals. Other factors that may influence diving behaviour, such as water depth and temperature, warrant further investigation. (*The Victorian Naturalist* **123** (1), 2006, 38-40)

Introduction

Little is known about the diving behaviour of Hardhead *Aythya australis*. Frith (1982) noted that individuals often stayed under water for around one minute, and could emerge up to '30 or 40 yards [18–27 m]' from where they dived below water. Marchant and Higgins (1990) suggested birds often swim up to 40 m under water using their feet, although they did not provide any data to support this supposition. This paper presents data on the dive-duration (time under water) of Hardhead and the time spent between dives (inter-dive interval). It also examines whether or not these parameters varied between individuals. The relationships between the inter-dive interval and the associated previous dive-duration, and the inter-dive interval and its following post dive-duration are investigated as well.

Methods

Study site

All observations were made at Pond Nine, Lake Borrie, at the Western Treatment Plant in Victoria. This pond covers an area of 109 ha, and the average water depth is 60 cm (Cartwright 1996, unpublished data). Further details about the site can be found in Hamilton and Taylor (2004) and Hamilton *et al.* (2002; 2004).

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Sampling protocol

Sampling was conducted on July 8 and 9, 1999. All observations were made from the embankment of the pond using either binoculars (Carton® 10 x 50) or a telescope (Leica® Televid 77, 20–60 x zoom magnification), depending on the distance from the focal bird (distance ranged from approximately 25–300 m). Focal individuals were chosen haphazardly. On the first and second dates, respectively, 95 and 35 dive-times were recorded. Likewise, 94 and 36 inter-dive intervals were observed. Birds that were near other diving Hardheads were not chosen as focal individuals, to avoid confusion when identifying emerging birds. In an attempt to reduce the occurrence of repeat sampling, observations were made on different parts of the lake. All observations were made within 2 h either side of midday. Another study at the same site demonstrated that the time Hardheads spent feeding did not change over this period (Hamilton *et al.* 2002).

Statistical analysis

All statistical analyses were performed in the statistical package GenStat (Version 6.1, Lawes Agricultural Trust, IACR-Rothamsted). The correlations between dive duration and post-dive duration, and pre-dive duration and dive duration, were tested using Pearson's product moment coefficient (Pearson 1920). The null-hypothesis that the correlation coefficient of the population (r) was not significantly different from zero was tested using the two-tailed F distribution test described by Cacoullos (1965).

The effect of individuals on dive-duration and inter-dive interval was examined using restricted maximum likelihood (REML) (Patterson and Thompson 1971; Hepworth and Hamilton 2001). REML is a more general procedure than ANOVA, and reduces to ANOVA in simple balanced cases. This design was unbalanced because the number of birds observed varied between dates, and the number of observations made varied between birds. Date was modelled as a random effect, which is analogous to a block effect in ANOVA. The mean percentages were compared using a Wald statistic, which is analogous to the variance ratio used to compare treatments in ANOVA, though it has an asymptotic chi-squared distribution rather than an F distribution. The inter-dive interval data were $\log_{10}$ transformed to ensure homoscedasticity.

Results

The mean dive duration was 13.7 s (SE = 0.04 s, min.–max. = 4.0 s–25.8 s), and the mean inter-dive interval was 10.6 s (SE = 0.41 s, min.–max. = 2.0 s–47.0 s). Dive duration was not significantly correlated with the inter-dive interval before the dive ($r = 0.166$, $P > 0.05$, $df = 101$) or the inter-dive interval after the dive ($r = 0.197$, $P > 0.05$, $df = 111$). In other words, length of the rest period did not influence the length of the following dive, and likewise, the length of the rest period was not dependent upon the duration of the preceding dive. There was a significant individual effect with respect to both dive-duration ($P < 0.001$, $df = 37$) and inter-dive interval ($P < 0.001$, $df = 39$). That is, there was significant individual variation in the length of dives and the post-dive inter-dive interval.

Discussion

Most studies on the diving behaviour of pochards *Aythya* spp have been conducted in artificial environments such as dive-tanks (Bevan and Butler 1992; Lovvorn 1994, Stephenson 1994; Parkes *et al.* 2002). In particular, there are little data on the length of dives by different species and in natural environments. The mean dive-duration observed for Hardhead in our study (13.7 s) was less than the mean times observed for pochards on lakes elsewhere. The mean dive-durations for male and female Greater Scaup *Aythya marila* at Lake Mývatn in Iceland were 22.8 s (SE = 0.39s) and 23.4 s (SE = 0.20s) respectively (Magnúsdóttir and Einarsson 1990). At the same site, male Tufted Ducks *Aythya fuligula* dived for 17.8 s (SE = 0.27 s), and females, 18.8 s (SE = 0.25 s). Lake Mývatn is relatively shallow, with a maximum depth of around 5 m (Magnúsdóttir and Einarsson 1990). From the data available, it is not possible to determine if the observed differences in dive-times are a result of species or environmental factors, such as water depth and temperature, or a combination of these.

It is possible that water depth plays a role in determining the dive-duration of Hardheads, and that studies at deeper water bodies, where Hardheads are known to forage (Frith 1982), will reveal different times from those observed here. A study on dive-times of Canvasbacks *Aythya valisineria*, Redheads *A. americana*, and Lesser Scaup *A. affinis* revealed a significant effect of water depth (Lovvorn 1994). In a 1.2 m deep tank, the respective dive-durations for these species were 8.2 s, 6.2 s, and 8.3 s, and in a 2 m tank they were 13.3, 8.6, and 11.2.

Significant variation between dive-duration of individuals has not been recorded before from field studies on diving-ducks. The significant effect observed here could mean that individuals have different foraging strategies, or it may indicate that there were differences in water depth or foraging patch quality in the pond. There is insufficient information on the spatial distribution of benthos or variation in water depth to test these hypotheses.

Previous studies on pochards and other diving-ducks in natural and artificial environments have demonstrated a positive relationship between dive-duration and the length of the subsequent inter-dive interval (Beauchamp 1992; Stephenson 1994; Malhotra *et al.* 1996; Parkes *et al.* 2002). More specifically, Parkes *et al.* (2002) found that the shape of the oxygen uptake curve and the mean volume of uptake were dependent on the length of the preceding dive, with more oxygen required for recovery after longer dives. The lack of a relationship between dive-duration and post-dive duration in our study could mean that the ducks were not only paying the oxygen debt from the previous dive, but were devoting some time to other activities such as scanning for predators or avoiding interactions with other ducks.

Dedication

This paper is dedicated to the memory of the late Emily Natalie Levu Hamilton.

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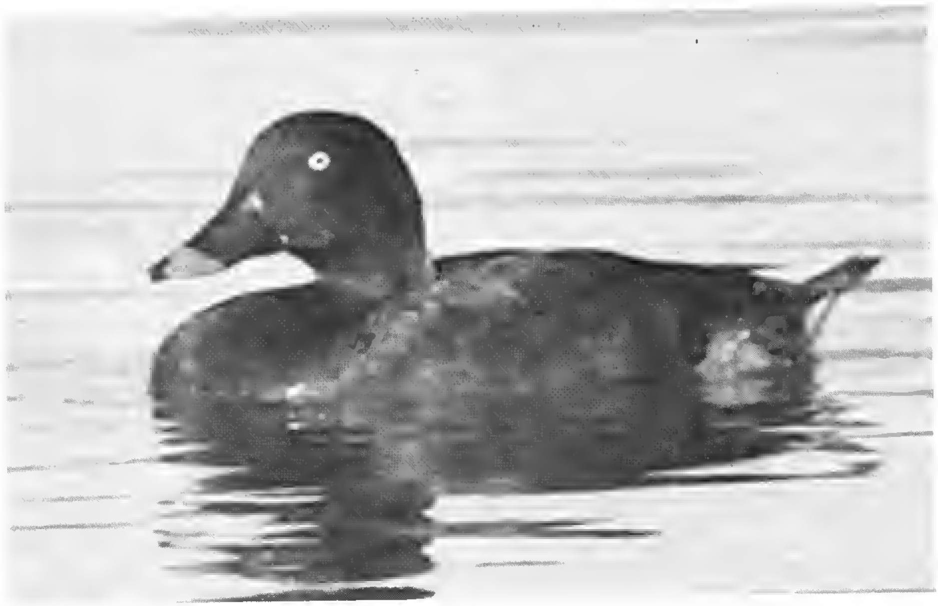

Male Hardhead *Aythya australis*. Photograph by Geoffrey Dabb.

Studies on Victorian bryophytes 2. The genus *Bazzania* Gray

David Meagher[1]

Abstract
Three species of the liverwort genus *Bazzania* occur in Victoria: *B. adnexa* var. *adnexa*, *B. hochstetteri* and *B. monilinervis*. These are described and illustrated, and their distributions in Victoria are delineated. *Bazzania involuta* is discounted from the Victorian flora. A key to the species is provided.
(*The Victorian Naturalist* **123** (1), 2006, 41-46)

Introduction

The family Lepidoziaceae is represented in Australia by 12 genera: *Acromastigum*, *Bazzania*, *Drucella*, *Hygrolembidium*, *Isolembidium*, *Kurzia*, *Lepidozia*, *Paracromastigum*, *Pseudocephalozia*, *Psiloclada*, *Telaranea* and *Zoopsis* (McCarthy 2003). All except *Isolembidium* are present in Victoria. The genera *Acromastigum* and *Bazzania* are grouped together in the subfamily Bazzanioidea, which consists of species with two rows of incubous lateral leaves, one row of underleaves, and minute-leaved ventral branches called flagella.

In almost all species of *Bazzania* the branches tend to grow as strongly as the stem from which they arise, so that the branching is distinctly Y-shaped and resembles dichotomous branching. For this reason, such branching is called 'pseudodichotomous'. In a very few species of *Bazzania*, including *B. involuta* of New Zealand and Tasmania, the branches are much weaker than the continuing stem and the branches are oriented more or less at right angles to the stem. This form of branching is called 'lateral'. In *Bazzania* the lateral branches are of the *Frullania* type; that is, the branch replaces the ventral half of a lateral leaf, leaving the other half of the leaf in the branch junction on the dorsal side. The flagella arise from ventral intercalary branching in the axils of underleaves, thus leaving underleaves intact. (In *Acromastigum* the flagella arise from ventral terminal branching, so the branch replaces half an underleaf.)

Scott (1985) reported only *B. involuta* and *B. monilinervis* from southern Australia, as he considered *B. adnexa* to be conspecific with *B. involuta*. However, *B. adnexa* differs from *B. involuta* in several respects (see under the description of *B. adnexa*), and *B. involuta* does not occur in any of the many collections from Victoria. It is therefore discounted here from the Victorian flora. An additional species, *B. hochstetteri*, has since been found in Victoria, and there are several other species in Tasmania and New South Wales.

Similar taxa

Of the other genera of Lepidoziaceae in Australia, only *Acromastigum* is likely to be mistaken for *Bazzania* in the field, as it is the only other genus in which ventral flagella are present. In *Acromastigum* each flagellum replaces half an underleaf, the leaf apex is either bifid (two-lobed) or entire but never trifid, the underleaf is usually trifid, and the cells in the outer layer of the stem are enlarged and transparent. In *Bazzania* the flagella arise from the axils of the underleaves, the leaf apex is usually trifid (but sometimes bifid or entire), the underleaf is usually entire (but dentate or lobed in some species), and the cells of the outer layer of the stem are not enlarged and are more or less opaque. Also, *Acromastigum* plants are usually much smaller than *Bazzania* plants.

Several species of *Bazzania* from Tasmania, central New South Wales and New Zealand are similar to Victorian species, and should be kept in mind when determining unusual specimens, notably *B. accreta*, *B. novae-zelandiae* and *B. fasciculata*. Synonyms are published in McCarthy (2003).

Description of species

In the following descriptions, dimensions are included only where they are useful in distinguishing species. In general, leaf and

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Key to the Victorian species of Bazzania

This key is based on features that are visible with a 10× hand lens. Field identifications should be confirmed in the laboratory using the microscopic characters mentioned in the descriptions.

1. Leaves with a distinct vitta 2–3 cells wide; leaf apices with three spreading, tooth-like lobes; underleaves distinctly ovate, ± entire .... ***B. monilinervis***

   Leaves without a vitta (but usually with a broad patch of enlarged cells in mid-leaf); leaf apices various; underleaves not ovate, with distinctly crenulate or toothed margins **2**

2. Leaf apices bifid or trifid on the same plant, lobes never with extra teeth; leaves very brittle and usually missing from much of the stem .... ***B. hochstetteri***

   Leaves always trifid; leaf apex often armed with additional small teeth; leaves not brittle, rarely missing .... ***B. adnexa* var. *adnexa***

cell dimensions are not useful taxonomic characters for these species. Distribution maps are based on a review of specimens in MEL, MELU, NSW and CANB. Open circles represent records more than 50 years old.

Bazzania adnexa (Lehm. & Lindenb.) Trev. var. *adnexa* (Fig.1).
Mem. Real. Istit. Lombardo Sci. Lett. **13** (ser. 3, part 4): 414 (1877)
Known distribution in Australia: Tas, Vic (Fig. 2), NSW, ACT, Qld, Lord Howe I.
Habitat: epiphytic on trees and tree-ferns (rarely on soil) in wet sclerophyll forest and rainforest.
Plants yellow-green to dark green, forming dense, overlapping mats; **branching** frequent, pseudodichotomous, the branches of *Frullania* type; **leaves** usually spreading widely from stem, to about 1.5 mm long and 0.8 mm wide, trifid, usually with extra small teeth around apex and margins, cells mostly thin-walled, trigones minute or absent except sometimes larger in basal mid-leaf; **underleaves** wider than long, patent to semi-erect, bulging or keeled at the base, with a distinct margin of thin-walled, empty cells (sometimes eroded), margin usually weakly to strongly toothed and sometimes reflexed or incurved; **perianth** on short ventral branches, more or less tubular with an inflated centre and constricted and pleated mouth without teeth or cilia; **capsules** ellipsoidal, dark brown, on a long, slender seta; **spores** brown with ± ruminate ornamentation, elaters bispiral.

Notes: In the past, *Bazzania adnexa* has been confused with *B. involuta*. Scott (1985) treated them as a single species, and called all southern Australian material *B. involuta*. But the two are very distinct species, and almost all Australian specimens previously identified as *B. involuta* are *B. adnexa* or other species. (In *B. involuta* the branching is mostly lateral, and the underleaves are not toothed and lack hyaline cells.) *Bazzania adnexa* is by far the most common species of *Bazzania* in Victoria, forming about 90% of collections. The leaves are very variable in colour, size, shape and degree of toothing, and the underleaves also vary in shape, size, width of the hyaline margin and degree of toothing. Despite its variation, *B. adnexa* is easily distinguished from the other Victorian *Bazzania* species. All Australian plants appear to belong to the variety *adnexa*. The species' range extends to New Zealand, where the variety *aucklandica* also occurs (Engel and Merrill 1994). That variety has the underleaves constantly incurved, a condition found only intermittently in var. *adnexa*.

Fig. 1. *Bazzania adnexa* (Lehm. & Lindenb.) Trev. var. *adnexa*. **A** Dorsal view of portion of shoot. **B** Leaves and underleaves. Dashed line in leaves indicates area of enlarged cells. Thin line in underleaves indicates area of chlorophyllose cells. **C** First branch underleaf and adjacent stem underleaf. **D** Cells in midleaf. **E** Cells in upper leaf. **F** Cells in keel of underleaf. **G** Cells in outer area of underleaf. **H** Margin of underleaf, showing border of hyaline cells and teeth. **I** Underleaves showing connection to ventral margin of leaf on both sides. **J** Elater and spore. **K** Perianth with bracts. (Scale bars: A = 2 mm, B, C, I, K = 1 mm, D–H, J = 100 µm.).

Fig. 2. Known distribution of *Bazzania adnexa* in Victoria.

Bazzania hochstetteri (Rchdt) Hodgs. (Fig. 3)
Trans. Roy. Soc. New Zealand **82** (1): 11 (1954).
Known distribution in Australia: Tas, Vic (Fig. 4), NSW
Habitat: epiphytic on trunks and branches of trees in rainforest
Plants yellow-green to mid green, forming weakly overlapping mats; **branching** frequent, pseudodichotomous, the branches of *Frullania* type; **leaves** usually spreading widely from stem, to about 1 mm long and 0.4 mm wide, trifid or bifid, without extra small teeth, fragile and often breaking, so that the lower stems may lack leaves, cells mostly thin-walled, trigones minute or absent except sometimes larger in basal mid-leaf; **underleaves** wider than long, rather wedge-shaped, patent to semi-erect, the upper 1/2 to 1/3 consisting of hyaline cells, the apex usually weakly toothed or lobed; **perianth** not seen.

Notes: This is a very rare species of *Bazzania* in south-eastern Australia, known from only a few localities in Tasmania and Victoria and one in southern New South Wales. In Victoria it is known only from warm temperate and cool temperate rainforest on Wilsons Promontory, in Tarra-Bulga National Park and in East Gippsland. Outside Australia it is known only from New Zealand. It has recently been recommended for listing as a threatened taxon under the Victorian *Flora and Fauna Guarantee Act 1988* (M. O'Brien, Executive Officer, Scientific Advisiory Committee, pers. comm. July 2005).

Bazzania monilinervis (Lehm. & Lindenb.) Trev. (Fig. 5)
Mem. Real. Istit. Lombardo Sci. Lett. **13** (ser. 3, part 4): 414 (1877)
Known distribution in Australia: Tas, Vic (Fig. 6), NSW
Habitat: epiphytic on trees and tree-ferns in wet forest and rainforest
Plants mid to dark green, usually forming dense, overlapping mats but sometimes creeping among other bryophytes; **branching** frequent, pseudodichotomous, of *Frullania* type, fully-leaved ventral branches also common; **leaves** spreading widely from stem, to about 1.2 mm long and 0.7 mm wide, distinctly trifid with narrow, spreading lobes, never with extra teeth, distinct vitta of enlarged trigonous cells close to the ventral margins, 2–4 cells wide and reaching 3/4 or more of the leaf length, cells otherwise small and thick-walled, more or less without trigones; **underleaves** longer than wide, more or less oval, often with a few small teeth at the apex, appressed to the stem, cells colourless so that underleaves are very pale in dry plants, thick-walled in lower part and thin-walled in upper part of the underleaf; **perianth** widely ovate, strongly multikeeled throughout, tapering to a narrow and slightly toothed mouth.

Notes: Although usually abundant where it occurs, this is not a common species in Victoria. It is restricted to cool temperate rainforest and tree-fern gullies in wet forest, and grows in dark, dense mats on tree-ferns and non-eucalypt trees, especially *Nothofagus cunninghamii*, sometimes among *Bazzania adnexa*. The presence of a vitta and the neat, widely spreading apical lobes, together with the colourless underleaves, make this species easy to identify in the field. In New South Wales it is known only from a single site on Mount Budawang, in the south-east of the state.

Acknowledgements
I am grateful to the curators of MEL, NSW and CANB for loans of specimens, and to Nic Middleton and Kathy Vohs (MELU) for providing facilities and arranging loans. Many thanks also to Dr John Engel (Field Museum, Chicago, USA) for valuable advice on the manuscript, and to the anonymous referee for making numerous useful suggestions for improvements.

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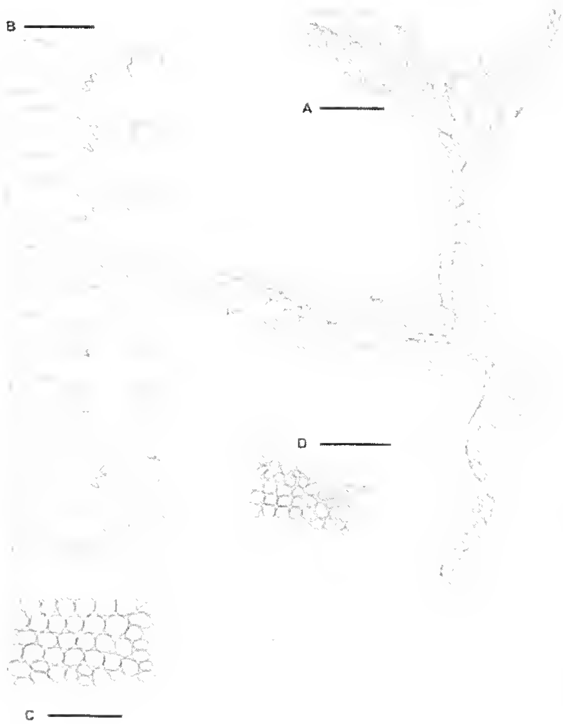

Fig. 3. *Bazzania hochstetteri* (Rchdt) Hodgs. **A** Dorsal vew of portion of plant. **B** Leaves and underleaves. Dashed line in leaves indicates area of enlarged cells. Thin line in underleaves indicates area of chlorophyllose cells. **C** Cells in mid-leaf. **D** Cells at leaf apex. **E** Underleaf. (Scale bars: A,B = 1 mm, C,D = 100 µm.)

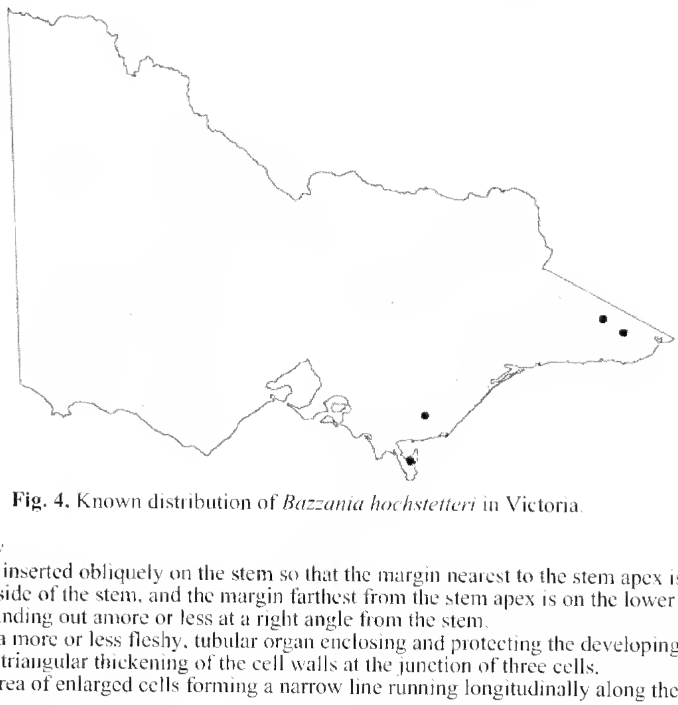

Fig. 4. Known distribution of *Bazzania hochstetteri* in Victoria.

Glossary

incubous: inserted obliquely on the stem so that the margin nearest to the stem apex is on the upper (dorsal) side of the stem, and the margin farthest from the stem apex is on the lower (ventral) side.
patent: standing out amore or less at a right angle from the stem.
perianth: a more or less fleshy, tubular organ enclosing and protecting the developing spore capsule.
trigone: a triangular thickening of the cell walls at the junction of three cells.
vitta: an area of enlarged cells forming a narrow line running longitudinally along the leaf.

Fig. 5. *Bazzania monilinervis* (Lehm. & Lindenb.) Trev. **A** Dorsal view of portion of shoot, showing a fully leaved ventral branched on the right. **B** Leaves and underleaves. Dashed line in leaves indicates vitta. Thin line in underleaves indicates area of thick-walled cells. **C** First branch underleaf and adjacent stem underleaf. **D** Cells of the vitta (showing oil bodies) and adjacent cells. **E** Cells in upper leaf. **F** Cells in mid-base of underleaf. **G** Cells at apex of underleaf. **H** Perianth with bracts. (Scale bars: A–C, H = 1 mm, D–G = 100 µm.).

Fig. 6. Known distribution of *Bazzania monilinervis* in Victoria.

Australian Natural History Medallion 2005

Pauline Reilly

Pauline Reilly joined the Australian Bird and Bat Banding Scheme in August 1958 and held Authority No. 92 until her resignation from the Scheme in 1995. This is probably the earliest documented activity of her long-held interest in birds and natural history which has led to the award of the Australian Natural History Medallion for 2005. The nomination was made by ANGAIR and was supported by a number of influential people in academic and natural environment management roles.

The Sherbrooke Survey Group was formed by members of the Bird Observers Club in 1958 as a response to the threat of destruction of lyrebird habitat. Pauline Reilly was a member of that group for seven years. From 1964 to 1981 she was regional organiser for the Bird Banding Scheme (a program of CSIRO Division of Wildlife Research) and from 1967 to 1981 she formed and led the Penguin Study Group until a permanent biologist was appointed to the Penguin Parade. She was active on the committee of the Australian Bird Banders' Association (now the Australian Bird Study Association) from 1966 to 1972, serving as Vice-president and President during that time. Pauline instigated and led the Flame Robin Survey in various parts of Victoria.

As well as the field work associated with her long term studies of lyrebirds, Flame Robins, and penguins in Victoria, Pauline led the Penguin Study Group on a trip to the Great Australian Bight and she banded shearwaters with Dr Dominic Serventy on Bass Strait islands. In the austral summer of 1978/79 Pauline Reilly instigated and led a three month study of Gentoo Penguins on Macquarie Island as an unpaid member of the Australian Antarctic Research Expedition (ANARE). She was accompanied by Anne Kerle, a post-graduate student from Monash University, and they found that the birds, five times the weight of a Little Penguin, proved to be a formidable subject to band.

During a muttonbird banding trip to Fisher Island in 1971, Dom Serventy spent the 16 days convincing Pauline Reilly that she should become President of the Royal Australasian Ornithologists Union (RAOU). This was at a time when that organisation was emerging from a controversial reform and was facing the prospect of hosting the International Ornithological Congress in Canberra in 1974. She accepted and during her Presidency the decision was taken to move from the cramped quarters of Clunies Ross House; to publish the first part of a new Checklist and the Interim List of Songbirds and to set up the Record Appraisal Committee. It was Pauline Reilly who obtained the concession that contributions to the Union for scientific purposes should be tax-deductible, thus acknowledging that projects approved by the Field Investigation Committee would be of scientific importance. It was she who led the delegation to Canberra which convinced the commonwealth department concerned that the Union possessed the human resources capable of compiling an atlas of the distribution of Australian birds. Pauline Reilly, with Stephen Davies and Margaret Blakers, was instrumental in ensuring the national coverage of the project by extensive travelling, calling meetings and inspiring local groups to take up atlassing. Pauline was RAOU President 1972-1975 and on its Research Committee 1969-1984.

The Victorian Wetland Trust was formed in 1988 with Pauline Reilly as its inaugural Vice-President. She held that position until 1993 and was also newsletter editor throughout that time. One of the initiatives of the Trust was to collaborate with Serendip Wildlife Reserve, so Pauline served on its Committee of Management from 1992 to 1996. Another organisation which benefited from her expertise was ANGAIR where she has been a member since 1983, contributing 'Bird of the Month' for its newsletter for many years.

The Penguin Study Group's findings on the biology of the Little Penguin were published in a series of reports between 1969 and 1974, written by Pauline and Peter

Balmford. Pauline followed this with a series of papers in *Emu* co-authored with Mike Cullen from Monash University. Two of her other study species, the Gentoo Penguin and the Superb Lyrebird, were the subject of additional papers in scientific journals. The 1983 'Ash Wednesday' bushfires at Aireys Inlet have special significance for Pauline as she lost her house and all of her records to them. She has monitored the effect of that wildfire on birds and patterns of recolonisation for more than eighteen years and reported her findings in the literature.

As well as her own writing, Pauline has prepared a number of book reviews and has refereed papers for *Emu, Corella, The Victorian Naturalist* and *Australian Bird Watcher* (now *Australian Field Ornithology*).

Probably the most well known of Pauline Reilly's books are those written for children. Three of them are teenage novels with a wildlife theme for remedial readers. Another thirty or so contain factual researched material which is told as a story for about 8-year reading level with illustrations that provide accurate information. These books are also used for Primary science and adult LOTE studies. Between 1985 when *The penguin that walks at night* was published and 1998, Will Rolland was the illustrator. A group of four of these books received the Whitley (Natural History) Commendation for the best children's series 1986/87, and five more were awarded the Whitley Commendation for the best children's educational series in 1994.

From 2000 Pauline Reilly and illustrator Kayelene Traynor formed Bristlebird Books. The eleven books published to date under that imprint have all been shortlisted or winners of the Wilderness Society Nonfiction Environment Awards for Children's Literature.

Penguins have been a large part of Pauline Reilly's life and, naturally, have resulted in a number of books: *Fairy Penguins: a brief life history*; *Fairy penguins and earthy people*; *Penguins of the world* (and a Japanese translation) and *Emperor: the magnificent penguin*.

She was co-author of the *Atlas of Australian Birds* (1984), which was awarded the Whitley Medal for best book in 1985, and also wrote *Lyrebird: a natural history*, greatly assisted by her early studies of that species with the Sherbrooke Survey Group.

Pauline Reilly's achievements in ornithology and conservation have been recognised by other awards. In 1981 she became the first female Fellow of the Royal Australasian Ornithologists Union and in 1994 a member of the Order of Australia. The RAOU Fellow citation described her as the epitome of those 'serious amateurs', and made the award for her distinguished service to Australian ornithology as a field worker, administrator and author. The John Hobbs Medal recognises contributions to ornithology by an amateur, and Pauline Reilly was the 2001 recipient. In 2005 she was awarded by Bird Observers Club of Australia one of the ten inaugural W. Roy Wheeler Medallions for Excellence in Field Ornithology

Although Pauline's greatest enjoyment comes from field work with birds, she has contributed much to administration and guidance for the community. She served on the Environment Committee of the Sandringham Council from 1976 to 1982 and, for the Surf Coast Shire, she chaired the steering committee which prepared its Conservation Strategy, was a member of its Environment Advisory Committee and its 2020 Vision planning committee. She was Secretary to the Aireys Inlet and District Association and has been called as an expert witness before VCAT hearings related to the Penguin Parade at Phillip Island and habitat encroachment issues for Bristlebirds and wetlands.

Pauline Reilly is still offering guidance to bird watchers and, in recent times, has been acting as mentor to students who carry out field studies in her local area. These activities have not only included a study of Bristlebirds at Aireys Inlet conducted by Deakin University but also research of a Japanese PhD student on Little Penguins in New Zealand. Pauline is a worthy winner of the Australian Natural History Medallion.

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The effects of a higher sea level on the coasts of Port Phillip Bay

Eric Bird[1]

Abstract
Sea level may rise in Port Phillip Bay in response to global warming and higher ocean levels, while channel deepening at the entrance will produce higher high tides. A rising sea level will lead to submergence and increased erosion on the bay shores, and the eventual disappearance of Mud Islands. The response to submergence should be landfilling to raise low lying areas, while increased coastal erosion should be countered by renourishment of protective beaches rather than the building of sea walls or boulder ramparts. (*The Victorian Naturalist* **123** (1), 49-54)

Introduction

Port Phillip Bay formed about 6 000 years ago during the world-wide sea level rise known as the Holocene Marine Transgression. The sea then flooded into a basin, the Port Phillip Sunkland (Keble 1946), through a narrow gap in the coastal fringe of Pleistocene dune calcarenite that forms the Nepean Peninsula to the east and the Point Lonsdale foreland to the west. This entrance, known as Port Phillip Heads, is 3.2 km wide at high tides.

There had been previous Port Phillip Bays during high sea level phases of the Pleistocene, and at first the submergence revived the outlines of an earlier bay, but there were soon modifications (Bird 1993a). Cliffs were cut back, and sand eroded from them formed beaches that extended around much of the 260 km coastline. Salt marshes and some mangroves occupied sheltered areas such as Swan Bay, the Yarra estuary and other smaller inlets. It is thought that the sea briefly attained a level a metre or so higher than at present, then fell back, leaving some emerged beaches and resulting in some of the cliffs being degraded to vegetated bluffs (Gill 1950, Bowler 1966).

Evidence from the earliest maps and charts, compiled in the nineteenth century, indicates that the coastline was beach-fringed, with several cliffy sectors and local salt marshes and mangroves. Much of this natural coastline persisted on aerial photographs taken in the 1930s and 1940s, but there had been changes associated with the development of the Port of Melbourne in the Yarra estuary, the construction of harbours and the building of protective structures (mainly wooden walls and groynes) on some eroding sectors (Bird 1988a).

The beaches of Port Phillip Bay were supplied mainly with sand and some gravel derived from eroding cliffs and shore outcrops, with some sand and shelly material swept in from the sea floor during the Holocene marine transgression. Shelly debris is still delivered by gentle wave action in relatively calm weather (Bird 1988b).

Beaches are eroded by storm waves that produce a weak swash and strong backwash, and restored by gentle wave action in subsequent calmer weather. Beach sediment is also moved alongshore when waves arrive at an angle to the shoreline. In winter, wave action in Port Phillip Bay is dominated by winds from the west and north-west which generate southward drifting on the east coast, while, in summer, winds from south-west and south move beach material northward. In consequence, beaches between Port Melbourne and Mount Martha become wider at their northern ends and narrower at their southern ends during the summer, a pattern that is reversed in the winter months.

These alternations complicate the assessment of beach changes but, when the present patterns are compared with those seen on aerial photographs taken in the 1940s, it is evident that beaches have been depleted. Their width at high tide has diminished, and they are generally steeper in profile than they were before 1945. Depletion has been largely due to the building of sea walls and rock revetments that have halted cliff erosion and thus the supply of sand to beaches. In addition the reflection of

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waves by these structures has scoured away the beach, removing sand to the sea floor. Beaches that have escaped erosion are those where sand has accumulated beside or behind harbour structures, as at Sandringham, Middle Brighton and Queenscliff, in each case with depletion of adjacent beaches (Bird 1993a).

Some beaches have been artificially restored, and on the north-east coast of Port Phillip Bay the existing beaches are largely those that were renourished by dumping sand in the 1970s to 1990s (Bird 1990). A renourished beach can be effective in halting cliff erosion, as has been shown on the coast south of Quiet Corner, Black Rock and north of Red Bluff, Sandringham. Renourished beaches maintain acceptable coastal scenery and provide a valuable recreational resource, in contrast to the ugliness of sea walls and rock revetments and the damage that follows their construction. Regrettably, there are still schemes to build or extend sea walls and rock revetments, even though it is clear that these result in beach depletion.

The present coastline of Port Phillip Bay is thus far from natural. It is unstable, and erosion is prevalent. Beaches that have been renourished are diminishing (being subject to the same processes that depleted their natural predecessors), and will have to be restored again in the future (like sea walls, they require maintenance, particularly after storm damage). Even with the sea at its present level and no change in climate the beaches of Port Phillip Bay will continue to diminish, and it is likely that the only beaches still present a century hence will be those that have been artificially renourished.

Causes of a rising sea level

Sea level could rise in Port Phillip Bay if there was subsidence of the land, which has occurred in the geological past within the Port Phillip Sunkland. It could rise if the general level of the oceans rose, because this would be transmitted into Port Phillip Bay. Alternatively, it could rise if the entrance at Port Phillip Heads was substantially enlarged, allowing more water to flow in on rising tides. Sea level can be raised temporarily by storm surges or tsunamis.

The Port Phillip Sunkland has been relatively stable, although earthquakes have occurred along bordering fault lines, particularly Selwyn Fault, which runs down the east coast of the bay from Frankston past Mornington to Dromana and across the Nepean Peninsula to the western side of Cape Schanck (Keble 1950). An earthquake occurred on this fault at Mornington in 1932, and there have been several lesser tremors, but no evidence that these tectonic movements generated tsunamis within the bay. Although tectonic subsidence could occur, leading to a rise of sea level relative to the land in Port Phillip Bay, the risk appears to be slight.

Global Warming and sea level rise

Monitoring of the composition of the Earth's atmosphere, which began in the International Geophysical Year (1957), has shown increases in carbon dioxide, methane and other gases that are known to increase the opaqueness of the atmosphere and thereby reduce the outflow of reflected solar heating from the Earth's surface. This is known as the Greenhouse Effect, and the consequent global warming is expected to cause a world-wide sea level rise, due to thermal expansion of the oceans and increasing inflow of water from the melting of snowfields and glaciers (Pearman 1988). In 2001 the Intergovernmental Panel on Climate Change estimated that global sea level would rise up to 30 centimetres by 2040 and up to 88 centimetres by the year 2100 (Church *et al.* 2001).

Analyses of long-term tide gauge records from coastal stations around the world has shown that over 70% of them show a rise in mean sea level, and it is widely believed that global mean sea level is rising at 1-2 mm/year. However, this is by no means uniform. Satellite sensing has shown that the ocean surface is bumpy and variable; some coastal land areas are rising (sea level falling) while others are subsiding (sea level rising); and the global distribution of reliable tide gauge records is patchy. Evidence from the Point Lonsdale and Williamstown tide gauges may not be reliable because modifications have been made, but it appears that mean sea level in Port Phillip Bay is much the same as it was a century ago (Mackenzie 1939, Bird

1993b). It will be some time before a global sea level rise becomes certain, but if it does sea level within Port Phillip Bay will rise accordingly.

Effects of a rising sea level

In general terms a rising sea level will transgress across the existing intertidal zone, submerging shore platforms and salt marshes as the levels of high and low tide increase around Port Phillip Bay. Mud Islands, surmounting the broad shoals in the southern part of the bay, consist of sandy beaches and dunes encircling a salt marsh, and are likely to be quickly reduced by erosion and submergence. The mouths of inflowing creeks and rivers such as the Yarra and the Werribee will become wider and deeper as high tides attain augmented levels. Nearshore water will deepen, allowing larger waves to break on the shore, intensifying erosion of cliffs and beaches. Where the cliffs are in hard rock, such as the granodiorite of Mount Martha, erosion will be slight as the sea rises, but the soft clay and sandstone cliffs of the Bellarine Peninsula and the north-eastern coast between Sandringham and Balcombe Bay are likely to be cut back more rapidly as wave attack reaches higher levels. Low-lying areas, particularly along the west coast of the bay, will be submerged unless sea walls are built to keep the sea out, or their levels raised by dumping land fill. Organisms that occupy specific intertidal zones will migrate upward on cliffs and shore structures such as sea walls and breakwaters and landward if there are suitable backshore habitats. Such habitats will not be available on much of the bay coastline because of built structures, notably sea walls, and the existing intertidal ecology zones will be squeezed as the habitats become narrower, or disappear.

Erosion has become widespread on coasts where sea level has risen because of coastal land subsidence, due to tectonic activity, as in southern England. Similar erosion has occurred where the coast has subsided as the result of extracting oil, as in southern California, or groundwater, as on the northern coast of the Gulf of Thailand (Bird 1993b). The seaward fringes of salt marshes in the Lagoon of Venice, where sea level is rising because of coastal subsidence, are cliffed and are eroding rapidly.

Beach erosion is extensive on subsiding coasts. The Bruun Rule states that as sea level rises the beach profile is re-shaped, with erosion of the upper beach and withdrawal of sediment to the adjacent sea floor (Bruun 1962). If a sea level rise is followed by a phase of stability the beach profile will be restored at a higher level (Figure 1). There are problems with the Bruun Rule because it assumes that the beach profile was initially in equilibrium, neither gaining nor losing sediment, and that the sea level rise is a specific event, followed by stability (Bird 2001). As has been noted, the beaches of Port Phillip Bay are already eroding, and the prospect is that global warming will lead to a continuing sea level rise. On subsiding coasts there is no doubt that as sea level rises beaches are eroded and sand transferred to the sea floor. Analyses of erosion rates when sea level rises around the Great Lakes in North America indicates that each centimetre of sea level rise results in a metre of beach recession (Schwartz 1967). The predicted rise of sea level could therefore result in up to 30 metres of recession on beaches bordering Port Phillip Bay. At high tide most of the beaches are narrower than this, so they will disappear by 2040 unless they have been artificially renourished.

Storm events

There have been many storms in Port Phillip Bay, and at the end of November 1934 there was a major storm surge. A combination of heavy rainfall and river flooding, low barometric pressure and southerly gales raised high tide water level in the bay by as much as a metre. This caused extensive flooding, rapid erosion of cliffs cut in soft clay and sandstone on the east coast of the bay, and erosion of beaches. There was extensive structural damage at sites along the north and east coast of the bay. The sea level rise was only temporary, and within a week Port Phillip Bay was back to its normal level. In this and other storms in Port Phillip Bay there was severe beach erosion, and sand was withdrawn to form sand bars just offshore, but in subsequent calmer weather much of this sediment moved back on to the beach, restoring the transverse profile.

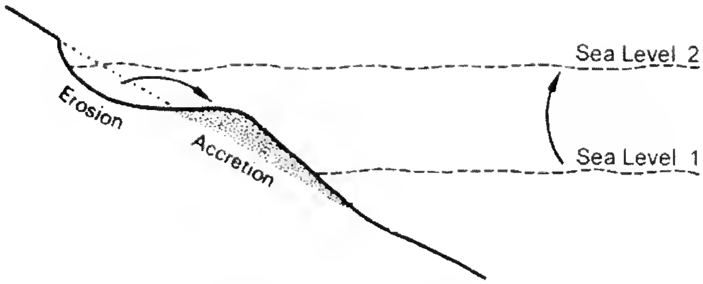

Fig. 1. The Bruun Rule states that a sea level rise will result in the erosion of a beach, as a volume of sediment is removed from the backshore and deposited in the nearshore area. Depletion of beaches in Port Phillip Bay will follow the dredging of shipping channels, which will raise high tide levels by just under a centimetre, and accelerate as sea level rises as the result of global warming by up to 30 centimetres to the year 2040.

In response to the 1934 storm surge the Victorian government made a Foreshore Erosion Survey in 1935 that showed that some cliffs cut in soft sandstone or clay had been receding at an average rate of a foot (about 30 cm) a year (Mackenzie 1939). This led to the building of masonry sea walls between 1936 and 1946 and the stabilisation of these rapidly eroding cliffs as artificially graded and vegetated slopes. Since 1946 sea walls have been extended and rock revetments added to several sectors of coastline, so that more than 40% of the coastline is now artificial.

Tsunamis

Tsunamis are seismic sea waves generated by earthquakes or volcanic eruptions on the ocean floor. These waves radiate across the oceans, and as they move into shallow water they grow in size, and may attain several metres in height when they break on the shore. The recent tsunami in the Indian Ocean (26 December 2004) was caused by an earthquake off the northern tip of Sumatra. This generated large waves that caused devastation and loss of life when they reached the coasts of nearby Aceh Province, the Andaman and Nicobar Islands, and the northern coasts of the Indian Ocean from Penang in Malaysia and Phuket in Thailand around to Bangladesh, eastern India, Sri Lanka and east Africa from Somalia south to Kenya. Similar tsunamis have occurred around the Pacific Ocean, and evidence of erosion and emplacement of boulders by a tsunami about 105 000 years ago has been found on the south-eastern coast of Australia (Bryant *et al.* 1996).

No such evidence has been found on the coast of western Victoria, but a tsunami could be generated by an earthquake in the Southern Ocean, producing a wave from the south or south-west breaking on the Victorian coastline. The arrival of a tsunami in Bass Strait would be signalled by a rapid withdrawal of sea water along the shore, and a strong outflow through Port Phillip Heads. Then, as large tsunami waves broke along the Victorian coastline, water would be transmitted into Port Phillip Bay. The incoming wave would be much reduced by friction as it passed through the narrow entrance and crossed the southern shallows. A small tsunami (about 3 metres) would produce waves similar to those now generated by large swells or storm waves of similar dimensions, which are about a metre high when they reach the shores of Lonsdale Bight and Nepean Bay, but diminish rapidly along the inner bay coastline. Such a tsunami would cause an upwelling of water similar to a sudden rise of the tide rather than a major breaking wave around much of the bay shore. With increasing tsunami size, waves would penetrate further, and a very large tsunami (> 10 metres) would produce waves, albeit diminished, around Port Phillip Bay. In calm weather there would be a brief coastal submergence, but if it was wet, stormy waves reaching higher levels could be as damaging as those in the 1934 storm surge mentioned previously.

Storm surges and tsunamis raise sea level only briefly and, although they may cause cliff recession and structural damage along the coast, their effects on beaches are usually temporary, sudden erosion giving place to gradual restoration after the sea returns to its present level.

A more permanent sea level rise would not permit such restoration.

Channel deepening

The development of the ports of Melbourne and Geelong has depended on ships entering and leaving Port Phillip Bay through the narrow gap between Point Lonsdale and Point Nepean. The navigation channel has been deepened and widened by recurrent local blasting of rock outcrops at intervals since 1902, but the increase in the size of cargo ships has led to a proposal for further dredging of the channel through Port Phillip Heads and shipping channels within the bay. There is the possibility that changes will occur on the bay shores as the result of this deepening.

Maximum tide range in Bass Strait is about 1.7 metres, and the tides flow in and out through Port Phillip Heads, an entrance that so restricts their flow that tide range at the head of Port Phillip Bay is only 0.6 metres. An increase in the cross-sectional area of the entrance channel would increase tidal ventilation (the volume of water that enters and leaves Port Phillip Bay), raising high tides and lowering low tides. Modelling, reported in the Environmental Effects Statement (2004) prepared for the Port of Melbourne Corporation, has indicated that tide levels in Port Phillip Bay after dredging the entrance and shipping channels will be up to 8 mm higher at high tide and as much at 9 mm lower at low tide. This implies that there will be little if any change in mean sea level: more water will flow in as the tide rises but more will flow out as it falls. High tides in Port Phillip Bay will be slightly higher, which would not be significant in calm weather, but when the augmented high tides coincide with storms the waves reaching beaches and cliffs will be larger and more erosive than they are now. The geomorphological impact of a rise in sea level due to deepening of the shipping channels will thus depend on the frequency with which the higher tides coincide with stormy weather. The changes that result will be minor compared with those that would result from a global sea level rise, even of only a few centimetres. The deepening of shipping channels will nevertheless slightly increase and accelerate the effects of a global sea level rise in Port Phillip Bay

Response to a sea level rise

Erosion of cliffs, beaches and salt marshes resulting from a rising sea level will pose problems for coastal managers. Where cliff erosion has accelerated and the loss of coastal land threatens built structures, the usual response has been to build sea walls along the cliff base, even though this results in wave reflection scour and the loss of bordering beaches. Beach erosion has sometimes been countered by sea walls or boulder ramparts that may halt coastline recession, but also cause further beach depletion. Eroded beaches can be replaced artificially, and restored beaches can be used to halt cliff erosion (Bird 1996). Coastal management in Port Phillip Bay will require further renourishment of beaches to maintain stability and scenic and recreational values. The proposal to dredge shipping channels in Port Phillip Bay at an estimated cost of $550 million could be beneficial if the extracted sediment is used to renourish beaches and build up coastal land levels. The predicted huge economic benefits of such dredging would also provide the Port of Melbourne Corporation with plenty of money to spend on beach nourishment and coastal management to maintain and improve the scenic, recreational and cultural values of the Port Phillip Bay coastline.

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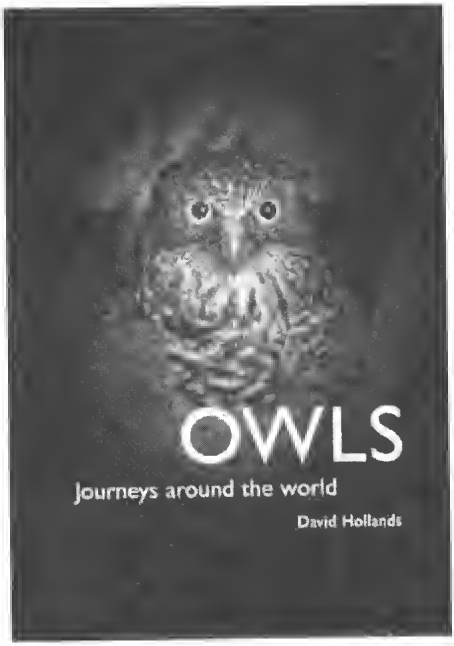
Received 20 January 2005; accepted 25 August 2005

Owls: Journeys Around the World

by David Hollands

Publisher: *Bloomings Books, Richmond, Vic, 2004. 192 pages, hardback, illus, 150 colour plates. RRP $59.95*



Owls by their very nature are cryptic speeies, whieh we regard with a speeial sense of mystery and awe. Their presence is extremely difficult to determine; their behaviour even more difficult to predict. Traeking down owls is challenging enough, but taking photographs of the quality displayed in this book is truly admirable. David Hollands has excelled himself with this publication, produeing another outstanding owl book with qualities equal to those shown in his previous owl book *Birds of the Night* (Reed Books: Sydney 1991).

Through this book, David takes us on a journey of passion, providing the reader with personal aeeounts and outstanding photographs of twenty-one owl species from six continents. David's passion and determination is obvious from the very beginning. His detailed and accurate aeeount of the different owl speeies is superb and his personal touches make this book a pleasure to read, both for the scientist and the lay person. I espeeially enjoyed reading about David's trials and tribulations, partieularly in relation to Alaska's Snowy Owl: the photographs and information provided on this species is a testament to David's sheer commitment.

The final owl that David deseribes in detail in this book is Australia's largest, the Powerful Owl. This speeies is very close to my heart and I thoroughly enjoyed (and related) to David's aeeounts of it. I agree wholeheartedly that the Powerful

Owl 'does not give away its secrets readily'. Having worked on this species for many years myself I can fully appreciate David's frustrations and jubilations. The information that David has provided on this species is accurate and highlights the result of many long cold nights sitting in the bush. One thing we all know for certain is that all the waiting is definitely worthwhile, as is highlighted through David's photographs.

The book finishes with a section on the future. This is a very valuable section, as it highlights various threatening processes that owls are currently contending with. David's predictions for the future are somewhat bleak, but hopefully through education and increased public awareness we can work together and begin to reverse this trend. Publications such as this one are certainly fantastic starting points with the photography and easy reading making it a book that everyone can enjoy and ultimately use to learn more about these amazing creatures.

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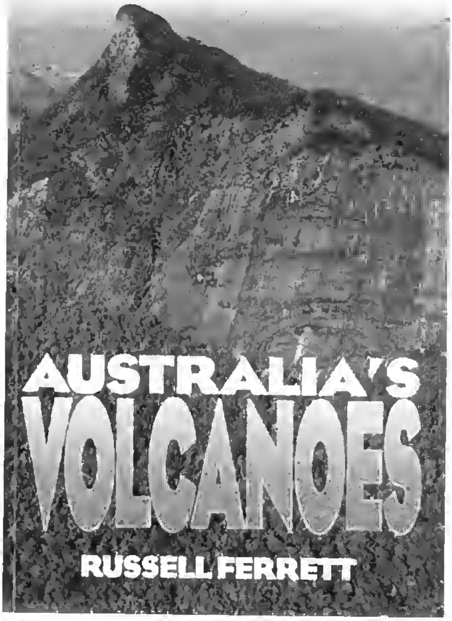
Australia's Volcanoes

by Russell Ferrett

Publisher: *Reed New Holland, Sydney, 2005. 160 pages; paperback; colour photographs. ISBN 1877069094. RRP $29.95*



This attractive and handy-sized (and priced) book begins with a good clear index map on page 5, a map of areas of volcanic activity on page 9, and another map on page 16 showing a hotspot moving from north to south down the eastern side of Australia and ending at Macedon in central Victoria. Other maps support the descriptions of local areas.

The contents are:

1. The formation of volcanoes
2. Eruptions, tephra, lava and rocks
3. Landforms
4. Queensland
5. New South Wales
6. Victoria
7. South Australia, Tasmania, Western Australia and Heard Island.

A useful glossary, list of references, and a good index complete the book.

Russell Ferrett is a geography teacher who has visited many of the world's volcanoes, and not finding suitable information on Australian volcanoes, he 'decided to write his own book to address this gap in our knowledge and understanding'.

He discusses the past 40 million years of volcanic activity in Australia, concentrating on the clearest examples, and mainly those from the Eastern Australian mainland. This means the young volcanoes of Queensland, NSW, Victoria and South Australia form a major part of the book. However the area now commonly known as the Newer Volcanic Province covering central and western Victoria, and SE South Australia, is not fully covered; there is a concentration on the Camperdown area, and on Tower Hill and Mt Eccles, and Mt Gambier in South Australia. Bill Birch's book is still the best guide for Victoria.

Descriptions of the earlier (older) Eastern Australia activity include the Glasshouse

Mountains of southern Queensland, and in New South Wales Mt Warning, the Ebor volcano, The Warrumbungles, Mount Canobolas (and Lord Howe Island). Areas in Tasmania are also described and, unexpeetedly, and of some interest, the Allendale diamond pipes in the less well-known diatremes of the West Kimberley, whieh formed about 20 million years ago.

Heard Island's Big Ben, until recently (and here also) called Australia's only active volcano (it's actually in Australian Territory) is also deseribed. Recently, after a long period of dormaney, McDonald Islands, located on the Kerguelen Plateau about 75 km west of Heard Island, began erupting in the 1990s, so we now have two aetive Australian volcanoes.

The terms 'dormant' and 'resting', used in the Preface on page 8, cannot be usefully applied to the young basaltie volcanoes of Queensland, Vietoria and SE South Australia, whose numerous short-lived eruptions began and finished quite quickly (perhaps just days, months or years) and will never erupt again. Such 'areal' volcanie provinees with numerous eruption points scattered over a broad area, such as the 400 small voleanoes found in Vietoria, are best diseussed in terms of the possibility of future new volcanoes forming. The provinee as a whole can be considered as dormant but the individual past volcanoes are extinct (see the discussions in the reeent thematie issue of the Proceedings of the Royal Soeiety of Victoria refereneed below).

The use of the term 'inflation' on page 61 is well up-to-date in explaining the way basaltic lava flows inerease in thiekness, and develop some otherwise difficult to explain features. The introduction of this eoncept to Australian workers was at the international Long Lava Flows meeting in Queensland in 1996 and Ferrett gives the referenee, though it may be diffieult to obtain.

It is good to see 'tumuli' used on page 62 rather than the older and incorreet term 'blister' often used for the flow features at Wallaeedale on the Byaduk flow from Mt Napier. Not so helpful is the use on page 60 of 'canals' for lava channels (as used loeally) and the use of 'tubes' when most loeals use the term (lava) eaves.

Using 'Mt Diogenes' (page 116) for Hanging Rock is unnecessary. Mt Rouse is not mentioned, nor the new Penshurst Voleanoes Discovery Centre nearby. A note on Mt Elephant on page 123 fails to mention that quarrying has now eeased and the local Derrinallum community has begun new aecess and management work. The useful 'Volcanoes Discovery Trail' leaflet eovering the Western Plains and SE South Australia is also not mentioned.

Oeeasional text boxes giving 'Further Information', pointing out 'Nearby Volcanic Features' and suggesting 'Activities' will be useful to the user in the field, and to teachers and students.

The book has excellent eolour illustrations, including 'home-made' colour sketches – and very acceptable they are too. As best as I ean check, it's error free, and spelling error free.

I recommend this book to the many people in Australia who are interested in voleanoes.

Notes

Below are some books on the topic, which readers may find of interest.

Birch WD (1994) *Volcanoes in Victoria*, Royal Society of Victoria, Melbourne. 36pages, paperback. (Covers both the young and much earlier volcanoes of Victoria, is very well illustrated with photographs, and suitable to carry in the field (but less of a field guide than Ferrett)).

Sutherland L (1995) *The Volcanic Earth*, UNSW Press, Sydney. 248 pages, hard cover. (A more detailed approach, with more on rocks and minerals, and detailed geological information, as well as some coverage of New Zealand.)

Joyce B (2004) The young volcanic regions of south-eastern Australia: early studies, physical volcanology and eruption risk. *Proceedings of the Royal Society of Victoria*, **116**, 1-13. (A recent review of the Newer Volcanic Province, including the history of its study, and the possibility of future eruption.)

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A Naturalist's Life

by Rica Erickson

Publisher: *University of Western Australia Press* and *The Charles and Joy Staples South West Region Publications Fund, 2005, 144 pages, paperback. ISBN 1 920694 27 7. RRP $34.95*

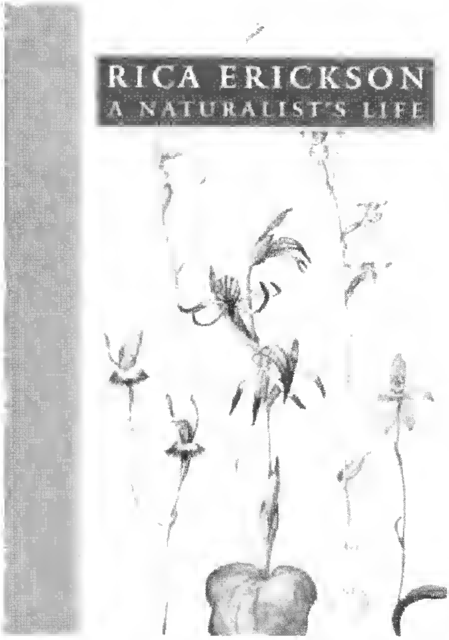
Mention the name Rica Erickson and I think of Western Australia, triggerplants, earnivorous plants, orchids and the *Drummonds of Hawthornden*. In the second sentence of A Naturalist's Life, the author says 'As a teenager I read *The Life of Jean Henri Fabre*.' That led to a life of exquisitely detailed observations of plants and insects and a correspondence with, and collection of specimens for, Australian and overseas botanists.

The first chapter of the book is a series of potted biographies of the author's mentors; she had initiated the *Dictionary of Western Australians* and is well practised in the art. Entries for Edith Coleman, Herman Rupp, Tarlton Rayment, Jim Willis, Dom Serventy and William Nicholls are included.

Chapter 2 is titled 'A Career in the Making' and tells the story of a ninety year life in the rural areas of Western Australia as she moved with parents, as a country teacher, and then with her farmer husband. Effectively self-taught, and guided by those few wildflower books available at the time, Rica Erickson became an authority on the orchids, triggerplants and earnivorous plants of Western Australia. Her own books and articles were meticulously illustrated with line drawings and watercolour paintings. After a wildlife art exhibition at the Art Gallery of Western Australia, six female artists started the Botanical Artists Group (BAG). These BAG Ladies gave themselves names such as Tea Bag and Paper Bag; Rica was Old Bag.

Later in life there was an Australia-wide excursion collecting, identifying and documenting the whole country's triggerplants—the surprise for Victorian readers is the revelation that the Tree Triggerplant *Stylidium laricifolium* grows in East Gippsland.

Two of her treasures were the portable microscope especially made for her by Mr Woollard, the same man who designed the



FNCV microscope with Dan McInnes, and the watercolour paintbox given to her by Frederick Rowe, her earliest guide to the natural world.

The final four chapters are headed Insects, Birds, Flowers and Conservation and each provides reprints or reminiscences of some of her most important discoveries and experiences. Studies on solitary burrowing bees, leaf-cutter bees and wasps, in which her children became involved, were published by Tarlton Rayment.

Banding shearwaters in the Furneaux Islands with Dom Serventy; questioning the field guide descriptions of juvenile Rufous Whistler's plumage and recording in detail this bird's breeding behaviour; the early days of the Eyre Bird observatory; and accompanying Graeme Pizzey to catch and photograph the newly re-discovered Noisy Scrub-bird: any one of these activities would be a lifetime highlight. Most of the articles in the Flowers chapter are facsimiles of those originally published in *Wildlife*, *Australian Plants*, and the *West Australian*, beautifully illustrated with the author's wildflower drawings.

This book, as well as giving insights into the development of a famous naturalist in Western Australia, also contains references to many Victorians associated with the FNCV. Both are good reasons to read it. A wealth of line drawings and coloured plates accompany the text.

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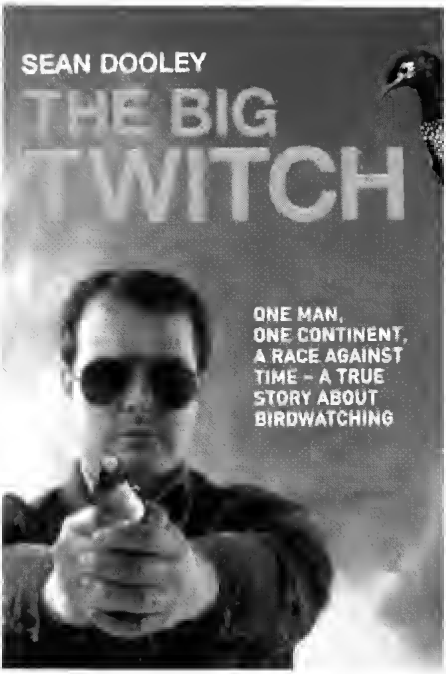
The Big Twitch

by Sean Dooley

Publisher: *Allen and Unwin, Sydney, 2005. 322 pages, paperback. ISBN 1741145287. RRP $26.95*



When asked to write a review for Sean Dooley's book *The Big Twitch* I was surprised, a little taken back even. You see, I appear to have developed a, largely undeserved (I think), reputation for being anti-twitcher. Still, I don't generally have a great deal of time for hard-core twitchers. I recently saw a good twitcher described as 'opinionated, aggressive, passionate, single-minded and distrustful'. Mind you, some people would say this could also describe me.

Anyway, not being one to pre-judge, I immersed myself in *The Big Twitch*, a story about one man's effort to set a new record for the number of bird species seen in Australia, and its territories, in one year. Well, it was more than set a new record; the previous highest total seen in a year was 633, the real goal was to see 700 species, a feat that very few birdwatchers achieve in a lifetime. Given that there are supposedly 695 bird species that are resident or regular migrants to Australia it is perhaps not surprising that many thought this was little more than an unachievable whim by a virtual unknown, at least outside Melbourne, who had an inheritance burning a hole in his pocket. Now, all of this is very unfair but first impressions being what they are ...

I guess I approached the book having a good idea of the premise behind the concept, and even much of the content. A quick explanation: in January 2002 Sean posted a message on the internet birdwatching discussion group Birding-Aus stating his intention to embark on this ambitious adventure. This was a bold move as it exposed Dooley and his intentions to all manner of scrutiny. In the year that followed there were regular updates on progress posted to Birding-Aus. The book essentially builds on these running commentaries.

Regardless of what one may think about twitchers or even the apparent folly of the exercise you can't escape the fact that the resulting book is an enormously entertaining read.

Birdwatchers, the converted, will enjoy the book. They may know many of the people mentioned, have been to the places described, or would like to visit them, and experienced many of the birds mentioned.

However, the book is clearly written for the general reader rather than the keen birder - they are, after all, a much larger market. The initial Birding-Aus postings of 2002 were written for an audience that understood what he was doing, while the book seeks to explain why anybody would have such a passion. I believe the book achieves this aim admirably.

My recommendation? Buy the book by all means. Dooley definitely needs the royalties now that he has squandered the family fortune. If you are a serious birder however, go back to the postings in the Birding-Aus archives. It is there that you will find the raw passion, the determination to succeed, the despondency that comes with dips, and the unalloyed pleasure of finding that long-sought-for species.

Congratulations Sean on producing such an enjoyable book.

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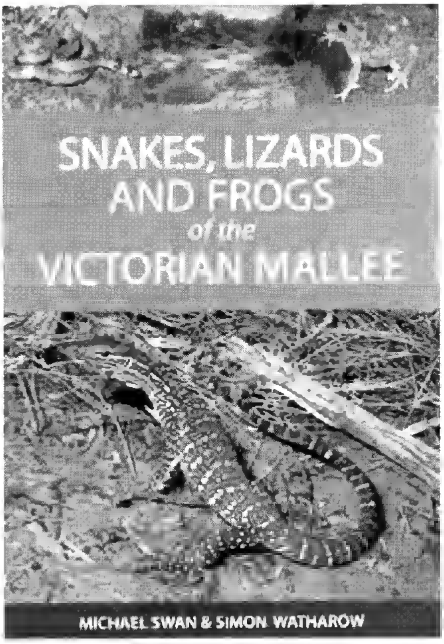
Snakes, Lizards and Frogs of the Victorian Mallee

by Michael Swan and
Simon Watharow
(illustrations by Rachael Hammond)

Publisher: *CSIRO Publishing, 2005.*
91 pages, paperback;
ISBN 0643091343. RRP $29.95



Most of us are probably aware that the Victorian Mallee is endowed with an abundance of reptiles. Those of us lucky enough to venture into this area at the right time of year have probably seen a Bearded Dragon basking on a fencepost, a Stumpy-tailed Lizard strolling across a track or a Brown Snake melting into the undergrowth. We are perhaps less aware that three species of frogs occur in true Mallee habitat (spending much of their lives aestivating underground), and several others occur in aquatic habitats that penetrate or delimit this region. The sheer diversity of reptiles and frogs in the Mallee make it a rewarding destination for herpetologists, and an interesting diversion for those who might be enjoying the springtime wildflowers. These animals are showcased in a new fieldguide, *Snakes, Lizards and Frogs of the Victorian Mallee*.

The book commences with a foreword by John Coventry, Emeritus Curator of Herpetology, Museum Victoria, and a person with a long association with the herpetofauna of the Mallee. John provides a neat summary of the reason for the herpetological diversity of the Victorian Mallee – it is a transitional zone between the mesic Bassian zoogeographic region of south-eastern Australia and xeric Eyrean zoogeographic region. This means that the fauna of the Mallee has representatives from both zoogeographic regions, and is further enriched by the intrusion of the Murray-Darling river system, which delivers some species from the Torresian zoogeographic region. The result of this confluence of faunas is the wonderful herpetological richness of the Mallee.

Coventry's foreword also touches on something that is self-evident in these kinds of books – they arise from the incredible passion and dedication of their authors. Both Swan and Watharow have a fondness that borders on obsession for the Mallee, and particularly for its reptiles and frogs. For many years they have undertaken self-funded expeditions to survey, research, photograph and generally enjoy these animals.

Of course a book such as this requires input from people other than the authors, and two contributions are worthy of particular mention. Peter Robertson (another veteran Mallee herpetofauna researcher) provides numerous spectacular photographs. His images of snakes, which are notoriously difficult photography subjects, are especially noteworthy. Peter's photographs are complemented by lovely images from others, including both authors. A stand-out feature of this book is the illustrations by Rachael Hammond. Technical diagrams of reptiles are not easy to do well (imagine drawing the tiny scales on the underside of a gecko's foot!). However, Hammond's artwork is impressive, and adds immense value to the book.

Following an introduction to the region that includes a history of the area, threats to Mallee habitats, and a description of the major reserves, the book is divided into the eight families of reptiles and frogs that occur in Victorian Mallee habitats. An introduction to each family is followed by detailed species accounts that include a description of their habitat and diet, reproductive information and conservation status. A regional distribution map and the means to differentiate between species accompany this information. This differentiation is made possible by use of a species-specific diagnostic table. The authors have deliberately steered clear of dichotomous keys, which can be difficult for the novice to use effectively.

An interesting dilemma for the authors was how to deal with the numerous species that occur in the Mallee area, but do not generally occur in true Mallee habitats. This is dealt with in the final major section of the book, titled 'Victorian Mallee fringe-dwellers'. This section provides a photograph and brief description of animals such as Broad-shelled Turtles, Tiger Snakes, Tree Goannas and Growling Grass Frogs, species whose distributions extend into the region, often in association with rivers, but which rarely occur in true Mallee habitats.

I am a fan of regional field guides. The larger (and more expensive) national field guides to Australia's reptiles and frogs contain so many species that trying to single out the nondescript skink you spy beside the trail can be a daunting, and often unsuccessful, exercise. By virtue of considering a limited geographic area, regional guides consider a much smaller number of species, and need to consider far less diagnostic features. They also generally cost less, and are of a more convenient size for carrying in the field.

I believe that no fieldguide concerned with Australian reptiles is adequate unless it provides information on modern snakebite First Aid. Swan and Watharow include this information, but go one step better. They provide a section on dealing with snakes around the home, reflecting the wisdom gained by Watharow during the countless snake removals he has conducted over the years. Other useful inclusions are a glossary and relevant reference list.

This is an attractive book with few faults that will appeal to herpetologists and anyone wanting to enrich their natural history experience when enjoying this beautiful part of Victoria.

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Guidelines for Authors – *The Victorian Naturalist*

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Authors may submit material in the form of research reports, contributions, naturalist notes, letters to the editor and book reviews. A ***Research Report*** is a succinct and original scientific paper written in the traditional format including abstract, introduction, methods, results and discussion. A ***Contribution*** may consist of reports, comments, observations, survey results, bibliographies or other material relating to natural history. The scope of a contribution is broad and little defined to encourage material on a wide range of topics and in a range of styles. This allows inclusion of material that makes a contribution to our knowledge of natural history but for which the traditional format of scientific papers is not appropriate. Research reports and contributions must be accompanied by an abstract of not more than 200 words. The ***abstract*** should state the scope of the work, give the principal findings and be complete enough for use by abstracting services. Research reports and contributions will be refereed by external referees. ***Naturalist Notes*** are generally short, personal accounts of observations made in the field by anyone with an interest in natural history. These may also include reports on excursions and talks, where appropriate, or comment on matters relating to natural history. ***Letters to the Editor*** must be no longer than 500 words. ***Book Reviews*** are usually commissioned, but the editors also welcome enquiries from potential reviewers.

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Authors are advised to note the layout of headings, tables and illustrations as given in recent issues of the Journal. **Single spaces** are used after full stops, and **single quotation marks** are used throughout.

In all papers, at the first reference to a species, please use both the common name and binomial. However, where many species are mentioned, a list (an appendix at the end), with both common and binomial names, may be preferred. Lists must be in taxonomic order using the order in which they appear in the references recommended below.

The journal uses capitalised common names for species, followed by the binomial in italics without brackets, e.g. Kangaroo Grass *Themeda triandra*.

References

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Lunney D (1995) Bush Rat. In *The Mammals of Australia*, pp 651-653. Ed R Strahan. (Australian Museum/Reed New Holland: Sydney)

Phillips A and Watson R (1991) *Xanthorrhoea*: consequences of 'horticultural fashion'. *The Victorian Naturalist* **108**, 130-133.

Smith AB (1995) Flowering plants in north-eastern Victoria. (Unpublished PhD thesis, University of Melbourne)

Wolf L and Chippendale GM (1981) The natural distribution of *Eucalyptus* in Australia. Australian National Parks and Wildlife Service, Special Publications No 6, Canberra.

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Mammals: Menkhorst PW (ed) (1995) *Mammals of Victoria: Distribution, Ecology and Conservation.* (Oxford University Press: South Melbourne)

Reptiles and Amphibians: Cogger H (2000) *Reptiles and Amphibians of Australia*, 6 ed. (Reed Books: Chatswood, NSW)

Insects: CSIRO (1991) *The Insects of Australia: a textbook for students and research workers.* Vol I and II. (Melbourne University Press: Melbourne)

Birds: Christidis L and Boles W (1994) *The Taxonomy and Species of Birds of Australia and its Territories.* Royal Australian Ornithologists Union Monograph 2. (RAOU: Melbourne)

Plants: Ross JH (ed) (2000) *A Census of the Vascular Plants of Victoria*. 6 ed. (Royal Botanic Gardens of Victoria: Melbourne)

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From the Editors

There are many interesting articles in this issue. The Naturalist Note on survival of a blind Bobuck with back-young (see page 112) is one of two articles on Bobucks, an ever popular topic. The colour photograph on the front page clearly depicts the blindness of the mother Bobuck. It is hoped that all issues for 2006 can be published in colour. If you would like to make a donation towards the extra cost involved, please contact the Editors.

Another paper originates from a talk given at the symposium held in May 2005, to celebrate the 125th anniversary of the FNCV. In this paper Doug McCann outlines the origins of the FNCV, the geological activities in the early days of the FNCV and the current state of the Geology Group of the FNCV. He also provides details about a number of notable geological contributors to the FNCV, past and present. (Part 2 of 'Victoria's living Natural Capital - decline and replenisment 1800 - 2050' by Ian Mansergh, Heather Anderson and Nevil Amos also originates from the symposium and will be published in a future edition.)

Attentive readers of *The Victorian Naturalist* may notice that the format for presenting author details has changed, in line with other scientific journals.

Finally, make sure to look at the back cover where there is a photograph of the magnificent Inland Carpet Python *Morelia spilota metcalfei*. See page 68 for the accompanying article.

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Front cover: Blind female Bobuck with back-young, active by day in the Strathbogie Ranges, Victoria. Photo by SM Martin. See article on p. 115.
Back cover: Inland Carpet Python *Morelia spilota metcalfei*. Photo by Geoffrey Heard. See article on p. 68.

Canid predation: a potentially significant threat to relic populations of the Inland Carpet Python *Morelia spilota metcalfei* (Pythonidae) in Victoria

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Abstract

In Victoria's contemporary rural environments, introduced predators may represent the principal predatory threat to many large, non-venomous reptile species. We present circumstantial evidence that introduced canids are predators of the Inland Carpet Python *Morelia spilota metcalfei*, using data collected during a radio-telemetric study of the sub-species' ecology across northern Victoria. Seven pythons (23% of those tracked) were killed by predators during the study, and evidence collected during transmitter retrieval suggested that foxes or wild dogs were involved in six of these cases (the seventh having been eaten by a goanna). Evidence includes the recovery of transmitters from fox den sites, their partial burial in several cases (consistent with caching behaviour) and damage to each transmitter consistent with chewing by a fox or dog (teeth marks in the silicon coating, puncture of the metal housing). Given the abundance of canids (specifically foxes) within these study sites, their ability to prey on carpet pythons, and evidence of their involvement with these predation events, we conclude that canid predation was the primary cause of death for each of these six snakes, and represents a potentially significant issue for carpet python conservation in Victoria. Suggestions for canid control programs and habitat management to minimise this threat to remaining populations of this endangered snake are offered. (*The Victorian Naturalist* **123** (2) 2006, 68-74)

Introduction

The Inland Carpet Python *Morelia spilota metcalfei* (Pythonidae) is a large (to 3 m total length), semi-arboreal snake that is distributed widely across the Murray Darling Basin of south-eastern Australia (Barker and Barker 1994; Greer 1997). In Victoria, the sub-species is considered endangered (DSE 2003) and restricted to the woodland habitats of the northern plains, primarily those associated with watercourses (River Red Gum *Eucalyptus camaldulensis* or Black Box *E. largiflorens* woodland) or prominent granite outcrops (Coventry and Robertson 1991; Allen *et al.* 2003). Apparent declines in the sub-species' Victorian range have been attributed primarily to habitat alterations; however, predation by introduced mammals has also been cited as a potentially threatening process (Allen *et al.* 2003). This snake may be particularly vulnerable to exotic predators; it is relatively slow moving, non-venomous, and inhabits inland regions of southern Australia where introduced predators can be abundant and ubiquitous across habitats (Newsome *et al.* 1997).

In this paper, we present circumstantial evidence that these pythons are vulnerable to predation by introduced canids (primarily the Red Fox *Vulpes vulpes* but potentially also Wild Dogs *Canis familiaris*). Specifically, we detail evidence that canids killed the majority of carpet pythons lost to predation during a radio-telemetric study of the sub-species' ecology conducted across Victoria's northern plains between 1997 and 2002.

Methods

Study areas

Pythons were radio-tracked in nine study areas, spanning three regions of northern Victoria (Fig. 1). In the north-east, 17 snakes were tracked in three study sites

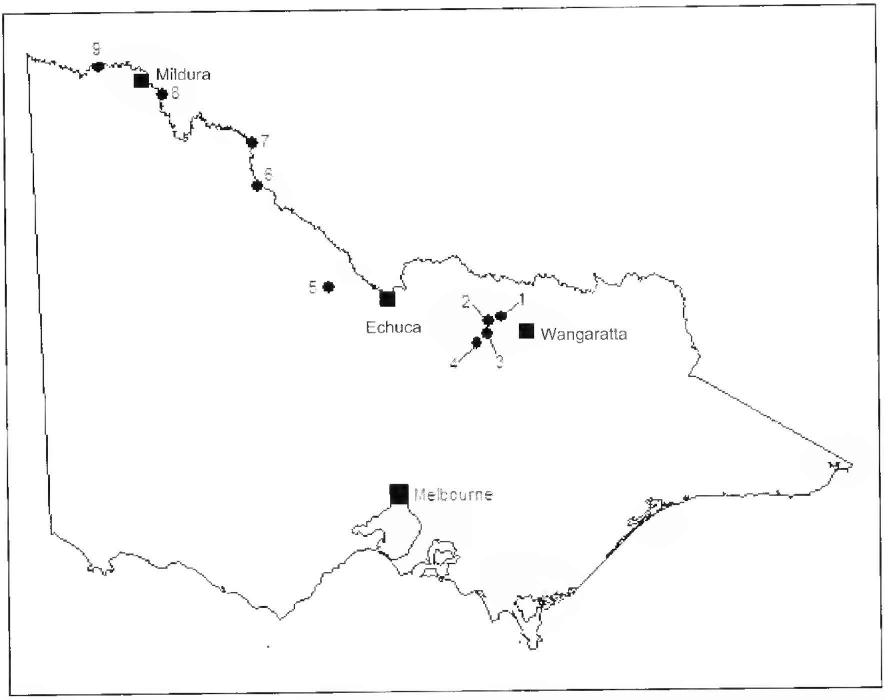

Fig. 1. The location of each study area in which carpet pythons were radio-tracked across northern Victoria. Study areas are: 1 - Mt Killawarra, 2 - Boweya, 3 - Mt Bruno, 4 - Mt Meg Flora and Fauna Reserve, 5 - Mt Hope Flora and Fauna Reserve, 6 - Nyah State Forest, 7 - Piambie State Forest, 8 - Lambert Island, 9 Walpolla Island State Forest..

either within, or adjacent to, the Warby Range State Park, including Mt Killawarra (36°15'N, 146°11'E), Mt Bruno (36°19'N, 146°09'E) and Boweya (36°17'N, 146°09'E). An additional study site, the Mt Meg Flora and Fauna Reserve (36°22'N, 146°05'E), is located in the Chesney Vale Hills, 22 km WSW of the Warby Range. All areas within the north-east are characterised by steep, rocky slopes (weathered granite outcrops and screes) with open granitic woodland or low heathland. At all locations, remnant vegetation abuts cleared agricultural land, with the extent of fragmentation being highest at Mt Meg, where a mosaic of remnant vegetation occurs (Heard and Black 2003; Heard *et al.* 2004).

Five pythons were radio-tracked within the Mt Hope Flora and Fauna Reserve (35°59'N, 144°13'E) in north-central Victoria. Mt Hope is a prominent granite massif that rises steeply from the surrounding plains, most of which have been cleared for agriculture. The reserve supports a shrub-land vegetation community dominated by Deane's Wattle *Acacia deanei paucijuga* (Conn 1993; Parks Victoria 2000).

Eight pythons were radio-tracked within the Riverine forests of north-western Victoria. From east to west, snakes were tracked at Nyah State Forest (35°05'N, 143°20'E), Piambie State Forest (34°52'N, 143°20'E), Lambert Island (34°21'N, 142°22'E) and Walpolla Island State Forest (34°07'N, 141°42'E). All sites were located on the floodplain of the Murray River. Vegetation composition varied little between the three localities, being dominated by River Red Gum and Black Box. Disturbance from cattle grazing, timber extraction and recreational activities are common to all localities.

Study animals and radio-telemetric monitoring

Temperature-sensitive, miniature radio transmitters (Holohil Systems Pty Ltd, Canada; Model SI-2T) were surgically implanted within the body cavity of snakes under aseptic conditions. A description of implantation techniques is provided in Heard *et al.* (2004). Units represented less than 2% of python body weight in all cases. We endeavoured to locate each python weekly (usually in the morning to early afternoon). However, logistical constraints occasionally resulted in this interval being reduced or extended between 2 and 21 days. A directional 'H' antenna and miniature radio receiver (Telonics Inc., Arizona) were used to track the signal of radio transmitters, and co-ordinates of each location were recorded in the Universal Transverse Mercator (UTM) system using a Trimble global positioning system (Trimble 10 channel Ensign XL GPS Unit).

Upon the death of a python, notes were maintained on the location of the carcass or transmitter, and descriptions of the surrounding habitat and specific collection site recorded. The identity of any predator involved was assessed by damage to transmitters (including teeth marks), collection site characteristics and the presence of scats or footprints.

Results

Seven carpet pythons (23% of those tracked) were killed during the study, five in the north-east and one each at Mt Hope and within the riverine forests of the north-west (Table 1). One of these animals 'NE11' apparently fell victim to a Lace Monitor *Varanus varius*; the transmitter was located within a tree-hollow some four metres above ground amongst numerous goanna scats. However, evidence collected during transmitter retrieval suggests that canids killed the remaining six pythons.

Two animals were killed in remnant woodland at Mt Meg. The first, 'NE13', died within 16 days of release. Prior to death, this animal was recorded sheltering in a hollow log amongst intact remnant woodland on the north face of Mt Meg. The heavily chewed transmitter from this snake was located within a fox den in dense shrubbery amongst the remains of other prey items, including rabbits and a possum. The second individual, 'NE12', died within two months of release. This snake was last recorded inhabiting remnant woodland on the south-eastern boundary of the Mt Meg Flora and Fauna Reserve, sheltering within a rock crevice. Its transmitter was subsequently located within an open paddock east of this site, partially buried in the soil, with numerous teeth marks in the unit's silicone coating.

The remaining two snakes lost in the north-east were both apparently killed within the vicinity of residential buildings. At Mt Meg, 'NE16' was last recorded inhabiting a roof cavity within a series of buildings in the south of the study site. The snake had occupied these buildings during all locations in the two months following her re-release, and thus appeared to have been taken during her first movement away from the buildings during the tracking period. Her transmitter was subsequently located lying on the ground in an open paddock east of this site. The unit had been bitten repeatedly, exposing its metal casing. At Mt Bruno, an immature female 'NE15' was killed after residing for several months in the vicinity of a residential building located in remnant woodland. This snake was also last found inhabiting a roof cavity. Its transmitter was retrieved from a wooded slope overlooking the property; it had been chewed and partially buried.

One python was killed at each of the Mt Hope and Piambie study sites (Table 1). At Mt Hope, the dismembered remains and transmitter of the large, adult female 'NW31' were found at the entrance to a rock crevice on 4 May 1999. The snake had been recorded within this rock crevice during the previous two tracking events (25 March, 14 April 1999), and had frequented the site during the months preceding death. This snake had been tracked for 565 days in total. Lastly, the Piambie animal 'NW01' was apparently killed whilst inhabiting a large, relatively open hollow log in River Red Gum woodland. The partially chewed transmitter (numerous teeth marks were evident in the silicone coating) from this snake was located approximately 50 m from this log, beneath loose woody debris. Closer inspection of the hollow log revealed numerous bird feathers and other vertebrate remains at its entrance, suggesting that a canid (probably a fox) regularly used the log. The python was an adult female and died within three weeks of release.

Table 1. Gender, morphometric data and tracking details for each python killed during the radio-telemetric study. Snout-vent length (SVL) and weight recorded upon capture. * first located in tree hollow from which transmitter was retrieved on 29 March 1998. ** first located at site from which transmitter was retrieved on 14 March 1997.

Scale-clip number	Study area	Sex	SVL (mm)	Weight (g)	Tracking period	Days tracked
NE11	Mt Meg	F	1750	3300	18/11/97 - 12/3/99	132*
NE12	Mt Meg	M	1460	1100	18/11/97 - 15/1/98	59
NE13	Mt Meg	M	1600	1450	15/11/97 - 3/12/97	19
NE16	Mt Meg	F	1530	1350	22/11/97 - 22/1/98	61
NE15	Mt Bruno	F	890	207	10/10/97 - 20/3/98	59
NW31	Mt Hope	F	1770	3068	16/10/97 - 4/5/99	565
NW01	Piambie	F	1640	1475	20/2/97 - ?	18**

Discussion

Predation of carpet pythons by canids is of significant concern for the conservation of this endangered snake in Victoria. Records collected during the telemetry study indicate that either foxes or dogs killed the majority (86%) of radio-tracked carpet pythons lost to predators. Whilst our data do not definitively prove this contention (or differentiate between fox or dog predation), we use several pieces of evidence to argue that canid predation is the most likely cause of death of these animals, and that conservation initiatives that minimise the sub-species' exposure to introduced predators should be pursued.

Firstly, additional evidence that canids prey upon carpet pythons is available. Shine and Fitzgerald (1996) documented seven instances of fox predation among a group of ten Coastal Carpet Pythons *M. s. mcdowelli* that died whilst being radio-tracked in north-eastern New South Wales (70% of mortality records, 37% of all snakes radio-tracked). Each of the seven retrieved transmitters displayed bite-marks characteristic of a canid, and the authors concluded that foxes were involved in each case. Similar evidence was gathered during the present study. Six of the seven transmitters were retrieved from the ground surface, in relatively open localities (one within a fox den) and either displayed numerous bite marks or had been thoroughly chewed (the exception in each case being the transmitter of 'NE11', which was evidently eaten by a goanna). Three of the transmitters were also partially buried. Foxes and dogs regularly cache food items (Saunders *et al.* 1999; Fleming *et al.* 2001), and the partial burial of these transmitters appears to be an example of this behaviour. Dietary studies have also identified carpet python remains in canid scats. Canid dietary analysis conducted at the Mt Meg study area identified python vertebrae in one of the scats examined (Heard 2001), and similar research has documented the occurrence of python remains in canid scats collected in south-eastern New South Wales (those of the Diamond Python *M. s. spilota*; Lunney *et al.* 1990).

Secondly, canids are the most abundant introduced predators present at these study sites (and possibly most abundant large predators in general), with foxes being particularly abundant. In north-eastern Victoria, where the majority of predation events occurred, foxes are the most commonly detected mammalian predator during regular spotlight surveys and scat sampling within and surrounding the Warby Range State Park (G. Barrow unpubl. data). Analysis of canid scats collected at Mt Meg during the summer of 2000 - 2001 revealed that 87% were deposited by foxes and 13% by dogs (Heard 2001). With the exception of one record of a feral cat, all tracks recorded on baited sand-pads during this period were those of foxes (Heard 2001).

Nonetheless, in the absence of observations of canids actually catching and killing carpet pythons, alternative explanations cannot be discounted. For example, it is possible that they merely consumed the remains of these snakes after some other event caused their death. Death through collision with vehicles is possible for example; however, python home-range rarely overlapped with roads in our study areas, and therefore death from such events seems improbable. Similarly, death resulting from illness is questionable given that all the pythons that died during our study were sequestered in shelter sites during their last re-location. We assume that these snakes would remain secluded within these shelters during any illness (as they generally do when shedding their skin) and therefore be inaccessible to canids. Shelter sites selected by these pythons generally provide excellent refuge from predators (the exception in this study being the log inhabited by 'NW01' prior to death, which had a relatively wide hollow and was evidently used by a fox).

It may also be the case that the fate of these animals was either unnatural due to behavioural changes resulting from transmitter implantation, or misinterpreted due to a failure in the telemetry technique. In the first instance, it may be argued that the death of several snakes within months of release ('NE12', 'NE13', 'NE15', 'NE16', 'NW01') was the result of transmitter implantation increasing their susceptibility to predation. For example, transmitter implantation may have increased the snakes' time spent basking (to maintain higher body temperatures, as has been observed when ingestible transmitters are used in snake telemetry projects; Lutterschmidt and Reinert 1990) or moving (due to the stress of captivity and surgery, or disturbance of their normal activity patterns). We cannot discount such behavioural shifts and associated increases in predator exposure. However, considering that these snakes displayed similar behavioural patterns to the other 23 pythons monitored, and one of the snakes killed had been tracked for several years prior to death, a consistent effect of the radio-tracking technique is not apparent. The techniques used during this study are considered standard for radio-tracking snakes, and have been applied widely in Australia without apparent negative effects on the behaviour, health or survivorship of the study animals in most cases (e.g. Shine 1979; Slip and Shine 1988; Madsen and Shine 1996; Webb and Shine 1997; Fitzgerald *et al.* 2002; Pearson 2002; Butler *et al.* 2005). In the second instance, it is possible that the transmitters of these pythons were chewed following their expulsion from the snake's body. Pearson and Shine (2002) documented 14 cases (of 75 pythons tracked) where radio-transmitters surgically implanted within the peritoneum of South-western Carpet Pythons *M. s. imbricata* were subsequently expelled through the alimentary tract, most being deposited within faecal pellets (71%). They subsequently cautioned against the conclusion that an implanted animal had been lost to predation if its transmitter alone was relocated (even if it had been chewed, as this may have occurred after expulsion), and advocated that inference of a radio-tracked snake's death due to predation be made only if the carcass was located. We agree that such evidence is required for unequivocal conclusions on the fate of tracked animals, but found no evidence of transmitter expulsion during this study. Also, considering that these pythons spent the major part of their time in secluded microhabitats (e.g. rock crevices, tree hollows; Heard *et al.* 2004) (and often defecated there) it seems improbable that expelled transmitters would be accessible to scavenging canids. The discovery of the dismembered remains of 'NW31' and the occurrence of non-fatal injuries consistent with canid attack on other pythons captured during the project (G.Barrow, P. Robertson pers. obs.), suggest that attacks do occur and are the most plausible explanation for the apparent predation events detailed here.

Given our conclusion that canid predation was the primary cause of death for 20% of carpet pythons radio-tracked during this study (and is potentially representative of predation rates in the population as a whole), the effect of canid predation on python population viability must be considered. Small wildlife populations with naturally low birth rates are particularly sensitive to environmental perturbations such as increases in predation levels, as mortality rates can easily exceed recruitment rates and plunge these populations into decline (Primack 2004). Victorian populations of carpet pythons have probably always displayed relatively low densities and reproductive rates as they inhabit a temperate environment that allows a relatively short active period; a circumstance in which snakes find it difficult to accumulate the energy stores needed for annual reproduction; Shine 1991). Thus, the sub-species is predisposed to be sensitive to increased predation rates. However, recent reductions in habitat quality through structural simplification, fragmentation and isolation, and concurrent population declines of many of their mammalian prey species (Bennett *et al* 1998) have probably further reduced population sizes and recruitment rates amongst Victorian populations of carpet pythons. Canid predation may subsequently be generating unsustainable mortality rates amongst these populations, and jeopardising their long-term viability.

Measures to reduce the threat of canid predation to remaining Victorian populations of carpet pythons should be pursued. Previous research at Mt Meg suggests that control programs that aim to reduce canid abundance before and during the summer months may be most beneficial. Scat analysis confirms that carpet pythons and foxes prey predominantly on rabbits in this region (P. Robertson, G. Barrow unpubl. data) and habitat use by these species suggests they forage primarily within areas of semi-cleared woodland where rabbits are most abundant. At Mt Meg, pythons frequent these habitats in summer when they disperse widely in search of prey (Heard *et al.* 2004). During this period they select microhabitats in close proximity to rabbit burrows and will also shelter in them at this time (Heard *et al.* 2004). Scat distribution and visitation rates to sand-pads indicate foraging activity by foxes is also centered on rabbit burrows at Mt Meg (Heard 2001). As carpet pythons move frequently during summer (often through open country between habitat patches) and their habitat use during this period overlaps significantly with that of foxes (both in terms of broad habitat associations and microhabitat locations), these snakes are likely to be most vulnerable to fox predation during the warmer months. It is notable that all pythons, except 'NW31', that were apparently killed by predators during this study died during, or late in, the summer activity season of these snakes (December – March).

In combination with control programs, habitat management will be crucial for reducing the susceptibility of carpet pythons to canid predation in Victoria. Vegetation clearing, grazing and timber extraction continue to fragment and degrade the woodland habitats of these pythons across the state's northern plains. Subsequent reductions in habitat continuity and complexity almost certainly expose carpet pythons to higher predation risk. These snakes rely heavily on camouflage and cryptic behaviour to avoid detection by predators; characteristics that are ineffectual when moving through open country (to move between habitat remnants) or structurally simplified habitats. Shine and Fitzgerald (1996) suspected that carpet pythons in their telemetry group were captured by foxes whilst moving through open habitats (orchards) within a study area in north-eastern New South Wales. Data collected during the present study are insufficient to describe the habitats or microhabitats in which pythons were killed (with the exception of 'NW31', the remains of which were located outside the rock-crevice previously occupied by the snake). However, it is apparent that most were killed during excursions from sheltered microhabitats. Two habitat management actions are appropriate: (i) maintaining and expanding connectivity between habitat remnants (through habitat acquisition and revegetation) to reduce the snake's need to cross cleared land when moving between habitat remnants; and (ii) preservation of ground cover such as woody debris, fallen timber and ground and shrub-layer vegetation within habitat remnants (through the elimination of grazing and timber extraction) to increase the snake's ability to avoid predators during daily thermoregulatory, foraging and movement activities.

We conclude by proposing that management actions which reduce canid populations (particularly foxes) within and surrounding python habitat during the warmer months, increase the continuity of the subspecies's woodland habitats, and enhance the structural complexity of these habitats are requisite components of conservation programs for this endangered snake throughout northern Victoria.

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The flora of Highbury Park, Burwood East, Victoria

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Abstract

The vegetation that once covered Melbourne's eastern suburbs has largely been removed, leaving only tiny remnant fragments, most of which are modified by weeds. This report is a descriptive account of the vascular flora of a small but relatively high-quality site in East Burwood. Basic floristic information is recorded, along with a brief discussion of the variation in vegetation patterns in the immediate area. Such descriptive accounts may be useful in future restoration projects. Several taxa of particular note are discussed, including the locally uncommon Shiny Wallaby-grass *Austrodanthonia induta*, a double-flowered form of Golden Weather-glass *Hypoxis hygrometrica*, and several putative hybrids. A full species list is provided. (*The Victorian Naturalist*, **123** (2), 2006, 75-83)

Highbury Park and its surroundings

Highbury Park is a reserve in Burwood East managed by the City of Whitehorse. It contains a small area (1 ha) of remnant bushland. The surrounding area is urbanised, and, apart from a few remnant trees between nearby houses, this bushland has existed as an isolated fragment for over fifty years (A McPhee, pers. comm.). The park is located on a broad, flat ridge dividing Dandenong Ck from Gardiners Ck and Scotchmans Ck. The soil is typical of Melbourne's outer eastern suburbs, being a clay-loam derived from marine sediments of Silurian origin. It closely resembles the 'Hallam Loam' described previously by Holmes *et al.* (1940), the surface being a grey loam with occasional ironstone fragments overlying a yellowish-grey clay.

In most urban bushland remnants, ecological diversity, pattern and function have been altered because of severe weed invasion and activities such as heavy mulching and planting (McLoughlin, 1997). Highbury Park has escaped severe weed invasion, has never been heavily mulched, and only a few plants have been deliberately introduced. Consequently, it retains a relatively high diversity of understorey plants resulting from natural and continuing recruitment. Given the ongoing interest in revegetation in urban areas, the descriptive information provided here may be of some practical value in future local restoration projects. This information complements a few other reports detailing the native vegetation of the area, most notably the paper by Salkin (1993) which documented, in detail, most areas of remnant bushland in the adjacent Waverley area.

The vegetation of Highbury Park and surrounding areas in an historical and regional context

The vegetation in Highbury Park is best classified as 'Valley Heathy Forest' (Ecological Vegetation Class (EVC) 127), as described by Oates and Taranto (2001) (Fig. 1). This EVC has largely been cleared locally (Frood, 1999), and is listed by the Victorian Department of Sustainability and Environment (DSE unpubl.) as endangered in all bioregions where it occurs except the East Gippsland Uplands (where it is vulnerable). Despite being the once-dominant vegetation over much of eastern Melbourne, relatively little easily accessible information exists on Valley Heathy Forest.

Like most vegetation units, Valley Heathy Forest encompasses considerable spatial and temporal variation. It supports a lower storey rich in both small shrubs and graminoid plants (grasses, sedges, lilies, orchids). The balance between a 'shrubby' or a 'grassy' appearance can be altered by management. In the case of Highbury Park, there is evidence that the vegetation has changed, but this record is difficult to interpret. In 1853, Bellairs noted on his survey map that the elevated

Fig. 1 Native vegetation in Highbury Park

plateau supporting Highbury Park was covered by 'heath and stunted stringy-barks' (This comment is placed just south of Highbury Rd). The area would have been subject to timber cutting, grazing and maybe a change in fire regime over the 18 years between settlement and Bellairs' description. It is difficult to know whether the 'heath' was a long-standing natural feature of this area, or a then-recent response to European settlement (e.g. it may have been an 'invasion' of *Leptospermum continentale* or *Kunzea ericoides*). It is also important to note that the term 'heathy' may be used broadly to refer to 'shrubs', or more narrowly to describe certain shrubs characteristic of sandy, infertile soils. Although small shrubs are diverse and common in Valley Heathy Forest generally, species characteristic of low fertility 'heathy' vegetation in southern Australia are scarce. For example, the only abundant members of Epacridaceae are Common Heath *Epacris impressa* and Honey-pots *Acrotriche serrulata*. The main shrubby elements are instead Common Flat Pea *Platylobium obtusangulum*, Prickly Tea tree *Leptospermum continentale* and several small wattles *Acacia* spp. Presently, the vegetation at Highbury Park is very grassy, with shrubs of any kind being relatively sparse. The present 'grassy' appearance probably results from the very long absence (more than 50 years) of fire (the last substantial fire in the area was on Scotchman's Creek between Springvale Rd and Blackburn Rd in 1954-55 [A McPhee pers. comm.]), leading to reduced recruitment in some shrub species, and local extinction of some shrubs caused by previous mowing/slashing before the reserve was fenced in the early 1990s. Whatever the history of the vegetation, it is probably most sensible to view the 'natural' state of the vegetation as one of tension/balance between an understorey dominated by grassy or shrubby species, largely determined by disturbance history.

Floristic variation between different areas of Valley Heathy Forest has been acknowledged and partially addressed in several previous publications (Frood, 1999; Oates and Taranto, 2001). Frood (1999) provided a provisional division of Valley Heathy Forest into 6 variants, where Highbury Park represents 'Variant 2 (plateau)', and closely resembles variants 3 and 4. Although the surrounding area is urbanised, traces of local variation can still be discerned. For example, among the remnant trees scattered in and around the Park on the higher plateau area, Yellow Box *Eucalyptus melliodora* is completely lacking. In adjacent urban areas, however, remnant Yellow Box trees are conspicuous. The local absence of Yellow Box trees, which tend to be well formed, may well have contributed to the 'stunted' appearance noted by Bellairs (1853).

The spatial and temporal variation noted can cause Valley Heathy Forest to closely resemble several other EVCs, including Valley Grassy Forest (EVC 47) and Lowland Forest (EVC 16) and to a lesser extent Grassy Woodland (EVC 175) (Oates and Taranto, 2001). The occurrence, noted below, of Eastern Globe-pea *Sphaerolobium minus*, along with the dominance of (comparatively) 'stunted' Mealy Stringybarks in this area (Bellairs, 1853), also suggests a local resemblance to Damp Heathy Woodland (EVC 793), and is consistent with Bellair's (1853) description of the area as notably 'heathy'.

The vascular flora of Highbury Park

In addition to these broader vegetation patterns, there is small-scale variation within the reserve. In the tree layer, Messmate *Eucalyptus obliqua* dominates the southern half of the reserve, but is largely absent from the north. Narrow-leaved Peppermint *Eucalyptus radiata* is common in the north, but largely absent from the south, while Mealy Stringybark *Eucalyptus cephalocarpa* is spread throughout the reserve. In the understorey, the western third of the reserve is heavily dominated by Veined Spear-grass *Austrostipa rudis* subsp. *rudis*. Other areas are dominated by Weeping Grass *Microlaena stipoides* (particularly around trees and in disturbed areas), Soft Tussock-grass *Poa morrisii* and Kangaroo Grass *Themeda triandra*. A few poorly-drained areas differ in supporting moisture-loving plants such as Common Love-grass *Eragrostis brownii* and Small Loosestrife *Lythrum hyssopifolia*.

In comparison with many nearby reserves, the flora is rich, particularly in the graminoid layer where 23 indigenous grass taxa occur alongside 23 other indigenous monocots. There are also notable absences. Several species which are common in comparable sites (eg, Glen Waverley railway cutting, Blackburn Lake Sanctuary, Charles St Reserve Mt Waverley, Antonio Park Mitcham, Bateman's St Wantirna) are absent. These are mostly small shrub-like plants, including Common Heath *Epacris impressa*, Common Correa *Correa reflexa*, Bitter-peas *Daviesia* spp., Common Hovea *Hovea heterophylla* and Grass Trigger-plant *Stylidium graminifolium*. These absences highlight the shift, noted above, that is possible to a conspicuously 'grassy' formation when Valley Heathy Forest is mown or slashed too frequently.

Table 1 lists the vascular plant species recorded in Highbury Park. Two previous unpublished lists were consulted. In 1990, Nyssen surveyed the area, and correctly recommended that it had potential to regenerate if fenced and protected from human traffic and mowing. Also in 1990, Lorimer provided a species list to the Council. Both of these note relatively few species because of the lack of regeneration then apparent, and the fact that they were compiled as summaries for the council in a limited timeframe. All of the species recorded on these lists remain, with the exception of Running Postman *Kennedia prostrata* (Lorimer, 1990) which may still exist as soil-stored seed, and Slender Rice-flower *Pimelea linifolia* (Nyssen, 1990) which may be a misidentification of Common Rice-flower *Pimelea humilis*.

Notable Plant Taxa

Several taxa are worthy of specific comment:

***Shiny Wallaby-grass* Austrodanthonia induta**

This grass is uncommon in the greater Melbourne area (Australian Plants Society, 2001). It is a spectacular grass, with culms in Highbury Park sometimes standing >85 cm high. In the Park, it is represented by about 20 tussocks. It also occurs nearby in Wattle Park (G. Lorimer, pers. comm.), at Cranbourne (Australian Plants Society, 2001), and commonly in Grassy Woodland

Table 1. Vascular plant species recorded in Highbury Park and Highvale Rd.. Cover values are given for species at Highbury Park, according to Gullan (1978). Species marked with a dash as a cover value are apparently extinct in Highbury Park. Germinants have been identified at Highbury Park for species marked #. *Austrodanthonia* species germinate regularly; however, their specific identity is difficult to determine until flowering, and this genus has not been assessed for germination. Several indigenous species have probably been (re-) introduced or planted at Highbury Park (e.g. Yellow Box). These are marked with a 'p'. Naturalised introduced species are prefixed with an asterisk '*', and are listed after the native species under each family. Obviously planted, non-naturalised species are not listed. This list is entered as FIS quadrat E03402 .

Cyperaceae		
Carex breviculmis	Short-stem Sedge	1#
Carex inversa	Knob Sedge	+#
Gahnia radula	Thatch Saw-sedge	2
Isolepis marginata	Little Club-sedge	+#
Lepidosperma gunnii	A Sword-sedge	1#
Schoenus apogon	Common Bog-rush	1#
**Cyperus tenellus*	Tiny Flat-sedge	+#
Juncaceae		
Juncus bufonius	Toad Rush	+#
Juncus holoschoenus	Joint-leaf Rush	+#
Juncus subsecundus	Finger Rush	+
Juncus ?sarophorus	Broom Rush	+
Juncus pallidus	Pale Rush	+
Luzula meridionalis var. *densiflora*	Common Woodrush	+#
Liliaceae		
Arthropodium strictum	Chocolate Lily	1
Burchardia umbellata	Milkmaids	+
Caesia parviflora var. *parviflora*	Pale Grass-lily	+
Dianella revoluta s.l.	Black-anther Flax-lily	1#
Hypoxis hygrometrica var. *?hygrometrica.*	Golden Weather-glass	+
Hypoxis vaginata var. *vaginata*	Yellow Star	+
Tricoryne elatior	Yellow Rush-lily	1
Wurmbea dioica var. *dioica*	Early Nancy	+
**Muscari armeniacum*	Grape Hyacinth	+
Orchidaceae		
Microtis ?unifolia	Common Onion-orchid	1#
Pterostylis ?pedunculata[1]	Maroonhood	+
Thelymitra pauciflora s.l.	Slender Sun-orchid	+#
Poaceae		
Austrodanthonia caespitosa	Common Wallaby-grass	+
Austrodanthonia laevis	Smooth Wallaby-grass	1
Austrodanthonia fulva	Copper-awned Wallaby-grass	1
Austrodanthonia penicillata	Slender Wallaby-grass	+
Austrodanthonia pilosa	Velvet Wallaby-grass	+
Austrodanthonia induta	Shiny Wallaby-grass	+
Austrodanthonia racemosa var. *racemosa*	Clustered Wallaby-grass	+
Austrodanthonia setacea subsp. *setacea*	Bristly Wallaby-grass	1
Austrodanthonia tenuior	Purplish Wallaby-grass	+
Austrodanthonia hybrid #1	Wallaby-grass	+
Austrodanthonia hybrid #2	Wallaby-grass	+
Austrostipa rudis subsp. *rudis*	Veined Spear-grass	2#
Austrostipa pubinodis	Tall Spear-grass	+
Deyeuxia quadriseta	Reed Bent-grass	+
Elymus scaber var. *scaber*	Common Wheat-grass	+
Eragrostis brownii	Common Love-grass	+
Joycea pallida	Silvertop Wallaby-grass	+
Microlaena stipoides var. *stipoides*	Weeping Grass	4#
Poa ensiformis	Sword Tussock-grass	+
Poa labillardierei var. *labillardierei*	Common Tussock-grass	+
Poa morrisii	Soft Tussock-grass	2#
Poa tenera	Slender Tussock-grass	+

[1] Rosette only, no flowers observed, leaves long-petiolate, rounded.

Table 1 continued

Poaceae continued		
Themeda triandra	Kangaroo Grass	1#
**Agrostis capillaris* s.l.	Brown-top Bent-grass	1
**Anthoxanthum odoratum*	Sweet Vernal-grass	2#
**Aira* sp.	Hair Grass	1#
**Briza maxima*	Large Quaking-grass	2#
**Briza minor*	Small Quaking-grass	+#
**Bromus catharticus*	Prairie Grass	+
**Cynodon dactylon* var. *dactylon*	Couch	1
**Dactylis glomerata*	Cocksfoot	+#
**Danthonia decumbens*	Heath Grass	+
**Ehrharta erecta* var. *erecta*	Panic Veldt-grass	+#
**Festuca rubra*	Red Fescue	+
**Holcus lanatus*	Yorkshire Fog	1
**Poa annua*	Annual Meadow-grass	1#
**Setaria gracilis* var. *pauciseta*	Slender Pigeon-grass	+
**Sporobolus africanus*	Rat-tail Grass	+
**Vulpia bromoides*	Squirrel-tail Fescue	+#
Xanthorrhoeaceae		
Lomandra filiformis subsp. *filliformis*	Pale Matrush	1#
Lomandra fiiformis subsp. *corriacea*	Pale Matrush	1#
Lomandra longifolia supsb. *longifolia*	Spiny-headed Matrush	+#
Xanthorrhea minor subsp. *lutea*	Small Grass-Tree	+
Apiaceae		
Centella cordifolia	Pennywort	1#
Asteraceae		
Cassinia arcuata	Drooping Cassinia	1#
Cassinia longifolia	Common Cassinia	+#
Cotula australis	Common Cotula	1#
Euchiton ?*collinus*	Cudweed	+#
Lagenophora gracilis	Slender Bottle-daisy	+
Leptorhynchos tenuifolius	Wiry Buttons	+
Senecio hispidulus subsp. *hispidulus*	Rough Fireweed	-
Senecio quadridentatus	Cotton Fireweed	+#
Solenogyne gunnii	Hairy Solenogyne	+
Solenogyne dominii	Smooth Solenogyne	+#
**Arctotheca caledula*	Cape Weed	+
**Lactuca serriola*	Prickly Lettuce	+#
**Sonchus oleraceus*	Common Sow-thistle	+#
**Soliva sessilis*	Jo-Jo	+
**Hypochoeris radicata*	Flatweed (Cat's Ear)	1#
Campanulaceae		
Lobelia/Isotoma sp.	Matted Pratia	+
Wahlenbergia sp.	-	+
Caryophyllaceae		
**Cerastium glomeratum*	Common Mouse-ear Chickweed	1#
**Moenchia erecta*	Erect Chickweed	+#
Casuarinaceae		
Allocasuarina littoralis	Black sheoak	+p
Clusiaceae		
Hypericum gramineum	Small St. John's Wort	+
Convolvulaceae		
Dichondra repens	Kidney Weed	+
Crassulaceae		
Crassula decumbens var. *decumbens*	Spreading Crassula	+#
Dilleniaceae		
Hibbertia australis s.s.	Upright Guinea-flower	+#

Table 1 continued

Droseraceae		
Drosera peltata subsp. *auriculata*	Pale Sundew	1
Drosera peltata subsp. *peltata*	Tall Sundew	1
Drosera whittakeri subsp. *aberrans*	Scented Sundew	1
Epacridaceae		
Acrotriche serrulata	Honey Pots	+
Euphorbiaceae		
Poranthera microphylla	Small Poranthera	2#
**Homalanthus populifolius*	Bleeding Heart	+#
Fabaceae		
Bossiaea prostrata	Creeping Bossiaea	1#
Dillwynia cinerascens	Grey Parrot-pea	+#
Hardenbergia violacea	Purple Coral-pea	+#
Indigofera australis	Austral Indigo	+p
Kennedia prostrata	Running Postman	-
Platylobium obtusangulum	Common Flat-pea	2#
Sphaerolobium minus	Eastern Globe-pea	+
**Trifolium dubium.*	Suckling Clover	+#
**Trifolium glomeratum*	Cluster Clover	+
**Ulex europaeus*	Gorse (Furze)	+#
**Vicia sativa*	Common Vetch	+#
Gentianaceae		
**Centaurium erythraea*	Common Centaury	+#
Goodeniaceae		
Goodenia ovata	Hop Goodenia	1#
Haloragaceae		
Gonocarpus tetragynus	Common Raspwort	2#
Loranthaceae		
Amyema pendula subsp. *pendula*	Drooping Mistletoe	+
Lythraceae		
Lythrum hyssopifolia	Small Loose-strife	1#
Mimosaceae		
Acacia dealbata	Silver Wattle	1p
Acacia melanoxylon	Blackwood	2#
Acacia pycnantha	Golden Wattle	+
Acacia myrtifolia	Myrtle Wattle	-
Acacia paradoxa	Hedge Wattle	2#
Acacia verticillata	Prickly Moses	2#
Myrtaceae		
Eucalyptus cephalocarpa	Mealy-leaved Stringybark	2#
Eucalyptus ?cephalocapra x *viminalis*	-	+
Eucalyptus macrorhyncha	Red Stringybark	+
Eucalyptus melliodora	Yellow Box	1p
Eucalyptus obliqua	Messmate	2#
Eucalyptus radiata subsp. *radiata*	Narrow-leaved Peppermint	2#
Eucalyptus viminalis	Manna Gum	+p
Leptospermum continentale	Prickly Tea Tree	1
Oxalidaceae		
Oxalis ?exilis	Wood-sorrel	+
Pittosporaceae		
Billiardieria mutabalis	Common Apple-berry	1#
Bursaria spinosa subsp. spinosa var. *spinosa*	Sweet Bursaria	1#
**Pittosporum undulatum*	Sweet Pittosporum	+#
Plantaginaceae		
**Plantago coronopus* subsp. *coronopus*	Buck's-horn Plantain	+#
**Plantago lanceolata*	Ribwort	1#

Table 1 continued

Polygonaceae		
**Polygonum aviculare* s.l.	Prostrate Knotweed	+#
Primulaceae		
**Anagallis arvensis* var. arvensis	Scarlet Pimpernel	+#
Proteaceae		
*Grevillea robusta	Silky Oak	+#
Rosaceae		
Acaena novae-zelandiae	Bidgee-widgee	+#
Acaena echinata	Sheep's Burr	1#
**Prunus cerasifera*	Cherry Plum	+#
**Rubus anglocandicans*	Blackberry	+#
Rubiaceae		
Opercularia ovata	Broad-leaf Stinkweed	1
?Opercularia ovata x *varia*	-	+
Opercularia varia	Variable Stinkweed	+#
**Coprosma repens*	Mirror Bush	+
Santalaceae		
Exocarpos cupressiformis	Cherry Ballart	+
Scrophulariaceae		
Veronica gracilis	Slender Speedwell	-
Thymelaeceae		
Pimelea humilis	Common Rice-flower	+
?Pimelea linifolia	Slender Rice-flower	-
Violaceae		
Viola hederacea s.s.	Native violet	+#

on the Mornington Peninsula (pers obs.). The taxonomy of this grass is confused, and it is also referred to as *Austrodanthonia procera* (Linder, 1997; Jacobs, 2001; Ross and Walsh, 2003)

Eucalyptus ?cephalocarpa x viminalis

A single tree in Highbury Park resembles *Eucalyptus cephalocarpa*, but is unusual in also having smooth, pinkish-grey ribbony bark on the branches, and slightly finer buds, fruits and leaves which are not markedly waxy. This tree is probably a hybrid involving *E. cephalocarpa* and another species, most likely *E. viminalis* (K. Rule, pers. comm.) which occurs nearby. Similar trees are present in other nearby areas. These have caused some confusion, since they closely resemble 'Scentbarks' (including the species *E. aromaphloia* (Pryor and Willis, 1954), *E. ignorabalis* (Hill and Johnson, 1991) and *E. fulgens* (Rule, 1996)) in many of their adult features. Several previous reports have noted scattered 'Scentbarks' in Melbourne's suburbs (under various specific names). Salkin (1993) notes 'Scentbarks' in Waverley, and Todd and Race (1992) record a specimen from Glen Iris. *The Flora of Melbourne* (Australian Plants Society, 2001) records 'Scentbarks' in Wantirna, Diamond Creek, Wattle Park and Belgrave South, while Yugovic *et al.* (1990) mention similar trees as occurring in the Koonung-Mullum valleys. Seedlings germinated from the tree in Highbury Park did not resemble Scentbark seedlings (having waxy, opposite leaves for many pairs, of slightly variable proportions), prompting the hybrid explanation noted above. Yugovic *et al.* (1990) also suggest that the trees identified tentatively as '*Eucalyptus ?aromaphloia*' arose from a similar hybridisation event. Such hybridisation may account for many (or all) of the scattered 'Scentbarks' reported in Melbourne's eastern suburbs.

Hypoxis ***species***

Highbury Park contains two *Hypoxis* species, both of which are uncommon in inner-suburban Melbourne. *Hypoxis hygrometrica* is of particular interest. The plants occurring in Highbury Park (like many populations) are difficult to place within a recognised variety, having the arrow-shaped anthers of var. *hygrometrica*, and the hairy sepals of var. *villosisepala*.

Interestingly, some plants in Highbury Park are also 'double flowered', with up to six (rather than the usual 3) petals. The extra petals develop at the expense of stamens. The phenomenon of double flowers occurs occasionally in other native plants (Woolls, 1885; Australian Plants Society, 2001). Ewart (1931) notes that petal and sepal number may also vary in *Hypoxis* by reduction in number.

Sphaerolobium *minus*

This species is relatively uncommon in Melbourne (Australian Plants Society, 2001), and most commonly occurs in Damp Heathy Woodland.

Opercularia ?ovata x varia

An Opercularia occurs in Highbury Park that combines the features of *O. ovata* and *O. varia*, both of which are also present. It has long (>50 cm), wiry, sprawling stems which are covered to varying degrees by short, stiff hairs. The leaves are intermediate between the two species, dullish and hairy with obvious venation, and highly variable in size and shape. The flowerheads resemble O. varia, but have fewer flowers. Although flowering profusely, fruits have never been observed. This apparent inability to fruit, combined with the variable morphology and intermediate features, suggests a hybrid origin. Similar plants have been observed elsewhere (eg, Kinglake, Hastings), in similar areas of clay-loam soil dominated by *E. cephalocarpa* and/or *E. obliqua*. These areas may represent regions where both putative parent species commonly co-occur. If the plants are not of hybrid origin, they may represent a variant of *O. varia*.

Poa *species*

In Valley Heathy Forest, the most common *Poa* species is usually *Poa morrisii*, as it is in Highbury Park. Highbury Park also contains other *Poa* species, each represented by single individual plants. These three species are all widespread and common in Melbourne, but fairly unusual in Valley Heathy Forest. *Poa ensiformis* is usually associated with gullies and sheltered slopes (eg, the nearby gully of Scotchman's Creek), *Poa labillardierei* is most common on wet valley floors, or moist or sheltered depressions, while *Poa tenera* is generally found in shaded situations, often in gullies.

Putative Wallaby-grass hybrids

Two unusual Wallaby-grasses occur at Highbury Park. The first forms a large, coarse tussock resembling *Joycea pallida*, and produces a tall, culm, bearing florets closely resembling those of *Austrodanthonia caespitosa*. These florets are almost always lacking a firm, viable grain, and it is likely that these plants are the result of hybridisation.

The second *Austrodanthonia*-like grass resembles *Joycea lepidopoda*. This species is only known in the broader Melbourne area from relatively few sites (Yugovic, 2000; Australian Plants Society, 2001). It is unique among the described Wallaby-grasses (locally including *Austrodanthonia* and *Joycea*) in possessing rhizomes. The material from Highbury Park is conspicuously rhizomatous; however, flowering has not been observed, and no definitive determination can be made. Other observers have noted similar rhizomatous Wallaby-grasses that flower infrequently (N. Walsh, G. Lorimer pers. comm.). The taxon at Highbury Park may be *J. lepidopoda*, or more likely, a hybrid involving two of the numerous Wallaby-grasses present.

Weed invasion in Highbury Park

As in most urban reserves, weed invasion is the major threat to the remnant vegetation in Highbury Park. The most serious weeds are Sweet Vernal-grass *Anthoxanthum oderatum* and Large Quaking-grass *Briza maxima*, which are actively invading undisturbed areas, and diminishing the Park's value as an example of the pre-settlement vegetation of the area. These weeds are, however, less common than they once were, as evidenced by older photographs and a 'weed map' compiled by the author in 2001 (not shown here). Improvement has been achieved through a combination of minimal hand weeding in the most intact areas, a small amount of targeted slashing, and extensive spraying, undertaken by Whitehorse City Council. The sprayed areas have generally regenerated with a dense sward of Weeping Grass where previously there was a covering of weeds and scattered native species. There was some minimal loss of indigenous plants in these sprayed areas along with a reduction in weeds. Other unwanted plants have been effectively eliminated from the Park. While once a problem, Gorse *Ulex europaeus*, Blackberry *Rubus anglocandicans* and Sweet Pittosporum *Pittosporum undulatum* have been removed, for the time being.

Brief note on the fauna, fungi and bryophytes of the Highbury Park

The bryophytes of Highbury Park have not been surveyed in detail. However, *Thuidiopsis furfurosa* is conspicuous in the understorey across much of the park. Several other species, such as *Campylopus clavatus*, are also fairly common. Fungi are diverse and numerous, but await investigation, as do invertebrates. The vertebrate fauna of the Park is unremarkable. All species recorded are also common in the surrounding suburbs. This paucity, despite the diverse flora, is presumably due to the very small size of the reserve, its isolation, the absence of reliable water, and its proximity to a major intersection.

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The Barwon estuary – an example of the estuarine management situation in Victoria

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Abstract
The importance of Australian estuaries is well established. However, the management of these estuaries is not receiving appropriate attention. This paper examines the management situation of estuaries in Australia through a catchment level assessment of the Barwon estuary. The study finds that there are potential gaps between the relevant management agencies. The study identifies the reasons for these gaps. The study also reveals that there are many opportunities through which estuaries could be managed very effectively. The study finally suggests the effective management approach for estuaries in Australia.. (*The Victorian Naturalist* **123** (2), 2006, 84-90)

Introduction

This paper examines the management situation of Australian estuaries through a micro-level assessment of the Barwon estuary. Estuaries in Australia are extremely important in terms of social, economic and environmental values. They are widely exploited for numerous diverse purposes (NLWRA 2000a), and thereby suffer many negative effects (Boxshall 2001). Nonetheless, effective management of Australian estuaries is still missing.

Australia has over 1000 estuaries, and most Australians live in towns and cities situated on or near estuaries (NLWRA 2000a). Many studies (e.g. Hancock 1995; Hutching and Saenger 1987; Saenger 1991) have emphasised the significance of Australian estuaries to commercial and recreational fishing. Australia's recreational fishing industry is worth over $2.9 billion each year and at least 60% occurs within estuaries (NLWRA 2000b). Production of prawns from the northern prawn fishery was worth over $107m in 1999/2000 (ABARE 2001).

Australian estuaries and their associated morphological units are the foundation of some of the most biologically rich and productive environments in the coastal zone (Butcher and Saenger 1994). The dominant ecological habitats found in Australian estuaries are salt marshes, mangroves, seagrass meadows, sandflats and mudflats (Morrisey 1995; Adam 1995; Poiner and Peterken 1995).

Despite the importance of estuaries and thus the need for careful management, past planning and management of estuaries in Australia has not been coordinated or integrated (Harty 2000) and sometimes is ignored (NLWRA 2000a).

This paper examines the management situation of small estuaries in Australia, through a catchment level assessment of the Barwon estuary in Victoria. The Barwon estuary was chosen for the following reasons:

- the region supports a large agricultural industry in its catchments (Loone 1996);
- the estuary has significant national and international importance (Roberts 1993);
- both coastal management programs and catchment management programs are in place in the region; and
- the estuarine environment is being degraded (Corangamite CALP Board 1997; Oliver 2000).

Barwon Estuary System

The Barwon estuary complex exhibits physical, chemical and biological characteristics representative of other Australian estuaries (Sherwood *et al.* 1988). In their study, Sherwood *et al.* (1988) divided the whole estuary complex into four spatial components (Fig. 1):

- Upper Barwon;
- Reedy Lake;
- Lake Connewarre; and
- Lower Barwon.

The catchment of the Upper Barwon River and tributaries is located in the north-eastern section of the Otway Range in south-western Victoria. The Upper

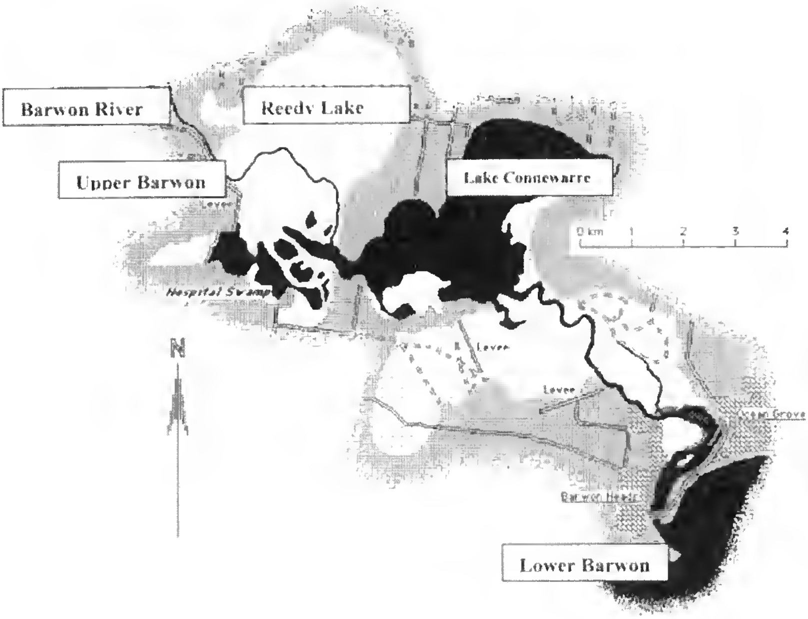

Fig. 1. The Barwon Estuary system

Barwon component of the complex is a river channel approximately 50 m wide, 3 to 4 m deep and about 10 km long (Sherwood *et al.* 1988).

Reedy Lake is the largest freshwater wetland in central Victoria (Glynn 1997), with an approximate area of 12 km^2 and a mean depth of about 0.6 m (Sherwood *et al.* 1988). It is supplied with fresh water from the Barwon River which has maintained the lake as more or less permanent.

Lake Connewarre is a large (9.5 km^2) shallow estuarine lagoon in the lower reaches of the Barwon River (Sherwood *et al.* 1988) and is part of the Lake Connewarre State Game Reserve. Lake Connewarre was listed as an internationally significant wetland under the Ramsar Convention on December 1982 (Roberts 1993) and contains natural vegetation of significance to the region (Roberts 1993).

The Lower Barwon is narrow, 3 to 4 m deep and about 10 km long (Sherwood *et al.* 1988). The organisms characteristic of this section of the complex are essentially estuarine forms that can tolerate a wide range of salinity. Mangrove and mud flats occur along the Lower Barwon (Sherwood *et al.* 1988).

Degradation of waterways in the region due to catchment activities

The Catchment Condition Report (Corangamite CALP Board 1997) identified 22 different degradation issues in the Corangamite region, many directly related to the estuary. The Corangamite CALP Board (1997) identified the most important management issue in the Barwon estuary as the excessive seasonal growth of blue-green algae. Trends at Queens Park, where the Barwon enters Geelong City, indicate increasing levels of phosphorus in the water. High to very high nutrient levels that pose threats to the viability of fish species and other estuarine fauna also have been recorded in the middle reaches of the Barwon River (Corangamite CALP Board 1997). Corangamite Catchment Management Authority (CCMA) (1998) stated that significant progress in waterway management had been achieved in the Corangamite region. Stream-side revegetation, stormwater pollution reduction, erosion control and enhancement of wetland habitats and urban waterways were having a beneficial effect on waterways. Nonetheless, the estuary itself is not getting enough attention. As well as nutrient problems, other forms of water pollution, nearby industry and beach littering also contribute to estuarine degradation (Adams 2000; Oliver 2000).

Current management of the estuary and its catchment

The management of the Barwon River Catchment falls under the jurisdiction of the CCMA, which provides advice on the management of the land and water resources in the region. The Regional Catchment Strategy (Corangamite CALP Board 1997) addresses issues relating to water quality, waterway management and river health. The Catchment Management Structures Working Party (1997) recommended that the Catchment Management Authority be the principal body for catchments within its region. Establishing close partnership with other organizations within the catchment is the main mechanism for developing relationships. For example, the relationship between Catchment Management Authority and Environment Protection Authority is established through the development of the State Environment Protection Policy (SEPP). As stated by Catchment Management Structures Working Party (1997) the EPA in consultation with the CCMA will develop a set of environmental objectives under the SEPP policy, which will act as the minimum environmental standards to be included within a Regional Catchment Strategy. The CCMA is responsible for the development and implementation of the Attainment Program required under the SEPP and is included in the Regional Catchment Strategy. Similarly, the relationship with the relevant water authority (Barwon Water) is established through the development of the Regional Catchment Strategy. The CCMA needs to ensure that the water authority is adequately consulted in the development of the Regional Catchment Strategy. The relationship with the Department of Sustainability and Environment (DSE) is developed through the inclusion of a representative on the Authority. The Catchment Management Authority (CMA) has a broad range of natural resource management responsibilities; however, in most cases they relate to a strategic and coordinating role. Working in partnership with other agencies, groups and organizations is, therefore, a key function of the Authority. In this context the CMA is to develop strategic directions for land and water management in the region and to develop and oversee appropriate work programs (DNRE 2000). DSE also assists in the management of the catchment, and is responsible for a number of activities that impact on the health of the region. Other primary management authorities in the area include the following:

- Environment Protection Authority (EPA) – setting policy for waterway health, regulating point source pollution, carrying out water quality monitoring programs, licensing of discharges;
- Barwon Water – responsible for the management of the Barwon River, ensuring

Table 1. Non-governmental organizations working in the Barwon Area.

Name of Groups	Activities	Grant Received from
Leigh and District Landcare Group	Revegetation of the riparian zones of many creeks	DSE
Barrabool Hills Landcare Group	Serrated tussock management (pest plant)	Victorian Farmers Federation
Stonehaven/Fyansford Landcare Group	Pest plant, pest animal and revegetation	Tree Victoria
Friends of Buckley Falls	Revegetation work	DSE
Victorian Field and Game Association	Preserve, restore, develop, maintain water birds' habitat	
Friends of the Bluff	Work closely with Barwon Coast Committee Management Incorporation, the primary activities are weed eradication, revegetation, and operation of an indigenous nursery.	Coastcare

adequate quantities of good quality water are available to consumers and that wastewater is disposed of in accordance with EPA license conditions (Barwon Water 1994);

- Parks Victoria – responsible for the management of Lake Connewarre State Game Reserve;
- City of Greater Geelong – carries out environmental work with Barwon Water and local schools to support the Waterwatch program and the revegetation of riparian zones on major streams (Corangamite CALP Board 1997);
- The Barwon Coast Committee of Management Incorporation (BCCMI) – is responsible for management of the foreshore reserves;
- Golden Plains Shire – actively supports local Landcare groups and projects, and the Corangamite Salinity Program.

In addition to these primary management authorities there are a number of community-based volunteer groups and Non-Governmental Organisations involved in the environmental management of the Barwon River and catchment (Table 1). It should be noted that there are two major Statewide environmental water quality monitoring programs in Victoria. These are: (1) the Victorian Water Quality Monitoring Network (VWQMN) managed by DSE. The VWQMN is contracted out to Water Ecoscience Pty. Ltd., with funding provided by DSE, four regional water authorities and Melbourne Water; (2) a network of fixed sites run and funded by the Environmental Protection Authority (EPA).

The VWQMN has three main components to monitor (Hunter 1993; Hunter and Zampatti 1994; Hunter and Hedger 1995) – rivers and streams, lakes and reservoirs, and wetlands. The EPA Fixed Site Network monitored 20 rivers and streams in 1996 throughout the State, and five lakes in the Western District of Victoria (VWQMN 1998).

Surprisingly, none of the programs has responsibilities to monitor estuaries. In the words of CALPC, DNRE and EPA (1996), 'Estuaries are poorly represented in the statewide water quality programs; consideration needs to be given to developing an estuarine component to VWQMN'. In this context, Jackson (pers. comm. 2000) indicated that there are many organisations working; however no one is doing work for the estuary. Oliver (2000), reported that the Barwon has always been neglected, therefore becoming more polluted day by day.

The above discussion reveals that, despite many organisations working around the estuary, there is no single authority responsible for the management of the estuary itself. There is no management plan for the estuary. At present, regulations exist for water quality management but they are generally applied under the different jurisdictions of each separate management agency. This results in fragmentation of responsibilities and an uncoordinated approach. The emphasis on reducing nitrogen and phosphorus levels has directed attention away from other important management issues, such as protection of estuarine shorelines, erosion, estuarine beach littering and clearing of native vegetation.

Scope for the better management of the estuary

Although the Barwon estuary itself is not receiving enough management attention, there are ample opportunities through which the Barwon could be managed very effectively. The establishment of two natural resource management programs in Victoria, that is, catchment and coastal management, has produced a means of better management not only for the Barwon estuary, but also for other estuaries in the State.

The relationship of Catchment Management Authorities with the Victorian Coastal Council

The *Coastal Management Act 1995* makes provision for the preparation of a Victorian Coastal Strategy and Coastal Action Plans and Management Plans for coastal Crown Land. Estuaries fall under the definition of Coastal Crown Land under the Act as:

> Coastal Crown Land means-
>
> (a) any land reserved under the *Crown Land (Reserves) Act 1978* for the protection of coastline;
>
> (b) any Crown Land within 200 metres of

the high water mark of-
i. the coastal waters of Victoria; or
ii. any sea within the limits of Victoria;
(c) the sea bed of the coastal waters of Victoria;
(d) the sea bed of any sea within the limits of Victoria; and
(e) any Crown Land which is declared by the Governor-in-Council under sub-section (2) to be coastal Crown Land - but does not include any land which the Governor-in-Council declares under sub-section (2) not to be coastal Crown Land for the purposes of this Act.

Therefore, coastal Crown Land includes all the estuaries of the Victorian coast and these are subject to the provisions of the *Coastal Management Act 1995*. In this context, not only the Barwon estuary but all other estuaries come under the custody of the *Coastal Management Act 1995*.

On the other hand, the Catchment Management Structures Working Party (1997) has delineated the responsibilities of Regional Coastal Boards on coastal land as 'Coastal Boards should focus their activities solely on the coastal fringe with Catchment Management Authorities being the primary organization within the catchment.' In their statement the Catchment Management Structures Working Party (1997) has indicated that 'there is some potential for confusion over the role of Coastal Boards and Catchment Management Authorities because the boundaries of the Coastal Boards' influence extend into the catchment.' Therefore, a formal mechanism for liaison was required to establish the relation between Coastal Boards and Catchment Management Authorities (CMAs). However, no principal guideline for a coordinating mechanism has been formed between them. Therefore, the link between catchment and coastal programs is ill defined.

Scope for effective management of the estuary through proper links between the catchment and coastal management programs

Management of estuaries should be linked with two components – catchment and coastal components. Thus the management efforts would involve catchment and coastal authorities, as well as the many other State and Commonwealth government bodies and private landowners. In recent years, catchment management has undertaken initiatives in minimising nutrient import from catchment activities, especially from agricultural activities, which could improve estuarine as well as coastal water quality and, ultimately, estuarine environments. The establishment of the CCMA in 1997 has coordinated waterways management across the region and achieved significant progress in waterways management (CCMA 1998). On the other hand, coastal management can protect estuaries from activities occurring within the coastal zone. The Victorian Coastal Strategy (VCC 1997) stated that a program to improve the management and conservation of estuaries, bays and river mouths will be established including:

- establishing accountability and responsibility for on-ground management;
- development of criteria for artificially opening river mouths and estuaries;
- establishing minimum criteria for ecological management;
- coordination with Catchment Management Authorities to reduce sedimentation and to improve water quality into estuaries and river mouths.

From the above statements it is obvious that both catchment and coastal programs have the vision for the improvement of estuaries. Nonetheless, in effect, estuaries still are not receiving adequate attention, as has been seen from the Barwon River estuary. There are several reasons for this. Firstly, the relevant agencies are not well coordinated because of confusion over responsibilities and power, especially coordination between the Catchment Management Authority and the Coastal Council, which are the two important authorities with major responsibilities for the management of the estuary.

Secondly, legislation for estuarine management is not adequate. In its proposed recommendations in the area of coastal management, the Land Conservation Council (LCC) Victoria emphasized the desirability of creating a focused body for marine, estuarine and coastal area management in Victoria (LCC, 1996). The LCC emphasized that the authority should be established by legislation to overcome fragmentation of responsibilities and legislative deficiencies in marine, estuarine and coastal area management in Victoria. To date, the role of legislation for estuary management has been overlooked or inadequately appreciated.

Thirdly, estuarine programs are inadequate. There are many catchment programs such as water quality monitoring programs in waterways and streams, re-vegetation programs, community education programs etc. However, no program has yet been brought to focus on the estuary itself.

Finally, there is no management plan for the estuary. Indeed, this study could not identify any particular agency responsible for the management of the estuary itself. Lack of plans or guidelines give rise to concern about the importance of estuarine issues. In effect, estuary management plans reflect the agreed position of all regulatory authorities and interested parties in relation to the future nature conservation, rehabilitation and development of the estuary. In the absence of a management plan, neither the catchment nor the coastal programs are combining their efforts for the management of the estuary.

Catchment management plans and coastal action plans are appropriate means to address management issues affecting smaller estuaries in Victoria (ECC 2000). Properly linked management of estuaries should be captured within catchment and coastal management programs. To do this, a bridge is needed between catchment and coastal management programs. This study argues that estuary management plans can set up that bridge to connect the gap.

Conclusion

The Barwon estuary provides an example of the management situation of estuaries in Victoria, especially for small estuaries. Most of the environmental issues in the estuary have resulted from a wide variety of land and waterway uses and activities. Excessive nutrients in the estuarine water, habitat loss, increased salinity and other problems are having a significant impact on the estuary. Catchment initiatives for reducing nutrient imports are being improved. However, overall management of the estuary is lacking. As a number of agencies have some responsibility for the management of rivers and adjacent estuarine areas, there is confusion about which body has ultimate authority and should take responsibility for all management decisions and implementations. For effective management of the estuary, both the catchment and coastal components must be addressed. It is important that the catchment program and coastal program work together to secure sustainable management of the estuary.

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One Hundred Years Ago

A tramp from Healesville to Buxton.
Botanical and Ornithological Notes for September.
By A.D. Hardy, F.L.S. and Mrs. Hardy.

…The walk from Healesville up the Blacks' Spur demands at any time a fair amount of exertion, but on this occasion, with 2 inches of snow on the road at Healesville, the conditions of the tramp at higher altitudes might be anticipated to present some difficulty. Notwithstanding the advice of old residents, who declared the Spur to be impassable on foot, we set out prepared for a rough time, cold feet, and a pedestrian achievement of some novelty. That a member of our Club should be the first lady to cross the Spur to Marysville with a reported foot depth of snow to walk through, and thereby establish a record, was a temptation irresistible.

...At the Maroondah or Watts Bridge, the former site of Fernshaw, the snow depth had perceptibly increased, and we were soon convinced that botanical inquiry was for the time almost impossible, as all but the tall trees and larger shrubs were completely hidden. Further on small branches from the overhanging eucalypts littered the ground, and here and there a great limb, unable to resist the increasing weight, had fallen and grounded the telephone wire. Creaking and cracking branches overhead warned us to get from under in time to avoid the impending danger, while from the more flexible twigs there came frequent and sudden showers of snow, and often heavier masses that fell without warning and drove one's hat down over the ears in a way that was more exciting than pleasant.

From *The Victorian Naturalist*, **XXII**, p. 164-165, February 8, 1906

Distribution and habitat requirements of the Yellow-footed Antechinus *Antechinus flavipes* at multiple scales: a review

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Abstract

This review synthesises present knowledge of the distribution patterns and habitat requirements of the Yellow-footed Antechinus *Antechinus flavipes*. Factors influencing the distribution of *A. flavipes* are examined at several spatial scales ranging from the broad climatic conditions prevalent over the species' entire range to the characteristics of nest sites used by individual animals. Analysis of the literature suggests that: 1) at the broad-scale, *A. flavipes* distribution is largely determined by warm, dry climatic conditions, the distribution of dry forests and woodlands and competition with closely related species; 2) at the landscape-scale the determinants of *A. flavipes* distribution are largely unknown, although initial investigations suggest some tolerance of fragmented landscapes; and 3) at a local-scale the distribution of *A. flavipes* is largely determined by the presence of large diameter trees, tree hollows, coarse woody debris, rocky crevices and leaf-litter. Directions for future research are suggested throughout the review. (*The Victorian Naturalist* **123** (2), 2006, 91-100)

Introduction

> In a few short years I have noted its final disappearance from areas where formerly it was possible to watch the bright-eyed little fellows running a few feet at a time along sun-bleached logs, stopping with a characteristic jerk and as quickly moving sideways, forwards, or circling a tree trunk in their own inimitable style. (David Fleay, 1949)

The Yellow-footed Antechinus *Antechinus flavipes* is a small dasyurid marsupial that occurs in a wide range of habitats across southern and eastern Australia (Van Dyck 1998). Knowledge of the habitat requirements of *A. flavipes* is limited, and much of its range corresponds with cleared and degraded temperate forest and woodland (Menkhorst 1995; van der Ree 2003). Consequently, the conservation of the species throughout much of its range may not be assured (Menkhorst 1995). Given that an understanding of the variables that influence the distribution of a species is essential for effective conservation-based management (Austin 2002; Gibson *et al.* 2004a), research into the habitat requirements of *A. flavipes* should be an imperative.

This review synthesises present knowledge of the distribution patterns and habitat requirements of *A. flavipes*. The two southern subspecies, *A. f. flavipes* and *A. f. leucogaster*, are the focus of the review as little has been published about the ecology of the north-east Queensland subspecies *A. f. rubeculus*. Beginning with a brief introduction to the life history and ecology of *A. flavipes*, I then highlight the importance of analysing the distribution of a species at multiple spatial scales. The distribution of *A. flavipes* is then examined at the broad-scale, landscape-scale and local-scale, and previous research on this species and its congeners is discussed. After indicating directions for future research throughout the review, I conclude with examples of experimental design that may be useful in furthering our understanding of the distribution and habitat requirements of *A. flavipes*.

Life history and ecology

A. flavipes is a small (20-75 g), semi-arboreal species (Smith 1984; Dickman 1991; Marchesan and Carthew 2004). Invertebrates are the main source of food, with nectar and small vertebrates taken opportunistically (Fleay 1949; Menkhorst 1995; Goldingay 2000). Although many populations are thought to be nocturnal (Wakefield and Warncke 1967; Van Dyck 1998), diurnal activity has been observed in Victorian populations (Coates 1995; Menkhorst 1995). The average home range of *A. flavipes* in dry forest in Victoria has been estimated to be 1.2 ha for males and 0.78 ha for females, using a grid-capture based method (Coates 1995).

The life-history of *A. flavipes* involves a brief mating period between June and September, the subsequent mortality of all males in the population following mating and the production of one litter of 8-14 young each year (Lee *et al.* 1982; Van Dyck 1982; Smith 1984; Marchesan and Carthew 2004). Although breeding is highly synchronised within local populations (Dickman 1980; Van Dyck 1982), breeding times between populations have been found to vary with latitude, climate and the timing of peaks in invertebrate abundance (Van Dyck 1982; Smith 1984).

Recent studies suggest that *A. flavipes* follows a male-biased dispersal strategy, with males dispersing from natal areas following weaning, and females remaining philopatric (Marchesan and Carthew 2004). Occurring at lower densities than other Antechinus species (Dickman 1980), population densities of *A. flavipes* have been estimated at between 0.11 to 4.17 individuals per hectare (Reeckman 1975 cited in Dickman 1980; Smith 1984; Watt 1997).

Spatial scale

A wide range of factors influence the distribution patterns of species, including abiotic processes (e.g. climate), biologically mediated processes (e.g. physiology) and processes governed by biotic interactions (e.g. competition) (Krebs 2001; Mackey and Lindenmayer 2001). The distribution patterns that we observe, and the processes that determine these patterns, can change with the spatial scale of investigation or observation (Wiens 1989; Levin 1992; Cooper *et al.* 1998; Luck 2002a). Consider the following example.

In the Central Highlands of Victoria, the presence of Leadbeater's Possum *Gymnobelideus leadbeateri* at the broad-scale is determined by the presence of ash-type forest and a narrow range of climatic conditions (Lindenmayer 2000). At the landscape-scale the species was found to inhabit large forest blocks, with distribution determined by past disturbances such as logging and fire (Lindenmayer 2000). At the local-scale the species was found to inhabit forest areas with numerous large trees, hollows and an understorey of Acacia species (Lindenmayer 2000). Preferred nest-trees had large diameter stems, were highly decayed, contained numerous cavities and were surrounded by a dense understorey (Lindenmayer 2000).

Spatial scale can be defined by two components that define the upper and lower limits of a study: extent is the overall area encompassed by a study and grain is the smallest unit of observation (Wiens 1989; Mayer and Cameron 2003). The above example highlights the importance of studying species at multiple spatial scales because investigations undertaken at only one spatial scale may fail to explain or observe important patterns and processes. For instance, by varying the extent of investigations from forest patches at a landscape-scale to the entire range of the species at a broad-scale, Lindenmayer (2000) was able to uncover the narrow range of climatic conditions that *G. leadbeateri* inhabits. Further, by varying the grain of investigations from the characteristics of habitat patches to the characteristics of individual trees, Lindenmayer (2000) was able to determine the features of preferred nest sites of *G. leadbeateri*.

Additionally, multiple scale analysis allows for diverse management strategies to be implemented, because each spatial scale of investigation often has a corresponding scale of management (Lindenmayer and Franklin 2002; Wiens *et al.* 2002). For instance, investigations at broad-scales correspond with the management of entire regions, whereas investigations at landscape-scales relate well to the management and implementation of protected areas and wildlife corridors (Lindenmayer 2000).

Considering the importance of studying species at multiple scales, the distribution of *A. flavipes* will be examined at three spatial scales: the broad-scale, the landscape-scale and the local-scale.

Broad-scale distribution

A. flavipes occurs in eastern and south-western Australia in a wide range of habitats including dry forest, tropical vine forest, swampy forest, dry woodland and heathy woodland (Van Dyck 1982, 1998; Menkhorst 1995). Three subspecies are currently recognised: *A. f. flavipes* occurs in southern Queensland, New South Wales, Victoria and South Australia; *A. f. rubeculus* occurs in north-eastern Queensland; and *A. f. leucogaster* occurs in south-western Western Australia (Van Dyck 1998). However, the taxonomic status of some populations is still in doubt (Crowther *et al.* 2002; How *et al.* 2002). For example, in south-western Australia, northern populations of *A. flavipes* are characterised by females that have ten nipples, while geographically separated southern populations are characterised by females with eight nipples (How *et al.* 2002). This suggests variation in reproductive potential and possible taxonomic differences between populations (How *et al.* 2002).

Although found in a variety of habitats, site location records indicate that the broad-scale distribution of *A. flavipes* is closely associated with the dry sclerophyll forests and woodlands predominant on the inland slopes of the Great Dividing Range and in south-western Western Australia (Wardell-Johnson 1986; Menkhorst 1995; Van Dyck 1998). For example, Victorian populations of *A. flavipes* are closely associated with dry forest, dry woodland and heathy woodland vegetation communities that run in a diagonal band through the centre of the state from the south-west to the north-east (Menkhorst 1995).

Fifty per cent of *A. flavipes* populations in Victoria occur in the Box-Ironbark region (ECC 1997), with other populations present in the Wannon and Grampians regions (Menkhorst 1995). *Antechinus flavipes* is generally uncommon, although not threatened, but is likely to play a significant ecological role in habitats such as box-ironbark forest and floodplain forest where it is one of few (or often the only) predominant native small-mammal species (ECC 1997; Mac Nally and Horrocks 2002). For example, Mac Nally and Horrocks (2002) suggested *A. flavipes* is likely to have a considerable influence on invertebrate populations of River Red Gum floodplain forest.

The climate analysis program BIOCLIM has been used to predict the broad-scale distribution of *A. flavipes* based on the climatic conditions of known site locations (see Sumner and Dickman 1998; Crowther 2002; Crowther *et al.* 2002). *Antechinus flavipes* was predicted to occur predominantly in warm, inland areas of south-eastern Australia with a mean annual temperature of 14.5 °C and a mean annual rainfall of 785 mm (Crowther 2002). The core predicted distribution followed the inland slopes of the Great Dividing Range, with a patchy distribution predicted for coastal and inland areas. *A. flavipes* was also predicted to occur in coastal areas of southern New South Wales and eastern Victoria, where there are no records of the species' occurrence, and to have a much greater range inland than is currently recognised (Sumner and Dickman 1998; Crowther 2002). Few location records exist from semi-arid inland regions (although see Ellis and Smith 1990). *A. flavipes* was predicted to occupy wetter, more variable environments in south-western Australia than in eastern Australia (Crowther *et al.* 2002).

Crowther (2002) examined the distribution of *A. flavipes* in relation to those of the Brown Antechinus *A. stuartii*, Agile Antechinus *A. agilis* and Subtropical Antechinus *A. subtropicus*, and found substantial differences in the climatic indices that determined each species's distribution. The predicted range for *A. flavipes* included areas with the lowest mean annual precipitation (an arid 282 mm) and the lowest annual mean moisture index (0.6) of the four species. This reflected the high evaporation rates within the species's range, and its tolerance of much drier, less predictable environments than other Antechinus species (Crowther 2002). The broader dietary niche of *A. flavipes*, indicated by dental and cranial characteristics which allow it to feed on a large range of prey, may explain its occurrence in a diverse range of habitats and its ability to survive in more unpredictable, drier environments than its congeners (Van Dyck 1982; Coates 1995).

The limited sympatry between *A. flavipes* and its congeners (Sumner and Dickman 1998) and the tendency of *A. flavipes* to be restricted to dry forest and woodland yet occur in wet forest when *A. stuartii* is absent (Van Dyck 1982), suggests that competition may influence its distribution at the broad-scale. Furthermore, bioclimatic analysis indicates that *A. flavipes* is absent from large areas of climatically suitable habitat. In these areas the presence of the Dusky Antechinus *A. swainsonii* and *A. agilis* could be limiting its distribution (Crowther 2002). The limited sympatry that does exist between *A. flavipes* and its congeners generally occurs at the margins of the species' range, for example with *A. agilis* in the eastern highlands of Victoria (Menkhorst 1995), and has been attributed to a distribution undergoing change or the presence of an ecotone (Van Dyck 1982).

Undoubtedly a range of factors not discussed here, such as soil, geology and altitude, also influence the distribution of *A. flavipes* at the broad-scale, and interact with the major factors discussed. However, the literature suggests that at the broad-scale *A. flavipes* is most influenced by the climatic parameters highlighted, broad vegetation patterns and competition with closely related species.

Future research into the distribution of *A. flavipes* at the broad-scale should focus on:

- surveying regions where *A. flavipes* was bioclimatically predicted to occur, but has not been verified by site records;
- taxonomic studies to clarify the level of similarity or difference between currently recognised subspecies and populations within these subspecies.

Landscape-scale distribution

Disturbances such as fire, flood and drought have long influenced the evolution of the Australian mammal fauna, but the advent of European settlement saw the type, scale, frequency and intensity of these disturbances change, and the addition of new disturbances such as vegetation clearance and habitat fragmentation (Wilson and Friend 1999). Despite altered disturbance regimes and habitat loss being recognised as a major threat to the Australian mammal fauna (Wilson *et al.* 2003), little information is available on the effects of these disturbances on *A. flavipes*.

In a study of *A. flavipes* in a fragmented landscape in South Australia, Marchesan and Carthew (2004) found that individuals that occurred in larger forest patches weighed less and occurred in lower population densities than those inhabiting smaller patches and strips of remnant vegetation. These differences, and successful reproduction in the area, suggest a tolerance by *A. flavipes* of fragmented landscapes and possible favourable responses to edge habitat (Marchesan and Carthew 2004). They suggest that the life-history strategy of *A. flavipes* allows the species to persist in fragmented areas because the complete male die-off after the breeding season leaves increased resources for lactating females and emerging young, with small populations then replenished by male dispersal following weaning. Tolerance of fragmented habitat was also reported in north-eastern Queensland by Laurance (1994) who found that *A. flavipes* was more abundant in rainforest fragments than in continuous rainforest. Additionally, 11 of 14 individuals were captured within 35 m of forest edges (Laurance 1994).

In north-eastern Victoria, van der Ree (2003) demonstrated that *A. flavipes* can successfully reproduce in a fragmented landscape. However, far from finding favourable responses to edge habitat, an absence of *A. flavipes* in 90% of linear habitat indicated limited tolerance to fragmentation in this area. The absence of the species was suggested to be a consequence of reduced quality of habitat and increased predation in remnant linear strips and patches (van der Ree 2003). Large diameter trees probably contributed to the persistence of the species in the rare sections of linear habitat where they were present (van der Ree 2003).

The ability of *A. flavipes* to move between remnant habitat patches across heavily disturbed areas remains largely unknown, although some incidental records are available. Dickman (1991) reported the species foraging 100 m from the nearest tree in open pasture, adjacent to open forest, in New South Wales. Additionally, relatively large movements of 1100 m and 700 m have been recorded (Dickman 1986; van der Ree 2003). Van der Ree (2003) suggested that the ability of *A. flavipes* to move through disturbed areas may be the reason it can remain in some fragmented landscapes. This was demonstrated by Marchesan and Carthew (2004) who recorded *A. flavipes* moving up to 720 m between remnant vegetation patches.

Fire is a major disturbance factor and plays an important role in shaping the Australian landscape (Wilson and Friend 1999). Altered fire regimes may have caused substantial declines in mammal species (Wilson *et al.* 2003). The response of small mammals to fire regimes has received considerable attention in the published literature (see Wilson *et al.* 1990; Wilson *et al.* 2001; Friend 2004), although little is known for *A. flavipes*.

Christensen and Kimber (1975) studied the effects of fuel reduction burning on sclerophyll forest in south-western Western Australia. In both wet and dry sclerophyll forest *A. flavipes* occurred mostly in areas where fire was excluded, and was rare in recently burnt areas. For instance, in wet sclerophyll forest that had remained unburnt for 40 years, the trapping rate was 7.41 individuals per 100 trap nights. In areas that had been burnt five and 20 years previously, trapping rates were less than 0.5 individuals per 100 trap nights (Christensen and Kimber 1975). Post-fire mortality was high as indicated by trapping rates of 1.91 per 100 trap nights before a burn and trapping rates of 0.23 per 100 trap nights 19 months after a burn (Christensen and Kimber 1975). Conversely, Thompson *et al.* (1989) indicated that fire had little or no effect on *A. flavipes* in dry sclerophyll forest in South Australia, with the survival and persistence of the small study population following a low intensity fuel reduction burn.

Other disturbances such as floods and drought may also influence the species's distribution. For example, Mac Nally and Horrocks (2002) highlighted that *A. flavipes* habitat in River Red Gum forests and woodlands in the Riverina region of Victoria regularly floods, with a likely outcome being large changes in the abundance of invertebrates and shelter sites.

Future research into the distribution of *A. flavipes* at the landscape-scale should focus on:

- the effects of habitat loss and fragmentation on the species (How large do remnant patches need to be to provide suitable habitat? Does the species respond more strongly to the structural components of remnant patches or patch size? Can linear patches and corridors provide a conduit for movement of the species between patches? Can habitat corridors provide resident habitat? Is an agricultural matrix a substantial barrier to movement?)
- metapopulation dynamics
- the long-term effects of disturbance regimes on the species. (What are the effects of fire intensity, season and frequency on the species? What are the effects of flooding in riparian habitats? What are the effects of drought?)

Local-scale distribution

Antechinus flavipes has a wide geographic distribution across a variety of vegetation types (Van Dyck 1998), which suggests that at local scales habitat components other than floristic composition may be of greater importance in determining its presence. Several studies have highlighted the importance of a number of habitat structural components in influencing the species's presence.

In a study analysing foraging behaviour and habitat use of small-mammals in southern Queensland, Stokes *et al.* (2004) revealed preferences of *A. flavipes* for microhabitats that were structurally complex. Using artificially placed netting, and by manipulating food availability, *A. flavipes* was found to forage most frequently where both logs and rock crevices were present, with tree and understorey cover found to be less important indicators (Stokes *et al.* 2004). The authors suggested that *A. flavipes* may perceive structurally complex habitats as having a lower predation risk, but also indicate that rocks and logs provide individuals with food, nest sites and shelter from the elements (Stokes *et al.* 2004).

The loss of structural complexity may be detrimental to populations of *A. flavipes*, as individuals may be forced to forage in more exposed areas, with higher predation rates a likely outcome (Stokes *et al.* 2004).

Studies undertaken in the Riverina region of Victoria have highlighted the positive relationship between *A. flavipes* and coarse woody debris, by manipulating wood loads at a number of sites (Mac Nally *et al.* 2001; Mac Nally and Horrocks 2002). Densities of *A. flavipes* were found to rise to significantly higher levels as wood densities reached >20 t/ha (Mac Nally and Horrocks 2002) and >45 t/ba (Mac Nally *et al.* 2001). Again, the shelter and food provided by the coarse woody debris were suggested as reasons for the association (Mac Nally and Horrocks 2002). This research also indicated the type of coarse woody debris favoured by *A. flavipes*. The species only responded positively to coarse woody debris in the form of logs or large boughs, as opposed to 'tree crowns' which failed to attract the species (Mac Nally and Horrocks 2002).

Large diameter trees are another important habitat component for *A. flavipes*. Dickman (1991) found that *A. flavipes* principally foraged on the surface of large eucalypts and under the hanging bark that they produced in open forest in New South Wales and Western Australia. Large trees are also important because they are more likely to contain tree hollows, the key nesting site of the species (Dickman 1991; Trail 1991). Wardell-Johnson (1986) suggested that the availability of hollows, and therefore large diameter trees, was a limiting factor in the presence of the species.

A. flavipes has heen recorded as using a range of hollows including crown hollows, stump hollows, coppice hollows and base hollows (Dickman 1991; Trail 1991; Coates 1995). Coates (1995) found that *A. flavipes* in dry forest in north-central Victoria used hollows close to the ground for communal nesting and hollows used for suckling young were located >2 m above the ground. This may be a strategy to avoid predators such as the Red Fox *Vulpes vulpes* and the Cat *Felis catus* while suckling young (Coates 1995).

A range of other nest-sites can also be used by the species. In dry heathland in South Australia, Marchesan and Carthew (2004) found that the majority of nest sites were in the crowns of *Xanthorrhoea semiplana tateana* (66%), with the remaining nest sites in tree hollows and stags. It is not known whether there was a preference for this species as a nesting site or whether it was due to its availability compared with other species (Marchesan and Carthew 2004). Rocky outcrops and rock crevices have also been recorded as providing nest-sites in Victoria and New South Wales (Fleay 1949; Dickman 1980, 1986).

Leaf litter is another important habitat component (Wardell-Johnson 1986). Christensen and Kimber (1975) reported that *A. flavipes* in dry sclerophyll forest in Western Australia favoured areas with a deep litter layer, with at least the first few centimetres of the ground layer consisting of dead material. Further, in another Western Australian study, Sawle (1979 cited in Wardell-Johnson, 1986) found that the highest number of *A. flavipes* were in structurally complex sites with distribution primarily related to litter depth. Leaf litter is thought to be a good indicator of the quantity of invertebrates, the main food source of *A. flavipes* (Wardell-Johnson 1986) Coates (1995) reported that 92% of telemetry observations placed male *A. flavipes* within 2 m of the ground, highlighting considerable use of the ground layer.

Although leaf litter is an important habitat component in some areas, it may not he true of all areas inhabited by *A. flavipes*. Wardell-Johnson and Nicholls (1991) noted that *A. flavipes* was absent from large areas of dry sclerophyll forest in Western Australia with a deep leaf litter. It seems likely that at different sites different habitat components are influencing *A. flavipes*' presence. For instance, Wardell Johnson (1986) suggested that in young forest or recently burnt areas the quantity of invertebrates was a limiting factor, and in older, less disturbed sites the availability of nest sites may be limiting.

Soderquist and Mac Nally (2000) tested the hypothesis that the abundance of mammals was higher in moist gullies than on dry hilltops, slopes and ridges in the Box-Ironbark forests of central Victoria. They found that *A. flavipes* was significantly more abundant in gullies. A greater number of large diameter trees with hollows in gully sites, compared to other topographic areas, is a likely reason for the positive relationship (Soderquist and Mac Nally 2000). Catling *et al.* (2002) modelled the distribution of ground-dwelling mammals in north-eastern New South Wales and found *A. flavipes* most commonly on flat to undulating terrain with a north-easterly aspect.

It appears that a number of structural components, influenced by topography, determine the distribution of *A. flavipes*, including large diameter trees, tree hollows, coarse woody debris, rocky crevices and leaf litter. Further research is required to transform this knowledge into information that can be used for the conservation-based management of the species.

Future research into the distribution of *A. flavipes* at the local-scale should focus on:

- providing quantitative information on the habitat requirements of *A. flavipes* for use by natural resource managers. (How deep does leaf-litter need to be? How many hollow bearing trees per hectare are required for nest sites? What are the required loads of coarse woody debris needed? (see Mac Nally and Horrocks (2002) for an excellent example of such research)
- the response of *A. flavipes* to habitat components across different areas of its range. (Which habitat variable is most limiting in each habitat type? Hollow bearing trees? Leaf-litter? Logs? Are responses to habitat variables in floodplain forest similar to those in dry forest and rainforest habitats?)
- the characteristics of hollows used as nest sites
- the effect of introduced predators such as the Red Fox and the Cat, which are likely to be detrimental to a small-mammal species such as *A. flavipes*.

Future Directions

I have highlighted present knowledge of variables that influence the distribution of *A. flavipes*, and shown that many knowledge gaps still remain. How can these knowledge gaps be addressed? Following are some suggestions for future research and examples of experimental designs that may provide useful insights into the distribution of *A. flavipes*.

Multiple scale research

Multi-scale investigations are essential because the processes that determine species distribution patterns change with our scale of investigation; investigations undertaken at only one scale may overlook important patterns (Wiens 1989; Levin 1992; Cooper *et al.* 1998). Wiens *et al.* (1987) suggested that the most likely way to avoid problems of scale is to conduct studies at several hierarchically nested scales, thereby observing different scales simultaneously. For example, Fischer *et al.* (2003, 2004) investigated the habitat relationships of reptiles at multiple scales using a hierarchical experimental design in a grazing landscape in southern New South Wales. A design consisting of small plots (10 x 10 m) nested within larger sites (equilateral triangles with a 25 m side length) nested within larger landscape units (equilateral triangles with side length of 250 m) allowed both microhabitat and landscape variables to be examined. This design showed that the Four-fingered Skink *Carlia tetradactyla* responded to both landscape variables, such as landscape units with a northerly aspect, and microhabitat variables, such as the abundance of spiders. Hierarchically nested designs offer insights not obtainable from a single-scaled study (Fischer *et al.* 2004) and would provide useful information on *A. flavipes*' distribution and habitat requirements.

Habitat requirements and the effects of fragmentation

Few studies have been undertaken with a focus on the effect of fragmentation on *A. flavipes*, although a number of such studies have been undertaken on its congeners (see Knight and Fox 2000; Wilson *et al.* 2001). Knight and Fox (2000) studied the role of habitat structure in mediating the effects of fragmentation on the abundance of *A. stuartii* in remnant forest in New South Wales. Analysis of remnant vegetation patches of differing size and degree of disturbance indicated that the direct effects of remnant area and disturbance on the abundance of the species were found to be marginal. *A. stuartii* responded more strongly to structural components of the remnant habitat, including understorey height, litter depth and the abundance of logs (Knight and Fox 2000). In turn, these structural characteristics were influenced by the remnant size and degree of remnant disturbance, highlighting that information at one spatial scale can inform what is happening at other scales. Similar research focusing on landscape-scale and local-scale distribution simultaneously is required to further knowledge of the distribution of *A. flavipes*, particularly in regards to habitat loss and fragmentation.

Predictive Modelling

Knowledge of species-habitat relationships and spatial distribution are essential components of effective conservation-based management (Austin 2002; Gibson *et al.* 2004a). The creation of statistical models that correlate the location of species with habitat components by comparing sites where species abundance differs, or where the species is present or absent, can be used to predict species responses (Luck 2002b; Scott *et al.* 2002; Mac Nally *et al.* 2003). These models have been developed for a number of small-mammal species (see Catling *et al.* 2000, 2002; Gibson *et al.* 2004a, b).

For example, Gibson *et al.* (2004b) examined the capability of models to predict the landscape characteristics associated with species richness and the occurrence of small mammals in coastal southwestern Victoria. A negative association between species richness, elevation, habitat complexity and sun index was found. The presence of *A. agilis* was negatively associated with habitat complexity and a sun index, and positively associated with elevation, distance to coast and distance to creeks (Gibson *et al.* 2004b). From these data a predictive distribution model was created, highlighting critical habitat areas, with the potential to guide conservation-based management of a number of mammal species (Gibson *et al.* 2004b). Predictive models based on the habitat relationships of *A. flavipes* would help to guide the management of this species.

Conclusion

A wide range of factors operating over a number of spatial scales influence the distribution of *A. flavipes*. Furthering our understanding of these factors will facilitate improved management of the species habitat and help to secure its long-term conservation.

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History of the FNCV Geology Group, 1880-2005

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Abstract

The history of the FNCV Geology Group from 1880 to 2005 is presented. This includes an account of the origins of the FNCV Geology Group, the geological activities in the early days and the competition with alternative geological forums for members. A case study is given of the involvement of Charles Brittlebank and the FNCV in the elucidation of the Bacchus Marsh glacial sediments. This paper provides detail of notable geological contributors to the FNCV such as TS Hall, Frederick Chapman, ED Gill, Tom Hart, Alf Baker, Jack Douglas, Neil Archbold and Noel Schleiger; it finishes with a description of recent activities of the group under the leadership of Rob Hamson. (*The Victorian Naturalist* **123** (2), 2006, 100-111)

Introduction

Geology as an area of study and recreation has been an integral part of the Field Naturalists Club of Victoria (FNCV)'s history since its foundation in 1880, although a separate geology group was not formed until 1946. This paper was written for the Club's 125th Anniversary celebrations in 2005 and does not attempt to be exhaustive. Reviews of the history of the Club have periodically been published in *The Victorian Naturalist* at key anniversary dates, i.e. 25th (Barnard 1906), 40th (Barnard 1920), 50th (Barnard 1930), 60th (Pescott 1940), 70th (Coghill *et al* 1950) and 100th (Willis *et al* 1980).

Along with Jim Willis's general review of the Club for the Centenary celebrations (Willis 1980) there was a review of the Geology Group by Edmund Gill (1980). Information on past geological activities can be obtained from this review and from an earlier review by Neil (1950). Further information can also be gleaned from the general reviews mentioned above as well as from the collective pages of *The Victorian Naturalist* itself.

Origins of the FNCV

During the 1870s and 1880s there was a noticeable groundswell in the desire for new cultural institutions in the burgeoning Colony of Victoria. The obvious reason for this was that there had been an abrupt increase in population and prosperity as a result of the gold rush of the 1850s. Victoria was flooded with people from Europe and Asia. As the population grew so did the people's demand for services, infrastructure and institutions similar to those available in their countries of origin. By the 1870s and 1880s income per capita in Victoria was one of the highest in the world. It was a period of great confidence and optimism, and of considerable vitality and innovation. Most of the new organisations were modelled on familiar existing British institutions.

In Victoria in the 1850s these developments initially led to the establishment of a range of societies across the intellectual spectrum. Some were more enduring than others. Scientific societies were formed, such as the Philosophical Society of Victoria and the Victorian Institute for the

Advancement of Science, both founded in 1854. In 1855 these two societies merged to form the Philosophical Institute of Victoria, which in turn became the Royal Society of Victoria in 1859. The Royal Society provided an intellectual forum for many of the early naturalists. Papers were presented and published, issues were debated, expeditions were organised, and specimens collected and exhibited. A specialist Geological Society of Victoria was established in October 1852 but had an ephemeral existence and had ceased functioning by the end of 1853.

By the 1880s the early pioneering exploration period was mostly over. Large areas of the continent had been traversed and a period of more intense examination of the geography and natural history had begun. Already a substantial body of scientific knowledge had accumulated and many natural history specimens had been collected. For those interested in natural history Victoria proved to be a fertile field for study and yielded much that was novel and fascinating. The early collections of William Blandowsky formed the basis for the founding of the National Museum of Victoria (precursor to the current Melbourne Museum) which was then rapidly developed under Frederick McCoy. As residential development proceeded and agriculture and mining was established, gross environmental changes were becoming evident. A desire to participate in studying, observing, collecting, and preserving Victoria's natural heritage were some of the motivations for forming a field naturalists club.

Some naturalists were of the opinion that what was needed was a more popular, accessible and sociable forum than that provided by the Royal Society of Victoria, which was perceived by them to be exclusive and formal, and which, at least at the organizational level, tended to be populated by professional scientists and academics. (Although, in principle, unlike the Royal Society of London, membership of the Royal Society of Victoria was open to all). It was against this background and the pervasive nineteenth century enthusiasm for natural history that the Field Naturalists' Club of Victoria came into being in May–June 1880. The new Club fulfilled a definite need and attracted a substantial membership and has since provided a base for the amateur naturalist over the last 125 years.

From its inception the range of interests and activities in the FNCV has been very broad, covering a wide variety of natural history topics such as botany, zoology, geology and their various sub-disciplines. In addition, there has been a sustained interest in conservation of natural resources. From the Club's beginnings to the present day geology has always been regarded as an important area of study.

Geological activities in the early days of the FNCV

With Frederick McCoy as the first President of the FNCV it would have been expected that geology and palaeontology would have had some priority in the Club's activities. McCoy was Professor of Natural Science at the University of Melbourne and lectured in geology and related subjects such as palaeontology, mineralogy and chemistry, and also in zoology, comparative anatomy and botany. He was also Government Palaeontologist and Director of the National Museum of Victoria. He served as President of the FNCV for three years from 1880 to 1883.

However, McCoy's direct influence on the Club's activities was not nearly as significant as one would have expected (Houghton 2001). McCoy was largely a figurehead for the Club and was happy to give his support and patronage but did not regularly attend any of the meetings or excursions, and appears to have had minimal input into the Club's activities. The only exception to this was his Presidential address at the Annual Conversazione. In his first Presidential Address (McCoy 1881) he argued that there needed to be more emphasis put on geological field work. He stated: 'It has been remarked that Geology had not had its fair share of attention from the members of the Club in their excursions, and yet there is a great deal of interesting geological observation and collecting to be done in the vicinity of the city, or within moderate excursion distance by rail, coach or steamer.'

McCoy went on to detail a number of geological formations and rocks within easy reach of the city, including Tertiary and Silurian sedimentary rocks at Royal Park, Tertiary rocks at Flemington, Mornington and Geelong, 'a red flaggy bed full of beautifully preserved leaves … near Bacchus Marsh', volcanic rocks such as basalt at Richmond and the Keilor Plains, and gem minerals in the Dandenong ranges. He concluded that: 'In fact the hands of geologists need be no more idle that those of other members of the Club, who certainly have hitherto left Satan but little for his mischief-making endeavours with such materials.' McCoy was quite correct, of course: Melbourne and surrounding districts contain some of the most interesting and diverse geological phenomena to be found anywhere (although whether this providential situation was because of the 'Creator's' beneficence and grace and personal concern for the progress of the FNCV and its members' as McCoy was suggesting is altogether another question).

It is noteworthy that there was a feeling by some members that geology had a lower priority than they would have regarded as ideal. An examination of the history of the FNCV over its 125 years indicates that botany and zoology have received much more attention than geology. This is perhaps reflected in the contributions of its early patrons, Frederick McCoy and Ferdinand von Mueller. Whereas McCoy published nothing of his palaeontological or geological work in the Club's journal *The Victorian Naturalist*, Mueller by contrast was an active and prolific contributor in his discipline of botany. With a mining and building boom in full swing and the creation of numerous quarries and excavations, the relative dearth of geological papers in the pages of the FNCV journal requires some explanation.

Competing forums

It is clear that there were several competing alternative forums for local geologists and geological enthusiasts to join and interact in and to discuss and to publish their work. The Royal Society of Victoria, in particular, appears to have been the preferred local venue for geologists, and many academic and professional geologists were ordinary members, council members and presidents. Another competing but also complementary forum was The Australasian Association for the Advance-ment of Science (AAAS, later ANZAAS) which began in 1888 and allowed access to serious amateurs as well as professional geologists. The AAAS conferences included a Geology and Mineralogy Section, and periodically specialist geology committees were set up.

In 1885 a Geological Society of Australasia was founded by Robert Litton (Branagan 1976). Litton initially intended it to be an amateur geological equivalent to the FNCV. Despite its more ambitious name it was essentially a Melbourne based organisation and therefore a direct competitor with the FNCV (Finney 1993). However, over time the Geological Society of Australasia evolved to attract the more career-oriented geologists such as James Stirling, Government Geologist of Victoria, Ralph Tate, Professor of Natural Science at the University of Adelaide, and TW Edgeworth David, Professor of Geology at the University of Sydney. On the one hand this tended to divert valuable potential professional members away from the FNCV, but on the other hand had little effect on the true amateurs who were more at home in the FNCV. The Geological Society of Australasia, while influential in its day, ceased functioning about 1907.

A Parting of the ways

To some extent the 1880s and 1890s in Australian science represented what Allen (1994: 158-174) referred to as 'a parting of the ways' between amateur and professional science. It was as discernible in the field of geology as in other natural history domains. This split was deepened with the establishment of specialist professional societies. One such geologically related professional body founded at this time was the Australasian Institute of Mining Engineers, which was established in 1893 in Adelaide, later named the Australasian Institute of Mining and Metallurgy (AusIMM). There were also the various Mining Departments and Geological Survey Organizations in each state. Professional geology in Australia in the late nineteenth century had come of age. There were a number of professional associations catering for the career geologist. The demarcation between amateur and professional, which was far less evident prior to the 1880s, was now quite marked. Professional geologists and palaeontologists such as Frederick McCoy were now numerically in the minority in field naturalists clubs but their contributions were invaluable and always greatly appreciated by the membership (as they still are today). While naturalists with a geological bent did have the choice of a variety of appropriate clubs and organisations to choose from, often the only convenient option was the FNCV or a local field naturalist's club. The natural home of the amateur geologist was the FNCV alongside a now reduced number of semi-professional and professional career geologists. It has been this mix of amateurs and empathetic like-minded professionals, and the social interactions between them, that has provided the Club and its members with a high degree of competence, knowledge, creativity and energy. One aspect of this interaction is the invitation to the professional geologist to speak on a particular topic in which that person has expertise, to publish papers and to lead excursions. Likewise the competent amateur or semi-professional is able to carry out similar tasks depending on their particular proficiency.

The following case-study of Charles Brittlebank (Fig. 1) and the Bacchus Marsh glacial sediments gives one illustration of how this interaction between amateurs and professionals can work.

Charles Brittlebank and the Bacchus Marsh glacial sediments

Charles Clifton Brittlebank (1862-1945) (Fig. 1) was an early member of the FNCV and 'to his confrères, and earlier members of the Field Naturalists' Club, he was considered one of the most versatile and knowledgeable men of science...' (Pescott 1946: 189). Brittlebank was born in Winster, Derbyshire, and with his parents and brother the family migrated to Australia, first to Queensland, then Tasmania, subsequently settling in Victoria at Springvale and finally on a dairy farm in the Pentland Hills near Bacchus Marsh in 1893.

Fig. 1. Charles Brittlebank. *The Victorian Naturalist*, vol. 62, p. 189.

From childhood Brittlebank had a deep and abiding interest in natural history. Initially his focus was on geology and ornithology but later his interests broadened to encompass entomology, botany and plant pathology. In 1913 he was appointed Government Plant Pathologist. He was also a gifted natural history artist and illustrated many texts and papers including Charles French's *Destructive Insects of Victoria* and AJ Campbell's *Nests and Eggs of Australian Birds*. In addition to his other duties he lectured on plant pathology at the School of Horticulture at Burnley and at the School of Agriculture at the University of Melbourne. In 1924 he became Biologist in charge of the Science Branch of the Department of Agriculture, retiring in 1928.

Field trips and excursions have always been a fundamental activity of the FNCV. One of the early field trips in which Brittlebank acted as the local guide is particularly notable (see below). It will be quoted in some detail because apart from its relevant content for this case study it illustrates a typical FNCV (geology) excursion in the late nineteenth century. The excursion was led by AJ Campbell with George Sweet as geological commentator. Following is Campbell's report from *The Victorian Naturalist* (Vol. 8, November 1891, pp. 99-100).

The Werribee Gorge Excursion

3rd October, 1891

For this most interesting locality only five members put in an appearance at the *rendezvous*. If that small number represents the vitality of a club with some 200 members – well, perhaps, the least said about it the better. At all events, 14 or 15 names were handed in for the excursion, which warranted the co-leaders in ordering breakfast beforehand, at Bacchus Marsh, for at least a dozen. You should have seen the faces of the landlady and her dutiful daughters when only 5 put in an appearance! Then it was fun to witness some of the coach horses whipped home in disgust. Two extra conveyances were brought in seven or eight miles in anticipation of the names furnished, and had to return empty. Moreover, the good mother of one of our co-leaders, at Myrniong, had prepared a sumptuous evening repast for the full number of 15 – a fitting termination for the day's work – but only the 5 beforementioned, *plus* 3 local members, turned up; and be it said to their credit, well did they endeavour to do justice for the 15. Now, all this is very disappointing of course for those members who remained at home. However, some sent written excuses on account of sickness probably the remainder were delayed through the *appearance* of rain. Surely their ardour is easily damped. Rain did fall on the Friday evening, and such refreshing rain that the local farmers said they would have rather seen the much-needed moisture than a whole cloud of naturalists. As it was the Saturday turned out most delightfully fine, one slight shower only fell about 4 o'clock, therefore none of the party got wet except one member, who fell into the river.

The five members who left town were Messrs. De Le Souëf, G. Sweet, J. Ashworth, A. J. Campbell, and E. H. Hennell, who were joined at Myrniong by three local members, Messrs. C. and T. Brittlebank and J. Lidgett. The gorge was entered about 11 o'clock, and by late in the afternoon its whole length was traversed and some tributary gullies explored. The scramble among such romantic surroundings was fully enjoyed by the party, with the varying scenes of native grandeur opening up at every bend. Here was a cliff of slate rock 200 feet high, with a miniature cascade at its foot; there, blocking up and turning the river's course a pyramidal crowned hill about 400 feet in height, where trees and scrub cling on amongst their rocky environments. And so on till the greatest elevation – 600 feet – is attained above the river's bed, forming a singularly beautiful vista, the steep hill side being fairly clothed with timber and capped with a pile of naked rocks, now known as the Falcon's Lookout.

Some photographs were taken with excellent effect, especially of the scene last mentioned, also pictures were taken of an eagle's aerie, a nesting tree of the Boobook Owl, and the nest *in situ* of a Sericornis cunningly cleft in a mossy bank. But it was observed by those who had visited the locality before that the destructive flood of last August had wrought great havoc with some of the most beauteous portions of the gorge, especially near the river. Some of the scenes depicted at the Club's last *conversazione* have been entirely obliterated. Judging by the former great flood (1863) it will be nearly 30 years before the river banks will be so beautifully margined with stately trees and shrubs. That is, of course, provided no other destroying flood occurs in the interim.

Birds were scarce compared with those observed by a contingent of Mr. Keartland's Melton excursion that visited the Werribee Gorge exactly this time last season. Six or seven species of orchids were noticed flowering. About the same number of ferns were seen. Many of the ironbarks and box-trees were in bloom; while the river's banks were adorned with several showy shrubs in flower.

Some instructive geological notes bearing upon the locality, and remarks upon impressions of leaves and fruits, will be probably offered by Mr Sweet on another occasion.

A. J. C.

In the report of the ordinary monthly meeting of the Club held in the Royal Society's Hall on 14th December (*The Victorian Naturalist* January 1892: 132) under the heading 'Exhibition of Specimens' it was noted, as follows, that some pebbles were exhibited by George Sweet:

By Mr. G. Sweet. – Pebbles, probably glaciated, from Myrniong.

This fleeting reference and the similarly brief one at the end of the Werribee Gorge excursion report (above) would hardly alert the naive reader that something of great importance had been found and furthermore that its significance had been fully appreciated by the parties involved. However, this is the essence of the claim later made by Brittlebank upon the publication of a paper in the *Proceedings of the Royal Society of Victoria* by two of Frederick McCoy's students at Melbourne University, Graham Officer and Lewis Balfour.

Officer and Balfour's paper titled 'Preliminary Account of the Glacial Deposits of Bacchus Marsh' was read before the Royal Society on 14 July 1892 and published in the Society's *Proceedings* of 1893. Officer and Balfour first visited the Bacchus Marsh district in June 1892 and prior to their second visit made contact with Charles Brittlebank. In the paper they acknowledged help given to them in their researches by Brittlebank as follows:

> Before making our next visit to the locality, we wrote to Mr. Charles Brittlebank, of Dunbar farm, near Myrniong who, we were led to believe, could give us information in our researches. Mr. Brittlebank readily responded, and during our subsequent visits has rendered us much valuable aid. He has accompanied us on most of our expeditions and shown us much hospitality, while his intimate knowledge of the locality, as well as his keen powers of observation have been of the greatest assistance to us. Mr. Brittlebank informs us that he found glaciated stones in this district four years ago. He thus appears to have been the first to actually prove the glacial origin of the deposits in question.

In fact, the claim that Brittlebank was the first to prove the glacial origin of certain rocks at Bacchus Marsh is not strictly correct. Even though he contributed a great deal to their elucidation and came to know them better than anyone else, there were others who preceded him in suggesting and demonstrating that they were glacial in origin (see Archbold 1998).

Previous workers on the Bacchus Marsh glacials

Alfred Selwyn (1861) was the first to speculate that the Bacchus Marsh sediments were 'very suggestive of the results likely to be produced by marine glacial transport' although he also noted that 'grooved or ice-scratched pebbles or rock fragments' had 'not yet been observed'. However, at the time there was a major international debate on the validity of claims about the glacial origin of some fairly recent (Pleistocene) rocks. After several decades of debate a consensus was emerging and the concept of an 'Ice age' was only just becoming accepted by northern hemisphere geologists. The rocks in question at Bacchus Marsh were known to be much older, perhaps as much as 200 to 300 million years or more. To suggest that there had been another earlier Ice age several hundred million years before the recently accepted Pleistocene one seemed to be stretching credibility.

Richard Daintree (1866: 11) reported that from 'mud-pebble beds, on the Lerderderg River' he had 'found a few pebbles grooved in the manner I have read of as caused by glacial action'. In 1889 EJ Dunn visited the Bacchus Marsh area and stated unequivocally that 'the forms of the included materials and the striatures and grooves on their surfaces prove that this conglomerate is of glacial origin' (Dunn. 1889: 81; *see also* Archbold 1998). Similarly, WH Ferguson (1891:32) reported on the 'glacial conglomerate' and stones that were 'striated, the result of ancient glacial action'. All of these reports were essentially internal reports with limited circulation, and seemed to have been somewhat overlooked by contemporary and later commentators. However, Officer and Balfour's paper published in the *Proceedings of the Royal Society of Victoria* did receive wide circulation, and despite the authors giving what they thought at the time was due and ample acknowledgement to Brittlebank for his assistance (see above) Brittlebank reacted critically and forcefully to their publication.

Priority Dispute

At the Adelaide meeting of the Australasian Association for the Advancement of Science, held in September 1893, George Sweet presented a paper titled 'Glacial Deposits of Bacchus Marsh' which was highly critical of Officer and Balfour's work. The paper implied that Officer and Balfour had intruded into an area of their own (i.e. Brittlebank and Sweet's) research and had published carelessly and with undue haste. Sweet claimed that ever since the Field Naturalists excursion to Werribee Gorge in October 1891, when he and Brittlebank first met, they had intended publishing their work.

> We then commenced and have since continued working together, with the intention of making the results of our investigations known at as early a date as possible, and as much was hinted at by the leader of the excursion above referred to in his report to the Field Naturalists' Club. We soon found, however, that the subject and the locality were such that they could not be fairly dealt with in a hurry, and we concluded that it was better to delay publication than give utterance before we had digested all the more relevant facts. However, we communicated to such fellow workers as we came in contact with the results of our work: for instance, to Professor R. Tate, in January, 1892, and one of us exhibited several of the striated pebbles at the Field Naturalists' meeting in the same month (Sweet and Brittlebank 1894: 376-377).

Officer and Balfour, who were absent from the Adelaide AAAS conference and clearly staggered by the criticism, were later able to defend themselves at the next AAAS conference in 1895. They were adamant that when they first visited Bacchus Marsh,

> we had not the slightest idea that anyone else was working in the same field, the latest reference to the glacial beds that we knew of being that of Mr. Dunn. Subsequently on our second visit we were introduced to Mr. Brittlebank, and learned for the first time that Mr. Sweet had been in the district before us. Neither of us were acquainted with Mr. Sweet; and Mr. Brittlebank, though we informed him of the object of our visit, never gave us the slightest hint that they were working together with a view to publishing the results of their observations. (Officer and Balfour 1896: 322).

Despite the pleading by Officer and Balfour that they were innocent of the charge of deliberately 'trespassing on a prior claim' and that Brittlebank 'had given us no intimation of any desire to publish anything on the subject' (Officer and Balfour 1896: 323), Brittlebank and Sweet would have none of it. At the 1898 Sydney AAAS meeting they stated bluntly that 'they have to take exception to some remarks made by Messrs. Officer and Balfour, at the Brisbane meeting of the Association.' and that they 'would point out that the statements made by them [Brittlebank and Sweet] at the Adelaide meeting are true in substance and in fact.' (Brittlebank *et al* 1899: 365).

International acceptance of a late Palaeozoic ice age

Brittlebank and Sweet's claims of priority were all but sanctified when they gained support for their work from Professor Edgeworth David, whose Presidential Address at the 1895 Brisbane AAAS conference was on glacial action in Australia. David put his name to the paper quoted above (Brittlebank *et al* 1899) in which Officer and Balfour were criticised. David's presentation on the Late Palaeozoic Australian glaciation to the Geological Society of London and the corresponding publication in the Society's Journal in 1896 signifies the general acceptance by the geological community of a vast Southern Hemisphere glaciation. As noted by David Branagan (1999: 333), JE Marr in his Presidential Address to the British Association in 1896 stated unreservedly 'as a result of the masterly resume of Professor Edgeworth David the bulk of British geologists are prepared to admit that there has been more than one glacial period, and that the evidence of glacial conditions in the southern hemisphere in Permo-Caboniferous times is established.'

By the late 1890s the Bacchus Marsh glacial sediments were receiving world attention, and Brittlebank and Sweet were now recognised as having produced the first material evidence for this (e.g. see Pritchard 1914). Contributors such as Daintree, Dunn, Ferguson and Officer and Balfour were generally overlooked. Brittlebank, who was essentially an amateur geologist, because of his assertiveness had succeeded in gaining credit for his contribution over more qualified professional geologists.

This case study highlights one of the strengths of field naturalists clubs in that an amateur naturalist can make important contributions to knowledge at many different levels and receive international recognition.

Notable geological contributors to the FNCV

In a review as brief as this it is not possible to give adequate credit to the legion of geological contributors to the FNCV. Many individual amateur and professional geologists have contributed in a variety of ways, for example, by organising and leading excursions, giving talks, writing papers, collecting, identifying and displaying specimens, preparing newsletters, sharing their experience and knowledge and encouraging others, or simply attending meetings. Some of these individuals have been identified in previous surveys (e.g. Gill 1980). Following are some brief comments on a selection of some of these outstanding figures.

Alfred William Howitt

Like Frederick McCoy, already mentioned, AW Howitt (1830-1908) achieved international recognition for his multi-disciplinary contributions to natural history. In Howitt's case his considerable talents spanned three major disciplines: geology, botany and anthropology. He was also a skilled bushman and in 1861 rescued John King of the Victorian Exploring Expedition (Burke and Wills expedition). Several months later he returned to Cooper's Creek on a second mission and collected the remains of Burke and Wills and carried them back to Melbourne for burial. Much of his early scientific work was done in virtual isolation when he was Police Magistrate and Warden of the Goldfields in Gippsland. The region that he supervised stretched all the way from Wilson's Promontory to Cape Howe. Each year he travelled thousands of miles on horseback and in the course of his normal duties made extensive geological and botanical observations. He published six papers in *The Victorian Naturalist* (however, only one was on geology).

James Stirling

Another notable geologist who lived and worked in Gippsland was James Stirling (1852-1909). He succeeded RAF Murray as Government Geologist in 1897. Stirling was responsible for the opening up of the black coal deposits in the Wonthaggi district and also reported on the Gippsland brown coal. Like many naturalists of his day he was proficient in several fields of natural history. He published just one article in *The Victorian Naturalist* (on botany) titled 'Notes on the Flora of Mount Hotham'.

Thomas Sergeant Hall

TS Hall (1858-1915) (Fig. 2) was born in Geelong and was a student at Melbourne University under both Frederick McCoy and Baldwin Spencer. He taught at Girton College in Bendigo, was director of the Castlemaine School of Mines, lectured in biology at The University of Melbourne, and later with GB Pritchard filled in for McCoy during his illness until the arrival of JW Gregory. One of the most capable palaeontologists ever to work in Victoria, his success in unravelling the local Ordovician graptolites sequence and his labours on Tertiary stratigraphy led to international recognition. Active in a number of forums including the Royal Society of Victoria and the AAAS, Hall joined the FNCV in 1888 and was President from 1901 to 1903. He was the first major geologist to fully dedicate himself to promoting the FNCV, publishing some 40 articles on a range of topics in *The Victorian Naturalist*. In 1909 he published the popular book *Victorian Hill and Dale*.

Fig. 2. Thomas Sergeant Hall. *The Victorian Naturalist*. vol. 32. p. 129.

George Baxter Pritchard

GB Pritchard (1869-1956) was a student of Frederick McCoy and collaborator with TS Hall on the stratigraphy of the Victorian

Tertiary. He worked briefly with Ralph Tate at the University of Adelaide before becoming a lecturer in metallurgy and assaying at the Working Man's College (later RMIT). His broad palaeontological concerns included a special interest in molluscs. He also collaborated with JH Gatliff on living molluscs. Prichard was an active member of the FNCV and published a number of short papers and excursion reports in *The Victorian Naturalist*. In 1910 he published *The Geology of Melbourne*.

John Dennant

An early contributor, John Dennant was a school inspector at Hamilton, and in collaboration with Ralph Tate worked on the rich deposits of Tertiary fossils at Muddy Creek and Grange Burn (west of Hamilton), in particular on bivalve molluscs and corals. Beginning in 1885 he published a significant serial article on the geology of south-west Victoria in *The Victorian Naturalist*.

Albert Ernest Kitson

One of the most distinguished early members was AE Kitson (1868-1937), who spent many years as a 'fifth class' clerk in the Victorian Public Service, first at the General Post Office, then the Lands Department and finally at the Geological Survey. He took a keen interest in geology, and while working in the Public Service pursued part-time studies in geology and mining. During this period he published a number of articles on a variety of topics in *The Victorian Naturalist*. In 1906 he was appointed head of the mineral survey of the Nigerian coast, and in 1915 became Director of the Gold Coast Geological Survey. He also helped set up the Geological Survey of Kenya. He was knighted in 1927.

Edmund Oswald Teale (aka **Thiele)**

EO Teale (1874-1971) followed a nearly parallel career path to that of AE Kitson in that he was also an employee of the Geological Survey of Victoria who gained a post in Africa. He served as Director of the Geological Survey of Tanganyika and as a mining consultant to the Tanganyika government from 1926 to 1940. Also like Kitson, he was a member of the FNCV and published a series of brief notes in *The Victorian Naturalist*.

Frederick Chapman

One of the most prolific geological contributors to the FNCV was Frederick Chapman (1864-1943) who published some 108 papers in *The Victorian Naturalist*. He was a world authority on the foraminifera. Chapman has sometimes attracted criticism for the accuracy of his work, but in his defence, as the first specialist palaeontologist at the National Museum he had the almost impossible job of describing fossils in the large collections of the Geological Survey of Victoria and at the University of Melbourne, which were transferred to the Museum. In 1927 he was appointed to an equally demanding job of the first Commonwealth palaeontologist.

Irene Crespin

Assistant to Frederick Chapman, and later his successor as Commonwealth palaeontologist, Irene Crespin (1896-1980) was also an expert in the foraminifera. She published just one article in *The Victorian Naturalist*, a report on an excursion to Green Gully.

Thomas Steven Hart

Teacher and lecturer in various Victorian schools and Professor of Geology at the Ballarat School of Mines, TS Hart (1871-1960) contributed 51 articles and excursion reports to *The Victorian Naturalist*, mainly on geology and botany. Hart had an extraordinarily broad encyclopaedic grasp of general knowledge and natural history. He was a lifelong contributor to the FNCV.

Daniel James Mahony

Links between the FNCV and the Melbourne Museum (formerly National Museum) have always been strong. DJ Mahoney (1878-1944), who studied geology under JW Gregory and EW Skeats, wrote several articles for *The Victorian Naturalist* in his younger days, and in 1931 became director of the Museum. He encouraged cooperation between the museum staff and amateur naturalists and established a policy of using honorary staff to assist the museum curators in their work.

Edmund Dwen Gill

The museum connection was further enhanced when ED Gill (1908-1986) became Curator of Fossils at the National

Museum and eventually Deputy Director. He was a dedicated supporter of the FNCV, contributing over 70 articles on a variety of geological and palaeontological topics to *The Victorian Naturalist*.

Alfred A Baker

In 1946 three specialist discussion groups were established, one of which was the Geology Group led by AA Baker. He remained secretary of the Geology Group for many years and was FNCV President 1953-1955. Baker contributed 16 articles to *The Victorian Naturalist*. The Geology Group has remained a viable active group for most of the time since its foundation as a specialist group.

John [Jack] Gordon Douglas

A long-time member and president of the FNCV 1986-1988, geologist and palaeobotanist Jack Douglas (b. 1929) has been a generous contributor to the Geology Group. His book *What fossil plant is that?* (Douglas 1983) has been a handy reference. In 1992 when the FNCV as a whole experienced some difficulties, and the Geology Group briefly ceased regular meetings, Jack Douglas agreed to act as chairman and from that time the group has generally functioned very well.

Neil Wilfred Archbold

Over the years the Geology Group has been assisted by a number of eminent professional geologists and palaeontologists. Neil Archbold (1950-2005) originally taught regular CAE courses in geology, which inspired several members to take up an interest in geology and fossils and join the FNCV. A noted brachiopod expert, he also made contributions to the history of geology and palaeontology. As Professor of Palaeontology at Deakin University he gave frequent talks, led excursions and was a steadfast supporter of the Geology Group, encouraging postgraduate students to participate in meetings and publish in *The Victorian Naturalist*.

Noel William Schleiger

One of the most committed FNCV members since joining in the late 1980s, Noel Schleiger (b. 1926) has been a major contributor to Geology Group activities. He has lectured, led excursions, published articles on geological topics and injected enthusiasm and energy into the group. His book *Roadside Geology: Melbourne to Ballarat* (Schleiger 1995), in particular, is an attractive and useful guide.

Other Contributions

Many other professional and distinguished amateur geological contributors could have (and should have) been mentioned. Lack of space and in a few cases lack of information prevents further detailed descriptions. Some of the earlier figures who made geological contributions to varying degrees include RW Armytage, W Baragwanath, FS Colliver, AW Cresswell, CJ Gabriel, JH Gatliff, HJ Grayson, JT Jutson, RA Keble, SR Mitchell, WJ Parr, AL Scott. No doubt there are many others worthy of mention who have been overlooked.

Recent contributions have been made by many professional geologists such as Ken Bell, Bill Birch, Eric Bird, Phil Bock, Dermot Henry, Bruce Hobbs, Julian Hollis, Bernie Joyce, Graham Love, Roger Pierson, Ian Plimer, Stan Rowe and Alan White. Considerable contributions also have been made by many serious amateurs such as Lyn Ansell, Clem Earp, Rob Hamson, Doug Harper, Frank Holmes, Dan McInnes, Ray Power and John Stewart.

The Geology Group since its sormation in 1946

Except for a few brief vacant periods in the 1990s, the Geology Group has been fortunate to have had a number of dedicated long-serving Group Secretaries, beginning in 1946 with Alf Baker who headed the group until around 1960. He was followed by RR Dodds (1960-1965), R Box (1966-1967), Tom Sault (1968-1983) and Helen Bartoszewicz (1984-1991).

Numbers were boosted when in the early 1990s the Adult Education Association (AEA) Geology Group ceased operating and most of the members transferred to the FNCV. Members such as John Spencer and Noel Brown have regularly attended the FNCV Geology Group meetings since that time.

In the early 1990s the FNCV suffered some organizational and accommodation problems and the Geology Group briefly ceased having regular meetings. Following that short interruption there was a return to business as usual and meetings were resumed with the support of Jack Douglas. Graham Love took over as Secretary in 1992, followed by Karina Bader (1993-1994) then Doug Harper (1994-1998).

Recent Progress

In 1998 there was another brief break in the succession. A committee was formed, assisted by Clem Earp, and since 1998 a stable period has ensued with Rob Hamson as Secretary. Attendances over recent years have been very healthy, averaging between 25 to 30 persons per meeting. The frequency of geological excursions, which declined markedly in the early 1990s, now averages about six per year, a comfortable number. Rob Hamson has been an extremely able and diligent organiser and the Group has prospered under his stewardship.

In February 2005 a Committee was established to assist with the running of the Group. The five members elected were Rob Hamson, Noel Schleiger, Ray Power, Clem Earp and Lyn Ansell.

The quality of the monthly presentations has been excellent, as can be seen from the reports in the *Field Nats News*. All of this is good news for the present and bodes well for the future. Although there is a lack of teaching of geology in schools at present, members of the public can still come along and join an accessible and friendly community-based group and share in the 'geological experience'.

Acknowledgements

I would like to thank Neil Archbold, Roger Pierson, Noel Schleiger, Rob Hamson and John Spencer for supplying relevant references and documents and for their helpful comments and constructive criticisms.

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Ellen Margery McCulloch OAM

23 April 1930 - 13 November 2005

Ellen Margery McCulloch (née O'Neill) who died on 13 November 2005, aged 75, was born on 23 April 1930. She was awarded the Australian Natural History Medallion in 1990, in recognition of her dedicated and tireless efforts for conservation of the environment, relating particularly to birds – a well-deserved reward.

Ellen's interest in birds commenced during walks to and from school in Kallista. It was an interest she never lost. Many years later, when she attended Jack Hyett's lectures at the Council of Adult Education (CAE), she realised that bird-watching, and all that it involved, was the recreation she most wanted to pursue. From then on she led a life of ceaseless activity. Despite having two small daughters, and home cares, she found time to involve herself more and more in the world of natural history. When she felt she was competent enough she also became a lecturer for the CAE. She also enjoyed cricket, music and spinning.

She joined Bird Observers Club of Australia (BOCA) in 1963 and held secretarial positions in that organisation for more than ten years. However, she really came into her own when she was appointed as the Club's Public Relations Officer. In this capacity she was responsible for setting up displays at shopping centres, nurseries and libraries. She also gave talks to schools, church groups and garden clubs. No opportunity was missed to further the cause of her beloved birds.

All of this was fitted in with her work as a twice-weekly volunteer in the Ornithology Department of the Museum of Victoria. She stayed there for sixteen years.

As a delegate for BOCA she attended meetings of the Department of Conservation, Forests and Lands. She was invited, as a lay person, to the Royal Melbourne Institute of Technology Experimental Ethics Committee, and chaired the Roadsides Conservation Committee.

During discussions between the Japanese and Australian governments, when they were putting into place a scheme to provide protection for migratory birds, Ellen was a non-governmental delegate, contributing her extensive and practical expertise. During the 1970s she was a BOCA representative at a series of lengthy discussions with the Victorian Fisheries and Wildlife Division. These led, in 1981, to the Land for Wildlife project. To be able to display the Land for Wildlife logo, interested property owners were required to fulfil certain requirements, such as providing habitat for birds and other wildlife. Today, thousands of property owners participate in this scheme, and of all Ellen's achievements this gave her the most pride.

She was responsible for many surveys on such species as Yellow-tailed Black Cockatoos, Pelicans and Bush Stone-curlews, and organised a team to monitor the dwindling Superb Fairy-wren population in the Royal Botanic Gardens.

She produced many leaflets on topical subjects in addition to writing numerous articles for a wide variety of publications. One leaflet, 'Australian Birds and the Law', was translated into nine languages. Her book, *Your Garden Birds* (1987) was followed by *Birds in Your Garden* (2000), an expanded and updated version of the earlier work.

She promoted bird feeders but when the trend veered away from inappropriate (e.g. human) food for birds, she publicised this fact. Instead she advised bird lovers always to provide drinking water – out of reach of cats.

An entry, 'Birds', appears above her name, posthumously, in the magnificent *Encyclopedia of Melbourne* (2005). She would have been proud.

She was honoured with a Life Membership of BOCA in 1985, the Australian Natural History Medallion in 1990, and in 1991 with a Medal of the Order of Australia, for 'services to ornithology'.

Ellen McCulloch OAM. Photo Gael Trusler

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One Hundred Years Ago

A tramp from Healesville to Buxton.
Botanical and Ornithological Notes for September.
By A.D. Hardy, F.L.S. and Mrs. Hardy.

...Leaving Narbethong and Fisher's Creek behind, we climbed the spur beyond. The third animal, other than birds, we saw here – a Wombat, *Phascolomys mitchelli*, Owen, standing with its legs deep in snow, and with the ends of a grass-like plant projecting from its mouth, being a very conspicuous object. It was far from any cover, and stood motionless, and apparently numbed with cold, until we stood within six feet of it. Our voices, however, caused it to beat a precipitous retreat down the steep hill-side, a shower of snow following as the weighed down bracken fronds were released and the stems acted like springs. Everywhere the stems of buried bracken fronds appeared like countless croquet hoops. We followed back the Wombat's tracks to ascertain what plant the animal had been eating, and found it to be *Xerotes longifolia*, of which the leaves had been pulled up, and the sweet, white, succulent parts near the root eaten. Here and there we found this Xerotes with the comparatively hard green leaves cropped off to the surface of the ground, the root parts being neglected.

From *The Victorian Naturalist*, **XXII**, p. 167, February 8, 1906

Neil Wilfred Archbold

14 August 1950 - 28 November 2005

It is with deep sadness that news of the death of Professor Neil Archbold has been received by members of the FNCV. It was only in May 2005 that Neil delivered the opening address at the Club's 125th Anniversary Symposium. He was a long-standing and committed supporter of the Club and encouraged others, including his students, to participate in Club activities. Professor Archbold was a palaeontologist of international standing. As well as being a leading fossil brachiopod specialist, taxonomist and biostratigrapher he was also a keen amateur field naturalist and had an interest in the history of geology and palaeontology.

It was not generally well known that as a child Neil suffered from a chronic life-threatening illness, and between the ages of eight and twelve underwent a long series of operations by distinguished wartime surgeon Sir Albert Coates, which saved his life. Over the years Neil periodically underwent further surgery but he always remained cheerful, alert, uncomplaining and optimistic. Consequently, despite periodic bouts of poor health in recent years, his death still came as a severe shock. Throughout his working life Neil had a remarkable ability to focus on his scientific research and pursue his academic interests no matter what his prevailing medical circumstances.

Neil's interests were many and diverse. He was a great collector. At an early age he began collecting all sorts or natural objects as well as stamps, coins and books. From about the age of eight he displayed a deep interest in natural history, especially the Lepidoptera. As well as butterflies and moths he also turned his attention to spiders, native birds, native animals and native plants generally, rocks, minerals, fossils, astronomy and later, to conservation issues, in particular the preservation of native fauna and flora and also geological heritage.

He followed his brother Jim in his devotion to natural history and to butterflies in particular. The family home was in Barkly

Neil with butterfly net at his family home in Mitcham c. late 1950s.

Terrace, Mitcham, and the local butterfly species collected included the Emperor Gum Moth (*Opodipthera eucalypti*), Wanderer or Monarch Butterfly (*Danaus plexippus)*, Orchard Swallowtail (*Papilio aegeus)*, Painted Lady (*Vanessa kershawi*) and the little brown Skippers (Hesperiidae). They collected the eggs and the caterpillars and bred them. Eventually the progeny were released. For several years they carried out banding of the Wanderer Butterfly. They noted population changes in years of abundance or scarcity. Neil and Jim took a strong interest in the accidental introduction of the European wasp, which had a negative impact on their beloved caterpillars, and they vigorously sought out wasp nests and destroyed them.

Neil Archbold at Deakin University c. mid 1990s.

Later Neil and his wide Linda cultivated a flourishing, mainly native, garden at their home in Doncaster East, featuring many drought-tolerant plants and a number of uncommon species such as araucarias and ginkgo. Neil grew specific plants to attract butterflies, such as stinging nettles (*Urtica*) to attract Painted Ladies, Swan plant (*Asclepias*) to attract Wanderers and *Buddleia* (for many species).

After completing his secondary school education at Camberwell Grammar School in Canterbury in 1969, Neil completed a BA (1973), MSc (1976) and PhD (1983) all at the University of Melbourne. His PhD was on Permian brachiopods in which he eventually became a recognised world authority. His supervisor was George Thomas, who had a special interest in Western Australian brachiopod faunas on which Neil did his original work and remained interested in throughout his career. This work expanded to include Late Palaeozoic biogeography and local and international stratigraphic correlations. For example, Neil published on stratigraphical relationships within Australia, such as between the Eastern and Western Australian provinces, as well as between the Australian faunas and those of other Gondwanan faunas, such as those in India, Timor, Irian Jaya and Thailand, and those even further afield, for example in Russia and Serbia.

Neil published more than 160 scientific papers. Of these he was sole author of 76 papers but he was also a great collaborator, publishing some 85 papers with 40 or so co-researchers from more than 20 institutions around the globe. The topics ranged from the taxonomy of brachiopods to palaeogeography, palaebiogeography, palaeoclimatology, palaeoecology, ocean circulation patterns, global stratigraphy and the history of geology and palaeontology.

His taxonomic output was impressive, describing more than 150 new species, nearly 40 new genera or subgenera, five new subfamilies and one new family of brachiopods as well as a new species of bivalve and a new genus and species of trilobite.

The Permian glacially-derived sediments of the Bacchus Marsh district held a special interest for Neil and he frequently conducted field trips with his students to this area. He was particularly interested in elucidating the palaeontological and geological details of what appeared to be a brief marine incursion in the area. He was pleased when he and his colleagues discovered that the marine incursion was far more extensive than had been previously believed despite 150 years of prior intermittent investigation.

Neil's academic career began in 1973 at the University of Melbourne where he was employed firstly as a part-time tutor (1973-1980) and then full-time tutor (1980-1982) in the Geology Department. He also tutored for many years (1973-1989) for the Council of Adult Education where he inspired many students to take up an interest in geology and palaeontology. A number of his mature-age students became active members of the Geology Group of the FNCV. He taught at a number of institutions until, in 1989, he became a full-time lecturer at Rusden campus of Victoria College (which was incorporated into Deakin University in 1992). He then underwent a rapid series of promotions, becoming Professor (personal chair) in

1996. From 1985 onwards he received 15 research grants from the Australian Research Council. He raised the status of the geology section at Deakin University from relative obscurity to one of national and international significance.

He was an encouraging and much appreciated tutor, lecturer and postgraduate supervisor. His own research received wide recognition and he established productive linkages with scientists both at home and abroad. He had a strong commitment to international cooperative research and the development of science in countries such as Russia, China, India, Argentina and Timor. He was a member of numerous scientific and academic societies and served on many local and international committees.

Perhaps his most treasured institutional contribution was to the Royal Society of Victoria where he served as honorary librarian for many years. He joined the RSV in 1975 and became a member of Council (1992-2005), Vice- President (1999-2000) and President (2001-2004). His work as custodian of the Society's valuable library and in finding it a permanent home was decisive to its preservation. He helped broaden the Society's appeal to the general public and defended and promoted the Society's traditional scientific emphasis. His legacy is a vital, active Society with a growing membership, in comparison with some similar institutions that at present are struggling for relevance and viability.

Universally regarded as a gentleman, Neil was admired and loved by his colleagues. He was an inspirational scientist, intellectual and teacher. His wisdom, insight, humour, gentleness and fortitude will be deeply missed. His untimely passing at the peak of his career is a grievous loss to science and natural history.

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Survival of a blind Bobuck *Trichosurus cunninghami*, Phalangeridae

The Bobuck or Mountain Brushtail Possum *Trichosurus cunninghami* is a large (2.6-4.2 kg), semi-arboreal, nocturnal marsupial which dens in tree hollows or, less often, hollow logs, disused Common Wombat *Vombatus ursinus* burrows or thickets on the ground. Its predominant food is foliage of Silver Wattle *Acacia dealbata*, and it spends most of its active time on the ground, moving between wattle trees and feeding on additional items including fungi and various understorey and ground-layer plants. General accounts of the Bobuck are provided by Menkhorst (1995, as *T. caninus*) and Kerle (2001, as *T. caninus*); Bobucks in the Strathbogie Ranges, in Victoria, have been intensively studied by Martin (2005; see also Martin *et al.* 2004).

On 16 October 2005, two of the authors (AAM, SMM) encountered an adult female Bobuck on the ground at Marraweeny (36° 44'S, 145° 45'E) in the Strathbogie Ranges, at 1705 hours on a warm, sunny day. She was in a grassy, creek-side area with fern-thickets and scattered Silver Wattles, moving towards the adjacent Peppermint (*Eucalyptus radiata* and *E. dives*) forest. The forest had been logged and included few hollow-bearing trees, but there were numerous used and disused Common Wombat burrows in the area. She was carrying a large back-young; both animals appeared to be well-fed and in excellent condition. In this area young are born in autumn or early winter and leave the pouch to travel on the back at about 6 months of age; hence this individual would have been 7-8 months old.

When binoculars were trained on the animals it was seen that the corneas of both eyes of the female were bluish-white and opaque (Fig. 1), although the eyes of the back-young appeared normal. There can be no doubt that she was completely blind; nevertheless, she climbed without hesitation on to a fallen tree-trunk and moved confidently along it.

Attention was first drawn to the animals by the barking of a dog. We do not believe that the female had been foraging; but think it likely that she had denned in a ground-level, creek-side thicket and was stirred from it by the dog. Although the dog did not continue to harass or pursue her, she did not forage or move from the log over the subsequent 10 minutes for which she was under observation.

On 13 January 2006, at 0625 hours (first light 0544; sunrise 0614), in clear, bright conditions, one of us (AAM) observed a blind Bobuck (doubtless the same animal) within 30 m of the previous sighting. On this occasion she climbed a Silver Wattle sapling about 2.5 m tall, and fed for about 5 minutes on foliage in its crown. She again appeared to be in good condition, but no back-young was present.

It is remarkable, in an area where dogs, foxes and feral cats are frequently seen and heard, that a blind animal should have survived at all, let alone coped with the hazards of diurnal foraging on the ground. There is direct evidence of foxes, at least, preying on Bobucks in this area (Martin 2005). There is no way of knowing how often this blind female Bobuck has foraged by day, nor for how long she has been blind. The fact that she has bred reveals that she was at least 3 years old in autumn 2005 (Martin 2005), but she may not have been blind for all of that time.

Back-young normally become independent of their mothers at about 12 months of age in this area; hence it is more likely that the back-young died (perhaps by falling victim to a predator) between October and January than that it achieved independence. It is also possible, however, that the young left its mother earlier than is usual if it was more reluctant than she was to be active in daylight.

Martin (2005) found that the home range area of adult Bobucks (male and female) in a forested area in the Strathbogies was 6.0 ± 0.4 ha (mean ± SE). The surprising survival of the blind female may, in part, be due to occupation of an atypically small home range. The presence of the permanent creek, the lush creek-side vegetation with dense thickets, the abundance of Silver Wattle and the availability of Common Wombat burrows may mean that she can find a number of refuges and other essential resources within a very small area which she has come to know intimately. Martin (2005) recorded female Bobuck home ranges as small as 1.1 ha in roadside habitat that contained abundant den-sites and food resources.

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The Gurdies Bobucks: how are they faring?

Readers of *The Victorian Naturalist* may recall that a previously unrecorded population of Bobucks *Trichosurus caninus* was reported from The Gurdies Flora and Fauna Reserve on Westernport Bay (Hynes and Cleeland 2005). In October and November 2005 a brief follow-up survey was carried out in The Gurdies and further south along the banks of the Bass River. Again, infrared-sensitive automatic cameras were used.

Although this second survey was far from exhaustive, it is now apparent that the Bobucks of The Gurdies are by no means confined to the Reserve itself. The cameras detected Bobucks at night on the ground in a creek bed approximately 100 m upstream from its confluence with the Bass River. Moreover, juvenile animals were photographed in the care of the female parent at both the Bass River site and within The Gurdies Reserve.

The fact that young are being detected indicates that the population is resident and not itinerant and that it is at least stable. Perhaps it is even expanding. It thus appears that Parks Victoria, the management organisation responsible for The Gurdies Flora and Fauna Reserve, succeeded in preserving a refuge for a reproductively viable subset of this unusual remnant Bobuck population.

Over a period of several months prior to October cameras were placed at various locations within the Reserve, but well away from the original 'Bobuck Creek' site. Animals such as Common Brushtail Possums, antechinus, rodents, wallabies, stray dogs and snakes were photographed. But no Bobucks.

While no systematic study of the animals' distribution within the study area has been attempted so far, it appears that Bobucks in this part of Gippsland may live only in close proximity to natural watercourses. The availability of thick ground cover in and around such watercourses seems to be a critical part of the animals' habitat. Sparse ground cover appears to mean no Bobucks, even where apparently suitable trees are present.

The Bass River site divulged a very numerous native fauna. Over a mere three night 'stake out' in November, wallabies, Common Brushtail Possums, wombats, rodents and echidnas were photographed as well as Bobucks. The author believes such rich diversity of native wildlife is entirely due to the presence of extensive stands of vegetation along parts of the Bass River and in declared parks such as The Gurdies Flora and Fauna Reserve.

For this the community at large perhaps owes a debt of gratitude to Trust For Nature who covenanted part of the only stretch of remnant riparian vegetation on the Bass River, thus permanently protect-

Fig. 1. Baby Bobuck at Gurdies

ing a unique habitat for these Bobucks and other native creatures.

Additional images of animals so far recorded in this survey may be viewed at the following website: http://www.thylacoleo.com/news/oct_dec2005/oct_dec2005.html

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Wildlife of the Box-Ironbark Country

by Chris Tzaros

Publisher: *CSIRO Publishing, 2005. 256 pages, paperback and CD; colour photographs. ISBN 0643069674. RRP $39.95*

Local and regional natural history and field guides are a useful starting point for learning about an area that is new, especially when written by someone such as Chris Tzaros, with a deep knowledge and love for the region being described. The author writes in the preface to *Wildlife of the Box-Ironbark Country*, 'I hope that this book will be used by many people, not only workers or students in the field of land and wildlife management, community extension or regional planning, but also landholders, naturalists, tourists, and anyone who may simply wish to learn more about the wildlife of Victoria's wonderful box-ironbark country'. I think he has succeeded; there is something in this book for everyone. This book would be especially useful for newcomers to the Box-Ironbark, such as landholders and research students who are unfamiliar with the region.

Over the past 200 years, Victoria's Box-Ironbark forests and woodlands have been so heavily cleared and modified for timber, mining and farming that now only about 15% remains, mostly in isolated remnants or as corridors along roadsides. Although there are some larger remnants, such as Warby Range State Park (11 084 ha), most of the remaining Box-Ironbark remnants are tiny, degraded fragments. Take a look at the maps of the 16 Box-Ironbark parks and conservation areas in this book and you will see that many, although seemingly large, are really only smaller areas cobbled together, many with long, ragged edges. It is sobering to note that there is only one very small patch of Box-Ironbark remaining that matches the official criterion of undisturbed and uncut 'old-growth' woodland.

What is left of the Box-Ironbark forests and woodlands provides critical habitat for a large number of woodland plants and animals, now threatened because of destruction of their habitat. Many species, such as the Regent Honeyeater, Swift Parrot, Squirrel Glider and Brush-tailed Phascogale, are dependent on the remnants that remain.

The first three chapters provide an excellent summary of the Box-Ironbark region, its history and its wildlife. The natural distribution of Box-Ironbark species, why the region has such a diversity of species and how they have been affected by the habitat destruction and modification of the past 200 years are covered. A succinct summary points out how current land-uses and processes and the loss of certain habitat features, such has tree hollows, ground-layer (leaf litter and fallen timber) and mature trees, has contributed to the decline of species in this region.

'Box-Ironbark habitats' is my favourite chapter and is an excellent introduction to Box-Ironbark floristics. The author has grouped the 25 floristic communities of the Box-Ironbark region (Muir *et al.* 1995) into six broad habitat types, for example 'Granitic hills woodlands and shrublands'. A full page is devoted to each habitat type, and the plant species which make up the overstorey, understorey and ground-layer, as well as the characteristic fauna found in each habitat type, are described. Plant species referred to in the descriptions are also listed at the back of the book (p 232). The author has wisely not included species descriptions or illustrations of individual plants in this book as they have been adequately covered in other publications such as *Victoria's Box-Ironbark Country: A Field Guide* (Calder and Calder 2002). You can also refer to specialist floristic publications such as Costermans (1992) and Corrick and Fuhrer (undated) to look up plants mentioned in the book.

In the 'field guide' section (Chapter 4), there is a description, colour photograph and distribution map for each species of mammal, bird, reptile and amphibian. The distribution maps, compiled from records in the *Atlas of Victorian Wildlife* database, contain a lot of information–the species distribution within the Box-Ironbark region and throughout Victoria, and the distribution records before and after 1970. The Growling Grass Frog map on page 182 is of particular concern as it indicates how quickly the populations of this animal have declined. The maps tell a similar story for many other species. I recommend that you read the section 'Interpreting the species maps' on page 11 carefully, as there is much more information to be gleaned from the maps than I initially realised. The only quibble I have with the species accounts maps is that the green and red dots showing the 'before 1970' and 'since 1970' time periods are very tiny and my failing eyesight made it very difficult to interpret some of the detail without the aid of a magnifier. Each species account also describes range and status, habitat, habits (which can be very useful for identifying unfamiliar species) and suggestions for locations where you can observe the animal.

Detailed maps of the locations mentioned in the species accounts are provided in Chapter 5, 'Where to watch wildlife'. Sixteen maps of parks and reserves give details of the characteristic flora and fauna and information about park facilities such as camping, toilets and water, and the nearest accommodation. There are also notes on the biodiversity values of the park, species that can be observed and a habitat description.

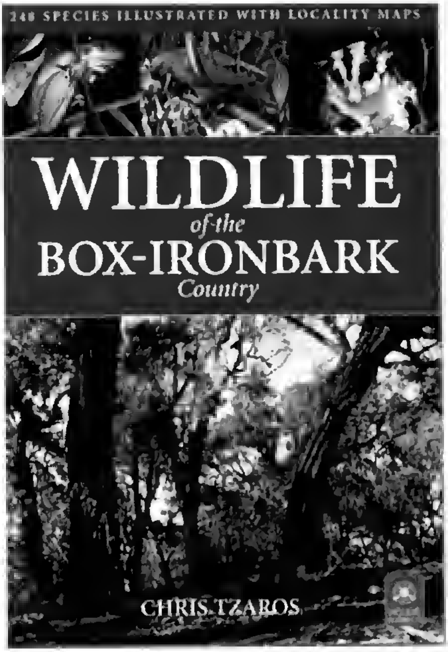
Unfortunately the numbers on the main map on pages 184-185 do not correspond to the numbers allocated to the wildlife viewing sites in the key, but this mistake has been corrected on the CSIRO website (www.publish.csiro.au/pid/4856.htm) and a corrected PDF map can be downloaded via a link from this site.

Towards the back of the book (p 225) there is a checklist of Box-Ironbark wildlife, with a box for 'tickers' to mark off sightings. Other features are a glossary, extra reading list and CD tucked into the back cover titled 'Box-Ironbark nature soundscape'. Over 85 species of bird, frog and mammal star in this recording. Field notes (p 243) provide a guide to the songs and calls on each track.

A more comprehensive index would enhance the value of the book. Species accounts are indexed, but there is plenty of other useful information that could be included, for example the interesting map on p 18 showing how the Grey-crowned Babbler has declined over the past 30 years, the Noisy Miner as a problem native species on p 35 and conserving the Brush-tailed Phascogale on p 30. Other examples are the text boxes describing the Swift Parrot recovery effort and the Lurg Hills Regent Honeyeater project. The wildlife viewing areas (parks and reserves) and the Box-Ironbark habitat types would also be useful additions to the index.

Outstanding photography, particularly of birds, is a highlight. (The most delightful photo in the book is that of the Dusky Woodswallows on pages 56-57.) There are a few photos that are not up to the general standard but this is understandable as they are of nocturnal animals which are particularly difficult to photograph. Some photos are repeated in the book, for example the Crested Shrike-tit (pp 10 and 135) and White-bellied Cuckoo-shrike (pp 54 and 142). Perhaps the space could have been better filled with more views of the different Box-Ironbark habitat types.

The few criticisms I have mentioned are all of a minor nature and do not detract from the book's usefulness. I recommend *Wildlife of the Box-Ironbark Country* to all who have a love of, or an interest in, the Box-Ironbark. Whether you are an experienced Box-Ironbark observer or a new chum to the region, you will learn something from this book. The CD from the back pocket is now in the stacker in my car so I can test myself on bird calls while going about my work, and the book now forms a valued addition to my 'car boot library' for use on future field trips.



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The nature of plants: habitats, challenges and adaptations

by John Dawson and Rob Lucas

Publisher: *CSIRO Publishing, 2005. 314 pages, hardcover, colour photographs; ISBN 0643091610. RRP $64.95*

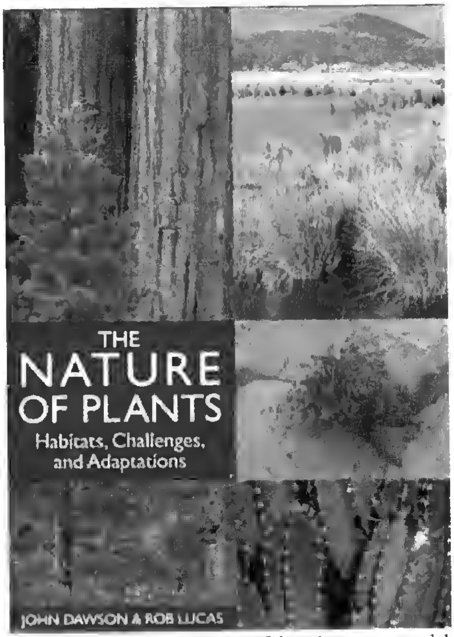
The first thing that strikes a person regarding this fascinating book is the excellent quality of the colour photographs, depicting such diverse plants, associated animals and habitats as:

- the tussock grass alpine landscape of Fiordland National Park, New Zealand,
- an outcrop of ultramafic rock with scattered, stunted pines and chaparral shrubs in the Coast Ranges of California,
- a 'giant daisy' on Mount Kilimanjaro, Tanzania,
- a baobab from Madagascar,
- Australian staghorn ferns,
- a grove of *Araucaria columnaris* on New Caledonia,
- a cabbage tree moth camouflaged on a dead leaf of a cabbage
- a puririmoth with a wing span of 15 cm
- the massive fronds of bull kelp, *Durvillea antarctica*
- and much, much more.

The photographs clearly depict and enhance the accompanying text which is written for those unfamiliar with scientific terms, but scientists also will appreciate the depth and breadth of information offered in *The nature of plants*.

There are nine chapters. Chapter 1, 'The freeloaders - plants using plants', includes an introduction to stem and leaf anatomy and photosynthesis, as well as an account of how many epiphytes there are and the adaptations that allow their survival. This chapter also includes a section on direct parasites, indirect parasites and the effect of parasites on their hosts. The authors describe the intriguing Balanophoraceae for which little is known of the pollination of their flowers. In fact, some species do not require pollination as they can form embryos by a 'type of cloning'! Some mycotrophic parasites feed from their host by an intermediary, a fungus that takes sugars from host tree roots and, in return, supplies water and some mineral nutrients to the tree. The parasite takes some of the sugars and other organic compounds from the fungus and, probably, gives nothing in return.

Chapters 2, 3, 4, 5 and 6 discuss plants from deserts and seasonally arid places, plants in fire prone areas, in regions of toxic soils, of aquatic and marine systems, and of alpine and arctic regions respectively. Plants from regions all around the world are explored. One particularly fascinating story comes from New Caledonia where certain trees, such as *Sebertia acuminata*, can actually store nickel in quantities sufficient to turn the milky latex it exudes when cut a bright blue-green. Another story, not commonly known, is a phenomonon related to survival of some Myrtaceae, where survival is not directly through the lignotubers but via scaly rhizomes arising from them. These rhizomes form an extensive network as much as 20 cm below the ground's surface and can form groves of trees up to 10 m high. Plants spreading by rhizomes are common among herbaceous plants but unusual for tree species. The authors have made a wealth of information available to the populace at large by their simple, clear and concise language and the many examples provided. One cannot convey the diversity of topics encompassed within these chapters. The book is highly recommended and will supply many hours of enjoyable reading. It is not the type of book one would read from cover to cover in a single sitting. The brain would go into overload with the sheer volume of information. It is a book that one would delve into many times in a day, a week, a month. It is a book, however, that one would pick up repeatedly.



The final three chapters deal with 'A love-hate relationship - plants and animals', 'mostly hidden relationships - plants, fungi and bacteria' and 'plant evolution through the ages - an overview'. The authors describe how some ants cut portions of leaves much larger than themselves, carry them to their nest and use them to make fungus gardens and then feed on the fungal growths. Another story relates to pollination of the fig which forms a specialized structure, the syconium, which is lined with flowers on the inside. The syconium has a small opening to the outside which is partly blocked by small scales. Usually there is an exclusive relationship with the fig and its pollinator, mostly a type of wasp that lays its eggs in the syconium. The male wasps hatch before the females, bore into flowers occupied by females, fertilise them and die. The female wasps hatch when the male flowers release pollen, thus as the female emerges from the syconium, it collects pollen over itself. If the female wasp then enters a female syconium to lay its eggs in the neuter flowers, it pollinates the female flowers in the process. Some of the hidden relationships include those of the nitrogen fixing bacteria and the mycorrhizae. The final chapter dealing with plant evolution is a romp through geologic time and presents an excellent overview.

The book provides hours and hours of entertainment and is highly recommended. It is ideal for those with little or no background in plant biology and would provide a wonderful and instructive resource for teachers and their students. It is also ideal for the armchair traveller, but beware, the armchair may be traded in for a ticket to any one of the fantastic places illustrated. Bye now, I'm off to see how anything can grow at Coyote Buttes near the Arizona-Utah border.

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Forgotten Flora Resource Kit

by J Milne, T Lebel, A Veenstra-Quah and G Shadforth

Publisher: *Royal Botanic Gardens Melbourne, Australia, 2004. 3 CD-R and 10 posters, ISBN 0975136232. RRP $154.00*

Forgotten Flora is aptly named. Indeed, bryophytes, fungi and lichens (fungi with one or two algal symbionts) have been overlooked by scientists and the public alike, yet they are vital to the ecology and health of all terrestrial habitats and most aquatic habitats. The resource kit consists of three CDs and ten posters. It is aimed primarily at teachers and is presented at a level such that those untrained in plant biology or mycology can understand and successfully use the information presented. The authors aimed to promote increased awareness of the Forgotten Flora, educate people about their importance to the environment, and show their beauty. They have done this admirably, and producing the kit for teachers of older primary and secondary school children ensures a future generation with a better understanding and appreciation of these small but exceedingly important organisms.

The CDs are presented much like a text book but are partially interactive. Hopefully, the next edition will be fully interactive. Each CD includes a brief introduction to the groups of organisms comprising the forgotten flora, and explains the existence of the other two CDs and the ten posters. The 'Educators Note' explains how the information in the kit can be incorporated into the Key Learning Areas of the Curriculum and Standards Framework for Biological Science. Following the general introduction, which is specific to the group of organisms pertinent to the CD in question, there are five sections which provide detail on the relevant group of organisms, their interactions, how to study them, a list of activities and associated worksheets and a bibliography and glossary. These are accompanied by superb photographs and drawings. The activities, which would be of great benefit to teachers, include making spore prints of fungi, using fungi to make ink, looking at what lives in the fruiting structures of fungi, graveyard lichens, finding out whether lichens are 'fussy', using lichens as bioindicators of pollution, finding out

why mosses have teeth and making a moss terrarium. Wordfinds, crosswords and a list of possible projects also are provided. The activities and worksheets sections begin with 'Fascinating Facts' presented as answers to a series of questions, for example: What have mosses got to do with the Tyrolean man? What are the green umbrellas growing with my pot plants? Each activity comes with a complete set of instructions and includes a list of materials so that the inexperienced teacher/technician easily can prepare and/or run the activity.

Although the bibliography provides a useful list of story books, general text books, field guides and keys, it would be more helpful if it was annotated to indicate the level of expertise required to use the item. For example, the key to the genera of Australian mosses by Buck *et al.* requires a good knowledge of bryology and associated terms while the field guide to mosses and allied plants by Meagher and Fuhrer can be used by both experienced and inexperienced bryologists.

Production of the CDs seems to have been rushed, indicated by the number of typographical errors, the admission that the CDs were only partially interactive and the occasional repetition of information in some sections. The posters, however, are excellent. They are visually pleasing, clearly presented and would be informative displays for primary, secondary and tertiary students. They also would be excellent for public displays and are ideal to educate the public on the ecologic significance of the Forgotten Flora. The posters centre around particular themes such as 'taking a liking to lichens' or 'Poisonous mushrooms', and provide answers to intriguing questions, for example, what mushrooms caused symptoms displayed by 'witches' in the 17th century and what are the little cups growing in the carpet of my car?

Limited resources dealing with bryophytes, fungi and lichens are available to teachers and the general public. Forgotten Flora successfully fills that void and is a valuable addition to any classroom. The authors are commended for their initiative and imagination and the resource kit is certain to fulfill their aim of increasing awareness, knowledge and appreciation of the forgotten flora. The CDs and posters are highly recommended for anyone with an interest in these frequently overlooked organisms but particularly to teachers.

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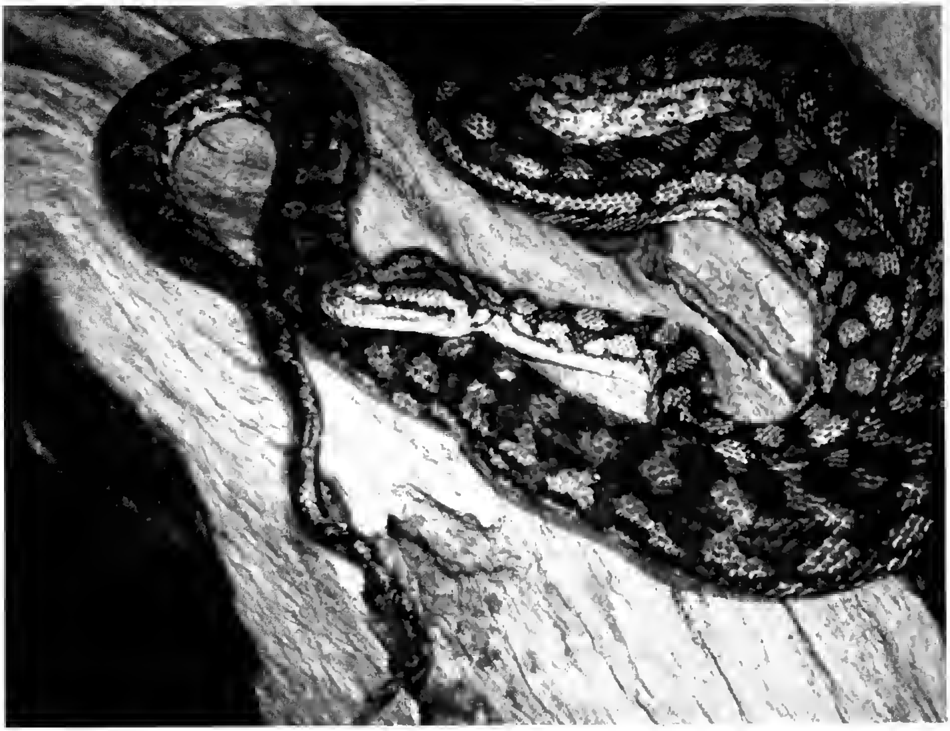

The Victorian Naturalist

Volume 123 (3) **June 2006**

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From the Editors

We are pleased to offer this issue of *The Victorian Naturalist* for the enjoyment and edification of readers. The contents cover a wide range of subjects and are certain to be of interest to many naturalists.

A notable feature of this issue is that two of the published articles relate to the work of government instrumentalities in giving legislative protection to the natural resources of this state. The first instance of this is the paper by James Fitzsimons, Cameron Williams and Paul FitzSimons, which provides detail of areas recently added to the protected estate. In the second instance, recent additions to the *Fauna and Flora Guarantee Act* are also listed.

Looking ahead to future events that may impact on the contents of *The Victorian Naturalist*, the next FNCV Biodiversity Symposium will be held in September of this year, and will focus on invasive species. Details about the Symposium can be obtained by contacting the FNCV office, on Monday to Wednesday. Following our usual practice, it is likely that papers from this Symposium will be presented in a future edition of this journal. This will happen either in a later issue of the current volume, or early next year.

In the meantime, we can give readers advance notice that the special issue of *The Victorian Naturalist* this year will be in August and will focus on bryophytes. Papers for this issue are well into preparation and, with the facility to include colour images, this promises to be a landmark issue.

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The Victorian Naturalist

Volume 123 (3) 2006 June

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Front cover: Crested Tern *Sterna bergii* (see article on page 176). Photograph by Jonathon Thornton.

Back cover: Pussy Tails *Ptilotus spathulatuson* in the newly-purchased Melton Gilgai Woodlands Nature Conservation Reserve (see article on page 134). Photograph by J Fitzsimons.

Flowering, pollination, and fruit set in Tongue Orchids *Cryptostylis* spp.

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Abstract
Study of Australian Tongue Orchids addresses questions of widespread interest about the evolution of sexually deceptive pollination, and provides information for conservation and management. We present recent data on flowering, pollination, and fruit set for three *Cryptostylis* species: the Bonnet Orchid *C. erecta* RBr, the Small Tongue Orchid *C. leptochila* F Muell. *Ex* Benth. and the Large Tongue Orchid *C. subulata* (Labill.) HG Reichb. (Jones 1988). These species are pollinated by male Orchid Dupe Wasps *Lissopimpla excelsa* (Ichneumonidae) when they 'pseudocopulate' with the flowers. *Cryptostylis subulata* flowered from December to February, and *C. erecta* flowered from November to March. *Cryptostylis leptochila* began flowering in December, and pollination was still occurring in late April. This species had the most flowers, but the lowest fruit set. In most field sites, the earliest flowers on a raceme were pollinated most often, although this did not occur when pollinators were scarce. Orchids may attract pollinators more easily at the start of the flowering season before the female wasps emerge, or pollinators could learn the locations or appearance of orchids and avoid later-opening flowers. We also found that pollinator abundance varied during and between seasons, there was no evidence of self-pollination, and *C. erecta* racemes were more likely to be eaten by predators after fruit set. (*The Victorian Naturalist* **123** (3), 2006,128-133)

Introduction

Species from the fascinating terrestrial orchid genus *Cryptostylis* are distributed throughout Australasia and the South Pacific (Jones 1988). There are five Australian species: the Bonnet Orchid *Cryptostylis erecta* RBr, Small Tongue Orchid *C. leptochila* F Muell. *Ex* Benth., Large Tongue Orchid *C. subulata* (Labill.) HG Reichb., Leafless Tongue Orchid *C. hunteriana* Nicholls and Slipper Orchid *C. ovata* RBr (Jones 1988).

The abundance and rarity of *Cryptostylis* species vary throughout their distributions. For example, *C. erecta* is common in NSW (Bishop 2000), but is listed as 'vulnerable' under Victorian legislation (Flora and Fauna Guarantee Act 1988). *Cryptostylis leptochila* can be locally common in Victoria and New South Wales, but is listed as 'endangered' in Tasmania's Threatened Species Protection Act 1995. One species, *C. hunteriana*, is extremely rare throughout its range in Victoria, New South Wales, and Queensland (Bell 2001; Clark *et al.* 2004). It is considered 'threatened' under the Victorian *Flora and Fauna Guarantee Act 1988* and 'vulnerable' under both the NSW *Threatened Species Conservation Act 1995* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. Research into the natural history of these species is valuable for the preparation of recovery plans, and general conservation and management activities. Furthermore, study of the most common *Cryptostylis* species in their areas of greatest abundance provides information that may be applied to rare *Cryptostylis* species, and other orchids with similar sexually deceptive pollination systems.

Whilst *C. hunteriana* is a leafless saprophyte, all other Australian *Cryptostylis* species have a solitary, evergreen leaf (Jones 1988). In *C. erecta* and *C. leptochila*, the leaf underside is purple. The flowers of *Cryptostylis* are resupinate with a very large labellum that is predominantly red or burgundy (Jones 1988). Plants can produce a single flower raceme between August and April. The multiple inflorescences on the raceme are thought to open sequentially throughout the flowering season (Jones 1988). The frequency of flowering in individual plants appears to vary unpredictably between years, a common characteristic of terrestrial orchids (for a review, see Kindlemann and Balounová 2001).

Cryptostylis species attract pollinators by sexual deception. The orchid flowers are thought to mimic the appearance and scent of female insects. Male insects that respond to the mimicry and attempt to copulate with the orchids' flowers inadvertently collect and distribute the pollinia. Australian *Cryptostylis* species are pollinated by males of a single species of Ichneumonid wasp, the Orchid Dupe *Lissopimpla excelsa* (Costa) (CSIRO 1991). For first-hand descriptions of pollination in *Cryptostylis* species see Coleman (1928, 1929, 1930), Dacy (1974), Watson (1961), and Stoutamire (1974). Although *Cryptostylis* species share a pollinator, and often have overlapping flowering seasons and distributions, no hybrids have been reported between species (Stoutamire 1974; Jones 1988). Cross-pollination of the species by hand suggests there are strong internal mechanisms that prevent hybridisation (Stoutamire 1974; Jones 1988; Lloyd 2003).

Pollinators are initially attracted to *Cryptostylis* orchids with a chemical signal thought to mimic sex pheromones emitted by female *L. excelsa* wasps (Schiestl *et al.* 2004). Other visual and tactile signals, e.g. colours, shapes, and textures that resemble the features of female wasps, may then stimulate males to attempt to copulate with the flower, and thus move vigorously enough to transfer pollinia. Deception by orchid flowers may impose costs upon duped insects (e.g. Wong and Schiestl 2002), and insect behaviour and learning may influence pollination success (e.g. Ferdy *et al.* 1998).

Here we report some interesting recent field observations and data on flowering, pollination, and fruit set for three species of *Cryptostylis*: *C. erecta*, *C. leptochila*, and *C. subulata*.

Methods

Field observations were made of natural populations of *Cryptostylis erecta*, *C. subulata*, and *C. leptochila* in open woodlands in New South Wales and Victoria. We used two populations of sympatric *C. erecta* and *C. subulata* near Sydney and Nowra, and one sympatric *C. leptochila* and *C. subulata* site near Melbourne. The fourth site, near Nowra, had only *C. subulata*. At each site we identified patches of orchids for study. A patch was defined as a cluster of plants that was more than two metres from any other *Cryptostylis* plants (Table 1).

In the summer of 2003-04, we visited the Sydney *C. erecta* and *C. subulata* site eight times throughout the flowering period and made detailed observations of individually labelled plants. We recorded the period for which individual flowers were open, the interval until pollinia collection and/or deposition, and the occurrence of fruiting, seed set, and predation.

During summer 2004-05, we visited all four field sites three times and made less intensive observations of flowering, seed set, and predation. Patches of orchids measured at the Sydney site during the first field season were not remeasured during the second year of the study. Analyses were pooled for each species, and confidence intervals of 95% were used.

At each field site, regression analyses were used to determine whether the position of a flower along a raceme (i.e. how early in the season it opened) affected its likelihood of being pollinated. For these analyses, the dependent variable was the proportion of pollination that occurred for flowers in each position along a raceme. The data were pooled according to field site because all *Cryptostylis* species share a single pollinator and pollinator abundances

Table 1. Number of patches surveyed for three species of Tongue Orchid *Cryptostylis* at four sites in New South Wales and Victoria. *denotes data combined from two study seasons, Summer 2003-04 and Summer 2004-05.

site	*C. erecta*	*C. leptochila*	*C. subulata*	*C. erecta* and *C. subulata*
Sydney	26*	-	5*	1
Nowra 1	1	-	6	1
Nowra 2	-	-	7	-
Melbourne	-	15	8	-
Total	27	15	26	2

may differ between the field sites. In two final regression analyses on the effect of flower position, we used data from *C. erecta* at the Sydney site for each of the two study seasons to compare pollination between years.

To test for self-pollination, we selected four pairs of flowering *C. erecta* plants in the Sydney field site. We isolated each plant in a mesh bag that prevented insect access to the flowers. One plant of each pair was hand-pollinated during the season. The second plant was not hand-pollinated, but used as a control. All the racemes were checked for fruit set during and after the flowering season.

We also assessed pollinator abundance and activity in an ad hoc manner by considering the time necessary to capture wasps on different days throughout the 2004-05 flowering season at the Sydney field site. Wasps were captured with a hand net when they arrived at our 'bait' flowers, as described by Peakall and Handel (1993) and Bower (1996).

Results and Discussion

Data were collected from 70 patches of orchids, including two patches of mixed *C. erecta* and *C. subulata*, which were excluded from subsequent analyses about single species patches. See Table 1.

Flowering seasons

In all sites, *C. subulata* had the shortest flowering period of the three species (December to February). For *C. erecta*, flowering commenced in November and had mostly finished by early March, although one plant with a flower was found in a sheltered area near a creek in May 2005. The populations of *C. leptochila* near Melbourne had a very long flowering season that began in December and finished as late as April, consistent with Backhouse and Jeanes (1995). Others have reported the flowering season for *C. leptochila* to end in February (Clyne 1970; Jones 1988), or March (Bishop 2000). In March, 48 racemes (92%) still had open flowers, but by May, only three racemes were still active (5.8%). Successful pollination occurred as late as April (nine flowers on seven different racemes).

Plant density and flowering

The average number of plants in each patch was highest in *C. erecta*, and lowest in *C. subulata*, but one patch of *C. subulata* had 900 plants (Table 2). The number of racemes per patch was similar for all three species, but *C. leptochila* had a higher average number of flowers per raceme (Table 2). One plant of *C. leptochila* had 35 flowers, which is three times the maximum number of flowers reported by Jones (1988), and twice that reported by Bishop (2000).

After opening, the flowers of *C. erecta* and *C. subulata* had pollinia collected or deposited after an average of 3.1 days. Some flowers were visited on the day they opened, and the maximum time until pollination was 8 days, but this was for a flower with a damaged labellum. On average, each flower was open for 6 days (min. = 1, max. = 9). Generally, each flower opened as the previous flower on the raceme was closing. Sometimes a flower opened up to six days before the previous flower closed. However, in one case, nine

Table 2. Flowering, pollination, and fruit set in three species of Tongue Orchids *Cryptostylis*. Values with parentheses are: mean (min., max.).

	C. erecta 2003-04	*C. erecta* 2004-05	*C. leptochila* 2004-05	*C. subulata* 2003-05	*C. subulata* 2004-05
plants surveyed	696	806	754	271	1687
% plants in flower	14.4	4	9.3	5.9	3.4
racemes per patch	8.3 (1, 27)	4 (1, 16)	4.7 (1, 10)	5.3 (1, 8)	2.5 (1,10)
flowers per raceme	5.5 (3, 12)	5 (3, 11)	9.6 (2, 35)	7 (3, 12)	4.7 (1, 11)
pollinated flowers per raceme	2.7 (0, 9)	1.13 (0, 7)	0.28 (0, 3)	2.86 (0,9)	0.77 (0, 5)
% plants that set fruit	72.6	71.9	27.6	75	50
% plants without fruit	19.4	27.1	54	25	38
% racemes predated	8	1	18.4	0	12

days passed between the closing of one flower and the opening of the next on the same raceme.

Pollination and fruit set

Despite the large number of flowers per raceme produced by *C. leptochila*, this species had the lowest average number of pollinated flowers per raceme and the lowest percentage of plants with some fruit set (Table 2). Approximately 70% of *C. erecta* and *C. subulata* plants had at least one pollinated flower in 2003-04, but only 50% of *C. subulata* were pollinated in the 2004-05 season. Schiestl *et al.* (2004) reported pollination rates of 85% for *C. erecta* and *C. subulata* in the Blue Mountains near Sydney in 2000. These data demonstrate that *Cryptostylis* species have a higher rate of pollination than that typically expected for orchids with deceptive pollination syndromes in the temperate southern hemisphere (~40%: Neiland and Wilcock 1998) and globally (~20%: Tremblay *et al.* 2005).

For three of the four field sites, the position of a flower along a raceme significantly affected the likelihood of pollination (Sydney: R^2=0.53, $F_{1,15}$=15.52, $p<0.05$; Nowra 1: R^2=0.45, $F_{1,11}$=8.03, $p<0.05$; Nowra 2: R^2=0.16, $F_{1,7}$=1.37, $p>0.05$; Melbourne: R^2=0.53, $F_{1,33}$=33.96, $p<0.05$). Pollination was most likely for flowers that opened earlier in the season (Fig. 1). Coleman (1928) suggested this was because the male *Lissopimpla excelsa* emerged earlier than females, and were most active as pollinators until the females were available. A second explanation may involve the learning abilities of the male wasps. In several sexually deceptive pollination systems, pollinators initially are

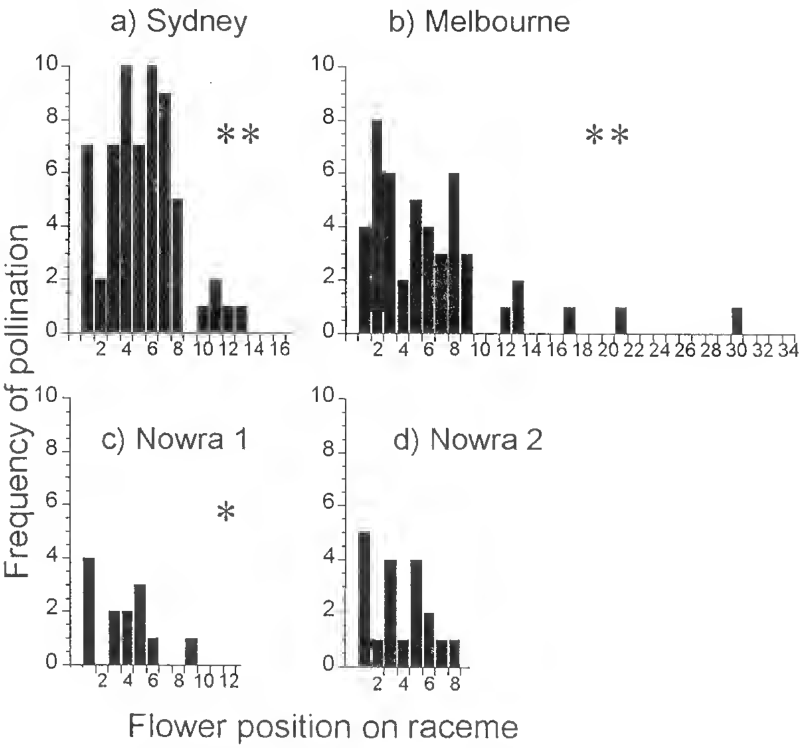

Fig. 1. Frequency of pollination of each sequentially-opening flower positioned along racemes of Tongue Orchids *Cryptostylis erecta*, *C. leptochila*, and *C. subulata*, in four sites in open forest in New South Wales and Victoria. Maximum value on x-axis is maximum number of flowers per raceme at site. Statistically significant effect of flower position at <0.005 level denoted by **, at < 0.05 level denoted by *

attracted strongly to a flower, but this decreases rapidly over a short period, presumably as the duped male pollinators learn that the flower is not a real female insect (e.g. Peakall *et al.* 1990; Peakall and Handel 1993; Wong and Schiestl 2002). Male wasps may remember and avoid the location of a false signal for some time, thus subsequent flowers on a raceme may not be visited. Furthermore, male ability to recognise flowers as false signallers may be frequency dependent and increase with repeated exposure (Ferdy *et al.* 1998).

The impact of male insect learning on orchids' pollination success also may depend upon pollinator abundance. In 2003-04, the effect of flower position on fruit set in Sydney *C. erecta* was highly significant (R^2=0.745, $F_{1,11}$=29.15, p<0.001), and the first flower to open on any raceme had a very high frequency of pollination (Fig. 2). However, during the second study season at this site, there were fewer pollinator visits, flowers 1-8 on racemes of *C. erecta* had similar pollination frequencies (Fig. 2), and flower position had no significant effect on pollination

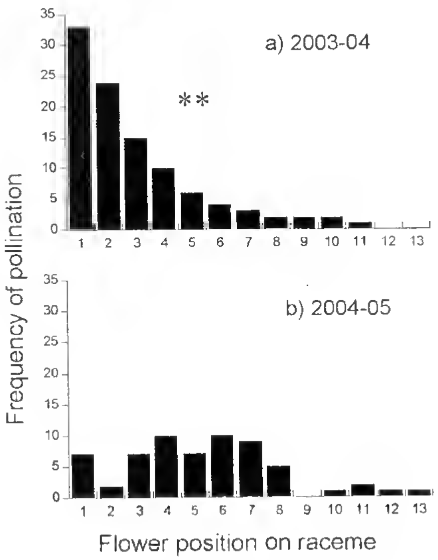

Fig. 2. Frequency of pollination of each sequentially opening flower positioned along racemes of the Bonnet Orchid *Cryptostylis erecta* in an open forest site near Sydney during two flowering seasons: a) 2003-04 and b) 2004-05

(R^2=0.195, $F_{1,12}$=2.671, p>0.05). As more flowers open during the season, males' frequent exposure and subsequent learning may lead to avoidance of most flowers.

Pollinators appeared most active between approximately 9.30 am and 2 pm on warm, sunny days. There were obvious peaks in abundance on certain days in different regions. For example, on one day during February 2005, nine wasps were caught in less than two hours at the Sydney field site (~4.5 wasps/hour). Previous capture efforts in the same area during January and February resulted in only four wasps in 18.5 hours searching over eight days (~0.2 wasps/hour).

Only two of the four pairs of bagged and isolated inflorescences survived the season. However, only those flowers cross pollinated by hand set fruit. None of the flowers in the control bags set fruit. This low sample size still corroborates evidence provided by Dacy (1974), Jones (1988), and Lloyd (2003).

Predation

The predation of racemes was quite low for all species except *C. leptochila* (Table 2). The higher level of predation at the Melbourne field site may have contributed to the lower pollination success for this species. Data from 2003-04 showed that 87.5% (n = 8) of the *C. erecta* racemes that were eaten by predators had recently set fruit. The fleshy fruit of *Cryptostylis* seem to be attractive food for browsing animals.

Despite their shared pollinator, and similar habitat and flowering season, the *Cryptostylis* species varied considerably in their patch sizes, flower numbers, fruit set, and predation rates. *Cryptstylis leptochila* appears to invest heavily in flowering, producing many flowers during an extended season. These features have been associated with strategies to maximise pollination success in other deceptive orchids (Neiland and Wilcock 1995; Kindlemann and Balounová 2001; Tremblay *et al.* 2005). However, *C. leptochila* had the lowest fruit set of the species studied. This may mean that extra investment in flowering has little effect on fruit set, particularly if there are other negative impacts, e.g. predation of fruits.

The generally high fruit set we observed suggests that, unlike many other orchid species, pollinator limitation is not a major conservation issue for *Cryptostylis* species. Management strategies could prioritise protecting plants from predation during the flowering season and conserving suitable open forest habitat (see Clark *et al.* 2004). In addition, care should be taken if information about *Cryptostylis* species is used to develop conservation plans for other orchid genera, which are likely to have considerably lower pollination rates (see Tremblay *et al.* 2005).

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Ecological attributes of strategic land acquisitions for addition to Victoria's public protected area estate: 2004-2005

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Abstract
The development of a comprehensive, adequate and representative reserve system is the key objective of the National Reserve System, and is supported by all Australian States and Territories. In Victoria, the purchase of private land for incorporation into the parks and reserves system assists in the protection of some of the State's most endangered ecosystems. This article outlines the ecological attributes of private land purchased for addition to the Victorian public protected area system between 2004 and 2005. (*The Victorian Naturalist* **123** (3) 2006, 134-145)

Introduction

This article documents some of the more significant land purchases made by the Department of Sustainability and Environment for addition to the public conservation estate from early 2004 until late 2005, and provides a brief description of their ecological attributes. It serves as an extension to previous descriptions of the operation of the Department's Conservation Land Purchase Program in Victoria (see Fitzsimons and Ashe 2003, Fitzsimons *et al.* 2004). The program aims to systematically improve the comprehensiveness, adequacy, and representativeness of the reserve system, with particular emphasis on high-quality examples of threatened and under-reserved ecosystems such as native grasslands and grassy woodlands. All acquisitions are on a completely voluntary basis.

Purchase priorities are derived from inventories of the most significant sites containing threatened ecosystems throughout the State and assessed in relation to the comprehensiveness, adequacy and representativeness of the existing reserve system. The Department also purchases private land to link park and reserve areas and remove inliers in order to consolidate protected habitat and alleviate potential management problems. All purchases described in this paper are managed for the conservation of biodiversity by Parks Victoria except for Melton Gilgai Woodlands Nature Conservation Reserve, which will be managed by the Shire of Melton.

The conservation status of all species listed in this paper is outlined in Appendix 1, while Appendix 2 lists communities listed under the *Flora and Fauna Guarantee Act 1988* represented in the new reserves. Fig. 1 indicates the location of recent purchases within Victoria.

1. Mumbannar Wetlands and Woodlands

This 155 ha block in Mumbannar, south-west Victoria, protects high-quality Freshwater Meadows and Damp Sands Herb-rich Woodland/Damp Heathland/Damp Heathy Woodland Mosaic Ecological Vegetation Classes (EVCs). Both ecosystems are endangered in the Naracoorte Coastal Plain (a national biodiversity hotspot) and very poorly reserved.

The wetlands and woodlands represented on the property, which have been substantially cleared and modified throughout south-western Victoria, are priority ecosystems for addition to the protected area system. The vegetation is characterised by a Brown Stringybark *Eucalyptus baxteri* woodland occurring on the higher areas of the property, with an intact understorey including *Xanthorrhoea* and *Exocarpus* species. This grades into a Prickly Tea-tree *Leptospermum continentale* and Scrub Sheoak *Allocasuarina paludosa* shrubland

Fig. 1. Location of recent land purchases (numbered) for addition to the reserve system (existing reserve system shaded).

and heathland, ultimately fringing a *Ghania* and sedge-margined wetland. Significant flora recorded on-site includes the Small Spotted Sun-orchid *Thelymitra* aff. *ixioides* (Western Victoria).

The property provides known habitat for nationally endangered species such as the Red-tailed Black-Cockatoo *Calyptorhynchus banksii graptogyne* and Southern Brown Bandicoot *Isoodon obesulus obesulus*, and acts as an important ecological stepping stone between larger protected forests. Other significant fauna recorded on the property include Brolga *Grus rubicunda*, Swamp Skink *Egernia coventryi* and Swamp Antechinus *Antechinus minimus maritimus*.

The new reserve is known as the Mumbannar Nature Conservation Reserve.

2. Bessiebelle Stony Rises Woodland, Mount Eccles

This 162 ha addition to the Mount Eccles National Park contains very high quality stands of Stony Rises Woodland EVC which is considered vulnerable and under-reserved in the Victorian Volcanic Plain. Stony Rises Woodland occurs on 138 ha of the property.

The remainder of the property contains the endangered Swamp Scrub/Plains Sedgy Wetland/Aquatic Herbfield Mosaic EVC. This ecosystem occurs on the drained seasonal wetland at the edge of the lava flow. The EVC once covered 8700 ha of the bioregion, but has now been reduced to less than 0.4% of this former range and is almost unreserved.

The Stony Rises Woodland provides potential habitat for the Spot-tailed Quoll *Dasyurus maculatus* which occurs in the adjoining National Park. The Stony Rises Woodland sections of the property are in excellent condition, with hollow-bearing veteran trees providing habitat for species such as the Yellow-bellied Glider *Petaurus australis*. The shrub and ground layers are intact with no woody weeds and very few grassy weeds present. The nationally vulnerable Clover Glycine *Glycine latrobeana* has also been recorded from the site.

In addition to the ecological values, the purchase of the Bessiebelle property also protects the significant Indigenous cultural heritage values, including stone huts.

3. Yambuk Wetlands

This 79 ha of Shallow Freshwater Marsh and Swamp Scrub at Yambuk represents one of the highest quality examples of protected estuarine wetlands in Victoria. These nationally significant wetlands and Swamp Scrub provide important breeding habitat for numerous bird and fish species, a number of which are nationally threatened. Such wetlands have been substantially drained and modified throughout southern Victoria and are priority ecosystems for addition to the protected area system. The purchased land adjoins the 453 ha Deen Maar Indigenous Protected Area, which contains contiguous wetland vegetation linked by the Eumeralla River, enhancing the long-term ecological integrity of the site.

Both Shallow Freshwater Marshes and Swamp Scrub have been substantially reduced in the Warrnambool Plain and are poorly-reserved. The Shallow Freshwater Marshes represented on the Yambuk Wetlands contrast with the semi-permanent saline wetlands of Deen Maar and saline wetlands of Lake Yambuk. Swamp Scrub is considered endangered in the bioregion and is almost unreserved. Remnants of the Damp Sands Herb-rich Woodland EVC occur on the higher ground.

The property provides drought refuge for waterbirds, while 24 fish species have been recorded in Yambuk Lake and wetlands.

The wetlands provide known habitat for a number of significant species, including Dwarf Galaxias *Galaxiella pusilla*, Yarra Pigmy Perch *Nannoperca obscura*, Orange-bellied Parrot *Neophema chrysogaster*, Blue-billed Duck *Oxyura australis*, Little Egret *Egretta garzetta*, Freckled Duck *Stictonetta naevosa*, Great Egret *Ardea alba*, Lewin's Rail *Rallus pectoralis*, Australasian Shoveller *Anas rhynchotis*, Australasian Bittern *Botaurus poiciloptilus*, Musk Duck *Biziura lobata*, Hardhead *Aythya australis*, Magpie Goose *Anseranas semipalmata*, Royal Spoonbill *Platalea regia*, Whiskered Tern *Chlidonias hybridus*, Nankeen Night Heron *Nycticorax caledonicus* and Pacific Golden Plover *Pluvialis fulva*. The wetlands are a breeding site for a number of these species. The Yambuk Wetlands are listed under the Directory of Important Wetlands in Australia (Environment Australia 2001), and the owners of Deen Maar are currently

Fig. 2. Dreeite Stony Knoll Shrublands and wetlands. Photograph by J Fitzsimons

investigating the possibility of listing them under the Ramsar convention (DEH 2004).

The new reserve is known as the Yambuk Wetlands Nature Conservation Reserve.

4. Laharum Lateritic Woodlands

This 173 ha woodland property on the northern boundary of the Grampians National Park protects significant vegetation types, habitat for threatened species and important landscape linkages. Some 60% of the property is covered by Lateritic Woodland EVC, a vegetation type almost unrepresented in the protected area estate in the Wimmera bioregion. Lateritic Woodland is a low grassy woodland dominated by Grey Box *Eucalyptus microcarpa*, Yellow Box *E. melliodora* and Yellow Gum *E. leucoxylon* with a herb-rich and grassy understorey. The community is considered vulnerable and this is the second largest remnant of this vegetation type remaining in the bioregion. The property also contains areas of Shallow Sands Woodland, Seasonally Inundated Shrubland and Heathy Woodland EVCs.

The Laharum Woodlands provide known habitat for threatened species such as the Bush Stone-curlew *Burhinus grallarius*, Squirrel Glider *Petaurus norfolcensis* and Tree Goanna *Varanus varius*. A number of threatened flora species are known to occur in Grampians National Park adjoining these woodlands and it is likely that many of these will also be present on the purchased land.

This property occurs between two areas of recognised flora and fauna significance in the Grampians National Park (Parks Victoria 2003), adjoins a Trust for Nature covenanted property to the north and vegetated private land to the west. Its addition to the Grampians National Park will ensure the long-term integrity of the ecosystems.

5. Ledcourt Woodlands

This 19 ha addition to the Grampians National Park complements land previously purchased to the north (see Fitzsimons *et al.* 2004). It contains areas of endangered Plains Grassy Woodland dominated by River Red Gum *Eucalyptus camaldulensis* and Yellow Gums along Mount William Creek, as well as Heathy Woodland, Shrubby Woodland and Sand Heathland. The block contains excellent assemblages of heathland providing potential habitat for Long-nosed Potoroo *Potorous tridactylus*, Heath Mouse *Pseudomys shortridgei*, and Southern Brown Bandicoot.

Fig. 3. Melbourne Yellow Gum and Grey Box Woodland, Melton. Gilgai Woodlands Nature Conservation Reserve. Photograph by J Fitzsimons

6. Winlaton Chenopod Shrubland

This 80 ha of chenopod shrubland at Winlaton near the Kerang Lakes protects not only significant vegetation communities but also a range of threatened species. The newly-protected woodland/shrubland, together with an adjoining 130 ha covenanted property to the south, represents one of the largest and the highest quality examples of this vegetation known from the Riverina. Such woodlands have been substantially cleared and modified throughout northern Victoria and are priority ecosystems for addition to the protected area system. The presence of a number of rare, threatened and unreserved species highlights the significance of the property. The area around Winlaton is a zone of gradation between the true semi-arid Mallee and the Riverine Plains (Frood 2000). Whilst derived from the Riverine Chenopod Woodland EVC, the vegetation today would best be described as a Low Chenopod Shrubland dominated by a range of *Atriplex* species (mainly Small Saltbush *A. eardleyae* and Slender-fruit Saltbush *A. leptocarpa*) with a range of spring and summer tussock grasses and scattered annual and perennial herbs. Small areas of Lignum Swampy Woodland EVC occur along the depressions.

Combined with the covenanted habitat to the south, the site is considered of national significance for its botanical values (Ogle and Foreman 1999; Frood 2000) and highly significant at the state level for reptiles and mammals (Robertson 2000).

The purchased land contains the first record of the saltbush *Atriplex turbinata* for Victoria, which is a significant southerly range extension from the nearest known locality at Broken Hill (N Walsh pers. comm. 2004; P Foreman pers. comm. 2004). Other significant flora species recorded on the purchased land include Winged New Holland Daisy *Vittadinia pterochaeta*, Leafless Bluebush *Maireana aphylla*, Yakka Grass *Sporobolus caroli*, Mealy Saltbush *Atriplex pseudocampanulata*, Bladder Saltbush *Atriplex vesicaria macrocystidia* and Spiny Lignum *Muehlenbeckia horrida horrida*.

Additional significant species recorded from the covenanted property to the south, which may also occur on the purchased property, include a large population of the endangered Samphire Skink *Morethia adelaidensis*, Grey-crowned Babbler *Pomatostomus temporalis*, Eastern Bearded Dragon *Pogona barbatus*, Fat-tailed Dunnart *Sminthopsis crassicaudata*, Chariot Wheels *Maireana cheelii*, Umbrella Wattle *Acacia oswaldii*, Dwarf Amaranth *Amaranthus macrocarpus* var. *macrocarpus*, Desert Sneezeweed *Centipeda thespidioides* s.l. and Mallee Cucumber *Mukia micrantha*. The initial discovery of the endangered Common White Sunray *Rhodanthe floribunda* on the covenanted property was the first record of this species in Victoria (Ogle and Foreman 1999). The covenanted property is considered likely to provide suitable habitat for Hooded Scaly-foot *Pygopus schraderi*, Plains-wanderer *Pedionomus torquatus* and Tessellated Gecko *Diplodactylus tessellatus*.

The new reserve is known as the Winlaton Nature Conservation Reserve.

7. Tomara Grasslands and Gilgais, Patho Plains

This large 332 ha Northern Plains Grassland at Terrick Terrick East forms part of a network of new native grassland reserves on the Patho Plains (see Fitzsimons and Ashe 2003; Fitzsimons *et al.* 2004).

The property consists of mostly Northern Plains Grassland, a *Flora and Fauna Guarantee Act*-listed community, with two identified finer scale sub-communities. An Annual Grassland occurring on the hard red loams is dominated by Common Wallaby-grass *Austrodanthonia caespitosa* with varying amounts of Rough Spear-grass *Austrostipa scabra*, Plump Spear-grass *Austrostipa aristiglumis* and Rigid Panic *Whalleya proluta* dominate small areas containing gilgais in this sub-community. A Wet Grassland sub-community is found on the grey soils in the drainage lines and depressions and is dominated by Windmill Grass *Chloris truncata* and *Enteropogon* spp. Both sub-communities are significant in that they are largely intact and contain only small areas where introduced species are present (Webster 2000).

Almost 60 species of indigenous plants have been recorded on the site, including the vulnerable Long Eryngium *Eryngium paludosum*, Pin Sida *Sida fibulifera*, Umbrella Wattle and the rare Spiny Lignum and Yakka Grass.

Previous studies on the property have indicated that the grasslands are of conservation significance for the Plains-wanderer (Maher and Baker-Gabb 1993) which is nationally vulnerable and endangered in Victoria. Brolgas have been recorded using the wetland area. While little further detail is known of the fauna values of the site, the size, condition and proximity to nearby reserves suggests there is considerable potential to support other important grassland fauna values (e.g. see Michael *et al.* 2003).

The purchase complements efforts to protect native grasslands across public and private land on the Patho Plains via the Northern Plains Conservation Management Network (see Bain 2005).

The new reserve is known as the Tomara Gilgais Nature Conservation Reserve.

8. Dreeite Stony Knoll Shrublands and wetlands

This 48 ha acquisition protects Stony Knoll Shrublands and permanent and ephemeral wetland communities at Dreeite, to the east of Lake Corangamite (Fig. 2). Stony Knoll Shrublands have been severely depleted throughout the Victorian Volcanic Plain bioregion and were previously unrepresented in protected areas. The shrublands are dominated by Tree Violet *Melicytus dentatus*, with scattered Blackwood *Acacia melanoxylon* and Black Wattle *A. mearnsii*. The new reserve forms part of a much larger area of Stony Rises in the Dreeite region.

The site provides critical habitat for the nationally endangered Corangamite Water Skink *Eulamprus tympanum marnieae*, which is endemic to the Victorian Volcanic Plain and which occurs mostly outside existing protected areas (Robertson 1998, Peterson 1999). The property supports large and stable populations of this and another significant species, the nationally vulnerable Growling Grass Frog *Litoria raniformis*, possibly due to the spring fed permanent wetland (G. Peterson pers. comm. 2003). These populations could act as an important source for recolonisation of adjacent sites following recent population declines and extinctions. The wetlands on the property are also utilised by a number of bird species that are threatened in Victoria (e.g. Brolga, Lewin's Rail, Freckled Duck, Australasian Shoveler *Anas rhynchotis*, Latham's Snipe *Gallinago hardwickii* and Whiskered Tern).

The property contains a number of significant Indigenous cultural heritage values.

The new reserve is known as the Dreeite Nature Conservation Reserve.

9. Melton Gilgai Woodlands

Almost 34 ha of endangered Plains Woodland at Harkness Road, Melton, was purchased in 2005 for nature conservation (Fig. 3). Although the site is located in the Victorian Volcanic Plains bioregion, it lies close to the southern slopes of uplands to its north. As a result the basalt of the plains is overlain with Quaternary colluvial outwash of the eroding uplands forming a swale/gilgai landform with gravels and soils derived from a mixture of basaltic, calcareous and siliceous sources (Webster 2001; Walters and Frood 2004).

The property is a site of botanical significance in western Melbourne (McDougall 1987). Grey Box Melbourne Yellow Gum *Eucalyptus leucoxylon* subsp. *connata* grassy woodlands (part of the Plains Woodland EVC) are considered endangered and are almost unrepresented in the reserve system in the bioregion. The new reserve represents a distinct floristic community of Plains Woodland EVC (Walters and Frood 2004). The diverse groundlayer is open, grassy and herbaceous, with low saltbush and a component of succulents. A soil crust of lichens and bryophytes is conspicuous over much of the site.

Over 80 indigenous plant species have been recorded from the property. A number of significant flora species occur on the site, including the rare Cane Spear-grass *Austrostipa breviglumis*, Heath Spear-grass *Austrostipa exilis*, Fragrant Saltbush *Rhagodia parabolica* and the vulnerable Melbourne Yellow Gum. A significant understorey population of the regionally depleted Turkey Bush *Eremophila deserti* also occurs in the understorey.

The purchased land represents one of the last remnants of once more extensive woodlands that covered the Melton/

Fig. 4. Grey Box and Buloke grassy woodland, Goomalibee. Photograph by J Fitzsimons

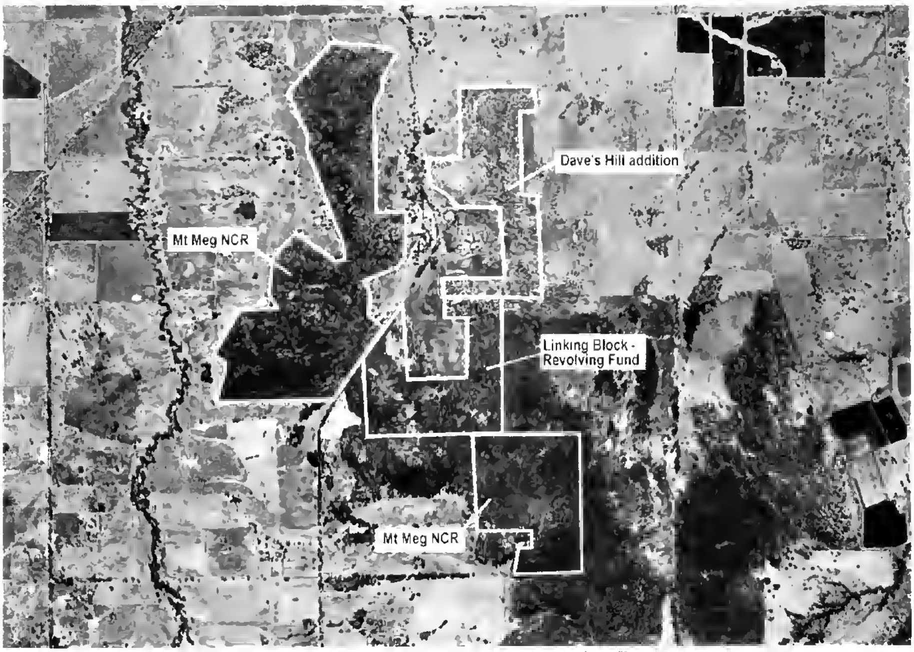

Fig. 5. Dave's Hill addition to the Mount Meg Nature Conservation Reserve.

Toolern Vale area (Robinson 1993). The property contains a predominance of key foraging trees for the nationally endangered Swift Parrot *Lathamus discolor*, a species recently recorded from similar roadside habitat in the area. A number of declining woodland birds can still be found on the site, including Diamond Firetail *Stagonopleura guttata* and Brown Treecreeper *Climacteris picumnus*. It is also anticipated that a range of amphibian species would occur in the swale/gilgai depressions that become inundated after prolonged and/or heavy rain episodes.

The new reserve is known as the Melton Gilgai Woodlands Nature Conservation Reserve.

10. Goomalibee Gilgai Plain Woodlands, Benalla

This 179 ha remnant of Gilgai Plain Woodland/Wetland Mosaic falls within the eastern Victorian Riverina bioregion, which is considered a high priority for further reservation. Such woodlands have been substantially cleared and modified throughout their range and blocks of this size are very rare.

The property comprises an open woodland with an overstorey of River Red Gum, Grey Box and Buloke *Allocasuarina luehmannii* and a groundlayer of wallaby-grass, tussock-grass, sedges and herbs (representing a component of the FFG-listed Grey Box-Buloke Grassy Woodland community) (Fig. 4). The significance of the property is highlighted by the presence of numerous gilgais, which are surrounded by a variety of herbs such as Swamp Billy-buttons *Craspedia paludicola* and Slender Goodenia *Goodenia gracilis*.

The Goomalibee Woodlands provide known habitat for two threatened bird species – the Bush Stone-curlew and Grey-crowned Babbler. This part of north-east Victoria is recognised as the stronghold for these species in the State. The nationally endangered Swift Parrot is known to use the adjoining roadsides. The significant roadside vegetation links the property to other patches of vegetation, providing corridors for the movement of other threatened species such as the Tree Goanna.

The new reserve is known as the Goomalibee Nature Conservation Reserve.

11. Dave's Hill, Chesney Vale Hills

The 99 ha addition of Dave's Hill to the Mount Meg Nature Conservation Reserve (NCR) enhances the protection of endangered vegetation communities and species habitat in the Chesney Vale Hills. The property is characterised by Granitic Hills Woodland EVC and nationally endangered Grassy White Box *Eucalyptus albens* Woodlands on the lower slopes. Grassy White Box Woodlands have been substantially cleared and modified throughout northern Victoria and the wheat-sheep belt of NSW (Prober and Thiele 1993) and are priority ecosystems for addition to the protected area system.

The Granitic Hills Woodland is dominated by Blakely's Red Gum *Eucalyptus blakelyi*, with a mix of Drooping Sheoak *Allocasuarina verticillata* and Lightwood *Acacia implexa* amongst complex granitic outcrops. Small areas of endangered Springsoak Herblands also occur on adjoining public land which will be added to the reserve.

The Chesney Vale Hills are considered one of the most important habitats in Victoria for the endangered Inland Carpet Python *Morelia spilota metcalfei* (Allen *et al.* 2003; Heard and Black 2003; Heard *et al.* 2004). The pythons move between Dave's Hill and Mount Meg (see Fig. 5). Dave's Hill provides important habitat for a range of other reptile species (Heard and Black 2003), including Tree Goanna and Eastern Bearded Dragon.

The Chesney Vale Hills are considered an important site for the nationally vulnerable Narrow Goodenia *Goodenia macbarronii* (Berwick 1996), and is one of only seven Northern Sandalwood *Santalum lanceolatum* populations known in the State (Johnson 1996).

The Dave's Hill purchase is linked to other components of the Mount Meg NCR through the acquisition of adjoining land by the Trust for Nature for covenanting and onsale through its 'Revolving Fund' (see Fitzsimons and Davies 2005). This land contains a number of additional significant species including the Turquoise Parrot *Neophema pulchella*, Bush Stone-curlew and Flat-leaf Bush-pea *Pultenaea platyphylla*.

12. River Point East, French Island

This small (1 ha) addition to French Island National Park forms part of a larger block of vegciation which was 'Rated A' for botanical significance in the Western Port district (i.e. Site of Significance No. 25 'River Point East' in Opie *et al.* 1984). The Coast Road block contains endangered Swamp Scrub as well as Heathy Woodland, and protects significant orchid populations such as the White Caladenia *Caladenia catenata* and the nationally vulnerable French Island Spider-orchid *Caladenia insularis*.

13. Kangaroo Swamp, Mullungdung Forest

This 105 ha purchase in the heart of Mullungdung Forest includes Kangaroo Swamp and surrounding Lowland Forest. Kangaroo Swamp represents the largest freshwater sedge wetland in central Gippsland, and has been identified as a site of zoological (Mansergh and Norris 1982), botanical (Gullan *et al.* 1984) and geomorphological (Rosengren *et al.* 1981) significance in that region.

The swamp's position within the Mullungdung forest (the largest remnant on the Gippsland Plain at ~25,000 ha) will ensure its long-term ecological integrity, and it is adjoined by Special Protection Zones within the Mullungdung State Forest (see DSE 2004).

The size and position of the swamp within Mullungdung makes it an important focus of the forest. Kangaroo Swamp is likely to be an important refuge for frogs and waterbirds during drought (Gilmore 1977). As there are few other perennial watercourses or waterbodies in the forest, the Swamp is a significant drinking location for forest fauna and an important nesting site for waterbirds and raptors. The large, hollow-bearing trees at the site provide important nesting opportunities for species reliant on such conditions. A number of significant species has been recorded on the property, including Barking Owl *Ninox connivens*, Powerful Owl *N. strenua*, Great Egret, Hardhead, Latham's Snipe, Spotted Quail-thrush *Cinclosoma punctatum*, Tree Goanna and Martin's Toadlet *Uperoleia martini*.

The new reserve is known as the Kangaroo Swamp Nature Conservation Reserve.

Other purchases

Other purchases include a small area of Gilgai Plain Woodland at Drumanure for addition to the Broken-Boosey State Park and land at Kalimna Park for addition to the Castlemaine Diggings National Heritage Park.

Future directions for land purchase and the protected area system

Such strategic acquisitions, combined with other instruments to protect ecosystems on private land, ultimately aim to improve the comprehensiveness, adequacy and representativeness of Victoria's protected area system. Negotiations for the purchase of other poorly represented ecosystems are currently in progress. Particular emphasis is on native grasslands and grassy woodlands. The Department's efforts are complemented by those of the Trust for Nature (Victoria) which has and continues to purchase properties containing grassy and other threatened ecosystems throughout the State as part of the National Reserve System program. Increasingly, creative solutions are being sought between DSE and the Trust to secure important conservation lands (see Fitzsimons and Davies 2005).

Further details, including Management Statements for a number of these purchased properties, can be accessed via the Conservation Land Purchase Program website: www.dse.vic.gov.au >parks and reserves>about parks and reserves>conservation land purchase program.

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ties have ensured the maintenance of these remnants. Many of the past owners still have a strong connection to the new protected areas. The Commonwealth Government, through the National Reserve System Program of the Natural Heritage Trust, provided funding for the purchase of a number of these properties.

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Appendix 1. Some species occurring (or likely to occur) on recently purchased land (and their conservation status). Abbreviations: (Victorian Status) ce, critically endangered; e, endangered; v, vulnerable; r, rare; n, near threatened; k, poorly known/data deficient; (FFG) L, listed under the *Flora and Fauna Guarantee Act 1988*; (Commonwealth Status); E, endangered; V, vulnerable. Derived from DSE (2003, 2005), *Flora and Fauna Guarantee Act 1988* and *Environment Protection and Biodiversity Conservation Act 1999*. Note: This table does not represent all species occurring in the above-mentioned reserves.

	Scientific Name	Common Name	Vic Status	FFG	Cwlth Status
Mammals	*Antechinus minimus maritimus*	Swamp Antechinus	n	L	
	Dasyurus maculatus	Spot-tailed Quoll	e	L	V
	Isoodon obesulus obesulus	Southern Brown Bandicoot	n		E
	Petaurus australis	Yellow-bellied Glider			
	Petaurus norfolcensis	Squirrel Glider	e	L	
	Potorous tridactylus tridactylus	Long-nosed Potoroo	e	L	V
	Pseudomys shortridgei	Heath Mouse	n	L	V
	Sminthopsis crassicaudata	Fat-tailed Dunnart	n		
Birds	*Anas rhynchotis*	Australasian Shoveller	v		
	Anseranas semipalmata	Magpie Goose	v		
	Ardea alba	Great Egret	v	L	
	Aythya australis	Hardhead	v		
	Biziura lobata	Musk Duck	v		
	Botaurus poiciloptilus	Australasian Bittern	e	L	
	Burhinus grallarius	Bush Stone-curlew	e	L	
	Calyptorhynchus banksii graptogyne	Red-tailed Black-Cockatoo	e	L	E
	Chlidonias hybridus	Whiskered Tern	n		
	Cinclosoma punctatum	Spotted Quail-thrush	n		
	Climacteris picumnus victoriae	Brown Treecreeper	n		
	Egretta garzetta	Little Egret	e	L	
	Gallinago hardwickii	Latham's Snipe	n		
	Grus rubicunda	Brolga	v	L	
	Lathamus discolor	Swift Parrot	e	L	E
	Neophema chrysogaster	Orange-bellied Parrot	ce	L	E
	Neophema pulchella	Turquoise Parrot	n	L	
	Ninox connivens	Barking Owl	e	L	
	Ninox strenua	Powerful Owl	v	L	
	Nycticorax caledonicus	Nankeen Night Heron	n		
	Oxyura australis	Blue-billed Duck	e	L	
	Pedionomus torquatus	Plains-wanderer	ce	L	V
	Platalea regia	Royal Spoonbill	v		
	Pluvialis fulva	Pacific Golden Plover	n		
	Pomatostomus temporalis	Grey-crowned Babbler	e	L	
	Rallus pectoralis	Lewin's Rail	v	L	
	Stagonopleura guttata	Diamond Firetail	v	L	
	Stictonetta naevosa	Freckled Duck	e	L	
Reptiles	*Diplodactylus tessellatus*	Tessellated Gecko	n		
	Egernia coventryi	Swamp Skink	v	L	
	Eulamprus tympanum marnieae	Corangamite Water Skink	ce	L	E
	Morelia spilota metcalfei	Inland Carpet Python	e	L	
	Morethia adelaidensis	Samphire Skink	e	L	
	Pogona barbatus	Eastern Bearded Dragon	k		
	Pygopus schraderi	Hooded Scaly-foot	ce	L	
	Varanus varius	Tree Goanna	v		
Amphibians	*Litoria raniformis*	Growling Grass Frog	e	L	V
	Uperoleia martini	Martin's Toadlet	k		
Fishes	*Galaxiella pusilla*	Dwarf Galaxias	v	L	V
	Nannoperca obscura	Yarra Pigmy Perch	n	L	V
Plants	*Acacia implexa*	Lightwood			
	Acacia mearnsii	Black Wattle			

Appendix 1 cont'd.

Scientific Name	Common Name	Vic Status	FFG	Cwlth Status
Acacia melanoxylon	Blackwood			
Acacia oswaldii	Umbrella Wattle	v		
Allocasuarina luehmannii	Buloke		L	
Allocasuarina paludosa	Scrub Sheoak			
Allocasuarina verticillata	Drooping Sheoak			
Amaranthus macrocarpus var. *macrocarpus*	Dwarf Amaranth	v		
Atriplex eardleyae	Small Saltbush			
Atriplex leptocarpa	Slender-fruit Saltbush			
Atriplex pseudocampanulata	Mealy Saltbush	r		
Atriplex turbinata				
Atriplex vesicaria macrocystidia	Bladder Saltbush	k		
Austrodanthonia caespitosa	Common Wallaby-grass			
Austrostipa aristiglumis	Plump Spear-grass			
Austrostipa breviglumis	Cane Spear-grass	r		
Austrostipa exilis	Heath Spear-grass	r		
Austrostipa scarbra	Rough Spear-grass			
Caladenia catenata	White Fingers			
Caladenia insularis	French Island Spider-orchid	v	L	V
Centipeda thespidioides s.l.	Desert Sneezeweed	r		
Chloris truncata	Windmill Grass			
Craspedia paludicola	Swamp Billy-buttons			
Eremophila deserti	Turkey Bush			
Eryngium paludosum	Long Eryngium	v		
Eucalyptus albens	White Box			
Eucalyptus baxteri	Brown Stringybark			
Eucalyptus blakelyi	Blakely's Red Gum			
Eucalyptus camaldulensis	River Red Gum			
Eucalyptus leucoxylon	Yellow Gum			
Eucalyptus leucoxylon connata	Melbourne Yellow Gum	v		
Eucalyptus melliodora	Yellow Box			
Eucalyptus microcarpa	Grey Box			
Glycine latrobeana	Clover Glycine	v	L	V
Goodenia gracilis	Slender Goodenia			
Goodenia macbarronii	Narrow Goodenia	v	L	V
Leptospermum continentale	Prickly Tea-tree			
Maireana aphylla	Leafless Bluebush	v		
Maireana cheelii	Chariot Wheels	v		V
Melicytus dentatus	Tree Violet			
Muehlenbeckia horrida	Spiny Lignum	r		
Mukia micrantha	Mallee Cucumber	r		
Pultenaea platyphylla	Flat-leaf Bush-pea	r		
Rhagodia parabolica	Fragrant Saltbush	r		
Rhodanthe floribunda	Common White Sunray	e		
Santalum lanceolatum	Northern Sandalwood	e	L	
Sida fibulifera	Pin Sida	v		
Sporobolus caroli	Yakka Grass	r		
Thelymitra aff. *ixioides* (Western Victoria)	Small Spotted Sun-orchid	k		
Vittadinia pterochaeta	Winged New Holland Daisy	v		
Whalleya proluta	Rigid Panic			

Appendix 2. Some listed *Flora and Fauna Guarantee Act 1988* communities occurring on recently purchased land.

Northern Plains Grassland Community	Victorian Temperate-woodland Bird Community
Grey Box - Buloke Grassy Woodland Community	

Terrestrial mammals of Phillip and French Islands, Western Port, Victoria

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Abstract
Standard survey techniques were used to assess the mammalian fauna of Phillip and French Islands in Western Port, Victoria between 1997 and 2005. In total, 16 native and 7 exotic species were recorded on Phillip Island and 13 native and 8 exotic species on French Island. The most diverse faunal group was the microbats (7 species in total). Species present were compared with those previously recorded on the two islands and the adjacent mainland. Deliberate and accidental introductions since European settlement of both Australian native and non-native species have substantially changed the species present on both islands. The greatest threats to current mammalian fauna on the islands include foxes (currently not resident on French Island), land-clearance, road traffic, and irresponsible human-induced introductions. (*The Victorian Naturalist* **123** (3), 2006, 146-156)

Introduction

Phillip and French Islands, located in Western Port, central coastal Victoria (Fig. 1) were separated from mainland Australia during sea-level rises approximately 10,000 years ago (Garden 2002). A study of past and present mammalian species on these islands can provide an insight into the local history and influence of humans on island biodiversity. Information on native species prior to European settlement may be inferred from bones in archaeological digs at Aboriginal middens (Gaughwin 1981) and mammal sightings mentioned in accounts of early settlers (Blandowski 1857; Wheelright 1862; Gliddon 1968). As in most Australian environments, European settlement greatly altered the species present. Current terrestrial fauna on the islands are the result of populations that survived the geographic isolation or migrated over water to the islands and by bridge to Phillip Island, and those that have survived human influences, including introductions of exotic and non-endemic, native species.

In 1980, a survey of vertebrate species within the Western Port catchment was the first to fully document the mammals present on the islands (Andrew *et al.* 1984). This paper utilises previous records and more recent surveys to document the status and dynamics of mammalian fauna on the islands. The history of human-induced changes on these adjacent islands differs considerably, and a comparison of their histories provides information on the impacts of anthropogenic manipulations, which are omnipresent in the Australian environment.

Methods

Phillip Island and Churchhill Island together comprise 100 km^2 of low lying mainly cleared farmland while French Island comprises 200 km^2 of heathland, eucalypt forest and cleared farmland. Between 1997 and 2004, standard survey techniques were used to record the presence and distribution of mammals on these islands. Techniques included Elliott and cage trapping and hair-tubing for small ground mammals (baited with peanut butter and oats or fish), spot-light searches for arboreal and macropod species, strip-transects to record macropod densities in some reserves, harp-trapping for bats, and daytime searches for animal signs. Traps (Elliott, cage and harp) were set at a location for one to three nights and were checked each morning. Surveys were conducted across all seasons. Exotic pest animals were trapped using cage and leghold traps or were shot; their stomach contents were checked for the presence of mammal remains (see methods in Kirkwood *et al.* 2000, 2005).

To broaden the scale of this study, trapping results from several contemporaneous

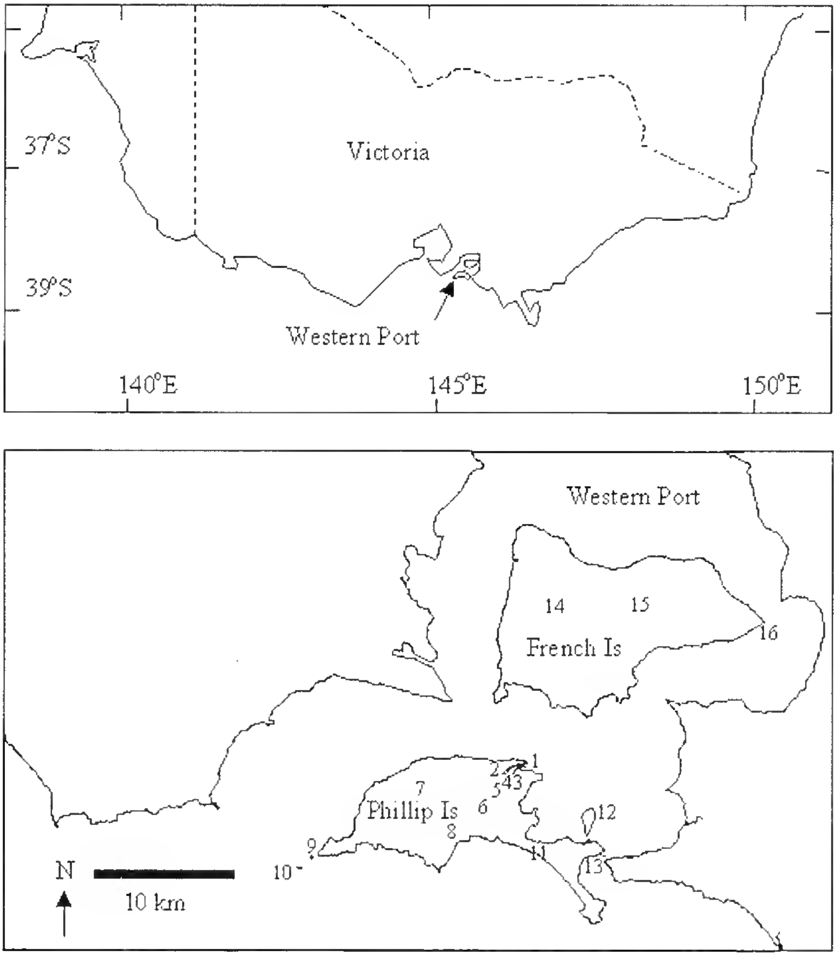

Fig.1. The location of Western Port, Phillip and French Islands, and sites referred to in the text. 1. Rhyll Inlet; 2. Silverleaves; 3. Rowell Swamp, 4. Conservation Hill; 5. Oswin-Roberts Reserve, 6. Koala Conservation Centre; 7. Ventnor Koala Reserve; 8. Stinker Bay; 9. Point Grant; 10. Seal Rocks; 11. Forest Caves; 12. Churchill Island; 13. San Remo Bridge; 14. Deuschers Swamp; 15. French Island National Park; 16. Spit Point.

research projects were incorporated (Campbell 2000; Harken 2000; Lanyon 2000; Johnston 2002; Scott 2003; Marks *et al.* in press;). Long-term residents were interviewed for their recollections of species present and records held in the Atlas of Victorian Wildlife Database were reviewed.

Results

Phillip Island

Between 1997 and 2004, 135 House Mice *Mus musculus* and 17 Black Rats *Rattus rattus* were caught from a total of 2132 Elliott trap nights in nine areas of Phillip Island (Table 1). The only indication of the presence of small, native, ground mammals was an area of 'Swamp Rat *Rattus lutreolus* like' runways through dense grass adjacent to Conservation Hill (Fig. 1). In the mid 1980s, a single Swamp Rat was trapped there, photographed and released *in situ* (R Baird 1998 pers. comm.). Trapping and hair-tubing in this area on three occasions in this study failed to record a swamp rat and over the course of the study, the runway systems deteriorated.

During a total of 737 cage trap nights in coastal areas at the western end of Phillip

Table 1. Small mammals caught during Elliott trapping on Phillip Island.

Location	Nights	Trap nights	House mice	Black rats
Summerland Peninsula	4-6 Feb 1998	141	2	.
Ventnor Reserve (a)	6-8 Jan 1998	117	.	.
Ventnor Reserve (b)	8-10 Oct 1998	150	.	.
Ventnor Reserve (c)	15-17 Oct 1998	150	.	.
Ventnor Reserve (d)	22-24 Oct 1998	150	.	.
Silverleaves	12-14 Feb 1998	111	22	.
Oswin-Rob. Reserve (a)	14-16 May 1999	130	1	.
Oswin-Rob. Reserve (b)	17-19 May 1999	150	5	.
Oswin-Rob. Reserve (c)	28-30 Jun 2004	60	.	.
Rhyll Swamp	26-28 Jan 1998	137	3	1
Rowell Swamp (a	11-13 Nov 1997	120	1	.
Rowell Swamp (b)	27-29 Apr 1998	30	.	.
Conservation Hill (a)	14-16 Dec 1997	145	27	3
Conservation Hill (b)	29-31 Jan 1998	121	.	.
Conservation Hill (c)	1-3 Apr 1999	90	20	2
Churchill Island (a)	25-27 Jan 1999	90	25	6
Churchill Island (b)	15-17 Mar 1999	90	19	1
Cape Woolamai (a)	in Feb 1999	90	.	4
Cape Woolamai (b)	18-20 May 2000	60	10	.
Totals	48	2132	135	17

Island, Harkin (2000) caught four Water Rats (*Hydromys chrysogaster*). Diggings suspected to have been made by a Long-nosed Potoroo *Potorous tridactylus* were observed at Rowell Swamp but no potoroos were caught there during 48 cage-trap nights, nor recorded using hair-tubes. Following the use of a remotely triggered camera, this activity was attributed to a Bassian Thrush *Zoothera lunulata*. Two records of Long-nosed Potoroo were made during the study period. A dead, adult male was collected from a beach along the north coast in May 2003 and a dying, adult male was found beside a road at the eastern end of the island in May 2004. Likewise, there were several records of Tasmanian Bettongs *Bettongia gaimardi* which had escaped from a wildlife park on Phillip Island just prior to this study (P Dann pers. comm.).

Five microbat species were trapped during a single-night exercise in November 1997 using three harp-traps in Rhyll Swamp; the Little Forest Bat *Vespadelus vulturnus*, Large Forest Bat *V. darlingtoni*, Chocolate Wattled Bat *Chalinolobus morio*, Gould's Wattled Bat *C. gouldi* and Lesser Long-eared Bat *Nyctophylus geoffroyi* (Table 2). Also, the distinctive audible call of White-striped Freetail-bats *Tadarida australis* was noted frequently, particularly in coastal areas around the island. During a study over 102 harp-trap-nights at the Koala Conservation Centre, central Phillip Island, in 1999, Campbell *et al.* (2005) recorded the Eastern False Pipistrelle *Falsistrellus tasmaniensis*, in addition to the above species (Table 2).

Swamp Wallabies *Wallabia bicolor*, Common Brushtail Possums *Trichosurus vulpecula*, Common Ringtail Possums *Pseudocheirus peregrinus*, Koalas *Phascolarctos cinereus*, Rabbits *Oryctolagus cuniculus*, Hares *Lepus capensis*, Red Foxes *Vulpes vulpes*, cats *Felis catus* and Black Rats were recorded during spot-light surveys. All these species were found across the entire island. Day-time strip-transect sampling in the 100 hectare Oswin-Roberts Reserve yielded estimates of about 192 Swamp Wallabies in August 1998, 280 in June 2004, and 200 in September 2005. In the 60 hectare Ventnor Koala Reserve, estimates were 60 Swamp Wallabies in July 2002, 80 in June 2004, and 40 in September 2005. Of the three arboreal species recorded on the island, Common Ringtail Possums were the most commonly seen. For example, in a 1 km circuit in Oswin-Roberts Reserve, Common Ringtail Possums were observed

Table 2.. Forest bats caught during harp-trapping on Phillip Island. Data for the Koala Centre come from Campbell (2000).

Species	Common name	Rhyll Swamp 1997 No.	%	Koala Centre 1999 No.	%
Vespadelus vulturnus	Little Forest Bat	95	86	284	26
V. darlingtoni	Large Forest Bat	6	5	330	32
Chalinolobus morio	Chocolate Wattled Bat	5	5	19	2
C. gouldii	Gould's Wattled Bat	1	1	41	4
Nyctophylus geoffroyi	Lesser Long-eared Bat	3	3	373	36
Falsistrellus tasmaniensis	Eastern false Pipistrelle			2	>1

on all 12 spot-light occasions (range 2 to 11 possums, mean = 6); Koalas were noted twice and Common Brushtail Possums once. Island-wide monitoring of the Koala has recorded a decline in recent years, from 847 in 1973 to <20 in 2004 (Fig. 2). Two sightings, 15 km apart, of adult Eastern Grey Kangaroos *Macropus giganteus* were reported during the 2004/5 summer and in June 2005 one adult was sighted crossing the San Remo Bridge onto Phillip Island and through the town-ship of Newhaven.

Rabbits are abundant and Hares were common across the island. Each year over the study period 37 to 91 Foxes and 58 to 93 Cats were killed. Lanyon (2000) caught seven cats in 791 trap nights in shearwater colonies at the western end of the island. The only mammalian hair identified in a predator's stomach was of a Brown Rat *Rattus norvegicus* in one fox.

Finally, Echidnas *Tachyglossus aculeatus* were common across Phillip Island and were occasionally caught in cage-traps.

French Island

During 2001, from 2700 Elliott trap nights in six one-hectare sites in French Island National Park, Marks *et al.* (in press) recorded Bush Rats *R. fuscipes* and Swamp Rats densities of 15-34 and 2-12 individuals per hectare, respectively. In a study involving 5133 Elliott and cage trap

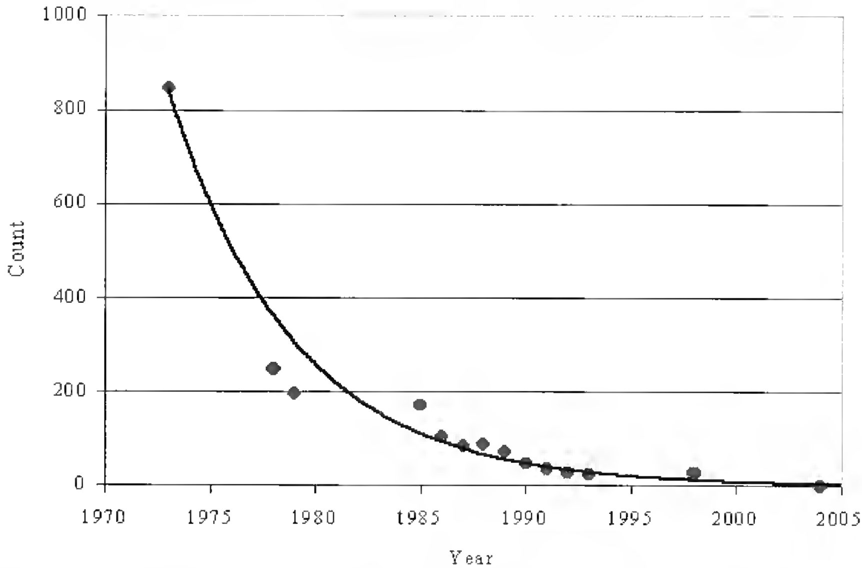

Fig 2. Numbers of Koalas counted on Phillip Island during censuses conducted in September in years between 1973 and 2004. The line represents an exponential regression through the data: y = 2E+147e-0.17x (r^2 = 0.92).

nights at 59 sites, Scott (2003) caught 742 individual Bush Rats (present in 98% of sites), 393 Swamp Rats (in 83% of sites) and 14 House Mice (which were generally associated with modified habitats). No Long-nosed Potoroo were trapped but there was evidence of digging activity at 32% of the sites (Scott 2003). A population was known to exist on French Island (Seebeck 1981) and individuals were occasionally reported during this study (M. Douglas, pers. comm.). Also, in a trapping study near the centre of the island during 2005/06, at least nine individuals were caught (K Handasyde 2006 pers. comm.). Water Rats have been reported around the island but their abundance and distribution were not assessed during this study.

Other native species recorded on French Island during this study, although not specifically surveyed, include Koala (common), Echidna (common) and a suite of microbat species (Little Forest Bat, Large Forest Bat, Chocolate Wattled Bat, Gould's Wattled Bat, White-striped Freetail-bats and Lesser Long-eared Bat; Johnston 2002). A single Eastern Grey Kangaroo was allegedly shot on the island in the early 1990s but little detail exists to describe how it came to be on the island (M Douglas 2004 pers. comm.). Also, a dead Platypus *Ornithorhynchus anatinus* that probably originated from off the island was found washed up at Spit Point during 2003 and a dead Common Wombat *Vombatus ursinus* washed ashore on the island in June 2005 (M Douglas 2004 pers. comm.).

Other extant exotic species include Black Rats, Rabbits, Cats, Sambar Deer *Cervus unicolor*, Goats *Capra hircus* and Pigs *Sus scrofa*; the latter having been recently released (A Ledden 2004 pers. comm.). During 2001, McTier (2002) monitored feral Cats across cleared grazing land and adjoining National Park and estimated the population of feral cats on French Island to be approximately 300. Johnston (unpublished data) caught 71 Cats in French Island National Park during two five-week trapping sessions. Sambar Deer were seen regularly when spotlighting in wetland areas such as Deuschers Swamp and Goats were widespread across the island, with large mobs (>20 individuals) occasionally seen (Johnston 2002). Conspicuously absent from French Island was the Fox, although a dumped, dead cub was found beside a road during 1999; three other reported sightings are thought to have been misidentified Cats (Johnston 2002; Parks Victoria 2004 unpublished data).

Discussion

In total, 16 native and seven exotic species were recorded on Phillip Island and 13 native and eight exotic species on French Island (Table 3). These data are representative only, as species monitoring was not exhaustive. For example, there are several bat species that may visit or reside in low numbers but were not recorded in this study. French Island in particular has not been fully surveyed for bat fauna. It is unlikely, however, that large populations of mammals remain undiscovered on the islands. Conversely, several records, namely Long-nosed Potoroos on Phillip Island and Eastern Grey Kangaroos on both Phillip and French Islands, are likely to represent individual arrivals and wildlife park escapes, rather than resident populations. These large bodied species probably would have been recorded more frequently had viable populations been extant on the respective islands.

This study represents a unique point in time for mammalian occupation of the islands in Western Port. Species compositions have changed in the past and are likely to change in the future. A review of previous records of mammals on these islands places this study in a temporal perspective.

Pre-European

Prior to separation from the mainland 10 000 years ago, the areas now occupied by Phillip and French Islands could have contained most of the mammalian species that were resident in south-eastern Australia. However, the now-islands are thought to have been either surrounded by open plains or swamp, which could have limited the sizes of resident populations (Rosengren 1988; Garden 2002). Once separated, low genetic diversity within the populations and Aboriginal hunting pressure or catastrophic events, such as fire or prolonged drought, may have caused local extinctions.

Table 3. Terrestrial mammals of Phillip and French Islands, Western Port, Victoria. Data for 1970-80 combines Andrews *et al.* 1984 and records from the Atlas of Victorian Wildlife Database. + indicates presence recorded. * indicates temporary visitors, either escapees from a local wildlife park, or individuals that crossed to Phillip Island via the San Remo Bridge. † indicates dead individuals dumped or washed ashore.

Species	Common name	Phillip I Established	Phillip I Early 1900s	Phillip I 1970-80	Phillip I 1997-05	Phillip I Status	French I Established	French I Early 1900s	French I 1970-80	French I 1997 05	French I Status
Australian native											
Ornithorhynchus anatinus	Platypus					absent				+	visitor †
Tachyglossus aculeatus	Short-beaked Echidna	~1930s	+	+	+	breeding			+	+	breeding
Isoodon obesulus	Southern Brown Bandicoot		+			absent					absent
Vombatus ursinus	Common Wombat					absent				+	visitor †
Phascolarctos cinereus	Koala	~1920s	+	+	+	breeding	~1920s	+	+	+	breeding
Trichosurus vulpecula	Comm. Brushtail Possum	~1950s		+	+	breeding					absent
Pseudocheirus peregrinus	Comm. Ringtail Possum	~1920s	+	+	+	breeding					absent
Bettongia gaimardi	Tasmanian Bettong				+	visitor*					absent
Potorous tridactylus	Long-nosed Potoroo			+	+	visitor*†		+	+	+	breeding
Macropus giganteus	Eastern Grey Kangaroo		+	+	+	visitor*					absent
Thylogale billardierii	Tasmanian Pademelon			+		visitor*					absent
Wallabia bicolor	Swamp (black) Wallaby		+	+	+	breeding					absent
Pteropus poliocephalus	Grey-headed Flying-fox			+		visitor			+		visitor
Pteropus scapulatus	Little red Flying-fox			+		visitor					visitor
Tadarida australis	White-striped Freetail-bat				+	visitor					visitor
Chalinolobus gouldii	Gould's Wattled Bat			+	+	breeding				+	breeding
Chalinolobus morio	Chocolate Wattled Bat			+	+	breeding				+	breeding
Falsistrellus tasmaniensis	Eastern False Pipistrelle				+	visitor					visitor
Miniopterus schreibersii	Common Bent-wing Bat			+		visitor					visitor
Nyctophilus geoffroyi	Lesser Long-eared Bat			+	+	breeding			+	+	breeding
Vespadelus darlingtoni	Large Forest Bat			+	+	breeding			+	+	breeding
Vespadelus regulus	Southern Forest Bat			+		visitor					visitor
Vespadelus vulturnus	Little Forest Bat			+	+	breeding			+	+	breeding
Hydromys chrysogaster	Water Rat		+	+	+	breeding		+	+	+	breeding
Rattus fuscipes	Bush Rat					absent		+	+	+	breeding
Rattus lutreolus	Swamp Rat			+		absent		+	+	+	breeding

Table 3 (cont.)

Species	**Common name**	**Phillip I Estab-lished**	**Early 1900s**	**1970 -80**	**1997 -05**	**Status**	**French I Estab-lished**	**Early 1900s**	**1970 -80**	**1997 05**	**Status**
Non-native											
Mus musculus	House Mouse		+	+	+	breeding			+	+	breeding
Rattus rattus	Black Rat		+	+	+	breeding			+	+	breeding
Rattus norvegicus	*Brown Rat*				+	visitor					absent
Vulpes vulpes	Red Fox	~1900s	+	+	+	breeding				+	visitor †
Felis catus	Cat	~1840s	+	+	+	breeding			+	+	breeding
Capra hircus	Goat					absent			+	+	breeding
Cervus dama	Fallow Deer	~1840s	+			absent					absent
Cervus elaphus	Red Deer	~1840s				absent					absent
Cervus unicolor	Sambar					absent		+	+	+	breeding
Sus scrofa	Pig	~1840s				absent	~1997			+	breeding
Lepus capensis	Brown Hare	~1840s	+	+	+	breeding					absent
Oryctolagus cuniculus	European Rabbit	~1880s	+	+	+	breeding		+	+	+	breeding

Analysis of mammalian bones in Aboriginal middens provides little evidence of species present during the several thousand years prior to European arrival. A midden at Point Grant, Phillip Island, dated at 2000 to 1500 years ago had bones of 'a wallaby, a possum and some seal' (D Gaughwin 1987 pers. comm., in a letter to the Phillip Island Nature Park). At Forrest Caves on Phillip Island, excavations recovered bones of a 'rufous-bellied wallaby' (possibly a Red-necked Wallaby, *Macropus rufogriseus*), a 'yellow-footed phascogale or marsupial mouse' (possibly an *Antechinus* species) and 'a rat' (possibly a Bush Rat) (Gill 1968). Likewise, a midden at Stinker Bay, Phillip Island (dated to 250 years ago) contained bones of one Red-necked Wallaby and Bush Rat teeth (Gaughwin and Brennan 1986). Given the possible transience of Aborigines in the area (Gaughwin 1981, 1983; Cole 1984; Belcher and Hastings 1983) it is possible that the wallaby and possum bones and cultural items in the middens came from carcases brought to, rather than killed on, the islands (Gaughwin 1981). Therefore, the middens do not uambiguously record the status of any mammalian species on the islands prior to European settlement.

1800s

European discovery of the islands was by George Bass in 1798, although French Island was considered to be part of the mainland until 1801 (Scott 1917). Bass noted a colony of Australian Fur Seals *Arctocephalus pusillus doriferus* at Seal Rocks off the western tip of Phillip Island, which drew some interest from early sealers. Sealers had operated on Seal Rocks between March and December 1801 (journals of Murray, reported in Cole 1984), and in 1809, the brigantine *Active* collected 1300 skins from Western Port (Cumpston 1973). Sealers occasionally camped on the rocks or on Phillip Island. A semi-permanent sealers' camp was present at Rhyll in 1826, when the island was visited by Dumont d'Urville (Cole 1984). There are no records from the early explorers or sealers of other mammals on the islands.

Soon after 1842 the first European farmers, the McHaffie family, arrived on

Phillip Island and started to clear the land (Gliddon 1968). AD Hardy, the elder daughter of J McHaffie, recorded in a diary that native mammals present at the time of settlement included Bush Rats, Bandicoots (probably the Southern Brown Bandicoot *Isoodon obesulus*) and Water Rats (quoted in Gliddon 1968). Wallabies 'appeared later, but it was not known how they gained access', Kangaroos were 'shot at times', there were 'no koalas or dingos', and 'seals were plentiful at Seal Rocks' (Hardy, in Gliddon 1968). The McHaffies became active members of the Acclimatisation Society and introduced Fallow Deer *Cervus dama*, Red Deer *C. elaphus*, Hares, Belgian Rabbits *Oryctolagus* sp., Pigs and Cats (Gliddon 1968). Red Deer did not establish, Pigs established a feral population for a brief period (Seddon 1975) and Belgian Rabbits probably were absorbed into the later introduction of European Rabbit.

In 1855, Blandowski (1857) noted that 'the wallaby is found scattered over the whole of Phillip Island, but is especially numerous on the eastern portion', but was absent from French Island. Around the same time, Wheelwright (1862) commented that the Dark-brown Swamp Wallaby *W. bicolor* 'abound in the scrub on Phillip Island'. The apparent abundance of Swamp Wallabies in the mid 1850s contrasts with their apparent absence ten years earlier (suggested by Hardy). Either Swamp Wallabies were present on Phillip Island prior to settlement and were not recognised until land clearance made them more obvious, or they colonised around the same time as the early settlers and the population quickly expanded.

Blandowski (1857) also mentioned that Water Rats were abundant around lagoons and waterways on both Phillip and French Island. Wheelright (1862) believed a small, yellow-bellied kangaroo, called a pademelon, was present on Phillip Island. This could have been the Tasmanian Pademelon *Thylogale billardierii* which occurred elsewhere along the Victorian coast (Menkhorst 1995). Brushtail and Ringtail Possums were common in the Western Port area, although not specifically mentioned to be on Phillip or French Island (Wheelright 1862).

In 1868, Phillip Island was surveyed and partly opened to free-settlement. At the time, there were about 2000 cattle, 10,000 sheep and over 200 deer resident (Glidden 1968). Vegetated areas continued to be cleared and burned to provide pasture, and logged to provide fuel for chicory kilns. Rabbits were released on the island, to provide targets for shooting parties (H Cleeland 2004 pers. comm.) and Koalas were introduced as a novelty (Gliddon 1968).

In summary, based on the notes of early explorers and residents, mammalian populations on Phillip Island prior to European settlement included Water Rats, Bush Rats, Southern Brown Bandicoots and possibly Swamp Wallabies and Tasmanian Pademelons. If Tasmanian Pademelon were present, their numbers are likely to have been low and they quickly became locally extinct, as there were no further records of them. There also may have been a small population of Eastern Grey Kangaroos that likewise became locally extinct, although those reported to Hardy (in Gliddon 1968) could have arrived with the settlers or have been misidentified wallabies. Without further evidence, it is assumed they were not present in a viable population prior to European settlement. By the end of the century there had been successful introductions to Phillip Island of Cats, Rabbits, Brown Hares, Fallow Deer and Koalas, and probably House Mice and Black Rats.

On French Island, European settlement proceeded at a slower rate than on Phillip Island, and there is less information on species present. Given later observations, it is likely that these included Water Rats (which Blandowski (1857) did report as being present), Bush Rats, Swamp Rats, and Long-nosed Potoroos. Koalas were reportedly released on the island in the 1890s and, in the absence of predators and diseases such as chlamydiosis, quickly became widespread (Parks Victoria 1998). Other successful introductions to French Island by the end of the 1800s perhaps included Rabbits, Goats, House Mice, Black Rats and Sambar Deer, for which periods of introduction are not known.

1900s

Red Foxes were reported on Phillip Island for the first time in about 1905. Although their mode of arrival is not known, several accounts suggest individuals may have swum to the island (Gliddon 1968). Within 15 years it was recognised that Red Foxes were having a devastating impact on seabird colonies in the island (Gabriel 1919). Curiously, Foxes have never established populations on French Island.

During the early 1900s, there was an increased settlement and development of townships on both islands, particularly Phillip Island, along with community interest in nature conservation (Seddon 1975). Reserves were established and, in addition to continued clearing, some revegetation projects commenced. On French Island, Koalas had become so numerous by 1923 that translocations off the island, including to Phillip Island, were initiated (Menkhorst 1995). Shortly thereafter, overbrowsing on Phillip Island vegetation was noticed; translocations of Koalas from that island commenced in the 1940s (Gliddon 1968). Further species were introduced to the islands by local residents, many by the Grayden family who were clearing land near Stony Point on the Mornington Peninsula and bringing marsupials they found back to their home at Newhaven, Phillip Island (K Grayden 2004 pers. comm.). Anecdotal reports for the establishment of non-endemic, native mammal populations on Phillip Island include Common Brushtail Possums by the 1920s and Short-beaked Echidnas by the 1930s (K Grayden and H Cleeland 2004 pers. comm.). Common Ringtail Possums and Eastern Grey Kangaroo individuals were introduced around the same time but did not establish wild populations (K Grayden 2004 pers. comm.). On French Island between 1900-05, a pair of Common Ringtail Possums was released by J Ratford (C Chandler 2004 pers. comm.). A breeding population of this species had established by the 1920s but became extinct by the 1940s (C Chandler 2004 pers. comm.). A feral Cat population was recognised on French Island by the 1930s (Lewis 1934) and Short-beaked Echidnas apparently had established by the 1950s (C Chandler 2004 pers. comm.).

In the 1930s and 40s, sport shooting became a popular pastime on Phillip Island. This resulted in the eradication of Fallow Deer, the near elimination of Swamp Wallabies and the further introduction of Rabbits to provide an alternative target (K Grayden 2004 pers. comm.).

A bridge connecting Phillip Island to the mainland was opened in 1945, providing a land route for animals like possums and Foxes (Gliddon 1968). Perhaps aided by this, Common Ringtail Possums had established populations on the island by the 1960s (K Grayden 2004 pers. comm.). The bridge stimulated further human settlements which exacerbated pressures on the native fauna, such as land clearing and roaming dogs. Southern Brown Bandicoots and Bush Rats, which were plentiful until about the 1960s, became locally extinct (K Grayden 2004 pers. comm.). A wildlife park opened on the island in the 1960s. Mammalian escapees from the park have included Long-nosed Potoroo, Tasmanian Pademelons and Eastern Grey Kangaroos, but none of these established breeding populations.

During the late 1900s, an increased awareness of conservation stimulated further revegetation activities, pest species control, native species protection and data recording. Much of this interest on Phillip Island was stimulated by concern over declining numbers of Koala on the island (see Every 1986). Summarising records from 1970 to 1980, Andrew *et al.* (1984) reported 10 native and 6 exotic terrestrial species on Phillip Island and 11 native and 7 exotic species on French Island (Table 3). About half of the native species were bats and flying foxes, which probably had existed on or visited the islands since prior to European settlement but had not been recorded previously. On a species list for French Island, Belcher and Hastings (1983) included the Grey-headed Flying-fox *Pteropus poliocephalus*, which probably referred to visiting individuals. Of the remaining species listed by Andrew *et al.* (1984), the only endemic natives were Water Rats and possibly Swamp Wallabies on Phillip Island, and Water Rats, Bush Rats, Swamp Rats, and Long-nosed Potoroos on French Island. Amongst the exotics, Foxes were found only on Phillip

Island, while Sambar Deer, Goats and wild Dogs *Canus lupus* were found only on French Island.

Between the 1980s (Andrew *et al.* 1984) and 2005 (this study), the only new species recorded for the islands were microbats (White-stripped Freetail-bat and Eastern False Pipistrelle on Phillip Island, and White-striped Freetail-bat and Chocolate Wattled Bats on French Island) and the single record of Swamp Rat for Phillip Island (R Baird 1998 pers. comm.). The bats probably were unrecorded residents or visitors, rather than new colonists. Swamp Rat may have existed on Phillip Island even prior to European settlement and been unreported up to the single capture at Conservation Hill in the 1980s. The subsequent local extinction of this population could have occurred as late as the 1990s, when we noted deterioration of the distinctive 'runways' at this location. Also between the 1980s and 2005, wild dogs were removed from French Island (Parks Victoria, unpublished data) and Rabbits were removed from 10 hectare Churchill Island, adjacent to Phillip Island (Phillip Island Nature Parks, unpublished data).

Conclusions

On Phillip Island, it appears that European settlement resulted in the local extinction of Southern Brown Bandicoots and Bush Rats and possibly Tasmanian Pademelons and Swamp Rats, while the survivors were a suite of microbats, Water Rats and Swamp Wallabies. On French Island, all species present prior to European settlement were extant in 2004, including a suite of microbats, Water Rats, Bush Rats and Swamp Rats and Long-nosed Potoroos. Long-nosed Potoroos are classified as 'threatened' (DNRE 2002), and the population on French Island represents a valuable component of the species.

Of the non-endemic, native species introduced to the islands, the Koala has had the greatest impact. Translocations of Koala from Phillip Island continued until 1978, when it was recognised that the population on the island was declining (Every 1986, Menkhorst 1995). From French Island, over 7000 individuals had been relocated off the island up to 1999 (Parks Victoria 2000) and translocations are continuing. Although detrimental to vegetation on both islands, the isolated Koala populations provided a source to restock areas of the mainland where Koalas were eliminated by deforestation, hunting and disease (Menkhorst 1995). Koalas also represented a flag-species for conservation groups aiming to protect native habitat, particularly on Phillip Island. Koalas now appear to be approaching local extinction on Phillip Island, perhaps due to limited habitat and increased mortalities on roads and from dog attacks.

Considerable effort now goes into the control of feral species, particularly Foxes, on Phillip Island. A principal factor in the demise of the small, native, ground mammals on Phillip Island, but the survival of comparable species on French Island could be the introduction of Red Foxes to only Phillip Island. In addition, on Phillip Island Foxes are considered to be the greatest land-based threat to Little Penguins *Eudyptula minor* (Dann 1992) and Short-tailed Shearwaters *Puffinus tenuirostrus* are a major component of their diet (Kirkwood *et al.* 2002; 2004). French Island is the only significant Victorian land mass where Foxes are absent and as such is a site of state significance for wildlife conservation (Andrew *et al.* 1984). The eradication of Red Fox from Phillip Island is a priority for the conservation of the fauna remaining on that island.

Postscript

On 24 April 2006, a dead Yellow-bellied Sheathtail-bat *Saccolaimus flaviventris* was found at Churchill Island, the first record of this species on the islands of Western Port.

Acknowledgements

We wish to dedicate this paper to Keith Grayden, a lover of Victoria's native fauna. We thank Parks Victoria Rangers Mick Douglas, Terry Easy and Aaron Ledden, local residents Chris Chandler, Faisal Iqbal, Keith Grayden and Harry Cleeland, and biologist Kath Handasyde, for sharing their knowledge of island fauna. We also thank Robert Baird for informing us of the Swamp Rat he caught at Conservation Hill, Ashley Reed and others for collecting the Koala census data on Phillip Island, the Victorian Wildlife Database for supplying wildlife records for the islands, and Catherine Ainsworth, Peter Dann, and two anonymous referees for reviewing the manuscript.

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Annotated records of the Feathertail Glider *Acrobates pygmaeus* from *The Victorian Naturalist*

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Abstract
The Victorian Naturalist was surveyed for past records of the Feathertail Glider *Acrobates pygmaeus*. We document many important records of their occurrence, as well as accounts on their feeding and behaviour. This report should be useful to researchers seeking primary source observations of this species. (*The Victorian Naturalist* **123** (3), 2006, 157-165)

Introduction

The Feathertail Glider *Acrobates pygmaeus* (family Acrobatidae) is a small (10-14 g) cryptic marsupial, which has a wide distribution in eastern Australia from far northern Queensland (QLD), through New South Wales (NSW) and Victoria (VIC) to the south-east of South Australia (SA) (Strahan 1995; Lindenmayer 2002; Goldingay and Jackson 2004). In Victoria the species is currently considered 'Secure' (Henry 1995) and/or 'Common' (van der Ree *et al.* 2004). However, documenting historical and more recent records of their occurrence in Victoria and elsewhere will be important for assessment of their ecology and conservation. To this end, this paper presents an annotated chronology of Feathertail Glider records in *The Victorian Naturalist* (1884-2005).

Feathertail Glider records from *The Victorian Naturalist*

In Volume 1 of *The Victorian Naturalist*, the 'Opossum Mouse' *Petaurus pygmeus* (=*A. pygmaeus*) was noted as part of the Victorian mammalian fauna (Forbes Leith and Lucas 1884). Feathertail Glider specimens were subsequently exhibited at numerous early meetings of the Club, including 'a case with opossum mice' [=*A. pygmaeus*] by TA Forbes Leith on 29 April 1885 (see Cresswell 1885); a 'flying mouse from Langi Kal Kal, Victoria' by Mary Simson on 10 June 1885 (Anon 1885); a 'pair of flying mice' by FGA Barnard of Kew, Victoria on 28 April 1887, 28-29 May 1896, 22-23 September 1908, 8 September 1913 and 10 June 1918 (Anon 1887; Anon 1896a; Anon 1908; Anon 1913; Anon 1918); and 'specimens of the flying opossum mouse' by Mr C French on 9 July 1888 (Anon 1888). On 13 July 1896, JA Kershaw exhibited a Feathertail Glider 'with three young, taken from nest composed of gum leaves under the bark of large eucalypt, South Gippsland' (Anon 1896b). On 16 January 1905, EB Nicholls exhibited a specimen of the 'Pigmy Flying-Mouse' captured at 'Olinda Creek, South Wandin' (Anon 1905). On 11 August 1930, JA Kershaw, then Director of the National Museum of Victoria, exhibited a 'Pigmy Flying Phalanger' (Anon 1930) and this was possibly the same specimen earlier exhibited by him in 1896 (see above).

At Mount Disappointment, Barnard (1911) noted that a 'flying mouse' was captured at Jack's Creek aqueduct. This animal was caught as it ran into a 'grass tussock' and forwarded to the National Museum of Victoria (now Museum Victoria). The collection time was noted as 5 o'clock in the afternoon, and this was thought unusual on account of its nocturnal habits. When the report was read to a meeting of the Club on 13 March 1911, EB Nicholls said that it was 3 o'clock in the afternoon when he captured his specimen (Anon 1911).

Mathews and Iredale (1912) reviewed a rare book written by George Perry (1811) and mention was made that this work included information on the Feathertail Glider. A copy of this book we examined, revealed an interesting illustration of this species (Fig. 1), drawn from a specimen reportedly belonging to a Mr Bullock. It was stated that this species lives 'in the trees and forests of Botany Bay and its neighbourhood' (Perry 1811).

Dr Edmund Hobson (1814 to 1848) took field notes in the forests between Melbourne and Arthurs Seat, and in 1837 he noted that 'The Petaurus pigmaeus [=*A. pygmaeus*] lives upon the gum of the two kinds of mimosa, mim. decurrens and viridis' (Kenyon 1930). The first plant is synonymous with the Green Wattle (*Acacia decurrens*), the second plant species is unknown. Hobson also noted that 'The movements of this little creature are so rapid that they give the impression of a mere spectre. By means of the skin stretched betwixt the hind and fore legs, they are enabled to reach the lower branches of trees some 18 or 20 feet distant' (see Kenyon 1930).

In 1926, David Orchard of Kinglake East reported that his domestic cat brought home alive a 'pigmy flying squirrel or phalanger', that died soon afterwards (Orchard 1926). He stated that they can be 'found in central Victoria along mountain creeks' but are 'very rare'. He also stated that:

> Tree fellers for saw mills are the people who mostly find them in bringing down some giant tree having a dry hollow somewhere on its side. Domestic cats also bring them to the country home occasionally, just as they bring in the ordinary mouse in the cities. I have received several specimens in that way. When the cats have kittens to feed they usually bring these flying mice home alive for the kittens to play with before killing and eating them.

David Fleay (1932) provided an article and photographs pertaining to the 'Pigmy Flying Possum'. A number of distribution records were detailed as well as some observations on the captive diet, behaviour and vocalisations of this species. A friend of Fleay's 'had seen large numbers' of Feathertail Gliders in an area of scrub in the Bendoc district (Fleay 1932). According to his (unnamed) friend 'there were hundreds' within a single area of bush, which led Fleay and a fellow-enthusiast to search the locality sometime afterwards. Clearing of the site was reportedly well advanced when Fleay arrived. Several trees were felled in an effort to capture Feathertail Gliders, but none was found. Only some 'empty nests' were discovered. However, at this site a week later, a large rotten tree came down, three Feathertails were seen, one of which was captured (Fleay 1933). Another was seen while spotlighting at a locality 'some miles distant' and also after felling some nearby trees the next day. Here, one was captured (a female with two pouch young) and was possibly the same animal that was spotlit the previous night. Unfortunately, the animals captured by Fleay at Bendoc did not survive long in captivity.

Feathertail Gliders seem 'to inhabit a variety of forest country, though it is most at home in the thick timber typified by Gippsland' (Fleay 1932). Also referred to were two juvenile male animals sent to Fleay from the 'red gum country near Mathoura', NSW. Only one of these survived, and was named 'Erastus' and lived for 'nearly three years', despite some lucky escapes from the jaws of Fleay's dog and the taloned-feet of a captive Boobook Owl. A female adult Feathertail Glider (with three young) captured near Warburton was also sent to Fleay and all were reported to be:

> perfectly healthy, with the exception of one of the immature females, which had a wound on the head, due to the bite of a dog which discovered the [Feathertail Glider] when the home tree fell. However, the mother refused to settle down. She declined food, and within a week had passed away...The [Feathertail Glider] with the tooth-marked head became very sickly two months after its arrival...Finally, after a week of continued torpidity, without touching a morsel of food, it died.

Other records provided by Fleay (1932) included the finding of breeding animals in the 'Ballarat district' and a family of 'several immature specimens discovered at a spot near Arthur's Creek', in 1931. Fleay (1933) noted the 'Pigmy Phalanger (*Acrobates pygmaeus*)' as resident in the Otway region and described its vocalisations as a slow hissing cry. Fleay (1935) reported that the 'Pigmy Flying Phalanger' is represented in the native fauna section of the Melbourne Zoological Gardens.

Fig. 1. Feathertail Glider from Perry's *Arcana* (1811)

Miss CC Currie reported that the 'Pigmy Flying Mouse' has been found at Lardner (Anon 1933); and JM Bocking from the Blue Mountains, NSW, reported that her neighbour's cat brought in a 'Pigmy Feather-tail, which unfortunately, did not live long in captivity' (Bocking 1939).

Six specimens of the Feathertail Glider from the 1930s and 40s are in the Donald Thomson Collection (DTC) in Museum Victoria (Dixon and Huxley 1989). They include a male collected at Ferntree Gully on 25 July 1930 (DTC 14 204; skin). Thomson noted that this species is 'apparently rare or little known in [this] district, inquiries failed to bring any others and it was the first the finder, a local resident, had ever seen there. Head 25 mm, Tongue 23 mm, Wt. 13.0 g'. A spirit specimen (DTC 36 413; male) collected by E. Collins is recorded for 20 August 1943 from Romsey, Monument Creek, via Woodend. Three live specimens (one male and two females) from Erica, Gippsland were sent to Thomson by 'Dyer, a Forest Officer' after a forest fire. The male (DTC 35 409; spirit) was captured on 9 May 1945, died 24 May 1946. One female (DTC 33 398; spirit) died soon after arrival; the second female (DTC 34 399) thrived for some months and then died. A sixth specimen in the Thomson Collection at Museum Victoria (DTC 37 416; spirit; female with 4 young), also from Erica, was collected on 16 September 1947 by 'Mr Ryan'. Thomson's detailed notes on three captive Feathertail Gliders (later to become DTC 35 409, 33 398, and 34 399) were published by Dixon and Huxley (1989). These contain a wealth of behavioural and feeding observations on captive specimens recorded between 12 May and 30 September 1945.

At a meeting of the Club, on 8 April 1946 a 'Pigmy Possum-Glider' was exhibited by Mrs EE Hill (Anon 1946). It was noted that this species is found in 'timbered country' in eastern Australia and was 'becoming rarer through the ravages of cats'.

In a note on the Feathertail Glider, Child (1948) wrote:

> 'When walking down a bush track at Kalorama one night in August [1948], I heard a rustle in the scrub and shone my torch light among the bushes. There was a little Pygmy Phalanger or "Feathertail" gliding from branch to branch (on a Pultenaea bush) [Bacon and Eggs plant]. In order to examine its feather-like tail, I was able to approach within a few feet of the tiny creature. I then stepped back as it glided from the bush to a gum tree about a yard away and so disappeared. After watching that beautiful little sprite for the first time, I felt happy to have seen one of Nature's most charming pictures'.

Another record from the 1940s is that of a Feathertail Glider from the north of Paddy's Ranges State Park (R. Bishop pers. comm. cited by Trainor 1992).

Norman Wakefield recorded Feathertail Gliders as sub-fossils from a number of cave deposits in far eastern Victoria including Pyramids Cave, Mabel Cave, M-27 and M-28 (Wakefield 1960a; 1960b; 1967a). These fossils were attributed to Quolls *Dasyurus* spp. and Owls which deposited remains of Feathertail Gliders and other species as prey remains in these caves. Sub-fossil Feathertail Gliders have also been reported from localities in western Victoria i.e. 'Natural Bridge', south-west of Mount Eccles (Wakefield 1964), Fern Cave, north-west of Portland (Wakefield 1963a), Victoria Range deposit in the Grampians (Wakefield 1963b) and McEachern's Cave, north of Nelson (Wakefield 1967b). The antiquity of the fossil deposits is Holocene to Late-Pleistocene (also see Harris and Goldingay 2005).

Wakefield (1960a) stated that the Feathertail Glider favours open forest and was plentiful in East Gippsland. In early December 1960, a Feathertail Glider was seen while spotlighting near Mount Tara at Buchan, and another was reportedly seen in a gully along the Gellibrand River (Anon 1961a, b). Wakefield (1962) stated that one of the special projects in hand at the National Museum of Victoria, under Mr J McNally, was 'the maintenance of a study colony of Feathertail Gliders'.

The front cover for March 1962 (Volume 78, Number 11) had a photograph, courtesy of the Victorian Fisheries and Wildlife Department, of two Feathertail Gliders displayed on the branches and inflorescence of a Heath Banksia *Banksia ericifolia* (Fig. 2). An accompanying caption explained that 'Feathertails are quite plentiful in most of the forested parts of Victoria but, because they hide away and sleep all day, they are rarely observed' (Anon 1962). The inside front covers of *The Victorian Naturalist* for May 1965 (Volume 82, Number 1) and April 1970 (Volume 87, Number 4) also featured photographs of a 'Pygmy Glider' by WH King. The caption, written by the Assistant Editor RHJ McQueen (1965), stated:

> This animal is the smallest gliding possum and is immediately distinguished by its distinct gliding membranes and feather-like tail. The gliding habit really consists of a series of agile leaps which are prolonged by a parachute effect of the gliding membranes. Feathertails are usually found in small colonies and their "nests" of shredded bark and gum leaves are built in knotholes or small hollows up to sixty feet [=18 m] above the ground. There is only one mainland species of Acrobates and this is widely distributed through the eucalypt forests of Eastern Australia, and although apparently quite common, the animal is rarely observed because of its smallness and nocturnal habit.

Another record of a Feathertail Glider from the 1960s is that of a female collected from a felled tree on 2 June 1965 at Trawalla Forest Reserve by the Fauna Survey Group (FSG) (Anon 1965). The specimen was reported to have been lodged with Fisheries and Wildlife Department by Mr Hodge, Forest Officer at Beaufort. At Tanjil Bren on 15 January 1966, a Feathertail Glider was seen on the ground by Mr W King (Anon 1966). There is also an FSG record for around this time for Powelltown/Labertouche State Forest (Anon 1967).

In March 1967, a Feathertail Glider was collected at Fyans Creek (14 km north of Pomonal) and a photograph shown to John Seebeck (Seebeck 1976). Another specimen found in a house at the junction of Redmans Road and the Pomonal South Road was also reported to Seebeck in 1968 (Seebeck 1976).

In May 1967, three 'Feather-tail Gliders' were seen during a trip to Stockman's Reward, north-east of Marysville, 'all in one tree in the middle of the valley' (Fryer and Temby 1969). Another was seen in June 1968 'on a hill beside the Big River Valley Road' in a Narrow-leaved

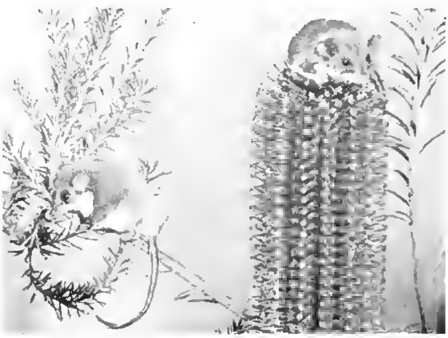

Fig. 2. A pair of Feathertail gliders *Acrobates pygmaeus* as pictured on the cover of the March 1962 issue of *The Victorian Naturalist*.

Peppermint *Eucalyptus radiata*. It was stated that compared with other possums and gliders, the Feathertail Glider was more difficult to find. 'Because [they] are so small...considerable patience and intense listening were necessary to locate them'.

In October 1967, Clyde O'Donnell and fellow naturalist Raymond Carlson, spotlit 'many' Feathertail Gliders on a single old eucalypt in the Porepunkah district (O'Donnell 1970). The gliders were observed leaping to another tree, a distance of 'about fifteen feet' [= 4.5 m]. When the location was visited a year later no living Feathertail Gliders were found, but 'sixteen lifeless bodies were discovered in their ancestral chamber'.

Seebeck *et al.* (1968) reported that in June 1966 and June 1967, the Mammal Survey Group examined a forest area south of Darlimurla:

> Three specimens only were seen, but this species was probably much more common than results indicate. Sightings are generally fortuitous due to the very small size of the animals. Two individuals were seen on the first night of the survey, one on the trunk of an old Messmate (*Eucalyptus obliqua*), the other in the branches of a young Narrow-leaved Peppermint (*Eucalyptus radiata*). Both were approximately 20 feet [= 6 m] from the ground when first sighted. The third specimen was captured when it ran along the top suspending rope of a mist net. Specimen: Skin and skull: P. 630 [male], 25.vi.1966.

On 25 May 1972, the Feathertail Glider was selected as one of 10 native mammal species to be studied by members of the Field Survey Group/Mammal Survey Group (Anon 1972). Mr A Heislers (Forests Commission of Victoria) advised that in recent years Feathertail Gliders had been found during timber cutting in the Upper Lerderderg Valley, although none was found during the spotlighting trips in that area organised by the Mammal Survey Group in 1968-1970 (Deerson *et al.* 1975).

Between September 1974 and November 1978, two Feathertail Gliders were recorded during tree felling operations just outside the Wallaby Creek catchment (Callanan 1981). Zirkler (1974) stated that Pigmy Gliders are known to occur at Tidbinbilla Nature Reserve, NSW. Brunner *et al.* (1977) recorded the 'Pigmy Glider' as present in one of 359 predator (mainly fox) scats collected from an area around Sumner Spur, near Powelltown. Gilmore (1977) reported that 'Mr R Austin of the Fisheries and Wildlife Division, Yarram, has a record of six animals obtained by FA Palmer from a dead stringybark tree that was felled on 30 July 1963, 6 km west of Giffard West'. Ambrose (1979) records Feathertail Glider as an uncommon resident in the Wallaby Creek Catchment, and as an obligate tree hollow user. Callanan and Menkhorst (1979) stated that the Feathertail Glider was not found during a mammal survey of the Werribee Gorge area, but thought that it was 'possibly present'. It was also noted that Feathertail Glider 'occurs in the Brisbane Ranges (F. Lobb, National Parks Service pers. comm.) and [as already mentioned] Lerderderg Valley (Deerson *et al.* 1975) and may well occur in the [Werribee Gorge] area'. Dixon (1979) listed the Feathertail Glider as present in the Alpine Area of Victoria and New South Wales.

In October 1980, the possible presence of the Feathertail Glider at the Mount Napier State Park was indicated 'when a large quantity of dried gum leaves were found coiled in 2 nest boxes' (Bird 1997). Boyce *et al.* (1981) stated that the Mammal Survey Group had recorded Feathertail Glider in the Cobaw State Forest.

Bennett (1982) cited Emison *et al.* (1975) in reporting that Feathertail Gliders have been 'described as occurring throughout all native woodland and forest communities in [the Woolsthorpe area] of western Victoria'. Bennett (1982) also reported that 'Mr H. Quinley, an amateur naturalist from Mortlake wrote, in a letter (November 1910) to the Director of the National Museum of Victoria regarding collection of marsupials' that he 'might by a fluke get some of the pygmy squirrels'. From literature reports, museum records and information gathered from local residents, Bennett (1982) was also able to state that Feathertail Gliders did occur in the Woolsthorpe area in 1840, but he believed they became locally 'extinct' in the early 1900s as a result of 'habitat destruction'.

Conole and Baverstock (1983) stated that one Feathertail Glider had been recorded in tall open-forest in the Mount Cawley area of the Otway Ranges in 1979 (see also Conole 1980). They also indicated that this species was widespread in the Angahook-Lorne Forest Park, but its status in this area was unknown. Nicholls and Meredith (1984) reported four sightings from Broad-leaved Peppermint *E. dives* open forest and Narrow-leaved Peppermint open forest made in the Mt. Timbertop region between 1971 and 1976. Loyn *et al.* (1986) recorded Feathertail Glider in one out of 14 pellets of the Sooty Owl *Tyto tenebricosa* examined from Thurra River, East Gippsland.

Conole (1987) reported on traditional Aboriginal names for a number of small marsupials from reading of the Victorian ethnographic literature. To the Krauatungalung tribe (Lake Tyers area), the Feathertail Glider is 'Toan' as recorded by Smyth (1878) or 'Tuan' as recorded by Howitt (1880). To the Bunurong and Woiworung tribes (Melbourne area) the Feathertail Glider is 'Tu-an-tu-an' (Smyth 1878). Conole (1987) also believed that 'Tirhatuan' from the Woiworung (Danendong area) was probably Feathertail Glider. Subsequently, Hercus (1988) and Scarlett (1988) discussed whether early English translations for this and other species were correct. Hercus (1988) thought that the name 'tuan-tuan' was not positively Feathertail Glider, and Scarlett (1988) stated that in Woiwurru, there could have been at least three names for Feathertail Glider, including 'Turnung', 'Tarrn-nin', and 'Teed'thung'. Scarlett (1988) also presented a mythical story of the Kulin tribes of central Victoria, in which the Feathertail Glider was featured.

Bennett (1988) did not record Feathertail Glider whilst trapping, spotlighting and hairtubing within roadside vegetation in the Naringal area during the period 1979-1982, and concluded that it was a rare species in this area. Dixon and Huxley (1989) commented that 'although this species is widely distributed in eastern Australia, few specimens are collected in surveys or seen by the public'. They also cited Russell (1980) and Fleming and Frey (1984) in stating that only limited behavioural studies have been undertaken on the Feathertail Glider.

Bennett (1992) noted that Feathertail Gliders were found by Suckling (1984) to be present in roadside vegetation in Gippsland. Conole and Baverstock (1992) reported the Feathertail Glider from the Bamgaine State Forest, about 45 km north-west of Geelong, and it was 'only observed in Swamp Gum [*E. ovata*] open-forest, where 5-6 individuals were seen in one flowering Swamp Gum on 29 January 1989'. The apparent absence of the species from the Messmate Stringybark *E. obliqua* open-forest, which was dominant at Bamgaine, was suggested to be 'more likely due to the larger leaves and denser canopy obscuring the diminutive mammal. Swamp Gums with their small leaves and open crown permit better visibility'. Lindenmayer (1992) recorded Feathertail Glider in the Mountain Ash forests in the Central Highlands. Trainor (1992) reported that Feathertail Gliders 'readily use nest boxes in the wetter forests of central Victoria (citing Calder *et al.* 1983; Orchard 1987), but have not been recorded in the drier forests of the [Paddy's Ranges] study area using this technique in a total of approximately 1800 nest box inspections'.

On 18 March 1995, a Feathertail Glider was observed on a clear full moon night while stagwatching in a Mountain Ash Forest in the Macedon-Woodend region of the Western Highlands (Larwill 2004). During the same survey, but at a different site, a Feathertail Glider was also captured during Elliott trapping. In this survey, the species was not detected by use of nest-boxes, spotlighting or predator scat analysis. Kutt and Yugovic (1996) mentioned that the Atlas of Victorian Wildlife Database has 'a historical record (pre-1900) of the Feathertail Glider', for the Grantville Gravel Reserve area, south-east of Melbourne. Although it was not found during their mammal survey (conducted in March 1994), they predicted that with more intensive survey, this species may be recorded here. Sometime between April 1985 and March 1995, a nocturnal observation of the Feathertail Glider was made in Tall Open Forest adjacent to the Parker River Inlet, Otway National Park (Westbrooke and Prevett 2002).

Menkhorst and Seebeck (1999) stated that the Feathertail Glider was 'uncommon' at Wilsons Promontory National Park, and the most recent record known to them at that time was from 1986. During 25 h spotlighting in Rushworth State Forest, Myers and Dashper (1999) recorded only one Feathertail Glider (0.04 per hour). This animal was seen while foraging in a large flowering Yellow Gum *E. leucoxylon*. Myers and Dashper (1999) also noted that the Atlas of Victorian Wildlife Database had one record for this species from Rushworth State Forest in 1990.

In 1999, the Feathertail Glider was recorded in the River Red Gum *E. camaldulensis* vegetation in Barmah Forest by Lawrie Conole (Loyn *et al.* 2002), but 'it is likely to occur more widely in the forest than this one record would suggest'. Taggart and Shimmin (1999) did not provide any records of occurrence of the Feathertail Glider, but did comment as part of a review on marsupial sperm competition that this species has 'large testes relative to body mass' which supported a high likelihood of sperm competition occurring in this species.

Between April 2000 and March 2002, the Fauna Survey Group (FSG) carried out a study of the vertebrates in and adjacent to the Black Range, south of the township of Stawell in western Victoria (Homan 2005). One Feathertail Glider was captured opportunistically on the ground in an area of Granite Hills Woodland, which was a vegetation community dominated by Scent-bark *Eucalyptus aromaphloia*. The Feathertail Glider was not detected in 1487 Elliott trap-nights, 687 pitfall trap-nights, 60 h spotlighting, stagwatching at 12 stags or through use of five artificial nest-boxes. Homan (2005) noted that Feathertail Glider is 'rare' in this part of western Victoria, and that spotlighting in similar woodland areas by the FSG have recorded only very small numbers (ie. Myers and Dashper 1999).

Pierson (2004) contributed some observations of antagonistic behaviour between Little Ravens *Corvus mellori* and Common Ring-tailed Possums *Pseudocheirus peregrinus*. In an accompanying note and reference supplied by the Editors of *The Victorian Naturalist*, it was noted that the Forest Raven *C. tasmanicus* has been recorded taking the Feathertail Glider (McCulloch and Thompson 1987). The most recent mention of Feathertail Glider in *The Victorian Naturalist* was made by Gibson and Thompson (2005) in reference to the late Robert Taylor showing beginners how to spotlight for the species in flowering banksia at Gembrook.

Conclusion

The Victorian Naturalist contains about 61 distribution records of the Feathertail Glider, excluding multiple records from the same locality and fossil records. These extend from before 1811 to about 2002, and document aspects of the life history, behaviour, and habitat requirements of this species. The large number of common names synonymous with the Feathertail Glider and survey methods applicable to this species have also been revealed. Despite the diminutive size, nocturnal habits, and generally secretive behaviour of the Feathertail Glider, knowledge of its natural history has been greatly augmented by naturalists' observations published in this journal.

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Seventy-four years ago

THE PIGMY FLYING POSSUM
BY DAVID FLEAY, B.Sc.

It is very doubtful whether any animal, small or large, furred, feathered, or scaled, is more aptly fitted with generic and specific names than Acrobates pygmaeus - the "pigmy acrobat" - one of our smallest marsupials and the midget of the Possum family. Yet this little silver-brown creature is very difficult to domicile for observation, and is of such delicate structure that one must exercise every care to avoid causing injury when handling it. …

One generally thinks of the Pigmy Flying Possums as an animal entirely lacking in powers of vocal accomplishment; and though it is mainly a silent species, soft little sounds are occasionally uttered, usually in daylight, when the "pigmies" are rolled up together in the nest. It is difficult to describe these low sobbing calls, but probably as good a description as any is to compare them with the quavering whistling notes of Dottrels [sic] flying over in the night skies. …

From *The Victorian Naturalist*, **XLIX**, November 7, 1932

Studies on Victorian bryophytes 3: The genus *Leptodon* D Mohr

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Abstract

Leptodon smithii (Hedw.) F Weber and D Mohr is the only species of the moss genus *Leptodon* in Victoria. This species is described and illustrated, its distribution in Australia is delineated, and its conservation status is discussed. (*The Victorian Naturalist* **123** (3) 2006,166-169)

Introduction

Leptodon is a genus of mosses in the family Leptodontaceae. More than 30 species of *Leptodon* have been described, but only four are generally accepted as good species (Stark 2000). However, the genus has been poorly studied and needs a comprehensive world-wide revision.

Leptodon smithii (Hedw.) F Weber and D Mohr is the only member of the genus known to occur in Australia. It is an almost cosmopolitan species, being found in natural habitats on all continents except Antarctica. Its stronghold is southern and western Europe, especially the Mediterranean countries (Dixon 1954; Jahns 1983), but it is also recorded from northern and southern Africa, North America, South America and New Zealand (Beever *et al.* 1992, Stark 2000). In Australia it is known from Victoria, New South Wales, the Australian Capital Territory and southern Queensland. *Leptodon smithii* has several common names, including the simple but descriptive Curly Moss, the imaginative Prince-of-Wales Feather-moss, and the dreary Smith's Leptodon.

Description

Leptodon smithii (Hedw.) F Weber & D Mohr

Ind. Mus. Pl. Crypt. **2** (1803)

Known distribution in Australia: Vic, NSW, ACT, Qld

Habitat: on well-shaded limestone or granite, or epiphytic on trees, shrubs or vines, in dry to wet sclerophyll forest or rainforest.

Plants with a creeping primary stem from which flattened, bipinnate, pale to dark green fronds arise; fronds strongly coiled when dry (Fig. 1); dioicous, sporophytes maturing over two years so that two generations of sporophytes may be present on one plant. **Rhizoids** arising from the primary stem and branches, reddish brown. **Branches** with many small ± linear paraphyllia and pseudoparaphyllia, the pseudoparaphyllia often shortly branched. **Leaves** ovate to tongue-shaped, rather variable in size but generally 1.0–1.3 × 0.6–0.9 mm on the stems, slightly smaller on branches, flat to slightly concave, rugose to plicate, weakly spreading from the stem when moist but appressed and flattened when dry, slightly decurrent. **Costa** strong, gradually weakening and ending well above mid-leaf, often forked. **Cells** in the leaves thick-walled, mostly isodiametric to diamond-shaped, typically 8–15 × 7–10 μm; a patch of longer, more rectangular cells usually present in the leaf base. **Capsules** ovate-cylindrical when mature; 2–2.5 mm long in Australian material, very shortly exserted, smooth to slightly pocked and ridged, yellow-brown when young, becoming reddish-brown when mature; outer peristome of 16 narrow, pale teeth, strongly curved into the capsule mouth when dry but ± erect when moist; inner peristome poorly developed or absent; operculum with a long, curved beak, acutely pointed. **Spores** yellow-brown, very finely papillose, 15–25 μm in diameter. **Calyptra** long, conical and pointed, somewhat hairy to naked. **Vaginula** hairy; hairs (paraphyses) pale yellow, often extending beyond the perichaetial leaves, (1–) 2 cells wide, the cells mostly long-rectangular, thick-walled. **Perichaetial leaves** much longer and narrower than normal leaves, straight

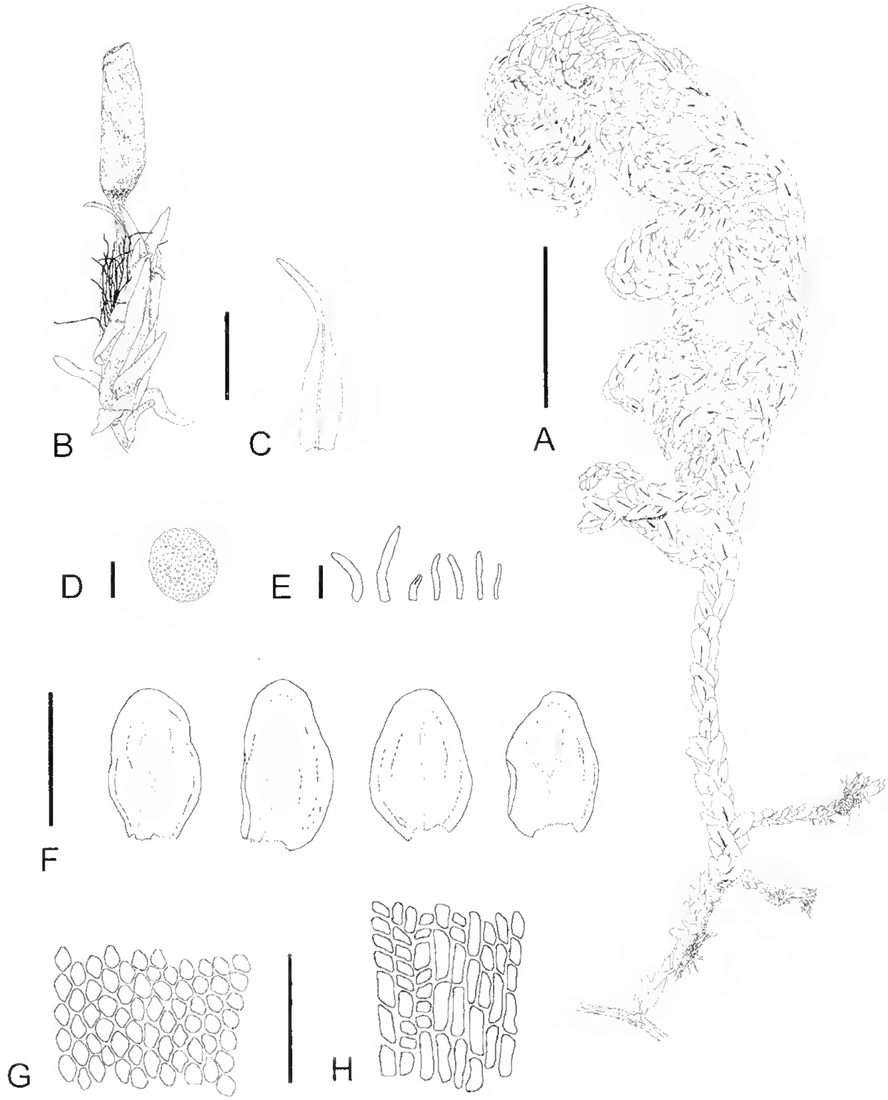

Fig. 1. *Leptodon smithii.* **A** Dry secondary stem. **B** Sporophyte and perichaetial leaves. **C** Perichaetial leaf. **D** Spore. **E** Paraphyllia and pseudoparaphyllia. **F** Leaves from stem. **G** Cells in mid-leaf. **H** Cells in leaf base. Scale bars: A = 5 mm, B, C, F = 1 mm, D = 10 µm, E, G, H = 100 µm. All drawn from MELU 7375.

to rather squarrose, with distinct shoulders, apex blunt; costa narrow, reaching well beyond 1/2 of the leaf length; cells thick-walled, mostly long and very narrow, to about 50 × 7 µm, sinuous, often porose, shorter at the margins and at the apex, ± rectangular in the base. Male reproductive organs not seen.

Notes: The range of variability in *Leptodon smithii* is yet to be satisfactorily delineated, and awaits a comprehensive re-evaluation of material from around the world. Descriptions of plants from Europe and North America usually state that the costa is weak and single or short and double, reaching to 1/2 the leaf length, and it is never described as forked. Spore size for northern hemisphere material is given as about 16 µm (Smith 1978) and 12–15 µm (Stark 2000). However, a sterile specimen from France (MEL 1031884) agrees well with Australian material although the forking of the costa is barely apparent.

Representative specimens seen: (1) VIC: Mt Alexander, near Castlemaine. On granite boulder. Stone s.n. 1969. MELU 7375. (2) VIC: East Gippsland, Jones Creek Reference Area. On rock in *Nothofagus* forest. Chesterfield s.n. 1987. MEL 1055056. (3) NSW: Mt Exmouth, Warrumbungle National Park. Southern side of mountain just below summit. Eurell (no. 79/7) 1979. MO (dupl. CANB 7910181). (4) NSW: Bungonia Creek Gorge. *Acmena smithii* and *Casuarina*-dominated creek bank through limestone gorge. On trunk of *Ficus*, in shade. Streimann (no. 6181) 1978. MO (dupl. CBG 7902598). (5) ACT: Orroral Valley Lookout, Namadgi National Park. Dry sclerophyll forest on moderate slope with large granite boulders. On shaded vertical boulder. Forming large colonies. Streimann (no. 53681) 1994. MO (dupl. CBG 9403868).

Similar taxa

Several other mosses might be confused with *Leptodon smithii* in the field, especially if the plant is moist and capsules are absent. *Cyptodon muelleri* has distinctly papillose leaf margins, distinct alar cells, and does not grow on rock, and its capsules are immersed. *Fallaciella gracilis* is not pinnately branched and has concave and slightly pointed leaves, and the costa is usually very weak and double. *Thamnobryum pandum* has coarsely toothed leaf margins, and the costa is strong and reaches almost to the leaf apex. *Camptochaete* species have a very weak costa or none at all, and the leaves are distinctly concave. Other similar mosses, such as *Forsstroemia* and *Cryphaea*, have pointed leaves. All of the above can be distinguished from *L. smithii* by the lack of coiling of the fronds when dry (although the branches of *F. gracilis* may be slightly curved), and capsules borne on medium to long setae (except in *Cyptodon muelleri*).

Discussion

Leptodon smithii is known in Victoria from only two localities: in dry sclerophyll forest on Mount Alexander (near Castlemaine) and warm temperate rainforest in East Gippsland (Fig. 2). In New South Wales and the ACT it has been found in lowland to upland sclerophyll forest and rainforest in several localities. In Queensland it has been found only in rainforest in the Bunya Mountains, south-west of Kingaroy. It is not known from Tasmania (Dalton *et al.* 1991, Streimann and Klazenga 2002).

In Victoria *Leptodon smithii* is exceedingly rare and endangered. It is a plant of deep shade, so habitat modification such as the destruction of the canopy or disturbance of boulders is a threat to the survival of populations. Mount Alexander and the Jones Creek Reference Area are prone to wildfire, and in fact Jones Creek was

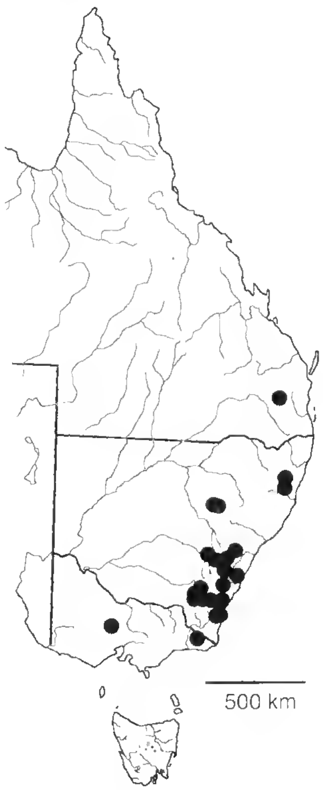

Fig. 2 Known distribution of *Leptodon smithii* in Australia.

severely burnt in 1983 (D Cameron, Department of Sustainability and Environment, pers. comm. Sept. 2005). At the time of writing, *Leptodon smithii* had been recommended for listing as a threatened taxon under the Victorian *Flora and Fauna Guarantee Act 1988* (M. O'Brien, Department of Sustainability & Environment, pers. comm. April 2006). From a national perspective the species appears to be secure because it has been collected in recent times from many localities in New South Wales.

The Mount Alexander material (MELU 7375, dupl. MEL) was collected from a granite boulder by Ilma Stone in 1969, but there is no record of the specific locality or habitat. Several searches by the author have been made for the species at Mount Alexander in recent years, without success. If it still occurs there it must be extremely rare. The East Gippsland specimen (MEL 1055056) was collected by Evan Chesterfield in 1987 in the Jones Creek Reference Area, now part of Coopracamba National Park. This locality has not been searched for the species since then. The early collections of *L. smithii* in Australia (dating from 1884) and its far-flung distribution in natural habitats demonstrate that it is not introduced here. Outside Victoria the species is known from numerous sites along and adjacent to the Great Divide, and appears to be secure nationally. But because it is known only from a single site in Queensland, its conservation status in that state should be carefully assessed. Scott (1997) did not consider the species to be rare or threatened in Australia, which seems reasonable on the available evidence. World-wide it seems to be a common species and is unlikely to be endangered.

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Glossary

alar cells group of enlarged or otherwise distinctly different cells at the corners of the leaf base
calyptra thin protective covering over the developing capsule; falls off when capsule is mature
costa thickening of the leaf forming a midrib or nerve
paraphyllia, pseudoparaphyllia minute leaf-like appendages arising from the stems or branches
perichaetial leaves modified leaves surrounding the female reproductive organs
vaginula cup-shaped structure at the base of the seta, formed from the lower half of the archegonium (female reproductive organ)

The Yellingbo population of Leadbeater's Possum – remnant or introduced?

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Abstract

In 1986 a small, outlying population of Leadbeater's Possum was discovered inhabiting lowland swamp forest at Yellingbo Nature Conservation Reserve. Given the pronounced differences between the vegetation community at this site and that throughout the possum's stronghold in the Victorian Central Highlands, some people have speculated that the species may have been introduced to Yellingbo. I list several reasons why this is unlikely to be the case. (*The Victorian Naturalist* **123** (3) 2006, 170-173)

In 1961, after 51 years without a confirmed sighting, Leadbeater's Possum *Gymnobelideus leadbeateri* was rediscovered in the montane ash forests of the Victorian Central Highlands (Wilkinson 1961). The discovery prompted a substantial amount of survey and ecological research during subsequent decades (e.g. Smith 1984*a*, 1984*b*; Smith *et al.* 1985; Lindenmayer *et al.* 1989, 1990, 1991*a*, 1991*b*; Smith and Lindenmayer 1992) which has ultimately resulted in a widely held belief that the species is something of a montane ash forest specialist (e.g. Loyn and McNabb 1982). Thus, in 1986, when a small, isolated population of Leadbeater's Possum was discovered in lowland swamp forest at Yellingbo Nature Conservation Reserve (Smales 1994), some people questioned the origin of the species at this site. It is a question that has been asked of me on numerous occasions during the decade over which I've been investigating the possum's ecology. Could Leadbeater's Possums originating from captivity or the Central Highlands have been released at Yellingbo? Below I list several reasons why this is unlikely to be the case.

- Very few people would have had access to Leadbeater's Possums for the purposes of release, as the species is notoriously difficult to trap in montane ash forest (Smith 1978, 1980). Whilst acquiring possums presents a major obstacle, it should be noted that the species is not particularly difficult to keep and breed in captivity, and one person, Des Hackett, did so successfully at his private residence in Blackburn during the late 1970s and early 1980s (Myroniuk and Seebeck 1992). According to Myroniuk and Seebeck (1992), all of the Leadbeater's Possums held in captivity by Des Hackett were handed over to the Melbourne Zoo, Healesville Sanctuary and Taronga Zoo between January 1981 and September 1986.
- Given that Leadbeater's Possum was presumed extinct between 1920 and 1960, it is reasonable to assume that any release of possums at Yellingbo, if indeed such an event took place, probably occurred after 1961. However, the considerable focus on montane ash forest that followed the species' rediscovery in 1961 makes it unlikely that the lowland swamp forest at Yellingbo would have been regarded as a suitable release site for the species.
- For an individual or group of people to undertake such an initiative in complete secrecy and to show no subsequent interest in the population would seem highly unlikely.
- The size and distribution of the Yellingbo population, approximately 100 individuals distributed along a narrow, 6 km length of floodplain forest (Harley *et al.* 2005), is more indicative of a naturally occurring population than one that has been introduced. For a translocation to produce this distribu-

tion pattern it would probably require the release of substantial numbers of possums at multiple release sites. Most successful translocation projects require multiple release events conducted over several years.

- The success rate of mammal translocations and re-introductions is generally quite low (Griffith et al. 1989; Short *et al.* 1992; Beck *et al.* 1994; Pietsch 1994; Wolf *et al.* 1996; Fischer and Lindenmayer 2000). There have been just two attempts to translocate Leadbeater's Possums to date, one of which involved captive-bred individuals, and both were unsuccessful (Macfarlane and Seebeck 1991; Harley unpubl. data). However, the related Sugar Glider *Petaurus breviceps*, which is of a similar size to the possum and has similar dietary and denning requirements, has been successfully established at a number of new localities (Suckling and Macfarlane 1983; Suckling and Goldstraw 1989; Irvine and Bender 1997).
- The occurrence of Leadbeater's Possum in lowland swamp forest at Yellingbo is anomalous with all but one of the other records of the species collected since rediscovery of the species in 1961. However, Smales (1994) proposed that the possum's occurrence at Yellingbo is consistent with the historic records of the species (1867–1910) from the Bass River near the town of Woodleigh and Koo-Wee-Rup Swamp near Tynong (McCoy 1867; Brazenor 1946). Prior to the clearance of native vegetation at these sites, they are likely to have supported habitat similar to that present at Yellingbo today (Smales 1994). Indeed, during the late 1800s and early 1900s, the possum was thought to be restricted to these types of habitats (e.g. Spencer 1921; Anon 1939) and there had been no suggestion that it might also occur in montane forest.
- Leadbeater's Possum is extremely cryptic and its presence at a site can be easily overlooked. Thus, it is not altogether surprising that it was not detected at Yellingbo prior to 1986, and its discovery there at that time was entirely serendipitous (Smales 1994).
- In addition to Yellingbo, Leadbeater's Possum recently has been detected at one other site dominated by Mountain Swamp Gum *Eucalyptus camphora*, the Silver Gum Reserve near Buxton (K Garth, pers. comm.; pers. obs.). This small, 17 ha reserve is situated approximately 55 km north of Yellingbo, and sections of it bear considerable resemblance to the latter.

Speculation concerning the origin of the Yellingbo population of Leadbeater's Possums seems to have arisen because of the notable differences between the floristics and structure of montane ash forest in the Victorian Central Highlands and lowland swamp forest at Yellingbo (see Harley *et al.* 2005). For instance, the latter vegetation community lacks *Acacia* spp., which are one of the possum's major sources of food in montane ash forest (Smith 1984*b*). The likelihood of the possum's presence at a site is positively correlated with the basal area of *Acacia* spp. in montane ash forest (Lindenmayer *et al.* 1991*a*). Lindenmayer *et al.* (1993) detected the possum at only one of 49 linear corridors of montane ash forest that they surveyed. In contrast, the lowland swamp forest inhabited by Leadbeater's Possums at Yellingbo is a naturally occurring corridor, stretching along a narrow floodplain that rarely exceeds 120 m in width (Harley *et al.* 2005). Despite these notable differences, the two vegetation communities share several attributes likely to be of significance to the possum. These include: the predominance of smooth-barked eucalypts (given that one of the species' main feeding behaviours involves licking surface exudates from their trunks), hollow-bearing trees (that provide den sites) and highly-connected vegetation in either the midstorey or canopy (that facilitates the possums' mode of locomotion through the forest). In addition, both forest types are characterised by a cold, wet climate.

The nearest records of extant Leadbeater's Possum populations to Yellingbo are approximately 17 km to the east and north-east in montane ash forest at Mt Beenak and Ben Cairn (Owen 1963; Loyn and McNabb 1982; Lindenmayer *et al.* 1989). This distance is considerably greater than the species' dispersal capability (the longest movement recorded for the species is approximately 1500 m; see Harley 2005), and this, coupled with habitat fragmentation during the last century, indicates that the Yellingbo population is isolated from those in the Victorian Central Highlands.

A molecular investigation into population differentiation in Leadbeater's Possum currently underway in the School of Biological Sciences at Monash University may be able to resolve the question surrounding the origin of the Yellingbo possums – remnant or introduced? Indeed, it offers the most likely source of hard evidence on the subject. If there has not been genetic interchange between lowland and montane populations for a significant period of time (e.g. centuries), then one would predict certain genetic differences to be apparent, leading to the conclusion that Yellingbo supports a remnant population. Conversely, the origin of the Yellingbo possums may be more difficult to establish using molecular techniques if there has been regular genetic interchange across the 17 km gap in the species' distribution within the last 100 years, as the genetic makeup of populations in the two areas may be similar.

While there is no doubt that the majority of extant Leadbeater's Possum populations inhabit montane ash forest, a recent survey of the species' distribution and abundance in sub-alpine woodland dominated by Snow Gum *Eucalyptus pauciflora* at Lake Mountain has revealed another significant population occurring outside montane ash forest (Jelinek *et al.* 1995; Harley, unpubl. data). It is likely that the extensive Snow Gum woodlands of the Mt Baw Baw/Mt Erica plateau also support a substantial Leadbeater's Possum population (Atlas of Victorian Wildlife Database). Such results are not entirely surprising, as the other three species of petaurid that occur in temperate south-eastern Australia (the Sugar Glider, Squirrel Glider *Petaurus norfolcensis* and Yellow-bellied Glider *Petaurus australis*), which occupy the same feeding niche as Leadbeater's Possum, are each found in a range of forest types.

In conclusion, there appear to be several reasons why the theory that Leadbeater's Possums were introduced to Yellingbo is unlikely, and no reasons in support of it other than that the forest at Yellingbo differs from montane ash forest. I suggest that the likelihood that the species was introduced to Yellingbo is extremely low, and that the site almost certainly supports a remnant Leadbeater's Possum population. Moreover, the speculation concerning the origin of the Yellingbo population appears to have arisen without recognition of the similarities that lowland swamp forest has with the vegetation communities present at the historic collection localities for the species.

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One hundred years ago

WALLABY AT SEA – Mr. F. Wisewould stated that when coming from San Remo recently he noticed an object in Western Port Bay, about 100 yards from the beach, which proved to be a wallaby swimming towards Phillip Island. It seemed very exhausted, and fell down upon reaching the shore, taking several minutes to reach the scrub, only a short distance off. It is alleged there are no wallabies on either French or Phillip Island. Should this be correct, the animal must have been caught by the tide on one of the mud banks or sand spits at the head of the bay, and carried by the ebb, which was running very fast, a distance of eight or ten miles.

From *The Victorian Naturalist* **XXII** (12) p. 224

David Hungerford Ashton, OAM

6 July 1927 – 22 November 2005

Dr David Ashton, was the authority on Australia's majestic Mountain Ash, aptly named by Mueller, *Eucalyptus regnans*, and devoted his professional life to the elucidation of ecological details of plant communities. An artist, poet, pianist and composer, as well as ecologist, David Ashton valued the beauty as well as the science of the living landscape.

David's school and university studies shaped his decision to become a botanist. Having studied agricultural botany and geology at Melbourne High School, he began an agricultural science course at the University of Melbourne in 1946. During our conversations not long before he died, he still remembered his first-year botany excursions to Frankston heath and forests in the Dandenong Ranges and his pleasure at being in the group led by the ecologically-enthusiastic professor of botany, John Turner. David was so impressed that plants had names and ecological reasons for growing where they did, that he switched to science and majored in botany and geology. He also remembered his introduction to more distant forests during his third-year ecology excursion to east Gippsland in 1948.

The following year, Professor Turner handed David Ashton, newly BSc, an ecological puzzle for his postgraduate research project, thereby seeding, and perhaps sealing, his fate as an ecologist. Mosaics of fire-generated, even-aged stands of Mountain Ash did not seem to fit the model of forest regeneration, which originated in the northern hemisphere where uneven-aged forests were perpetuated by continuous regeneration in forest gaps. It was well-known that Mountain Ash regenerated vigorously after fire; but could it regenerate in forest gaps? Or was the dramatic episodic disturber, fire, essential for its regeneration?

Venerable stands of *E. regnans* (over two centuries old) in Melbourne's water catchment on the Great Dividing Range north of the thirsty city had escaped the ferocious 1939 fires. In 1949 David began the difficult and arduous task of mapping the vegetation and soils of the Big Ash forest in the Wallaby Creek catchment and initiated a study of regeneration in these long-unburnt stands – a tall order indeed. Little did young David realise that this was the beginning of his fifty-year solo investigation of *E. regnans* and its forests. In the 1950s, despite weather-, wombat- and leech-induced tribulations, and the lack of an ecologist-supervisor, David managed to reveal many details of the Mountain Ash's life-story, including its apparent ability to regenerate in a forest gap. In 1957 he was awarded a PhD for his thesis, 'Studies on the autecology of *Eucalyptus regnans* F.v.M.'.

Meanwhile, David thrice joined Professor Turner's summer team to assess the vegetation in plots which Maisie Fawcett (later Mrs Carr) had established in grazed (unfenced) and un-grazed (fenced) areas on the Bogong High Plains in the mid-1940s.

Dr Ashton interested generations of Melbourne University students in ecological processes in Victorian plant communities. From 1960 he taught ecology to science and forestry undergraduates, introducing them to various plant communities during excursions. An annual week-long excursion to such distant destinations as Wilson's Promontory, Lake Mountain, a patch of warm temperate rainforest near Marlo in east Gippsland, the Snowy River valley near Suggan Buggan, the Bennison High Plains, Mt Eccles and Mt Cobbler, allowed final-year undergraduates to undertake a detailed ecological study.

From the early 1960s David Ashton also supervised postgraduate research projects on a wide range of plant communities, including messmate forests near Wallaby Creek and on Wilson's Promontory, Lilly Pilly *Acmena smithii* on Wilson's Promontory, Myrtle Beech *Nothofagus cunninghamii*, on Mt Donna Buang, the intriguing outlier of Bull Mallee *Eucalyptus behriana* near Melton, Brisbane Ranges plant communities, Westernport Bay mangroves *Avicennia marina*, Cypress Pine *Callitris glaucophylla*, in the Snowy Valley, Kanooka *Tristaniopsis laurina* in east Gippsland warm temperate rainforests, Lake Mountain Snow Gum *Eucalyptus pauciflora*, and Bogong High Plains grasslands.

He helped with the tabulation of plant community information for Victoria's first conservation survey, which was undertaken by his postgraduate student, Judy Frankenberg, after submitting her MSc thesis on Wilson's Promontory Lilly Pilly in 1965. Frankenberg's *Nature Conservation in Victoria* (VNPA, 1971) reveals the sometimes urgent need for the conservation of many of the plant communities which Ashton had the ecological foresight to have his postgraduate students investigate.

David Ashton joined the FNCV in October 1965 – two months after his first paper appeared in *The Victorian Naturalist*. It presents the results of his final-year ecology students' investigation of seed germination in the soils of nine Victorian plant communities in 1964. He continued to use *The Victorian Naturalist* to report work undertaken by his ecology class. The November 1967 issue carries the report of another soil seed study – of germinable seed in soils from long-unburnt and 1939-regenerated snow gum woodland at Lake Mountain. Subsequent issues of *The Victorian Naturalist* carry reports of students' investigations during the annual week-long ecology excursion in the late 1960s – 'Ecological Studies of Tunnel Cave, Mt. Eccles' in volume 85 in 1968, and 'Ecological Studies on the Bennison High Plains' in volume 90 in 1973. Other papers discuss epiphytes on Myrtle Beech trees at Mt Donna Buang, gum-topped stringybarks in the Trentham district, a possible tri-hybrid eucalypt and root fusion between *E. regnans* and *E obliqua* in the Cathedral Range area, and artificial hybrids of *E regnans*. Dr Ashton also contributed a paper on the history of the McCoy Society to a special McCoy issue of *The Victorian Naturalist* in 2001.

Ashton's Wallaby Creek and High Plains investigations reveal the crucial importance of long-term studies, with decades, not years, being required for the elucidation of adequate ecological explanations. Had he transferred his ecological attention away from the Big Ash forest in the 1950s, he would not have noticed the subsequent demise of the few saplings that had managed to grow from seedlings in a forest gap, and would not have been provoked to examine in more detail the biology and ecology of *E. regnans* in order to explain properly the intimate intricacies of its life. In the 1990s he prepared three substantial papers on his half-century's scientific scrutiny of *E. regnans*, which were published in 1999 and 2000.

In the 1980s, after several re-surveys of Maisie Carr's plots, Dr Ashton supervised Dick (RJ) Williams' doctoral investigation of vegetation dynamics on the Bogong High Plains. Over four decades after their 1939 (post-fire) regeneration, shrubs were senescing above carpets of grass rather than shrub-seedlings, allowing Dick Williams to confirm the cattlemen-confronting irony Maisie Carr had earlier reported – that heathland shrubs are eventually replaced by grasses.

Awards and honours followed University retirement, beginning with the prestigious Medal of the Ecological Society of Australia in 1990. Dr Ashton became a Foundation Fellow of the Royal Society of Victoria in 1995. In 1999 he was doubly honoured. Victoria's Department of Natural Resources and Environment established the 'David Ashton Biodiversity Award' for departmental staff for scientific achievements which enhance the understanding, conservation or management of Victoria's biodiversity. Rangers at the Kinglake National Park, which then included the Big Ash forest, organised a celebration for his research jubilee, and a beautiful bronze commemorative plaque was unveiled at Wallaby Creek. Since this is still part of Melbourne's water catchment and therefore inaccessible to the public, the plaque was erected near the Toorourrong Reservoir carpark, in sight of the tall forests David Ashton knew so well. In 2000 he received a Parks Victoria Kookaburra Award for his contributions to Victoria's parks, in 2001 a medal of the Order of Australia for services to plant science, and in 2002 a University of Melbourne DSc degree for his published work.

Thanks largely to the establishment of national parks, Dr David Ashton is outlived by plant communities which he and his students investigated. He is also survived by his published papers, which provide foundations for wise conservation and management decisions; by the ideas and practices of his postgraduate students in CSIRO, national parks and forestry, universities and schools; and by the 'David Ashton Biodiversity Award' to encourage the conservation of Victoria's biodiversity.

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The Victorian Twitchathon: racing for ornithological conservation

On a warm weekend in November 2005 the Seven Year Twitchers raced and won Birds Australia's Victorian Twitchathon. The following article is a diary of this remarkable two-day event.

So what is the Twitchathon? The Twitchathon is a 24-hour race that involves dozens of birdwatchers madly rushing around the Australian bush attempting to see or hear (read twitch) as many bird species as possible. The aim of the Twitchathon is to raise money, through team sponsorship, for ornithological research and conservation.

The name of the race is based on the term 'twitcher', hard-core birdwatchers who chase rare birds. The rules state that each team must have at least two participants, with four being the norm. Our team had four members: Tim Dolby, Greg Oakley, John Harris and Fiona Parkin.

An important aspect of winning the Twitchathon is that teams must cover enormous distances in a 24-hour period. If you include the pre-race reconnaissance, by the end of the race we had travelled well over 1400 kilometres. The main reason for this is that in order to see a wide variety of bird species you must also cover as many different habitat types as possible. During the race we visited Mallee, Box-Ironbark, grassy woodlands, wet and dry sclerophyll forests, freshwater wetland, coastal heath, saltmarsh, mudflat and the open ocean. The diversity of birds we saw reflected these diverse habitats.

Day One

Over the years the Seven Year Twitchers have used a number of different routes around Victoria. This year we chose to start our race at Goschen Bushland Reserve, a small isolated mallee reserve west of Lake Boga in northern Victoria. Goschen usually contains spring-flowering Long-leaf Emu-bush *Eremophila longifolia*, a small rough-barked tree that acts as a vital food source for some of our rare and nomadic honeyeaters. One bird in particular, the elusive, almost mythical, Black Honeyeater loves the stuff. A member of

Spotted Pardalote *Pardalotus punctatus*.
Photograph by Jonathon Thornton

Black-chinned Honeyeater, *Melithreptus gularis*. Photograph by Jonathon Thornton

our team had not seen (or heard) Black Honeyeater before, so during our pre-race reconnaissance I demonstrated my somewhat dubious impersonation skills of a Black Honeyeater call. To everyone's surprise someone immediately exclaimed, 'There's one, right behind you!' Of course this was the only Black Honeyeater we saw at Goschen, a good two hours before the race had begun.

Still on our pre-race reconnaissance, 30 minutes before the start of the race, we came across a pair of Variegated Fairy-wren. This can be a notoriously tricky bird to get on to, especially when you are in a hurry. We were not going to make the same mistake twice, so we surrounded the wrens in a bush, stood around for half an hour, and then ticked it as our first bird for the Twitchathon at 4:00 pm sharp. The race was on!

After a mad dash around Goschen we also ticked White-

Tim Dolby seaching for albatross. Photograph by Tanya Bramley browed Woodswallow, Hooded Robin, Rufous Songlark, White-winged Triller, Yellow-throated Miner, White-browed Babbler, Spiny-cheeked Honeyeater. Chestnut-rumped Thornbill, Brown Treecreeper, Striated Pardalote, Black-faced Cuckoo-shrike and Rufous Whistler. However we had dipped (a birding term meaning 'missed seeing') on a few birds we had hoped to see at Goschen, including Black Honeyeater, Budgerigar and Cockatiel. It was still a good start to the race. The call went out, 'We've been here twenty minutes. Let's go!'

Next stop was Lake Boga. On the way out of Goschen we were fortunate to pick up Blue Bonnet and Pied Butcherbird, and we stopped at a nearby dam, ticking Greenshank, Whiskered Tern, Pink-eared Duck, Australian Shoveler, Australian Reed-Warbler and Little Grassbird.

Lake Boga is known as the 'Home of the Catalina' because it was a Flying Boat Repair Depot during the Second World War. For the moment we were not interested in seeing this magnificent flying machine. We were planning to catch up with a smaller flying machine, Gull-billed Tern, which can sometimes be seen hawking around the lakes. Lake Boga is one of the only sites in Victoria where you can reliably expect to see this bird, and this year several tern were seen on the lake's fringe. We also added Great Crested Grebe, Black-fronted Dotterel, White-breasted Woodswallow and Blue-faced Honeyeater.

Lake Boga is part of a larger freshwater lake system, which takes in the Kerang Lakes. The nearby Lake Tutchewop, on the other hand, is saltwater and as a consequence is a major inland site for migratory waders. At this stage of the race, however, we weren't particularly interested in seeing the waders. (We'd catch up with them later at the Western Treatment Plant near Werribee.) What we were after was the glorious White-winged Fairy-wren, a bird that inhabits the saltbush around the edge of the lake. In full plumage this must surely be one of Australia's most attractive birds. We quickly heard, then saw, some of these beautiful wrens and we also got on to Australian Pipit, Brown Songlark and Fairy Martin. Sadly we dipped on both Zebra Finch and Great Egret, two birds we had seen at Lake Tutchewop before the race.

Another bird we had seen earlier in the day was a pair of Brolga along the roadside between Kerang and Bendigo. Of course they had also moved on. On the road, however, we did catch up with some good raptors, Black Kite, Nankeen Kestrel, Brown Falcon, Whistling Kite and Swamp Harrier. I had a site for White-backed Swallow at a quarry just north of Terrick Terrick National Park; however, we somehow managed to take a wrong turn. I'm sure the map is wrong! Fortunately this mistake produced a couple of bonus birds, Masked Woodswallow and Long-billed Corella.

Declared a national park in 1998, Terrick Terrick contains one of the most significant remaining areas of native grasslands in Victoria. It is also home to a number of rare and threatened bird species such as Plains-wanderer and Grey-crowned Babbler. One of the best areas for birding is around the picnic ground at the base of Mt Terrick, which is nestled in woodlands dominated by White Cypress-pine. Bird-wise, Terrick Terrick can run hot or cold. Luckily today it was a hot! On the drive into the picnic area we immediately picked up Diamond Firetail, Mistletoebird, Jacky Winter, Peaceful Dove and White-winged Chough. Then, at the base of the rock, we also ticked Gilbert's Whistler, Red-capped Robin, Mallee Ringneck (a bird that had been noticeably absent just a few weeks earlier) and then our 'best bird' for the Twitchathon, a nesting pair of Painted Honeyeater. After forcing ourselves to move on (and not grab a camera) we added Southern Whiteface, Yellow-rumped Thornbill, Restless Flycatcher, Common Bronzewing and Little Eagle. Great birding!

At this stage we calculated our total to be around 110 bird species. It was getting late and we had to hurry to make sure that we could add some Box-Ironbark and Whipstick birds to our list. At Kamarooka, part of the newly formed Greater Bendigo National Park, we quickly got on to Black-chinned, Fuscous and Yellow-tufted Honeyeater and then heard a distant Crested Bellbird. At the nearby Whipstick, a fantastic area of broombush mallee, we ticked our target species Shy Hylacola, but also recorded both White-eared and Tawny-crowned Honeyeater.

The sun was setting and we had two options: either go straight to our next destination, the Otway Ranges (over four hours drive away), giving us time to try for some night birds and hopefully to get some sleep, or hang around for an hour or so and try to pick up a Spotted Nightjar. Of course we hung around, thankfully spotlighting the nightjar just after dusk. We also ticked a night-calling Pallid Cuckoo.

We then drove to the Otways and to a bush campsite near Lorne, arriving around 2:00 am. We immediately heard Boobook Owl, Owlet Nightjar and, surprisingly, a Fantailed Cuckoo. This was the second cuckoo we had ticked during the night; since when had cuckoos become nocturnal?

Day Two

After approximately three hours' sleep (deep sleep in my case and yes, I dreamt about birds), dawn broke in the coastal sclerophyll forests of the Otway Ranges. The area we birded was in a deep valley bordered by towering Blue Gum and Mountain Ash. This is a great spot to bird-watch. At times the sound of the dawn chorus is almost deafening, precisely why it is such a good place to race a Twitchathon. Listening to that dawn chorus, not only can you tick a dozen new species by just standing in one place, you can tick half a dozen before you've even got out of your sleeping bag! We added Crescent Honeyeater, Satin Bowerbird, Rose Robin, Gang-gang Cockatoo, Golden Whistler, White-throated Treecreeper, Australian King-Parrot, Pied Currawong, Eastern Spinebill, White-browed Scrubwren, Brown Thornbill and Eastern Yellow Robin.

After packing up our tents, we drove down to the coast, and then east along the Great Ocean Road, first to Aireys Inlet for Latham's Snipe and Rufous Bristlebird, and then the Anglesea heath for Southern Emu-wren. At Point Addis, Blue-winged Parrot and Yellow-tailed Black Cockatoo flew above our heads as we scoped Shy Albatross and Short-tailed Shearwater. We were also particularly interested in catching up with Painted Button-quail at Point Addis Ironbark Reserve. Their platelets, small circular clearings the size of cow paddies created when they feed, were everywhere. A few weeks earlier a member of our team had been kicking Painted Button-quail out of the way; of course, today there were none. We did however tick Satin Flycatcher and Red-browed Finch, but dipped on Buff-rumped Thornbill, a bird that can usually be found around the Ironbark Reserve car park.

Breamlea is a place that always seems to throw up major surprises. Last year we saw a Greater Sand Plover. This year we ticked both Common Sandpiper and Whimbrel, two bonus birds that we had not previously considered for our final tally. There were however, no Hooded Plover, our target species for Breamlea.

After Breamlea we drove around the Bellarine Peninsula, stopping at Barwon Heads for Eastern Curlew, more Whimbrel, Pied Oystercatcher, Royal Spoonbill, Black-tailed Godwit, Bar-tailed Godwit, Caspian Tern – and then to Lake Lorne (at Drysdale) for Freckled Duck and Blue-billed Duck. On the way through Geelong we picked with Nankeen Night Heron and Crested Shrike-tit on the Barwon River.

Our next stop was a Mecca for Victorian birders, the Western Treatment Plant – known to birders as 'Werribee'. Werribee is a truly magnificent site for birds, with nearly 300 species being recorded. It is home to thousands of wildfowl, and in summer thousands of waders arrive from their breeding grounds in the northern hemisphere. A week earlier I had done some reconnaissance of Werribee and the place was teeming with good birds. Today, however, it was quiet! (Or maybe we were just in a rush?) We didn't see any Curlew Sandpiper (possibly our biggest dip), a bird I had seen easily the previous week, and also there were no egrets (our other big dip). We did see Red-kneed Dotterel, Black-tailed Native-hen, Australasian Gannet, Striated Calamanthus, Yellow-billed Spoonbill, Musk Duck, and large numbers of Cape Barren Geese (the most I have ever seen at Werribee). We also came across an albino Australian Shelduck, which, take away the colour, looks surprisingly like a white domestic duck.

At this stage we did a quick analysis of our race total. Somehow, somewhere, we had miscalculated! We had initially thought we were around 190, and well on the way to 200 plus. After a quick recount

Tawny-crowned Honeyeater *Glyciphila melanops*. Photograph by Jonathon Thornton.

we found our total was 10 birds down, just over 180! I was stumped. We couldn't retrace our steps and pick up the birds we had missed, and we were going to have to rush just to get to 190. We had better hurry!

The You Yangs always surprise me. One of the best birding spots is a dry erosive creek bed appropriately called Hovels Creek. To get there you have to walk a kilometre down a track bordered by plantation eucalypts, climb over a tricky barbed-wire fence, hopefully avoiding tetanus and injury to the nether regions. Fortunately, what is most surprising is that you tend to pick up the woodland birds that you've missed previously, including Sacred Kingfisher, Rainbow Bee-eater, Purple-crowned Lorikeet, Musk Lorikeet and Olive-backed Oriole. We also saw Black-chinned Honeyeater, a bird we'd ticked earlier, but nonetheless a good sighting for the You Yangs.

It was 3:15 pm, the race was scheduled to finish at 4:00 pm, and we had mistimed our run home. What do we do for the next three quarters of an hour? We had recorded all the birds that we were likely to see in the You Yangs, and we were committed to being at the post-twitchathon BBQ at the Big Rock Picnic Area. Basically we had to hang around and wait. There was, however, one target bird we had not seen at the You Yangs, a Wedge-tailed Eagle. If you are lucky you can see Wedgies circling one of the hilltops, so we quickly drove to the highest point that we could reach and with 10 minutes to spare we ticked a single Wedge-tailed Eagle disappearing over a distant hillside ridge.

For me, one of the great puzzles of participating in a Twitchathon is what do you do in the last 10 minutes of racing? You usually have no time to go anywhere, you are unlikely to add any new birds to your list, and you are also totally zonked. So what do you do? Of course we sat down and pished! 'Pishing' is a birding term which means making strange squeaking noises with your mouth. It is somehow meant to imitate the sound of an injured animal, or something like that. Surprisingly, birds in their curiosity are attracted to this sound. Indeed, it is a technique that can be surprisingly effective, working particularly well in enclosed areas such as mangroves. By pishing we may still stand a chance of adding Speckled Warbler or perhaps Scarlet or Flame Robin. (One of the ironies with our Twitchathon route was that we were far more likely to see Hooded, Red-capped and Rose Robin than we were to see the more common Scarlet or Flame Robin.) Needless to say, our first bird for the Twitchathon was Variegated Fairy-wren and our last bird was Wedge-tailed Eagle. Quite rightly so!

By the end of the race we had travelled over 1400 kilometres, with our final total at 192 species in 24 hours. We were all very tired but ready to take on the challenge of another Twitchathon in 2006.

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An observation of a Southern Water Skink *Eulamprus tympanum* giving birth

The Southern Water Skink *Eulamprus tympanum* is a common and widespread reptile throughout much of southern and central Victoria (Atlas of Victorian Wildlife Database).The species reproduces by giving birth to live young and usually inhabits moist or waterside habitats (Wilson and Swan, 2003). It is, however, also found in drier areas, provided suitable habitat such as fallen logs or rocks are present.

At one such site in Blue Gum forest in the Otway Ranges, about 2.5 kilometres south-west of Lorne, a dry, steep slope is covered in numerous fallen logs of various sizes. I regularly visit this location for birdwatching and to observe reptiles, especially the arboreal Spencer's Skink *Pseudemoia spenceri* and the Southern Water Skink. One particularly large log has many cracks and exfoliating pieces of timber, making ideal habitat for these species of lizards.

On 12 January 2006, during one such visit, an adult Southern Water Skink emerged from a crack in this large log at about 11.15 am daylight saving time. The skink proceeded to move slowly over the log, searching for prey amongst the cracks, but soon partly disappeared between sections of timber, so I momentarily turned my attention to a Spencer's Skink that was climbing a nearby daisy bush.

After a few minutes I returned my gaze to the large log and found that the Southern Water Skink had moved out into an open sunny position, but appeared to be convulsing and twisting its body with its mouth partly open. By this time I was very close to the skink, but it completely ignored my presence.

Initially I thought the skink may have been choking on some item of prey, but then I noticed something wriggling under the base of its tail. Looking closely I could see what looked like a small tail, when suddenly a tiny, wet juvenile skink appeared from underneath the adult between the base of the tail and one of the hind legs. The juvenile skink, which had been born tail-first, remained motionless for a few seconds and then suddenly disappeared down a crack in the log. Several seconds later the adult also disappeared down a different crack.

During the birth the female remained in an upright position on the log. The only evidence that the birth had taken place was a yellowish, slimy patch on the log, which soon dried up in the warm sun. I estimated the adult to have an overall length of about 180-200 mm and the juvenile's overall length to be about 35-40 mm. The temperature at the site was approximately 20-22 degrees Celsius.

References:

Atlas of Victorian Wildlife Database, Department of Sustainability and Environment, Victoria.

Wilson S and Swan G (2003) *A Complete Guide to Reptiles of Australia.* (Reed New Holland: Sydney)

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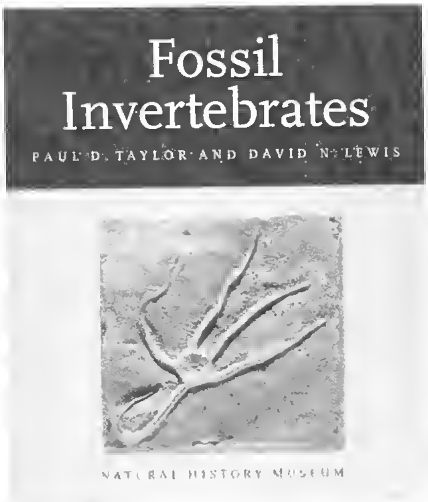
Fossil Invertebrates

by Paul D Taylor and David N Lewis

Publisher: *Natural History Museum, London, 2005. 208 pp, illus. ISBN 0565091832. RRP $69.95*



Inside the dust cover of this attractively presented book are the words, 'Ideal for any undergraduate or amateur fossil enthusiast...' However, the book is not really directed at the person who has a passing interest in invertebrate fossils; it requires a certain amount of prior knowledge to appreciate its content. Apart from an annotated diagram of a trilobite species and one of a Portuguese man-of-war, the volume lacks labelled diagrams to which a reader may refer in order to check the names of the components comprising the fauna. Inevitably the book uses complex morphological terminology. Persons with some expertise in a particular fossil class would readily understand this nomenclature, but it could be overwhelming for some readers. The provision of annotated diagrams and a comprehensive glossary would go a long way towards overcoming this problem.

The volume's introductory chapter takes the reader through the definition of fossils, how they are formed and preserved, and how they may be used to date sediments on a relative timescale. It then broadly describes the phyla of invertebrate animals covered in the book and charts their diversity through time, from the Cambrian Explosion to the present.

Fossils of colonial animals are the first group discussed, beginning with the Cnidaria, the most ancient of which were species of the Ediacaran fauna. The Bryozoans, Sponges and Graptolites are covered next. As with each of the subsequent chapters, an explanation of the chapter topic is provided first, followed by descriptions, and in many cases photographic figures, of selected fauna. These images give the reader an insight into the complexity and variability exhibited by the fauna under examination through time. The authors regularly relate and compare fossil species to living species.

Shelled marine animals follow: Molluscs, Bivalves, Gastropods, Cephalopods (Nautiloids, Ammonoids, and Coleoids), Monoplacophorans, Bellerophontids, Polyplacophorans, Rostroconchs, and Scaphopods are explained. The chapter concludes with coverage of the Brachiopods. A particularly stunning image of the spiriferide brachiopod *Spiriferina* with its delicate brachidium is shown.

Worms and tubes: Annelids, Nemotoda, Onchophora, Priapulida, Sipuncula, and enigmatic tubular fossils provide a short chapter.

A chapter on joint-limbed animals, the Arthropods, follows, beginning with a relatively detailed study of the Trilobites. Chelicerates (spiders, scorpions, mites), Crustaceans (crabs, ostracods, barnacles) dubbed 'the insects of the sea' because of their marine diversity, Myriapods (millipedes and centipedes), and Insects complete the chapter.

Fossils of spiny-skinned animals are the final group discussed. Echinoids, Crinoids, Ophiuroids, Asteroids, Holothurians, Cystoids, Blastoids, Eocrinoids, Helicoplacoids, Ophiocistoids, Cyclocystoids, and finally Carpoids are described and figured.

Most of the images in the book are black and white. Thirty-nine coloured figures are provided to give added impact for selected specimens.

A list of sources of further information on invertebrate fossils from both print literature and from websites is given at the end of the volume. The bryozoan website of FNCV Member, Phil Bock, at *http:/www.civgeo.rmit.edu.au/bryozoa/default.html* is given as one such source. A comprehensive index is provided.

The dedicated enthusiast will find that this book covers the subject of invertebrate fossils well.

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Ocean shores to desert dunes: the native vegetation of New South Wales and the ACT

By David Keith

Publisher: *Department of Environment and Conservation, Hurstville NSW, 2004. 353 pages. ISBN 0731367804. RRP $84.00*

Many Australians have no idea of the diversity of vegetation types within their country, their state or even within the region where they live. This is a lamentable situation indeed. The vegetation of Australia is unique; the diversity of the vegetation is unique. It is wonderful, therefore, to see a book such as *Ocean Shores to Desert Dunes* as it describes the kaleidoscope of our natural vegetation, albeit just for New South Wales and the Australian Capital Territory.

The book is very well written and beautifully presented. It is divided into three sections. Part I is an introduction to native vegetation and explains how Australia's heritage is closely entwined with the vegetation. It describes the ecology of vegetation, the classification and mapping of vegetation and how to use the book. The key on pages 26-28 can be used to determine the vegetation formations anywhere in NSW and the ACT. The simple instructions and glossary ensure that even the uninitiated will have no problems using the key.

Part II describes the vegetation formations and classes. The appropriate vegetation class is determined by simply reading the descriptive profiles within the identified vegetation formation and the process of elimination. There are 12 vegetation formations: Rainforest, Wet Sclerophyll Forest, Grassy Woodland, Grassland, Dry Sclerophyll forest, Heathland, Alpine complex, Freshwater Wetland, Forested Wetland, Saline Wetland, Semi-arid Woodland and Arid Shrubland. Dry Sclerophyll Forest has the greatest number of vegetation classes, 24, while each of the wetlands has only four. Each vegetation class is presented within a page opening. The structure of the vegetation is described as is its extent (along with a map) and a little of the ecology of the area or pertinent issues. In every instance, a list of indicative species for each stratum is provided, as are superb photographs.

The introduction to each vegetation formation is specific to that formation. For example, the introduction to Alpine Complex explains why its four classes are grouped into the same formation; it discusses why there are no trees above the tree line and why Australia's tree line is so much lower than tree lines of many other countries. Some of the unique fauna is explored, including the often forgotten invertebrates. Many species of invertebrates are found only in the Alps. One of these is a grasshopper that can change its colour to maximize or minimize heat-absorption in the cooler or warmer parts of the day respectively. The evolutionary links of the Australian alpine flora is described, with some being typically Gondwanan while others have relatives in temperate latitudes of the northern hemisphere. The flora also is described as being 'an evolutionary pump'. Human use of the area is described and, importantly, so are the effects of climate change. Significantly, the area covered by snow is predicted to shrink over the next thirty years by 18-66 per cent!

Part III comprises compilation maps of the native vegetation of NSW. These detail existing vegetation and reconstructed vegetation. There are three appendices. One provides estimates of present-day area of vegetation classes in NSW and the ACT and per cent cleared since settlement. Another lists endangered ecological communities and their inferred relationships to the vegetation classes, and the third lists the changes to vegetation class and formation names between version 1.1 of the vegetation classification of NSW and version 2.1 (this book).

Ocean Shores to Desert Dunes is ideal, not only for the student of vegetation formations but also for someone with no knowledge of vegetation classification. In fact, if this book was provided to a person with no interest in vegetation, they would become a convert.

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Albatross: elusive mariners of the Southern Ocean

by Aleks Terauds and illustrated by Fiona Stewart

Publisher: *CSIRO Publishing, 2006. 176 pages, paperback; colour photographs. ISBN 1877069264. RRP $39.95*

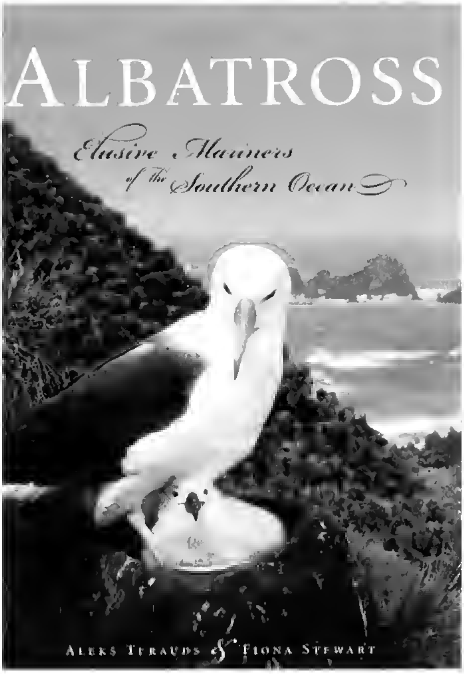
Albatross is a fine work that focuses on five species of Albatross that breed at Australian sites in the Southern Ocean. The book is lavishly illustrated with stunning photographs of some of the largest flying birds on earth. Scattered throughout one also finds images of the remote sites at which they breed and the other mostly marine species that share these islands.

The book consists of five easy-to-read chapters. The reader is first provided with an overview of the four breeding sites, three scattered around Tasmania and the fourth, Macquarie Island, well to the south and approximately halfway to the Antarctic continent. A chapter documenting the catastrophic impact that humans have had on the marine mammals and birds in Bass Strait and the Southern Ocean follows. Here we learn that 18th and 19th century industries, focused on the recovery of oil, fur and feathers, decimated marine vertebrate populations. In a climate of economic greed and fierce competition accessible whale, seal, penguin and albatross populations were taken to the brink of extinction. Some, such as Elephant seals and Australian Sea Lions in Bass Strait, were pushed over the edge. Following the collapse of these land-based industries, feral animals impacted on returning fauna, especially the smaller seabirds. With the development of long-line fishing in the late 1950s a new threat for the larger seabirds, including the albatross, appeared. Although much has been done to mitigate the impact of these fisheries we learn that it is these activities that now pose the greatest threat to our albatross. Reflecting Aleks Terauds' passion for albatross, this conservation message extends well beyond this chapter and is the central theme of the book.

A third chapter provides an overview of each of the five species treated here: Wandering, Shy, Black-browed, Grey-headed and Light-mantled Sooty Albatross. From tips on identifying these species at sea to detailed accounts of life history, population trends and feeding habitats, the reader is provided with a very thorough understanding of their ecology. The book concludes with two shorter chapters; one providing a synopsis of the Australian conservation efforts, the other providing insights into the challenges and joys of living and working on the island breeding sites.

Although upfront in stating that this book covers albatross that breed in Australia, a brief foray into those species that occur in Australian waters as non-breeding visitors would have been welcome. At times several such species (e.g. Yellow-nosed Albatross and Buller's Albatross) are a major component of the albatross fauna in near coastal waters of southern Australia yet these receive no mention. Indeed, taking this a step further, a short chapter on the albatross of the world would have helped set the context for those species that breed in Australia.

Reflecting the author's experiences almost of all of the photographs were taken on the nesting grounds. Given that albatross spend most of their lives in the open



ocean, and it is here that they are truly masters of their environment, a wider selection of photographs showing birds at sea would have also been welcomed.

These are, however, minor criticisms reflecting personal taste and do not detract from what is a beautifully illustrated and well-researched book. Aleks Terauds and Fiona Stewart are to be commended for providing a window into the lives of albatross, a glimpse at the wild places on which they nest, and for bringing the plight of these magnificent birds to the attention of all. This work is recommended to anyone with an interest in natural history, conservation or marine environments.

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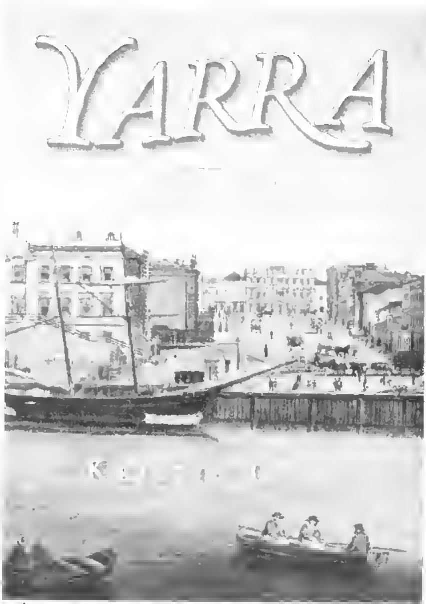
Yarra
A diverting history of Melbourne's murky river



by Kristin Otto

Publisher: *Text Publishing, Melbourne, 2005. 245 pages, paperback. ISBN 1920885781 RRP $32.00*

Recent articles in *The Age* attest to the central place the Yarra River has, both for Melbourne and Melburnians. That enduring interest has given rise to a number of books, the most recent of which is this well-presented work.

The book is structured into six chapters, each focusing on a particular aspect of the river, such as 'The source', 'The flow', 'Working the river'. At the end of Chapters 2 to 5 there are four sections that literally cut across the main narrative and focus on the Yarra's bridges. The illustrations (all black and white), sprinkled throughout the book, are well chosen and generally augment the informative text.

In style, at least, this book seems to owe something to Robyn Annear's *Bearbrass*. This is not necessarily a fault, although imitating a quirky style is difficult and, as here, doesn't always work. Otto signals the manner in which her narrative is to proceed, with an epigrammatic statement at the beginning: 'There are meanders in the telling, billabongs, islands, snags, floods...'. This is an accurate metaphor for the way in which the book is written, but the meandering text also displays wide-ranging research on the part of the author.

Perhaps the catchment area might have been larger; I was diverted occasionally by some unfortunate historical inaccuracies. One example will suffice. Following mention of the attempt at settlement at Sorrento in 1803, we are told (p. 15) that 'no white man lived in the Port Phillip District until 1835'. Of course, this ignores the settlement at Corinella in Westernport Bay, which began in December 1826 and lasted for about 17 months.

As with its subject, this book carries a lot of material, and while a few pieces might not be relevant to the Yarra River, it is all nonetheless interesting. But as a history, it also has two noticeable deficiencies. Firstly, very little of the information is properly sourced or adequately referenced. The 'Sources' section at the end of the book does not provide publishing details of the books used as sources. Moreover, all the journal articles used are grouped, curiously, in chronological order under headings of the journal title, without volume or page numbers. These features will make it difficult to trace any source. Otto is quoted (*theage(Melbourne)magazine*, No. 12, p. 66) as saying she couldn't write a 'proper' history of the subject, meaning one with footnotes, but that shouldn't absolve her of the responsibility of telling her readers precisely where the information came from.

The second major omission is a map that illustrates the course of the Yarra's entire length. This would have been particularly useful in the chapter dealing with the source of the river.

These reservations notwithstanding, this book is recommended to anybody who wants a readable account of much that has happened along and in the Yarra River, in the history of that murky stream.

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Flora and Fauna Guarantee Act 1988

The **Flora and Fauna Guarantee Act 1988** enables members of the public to nominate species, communities and potentially threatening processes for listing under the Act. Nominations under the Act are considered by a Scientific Advisory Committee, which makes recommendations to the Minister.

The Committee has made a number of final and preliminary recommendations. A brief Recommendation Report has been prepared for each final or preliminary recommendation. Copies of the reports can be obtained from the Head Office and major country offices of the Department of Sustainability and Environment (DSE). The **Flora and Fauna Guarantee Act 1988** and the Flora and Fauna Guarantee Regulations 2001 can be viewed at these offices.

Recommendations of the Scientific Advisory Committee

The Scientific Advisory Committee has made final recommendations on the evidence available, in accordance with Section 15 of the Act, that the nominations for listing of the following items be supported in accordance with Section 11 of the **Flora and Fauna Guarantee Act 1988**.

Items supported for listing

743 *Nymphoides crenata*	Wavy Marshwort
744 *Leptodon smithii*	Prince-of-Wales Feather-moss
745 *Caladenia* sp. aff. *venusta* (Stuart Mill)	Stuart Mill Spider-orchid
746 *Corunastylis* sp. aff. *nudiscapa* (Otway Ranges)	Otway Midge-orchid
747 *Caladenia ornata*	Ornate Pink-fingers
748 *Pterostylis* sp. aff. *bicolor* (Woorndoo)	Dense Greenhood
749 *Pterostylis chlorogramma*	Green-striped Greenhood
750 *Pterostylis* sp. aff. *cycnocephala*	Cygnet Greenhood
751 *Pterostylis* sp. aff. *dolichochila* (Portland)	Portland Shell-orchid
752 *Pterostylis* sp. aff. *furcata* (Woolly Tea-tree)	Small Sickle Greenhood
753 *Pterostylis* sp. aff. *mutica* (Basalt Plains)	Leprechaun Greenhood
755 *Dianella amoena*	Matted Flax-lily

Item for de-listing

758 *Edelia obscura*	Yarra Pygmy Perch

Recommendations of the Scientific Advisory Committee

The Scientific Advisory Committee has made preliminary recommendations on the evidence available, in accordance with Section 14 of the Act, that the nominations for listing of the following items be supported in accordance with Section 11 of the **Flora and Fauna Guarantee Act 1988**.

Items supported for listing

730 *Breutelia elongata*	Tasman Breutelia
739 *Climacium dendroides*	Marsh Tree-moss
760 *Lindsaea trichomanoides*	Oval Wedge-fern

Items supported for listing

737 *Pultenaea williamsoniana*	Williamson's Bush-pea	rejected
754 *Cercartetus nanus*	Eastern Pygmy Possum	rejected
761 Degradation of listed communities by urban, semi-urban, industrial and related development (e.g. infrastructure development) (potentially threatening process)		rejected

The Victorian Naturalist

Volume 123 (4) **August 2006**

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From the Editors

From time to time it is felt necessary to concentrate, through the pages of *The Victorian Naturalist*, on a particular group of species of plant or animal, or on the natural history of a particular area. This happens for a variety of reasons, including the celebrating of historical events (e.g. the life and work of Frederick McCoy, the reservation of Wilsons Promontory, the formation of the FNCV); the threat to particular ecosystems (Box-Ironbark forests); or to focus attention on a lesser-known part of the plant or fungus worlds (mistletoes, fungi). The present issue falls into the latter category, drawing attention to the subject of bryophytes.

The subject of bryophytes (mosses, liverworts and hornworts) is certainly not well known to a general readership. Because of that, the terminology used in their study may be unfamiliar to our readers. For this reason, a glossary of relevant terms has been prepared for this issue, and is included at the end, following the final paper.

We trust readers will find some interest in the contents of this issue. The papers presented here should at least serve both as an introduction to a subject area that is not commonly featured in the pages of this journal, and as another indication of the enormous diversity that exists in the plant kingdom.

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The Victorian Naturalist

Volume 123 (4) 2006 August

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ISSN 0042-5184

Front cover: *Dawsonia longiseta*. Photograph by Matthew Dell.
Back cover: .Soil crust at Wyperfeld National Park (see article on page 195). Photograph by Chris Tyshing.

Introducing bryophytes

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Bryophytes are small but beautiful plants. They are frequently overlooked yet are vital components of most ecosystems. Bryophytes are early colonizers after disturbance e.g. by fire (Fig. 1), protecting the bare soil and nutrient-rich ash from wind and water erosion, and providing a moist bed for seed germination of vascular plants. They contribute to nutrient cycling, provide shelter and protection for invertebrates – and thus harbour a food source for a wide variety of animals – and provide nesting material for birds and cocoon-forming insect larvae. They have been used as bioindicators and biomonitors of environmental pollution as well as phytoremediators, and a number of them have antifungal and antibacterial properties. In spite of all this, relatively little is known of bryophyte ecology or, indeed, what occurs where.

This special issue of *The Victorian Naturalist* highlights some of the current investigative work being done in Victoria. Papers included in this issue consider the soil crusts of the Little Desert National Park and their associated invertebrates, a comparison of the epiphytic bryophytes of Myrtle Beech with those of Mountain Ash, the bryophytes of Cool Temperate Rainforest, and bryophytes of stream rocks.

Bryophytes are divided into three groups, the mosses, liverworts and hornworts. None of them has roots; instead, they attach to their substratum by rhizoids which do not take up nutrients as roots do. Bryophytes take up nutrients dissolved in water directly through the plant body. Mosses have stems and leaves (Fig.2), while liverworts consist of stems and leaves or a thallus consisting of flattened

Fig. 1. *Funaria hygrometrica*, a moss, forms thick carpets after fire, protecting the ash bed from erosion and providing a moist habitat for regeneration of other plants. The photograph was taken at Wilsons Promontory, approximately six months after the easter bushfire.

green strap-like or lobed structures (Figs. 3 and 4). Moss leaves often have a vein (costa) running down the centre. Leafy liverworts never have a costa. The leaves of both mosses and liverworts usually are one cell in thickness, although some mosses have more cell layers, especially around the costa. Liverwort leaves are often two-lobed, with each lobe growing from two distinct apical points. Most moss species have leaves arranged around the stem in a spiral. Leafy liverworts have leaves arranged in rows; many have two rows of lateral leaves and a row of smaller leaves on the undersurface. Mosses have multicellular rhizoids; liverworts have unicellular rhizoids.

Hornworts are thallose, so superficially resemble thalloid liverworts, but many features distinguish the two. Each hornwort cell usually has only one large chloroplast, but liverwort cells have many small discoid chloroplasts. Hornworts have stomata but liverworts do not. These features, however, are difficult to see in the field. Hornworts are often rosette-like and one to two centimetres across. Usually they have many internal cavities filled with mucilage, which can be seen with a handlens by slicing through the hornwort and looking at the cut edge. In liverworts such cavities are air filled.

Many other features can be used to distinguish the three groups of bryophytes. Most of these require microscopic analysis, but with a little practice it is surprising how quickly one intuitively recognizes whether a bryophyte is a moss, liverwort or hornwort. Identifying a bryophyte to genus or species level is more difficult. Over the last ten years, the increased production of beautifully illustrated field guides with many accompanying photographs has helped greatly, but photographs frequently are insufficient to distinguish a bryophyte to either genus or species level. The serious student of bryophytes requires simple, easy-to-use keys. This issue of *The Victorian Naturalist* presents several keys, one to the genera (and many species) of leafy liverworts, one to the thallose liverworts and hornworts and one to the moss genus *Fabronia*. The paper dealing with *Fabronia* also includes a discussion on its affinities and conservation status.

Fig. 2. *Cyathophorum bulbosum*, a moss with a leaf arrangement common in leafy liverworts, i.e. two lateral rows of leaves and a row of smaller leaves on the undersurface (not shown).

Fig. 3 *Marchantia bertoroana*, a common thalloid liverwort.

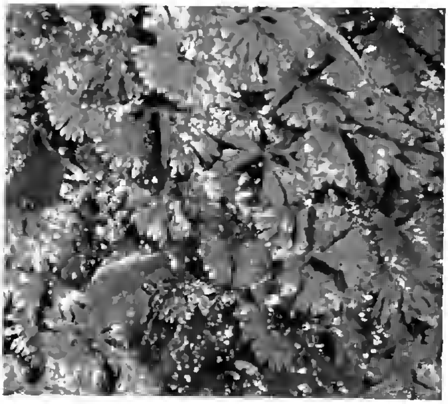

Fig. 4. *Hymenophyton flabellatum*, a stalked thallose liverwort common in wet forests.

Bryophytes can reproduce sexually and asexually (without sex). Asexual reproduction is generally vegetative and includes fragmentation with subsequent growth of the fragment into a new plant, development of specialized structures such as gemmae, which grow into new individuals, and new growth of shoots that develop rhizoids and become independent following degeneration of older parts. Sexual reproduction involves an alternation of generations (Fig. 5). The green plant normally recognized as the bryophytic plant is the gametophyte generation, which produces the gametes, that is, the eggs (ova) and sperm (antherozoids). Fertilization of the egg results in development of the second generation, called a sporophyte, which produces the capsule that contains spores. Sporophyte cells have twice the chromosome (genetic material) component of the gametophyte. Within the capsule a process called meiosis occurs, resulting in development of spores that have half the chromosome complement of the sporophyte. Upon release and dispersal to a suitable habitat, the spores germinate and develop into another gametophyte generation. This basic cycle occurs in all three groups of bryophytes but each group has its own variations; for example, most mosses have a filamentous stage of the gametophyte, called the protonemal stage, which produces buds that grow into leafy plants with rhizoids. In liverworts, the protonemal stage is reduced and each protonema produces only a single plant. Protonema do not occur in hornworts. Sporophytes easily distinguish the bryophyte groups from each other but, inconveniently, are not always present. Some species never produce sexually so never produce a sporophyte. Other species may reproduce sexually in one region but not another. Studies on the sexual reproduction of bryophytes are comparatively few worldwide but are particularly rare in Australia. This issue presents an investigation of the sexual reproduction of *Atrichum androgynum*, a common moss of wet forests in Australia.

Also included in this issue is a paper dealing with the bryophyte collection of the National Herbarium of Victoria. This paper provides a historic timeline of the collections and provides details on some of the more significant collectors.

This landmark issue of *The Victorian Naturalist* showcases some of the research occurring throughout Victoria and should encourage others to look at the many and varied aspects of bryophyte taxonomy and ecology. Hopefully, this will be reflected in an increase in the publication rate of bryological papers in *The Victorian Naturalist*.

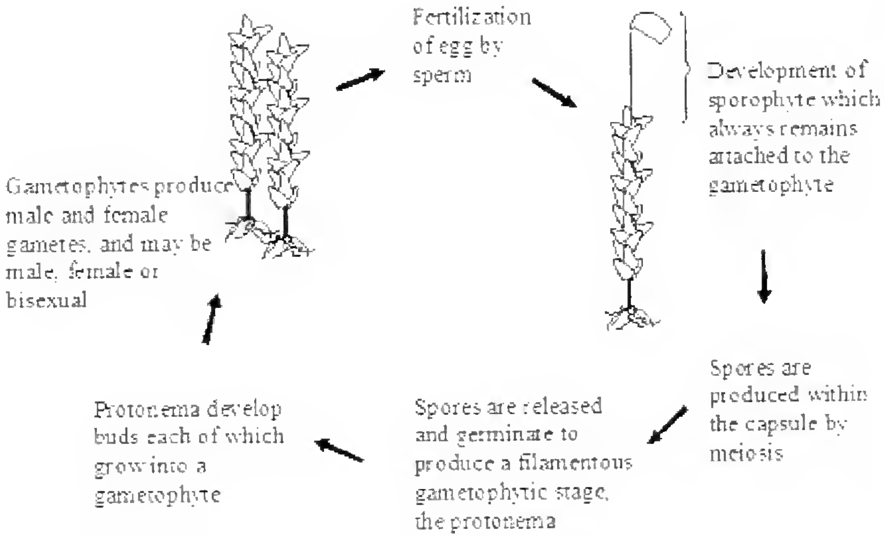

Fig. 5. Basic alternation of generations in a moss.

A preliminary study of bryophytes and invertebrates of soil crusts in the Little Desert National Park and surrounds

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Abstract

This study is preliminary to ongoing investigations of soil crusts and associated invertebrates in north-west Victoria, focusing on the Little Desert National Park. Ninety quadrats from nine sites were sampled. Eighteen bryophyte species (nine mosses, nine liverworts) were identified within the quadrats. All invertebrates were from the Phylum Arthropoda. Overall abundance and diversity of invertebrates was low. While sampling in the drier months is valuable for observing the dynamics of soil crusts in this region, a more comprehensive assessment of species diversity is gained by sampling during wetter periods. (*The Victorian Naturalist* **123** (4), 2006, 195-203)

Introduction

Soil generally is considered a precious resource, but what is the value placed on the organisms that comprise soil crusts? Bryophytes, together with lichens, fungi and cyanobacteria (blue-green algae) make up the biological or cryptogamic crusts that play a very important role in protecting soils of the arid and semi-arid zones of Australia, including sensitive rangelands (Eldridge and Tozer 1996; 1997a; 1997b; Hodgins and Rogers 1997, Rosentreter and Eldridge 2002). Biological crusts protect soils from erosion, regulate infiltration of rainfall, provide a suitable microhabitat for germination of seed, photosynthesise when moist, therefore acting as a carbon sink (Moore 1998; Eldridge 2000), and provide food and shelter for invertebrates. In turn, invertebrates play an important role in the regulation of decomposition and nutrient cycling within the crust and soil beneath (Belnap 2001). Recent research (Eldridge 2005) has highlighted the importance of biological crusts as indicators of the effectiveness of landscape management. Conservation of soil crusts requires not only an understanding of the organisms that comprise them, but also of the interactions that occur within them, and how species composition varies geographically.

In Australia, a number of studies have examined the composition of soil crusts in arid and semi-arid areas and rangelands (Eldridge and Tozer 1996; 1997a; Eldridge 1998a; 1998b; Eldridge 2001), the impact of particular landuse (e.g. grazing, cultivation) on the dynamics of soil crusts (Eldridge *et al.* 2000) and the effect of management activities (e.g. burning off) on these crusts (Eldridge and Tozer 1997a; Hodgins and Rogers 1997). These studies concentrated on areas of western New South Wales, south-western South Australia and Queensland and highlighted the diversity of cryptogamic organisms in soil crusts and the abiotic conditions conducive to development of these crusts. In Victoria, short lists of bryophytes have been included in vegetation studies of Hattah Lakes (Willis 1970) and Wyperfeld (Scott 1982) National Parks, but there are no formal systematic studies of soil crust bryophyte species, the invertebrates that inhabit them, or studies focusing on the dynamics of soil crusts.

The objectives of this preliminary study were to record the composition and abundance of soil crust bryophytes and document the invertebrate fauna inhabiting these crusts in the semi-arid zones of north-western Victoria, in particular the Little Desert National Park (LDNP), Little Desert Lodge, North Goroke State Forest and Jane Duff Reserve.

Methods

Study area

The Little Desert National Park is located in the Wimmera 375 km north-west of Melbourne. The area is described as semi-arid with mean daily maximum summer temperatures ranging from 28 to 30 °C and mean maximum winter daily temperatures ranging from 14 to 15 °C (Bureau of Meteorology August 2004). Mean annual rainfall is 415 mm with most of the rainfall occurring from May to October (Bureau of Meteorology August 2004). The Wimmera plains were originally covered by woodlands of Yellow Gum, Buloke and Black and Grey Box with large expanses of grassland between the woodlands (Land Conservation Council 1985). Since European settlement most of the natural vegetation has been cleared for agriculture and the LDNP is all that remains of the original vegetation. The national park began as a small reserve for the protection of the Malleefowl (National Parks Service 1996). In the late 1960s there were plans to further develop the area for agriculture. This proposal met with strong public opposition and in 1968 the area was proclaimed a national park. The LDNP has expanded over the years, and by 1988 comprised 132 000 ha (National Parks Service 1996). The vegetation of the national park is predominantly Brown Stringybark *Eucalyptus baxteri*, with large patches of heath and Mallee–broombush *Melaleuca uncinata*, particularly in the eastern and central blocks. The western block is almost all brown stringybark with small scattered patches of gum–box-Buloke woodland (consisting of Yellow Gum woodland and Slender Cypress Pine woodland) and Mallee–broombush (Land Conservation Council 1985). The LDNP occurs predominantly in what is now referred to as the Wimmera Bioregion (DSE 2006). Part of the western block of the LDNP is also within the Lowan Bioregion (DSE 2006). Ecological Vegetation Classes have been determined for the two bioregions within the LDNP (DSE 2006).

The first fieldtrip in November 2003 surveyed sites in the 'eastern block' of the LDNP and sites within the Little Desert Lodge (Fig. 1). The second fieldtrip conducted in June 2004 surveyed sites in the 'western and central blocks' of the LDNP and in the North Goroke State Forest. In this study, a total of nine sites was examined in detail (Fig. 1). It was originally proposed to

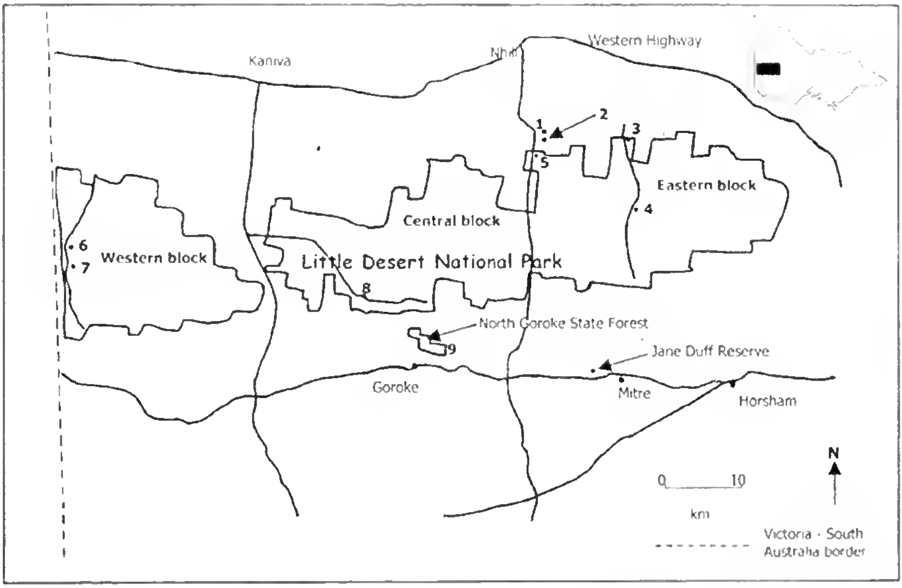

Fig. 1. Location of study sites and predominant vegetation type at each site. **1.** Whimpy's Little Desert Lodge Nature Trail 'claypan 1' (Slender Cypress Pine Woodland); **2.** Whimpy's Little Desert Lodge Nature Trail 'claypan 2' (Slender Cypress Pine Woodland); **3.** Kiata camp ground (Yellow Gum Woodland); **4.** Salt Lake Road (Heathland); **5.** Stringybark Walk (Slender Cypress Pine Woodland); **6.** Mt Moffat Track (Yellow Gum Woodland); **7.** Mt Moffat Track, just north of East-West Road (Yellow Gum Woodland); **8.** Southern end of Sambell's Track (Yellow Gum Woodland); **9.** North Goroke State Forest (Yellow Gum Woodland).

sample along transects in diverse vegetation types within the national park, but once in the field it became evident that sites which soley consisted of sandy soils supported little or no soil crusts. Any bryophytes present were restricted to the base of shrubs. Therefore, sampling took place in heathland and in woodlands dominated by Slender Cypress Pine *Callitris gracilis* R.Baker (Fig. 2a) or Yellow Gum *Eucalyptus leucoxylon* F.Muell. subsp. *leucoxylon* (Fig. 2b). At each of these sites there was some clay component in the soil. The Jane Duff Reserve, 5 km west of Mitre, was visited en route to the national park.

Data collection

A transect (100 m) was set out at each site. Soil crust bryophyte and lichen species were sampled from 30 x 30 cm quadrats, at 10 m intervals along the tran-

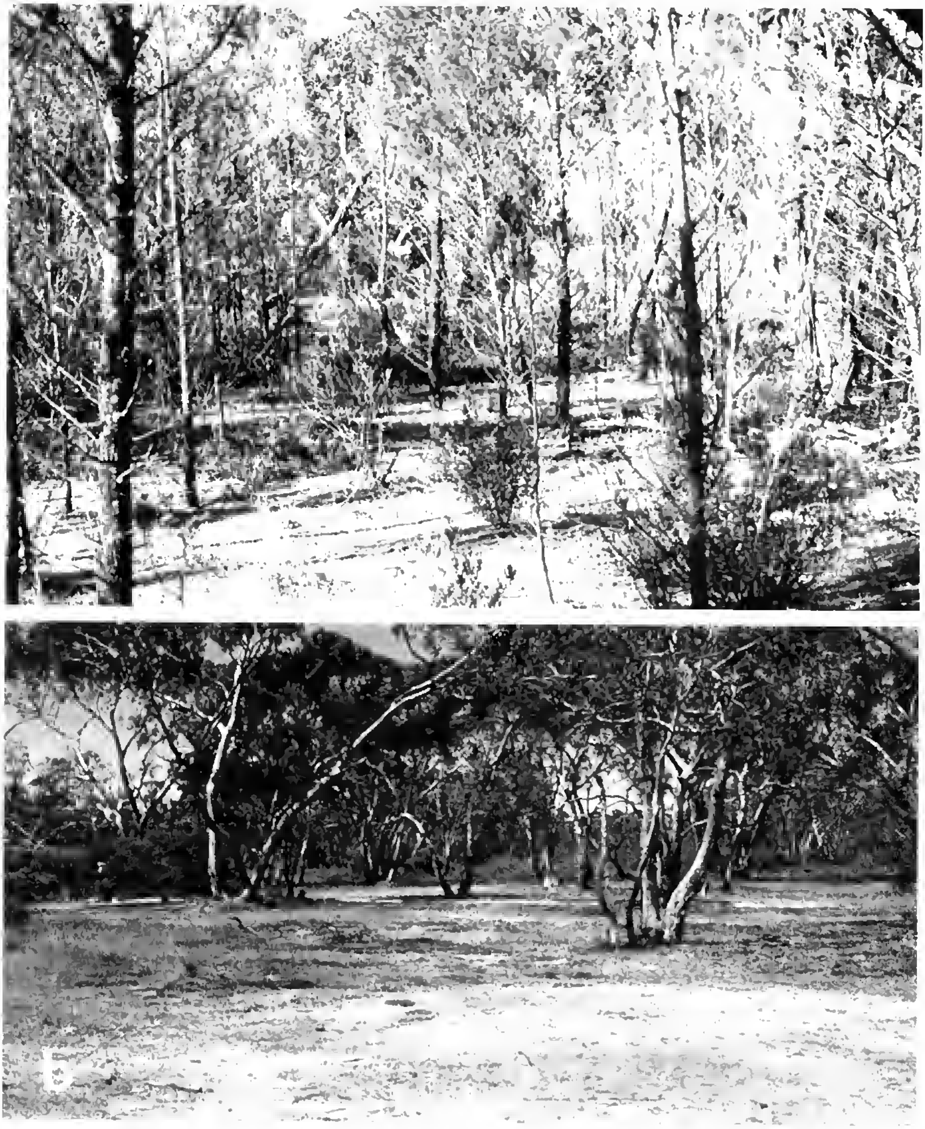

Fig. 2 a. Slender Cypress Pine *Callitris gracilis*, **b.** Yellow Gum Woodland *Eucalyptus leucoxylon* subsp. *leucoxylon*.

sect. Soil surface features are important as they are indicative of the likelihood of soil crust formation. Biotic and abiotic aspects were recorded for each quadrat along a transect, including characteristics of soil surface morphology e.g. slope within a quadrat, surface microtopography and crust coherence (see Eldridge and Tozer 1997). Within each quadrat the vascular plant cover and leaf litter cover were estimated. The percentage total soil crust cover within the quadrat was then estimated together with the proportion of the algal, bryophyte and lichen components. Small samples of mosses and liverworts were taken to confirm identification. Some collections of the liverwort *Riccia* were fertile. Their spores were examined with a scanning electron microscope (SEM) because the microscopic structure of spores assists in the identification of these plants. The relationship between the suite of soil crust species and vegetation type, leaf litter cover, topography, soil type and associated water retention will be reported elsewhere.

Soil crust samples (10 x 10 x 2 cm deep) were collected from quadrats along each transect and the macro-invertebrate fauna extracted in the laboratory using Tullgren funnels (Gullan and Cranston 2000). In the first fieldtrip, soil crust samples were taken from four quadrats per transect, but as this yielded a low number of invertebrates, five quadrats were sampled along each transect during the June 2004 sampling period. After the invertebrates were extracted, any mosses and liverworts present were identified.

Soil from the November 2003 crust samples was potted out in small sterile pots filled with sterile coarse sand to determine whether spores or asexual propagules of mosses and liverworts were resting in the soil. The pots were placed in ambient light and temperature, watered regularly with distilled water and covered with a plastic sheet to avoid contamination.

Taxonomic nomenclature follows Streimann and Klazenga (2002) for mosses, and McCarthy (2003) for liverworts.

Results

Crust floristics

Eighteen bryophyte species (nine mosses and nine liverworts) representing 11 families were identified (Table 1) from 90 quadrats sampled from nine sites. A further two moss species *Rosulabryum billardierei* and *Tayloria octoblepharum* were recorded in the vicinity of some of the quadrats. Of the 12 moss taxa, five were from the family Pottiaceae and two from the family Bryaceae. The predominant liverworts recorded were the thallose genera *Asterella* and *Riccia* and the leafy species, *Lethocolea pansa* and *Fossombronia* (Table 1). The Jane Duff Reserve proved rich in *Riccia*

Table 1. Bryophytes recorded within quadrats in the Little Desert National Park, Little Desert Lodge and North Goroke State Forest Victoria, Australia.

Taxa
Mosses
Bryaceae
Rosulabryum billardierei (Schwägr.) J.R.Spence*
Rosulabryum campylothecium (Taylor) J.R.Spence
Ditrichaceae
Eccremidium sp.
Gigaspermaceae
Gigaspermum repens (Hook.) Lindb.
Leucobryaceae
Campylopus introflexus (Hedw.) Brid.
Polytrichaceae
Polytrichum juniperinum Hedw.
Pottiaceae
Barbula calycina Schwägr.
Barbula crinita Schultz
Didymodon torquatus (Taylor) Catches.
Tortula antarctica (Hampe) Wilson
Triquetrella papillata (Hook.f. and Wilson) Broth.
Splachnaceae
Tayloria octoblepharum (Hook.) Mitt.*
Liverworts
Acrobolbaceae
Enigmella thallina G.A.M.Scott and K.G.Beckm.
Lethocolea pansa (Taylor) G.A.M.Scott and K.G. Beckm.
Arnelliaceae
Gongylanthus scariosus (Lehm.) Steph.
Aytoniaceae
Asterella drummondii (Hook.f. and Taylor) R.M.Schust. ex D.G.Long
Asterella sp.
Fossombroniaceae
Fossombronia intestinalis Taylor
Fossombronia sp.
Ricciaceae
Riccia papulosa (Steph.) Steph.
Riccia sp.

* Recorded at study sites, but not in quadrats.

with three species being recorded, *R. cavenosa*, *R. cristallina* and *R. multifida*.

Two mosses, *Fissidens* sp. and *Funaria* sp., that were not recorded in the quadrats grew in the pots from soil samples collected in November 2003.

The impact of season on the percentage of soil crust cover and the contribution particular cryptogams made to crust cover is depicted in Fig. 3. Sampling in June 2004, after substantial rainfall, showed that algae and liverworts, particularly *Asterella* sp., *Fossombronia* sp. and *Lethocolea pansa* formed the predominant components of the soil crusts (Figs. 4d and 5b). In contrast, crusts sampled during the dry period of November 2003 consisted mainly of mosses (Fig. 3).

Invertebrates

All invertebrates collected in this study were from the Phylum Arthropoda. Increased abundance and activity of invertebrates was noted in the June 2004 sampling period. They were observed crawling over the soil crusts, whereas none was observed in the drier conditions in June 2003. No difference in either abundance or diversity of extracted macro-invertebrates was found between the two sampling periods, with the exception of the insect order Collembola (springtails). The majority of arthropods extracted were mites and springtails (Table 2). Only a small number of ants were extracted from the soil crusts, but our field observations suggest that ants are present at most sites but appeared to be moving across soil crusts, between patches of shrub and litter cover, rather than inhabiting the areas of soil crusts. Eight ant species were recorded moving across transects: *Anonychomyrma* sp., *Iridomyrmex* sp. (meat ant), *Camponotus* sp., *Doleromyrma* sp., *Pheidole* sp. 1, *Pheidole* sp. 2, *Rhytidoponera* sp., and *Tapinoma* sp. In the June 2004 sampling period, there were Diptera, Coleoptera and Lepidoptera larvae in the crust samples.

Table 2. Invertebrates recorded in soil crust within the Little Desert National Park, Little Desert Nature Lodge and North Goroke State forest, Victoria, Australia.

Order	Morphospecies collected Nov 2003	Jun 2004
Araneae	-	1
Acari	6	9
Hymenoptera	1	2
Coleoptera (larvae)	-	2
Lepidoptera (larvae)	-	1
Diptera (larvae)	-	1
Hemiptera	1	-
Blattodea	1	-
Collembola	1	5
Total	10	21

Discussion

The majority of bryophytes recorded in this study also have been documented in other soil crust studies (Eldridge and Tozer 1996; 1997a; 1997b; Eldridge *et al.* 2000; Thompson and Eldridge 2005). The liverworts *Gongylanthus scariosus*, *Lethocolea pansa* and *Riccia multifida* have not been documented in previous soil crust studies. Differences between the suite of species recorded can be attributed to vegetation communities, soil types, level of disturbance (Eldridge and Tozer 1996; 1997a; Hodgins and Rogers 1997) and sampling season. Also, because of the small size and ephemeral nature of many soil crust bryophytes, taxa can be overlooked. In this study, the season in which surveys were conducted influenced the taxa recorded and, in particular, their relative abundance. Substantial rainfall in early winter (June 2004) influenced the dynamics of the soil crust cover at the study sites, and the ephemeral nature of liverworts became quite apparent. There had been heavy rainfall in the weeks prior to this trip and liverworts formed one of the predominant components of the soil crusts. In the November 2003 fieldtrip, much of the liverwort biomass was not evident, being in a dormant summer phase and nearly impossible to detect, or resting in the soil as either spores or asexual propagules, which produced new plants with the onset of rain (Fig. 5b). The growth of liverworts from soil collected in November 2003 is evidence that the soil does acts as a diaspore bank. In June 2004, gemmae were detected amongst the leaves of the liverwort *Lethocolea pansa* indicating a strategy in this species of producing many asexual propagules at the beginning of the growing season, prior to the production of gametangia (male and

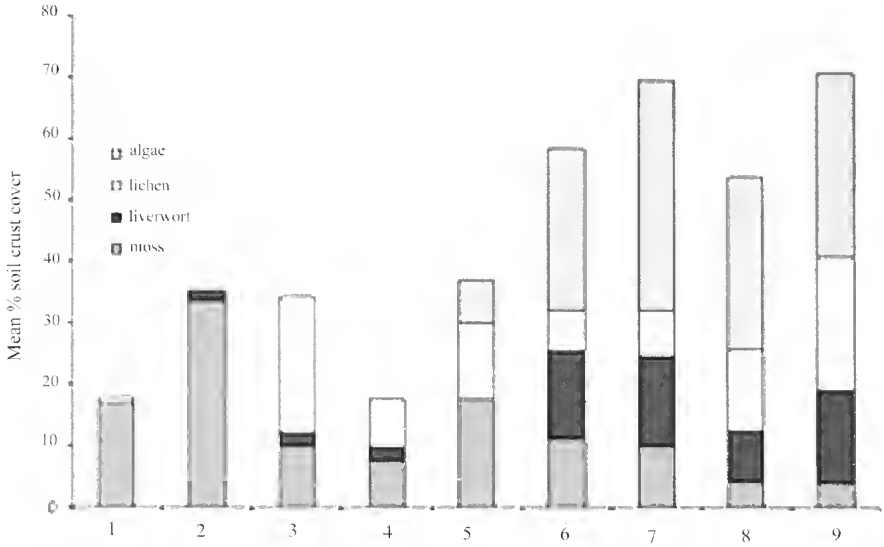

Fig. 3. Mean percentage cover of moss, liverwort, lichen and algae in soil crusts at sites surveyed in the Little Desert National Park, Little Desert Lodge and North Goroke State Forest, Victoria.

female sex organs) (Beckmann 1993). It became apparent that once pots were allowed to dry out, some liverwort species e.g. *Fossombronia* sp. and *Lethocolea pansa*, shrivelled and dried very quickly and were difficult to detect on the soil surface. The stems of these perennial species often act as tubers that persist after the extremities have dried and deteriorated and new growth is initiated once favourable conditions return (Beckmann 1993). In this state, the presence of these plants is difficult to detect and would explain the lower percentage of liverwort crust component in the November 2003 sampling (Fig. 5a). In contrast, the liverworts *Riccia* and *Asterella* were recorded during the November 2003 sampling. These species

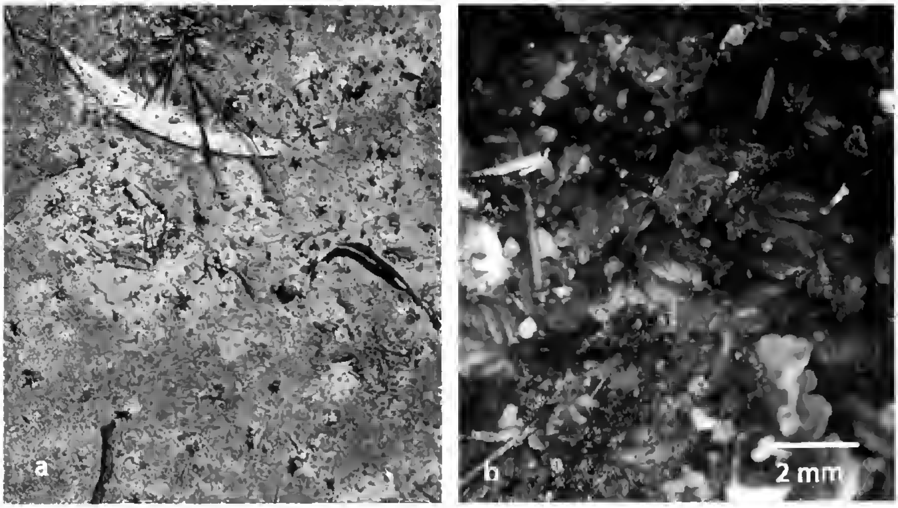

Fig. 5 a. Patch of dry cryptogamic crust, November 2003, **b.** magnified section of soil crust after significant rain, showing growth of ephemeral liverworts *Fossombronia* sp., *Lethocolea pansa* and the moss *Eccremidium* sp., June 2004.

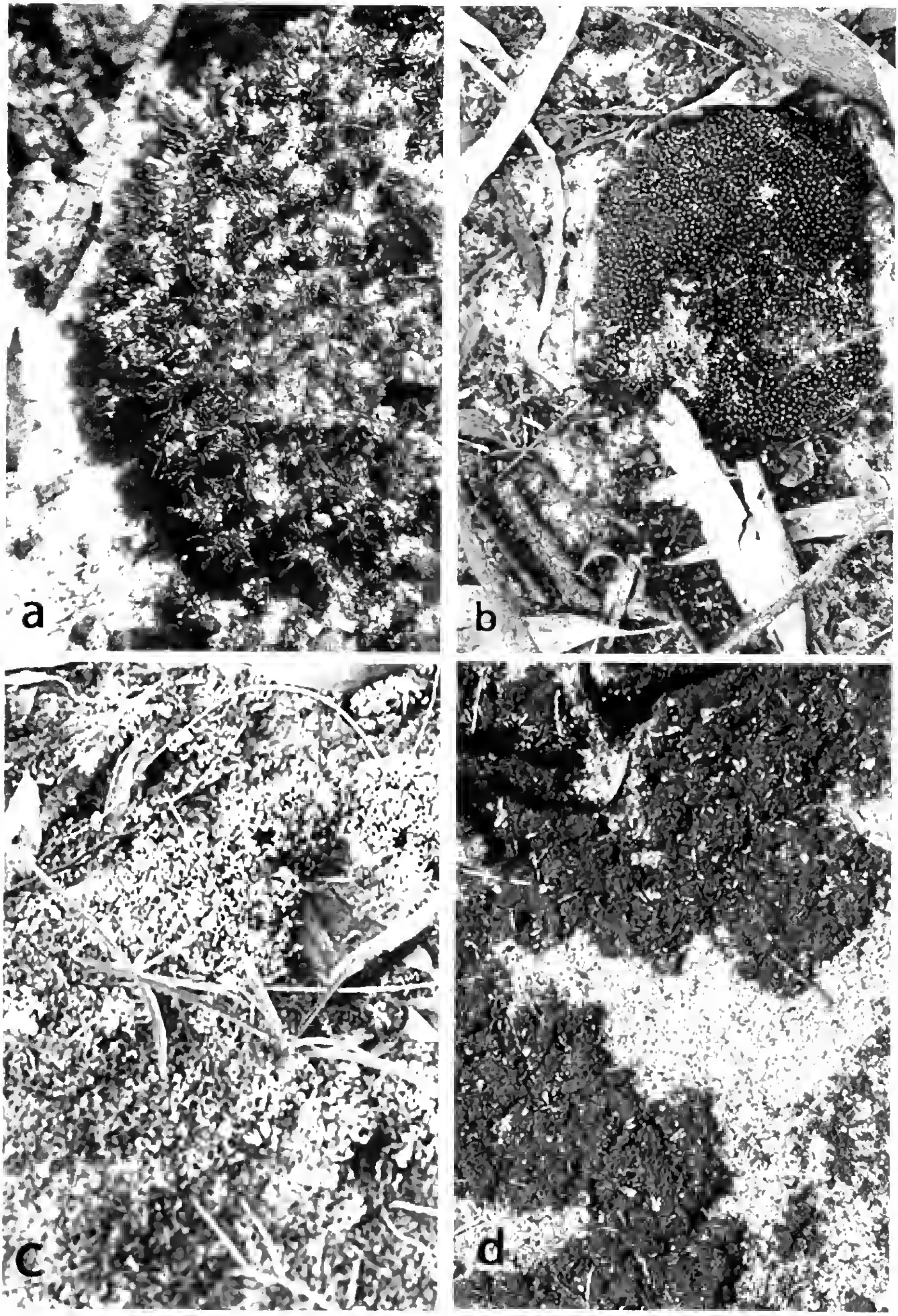

Fig. 4 a. Dry moss cushion, partially inundated with sand, **b.** moss cushion after rain, **c.** mosses between patches of foliose lichen, **d.** algal crust in *Callitris gracilis* woodland.

demonstrated a strategy of desiccation tolerance where plants employed various mechanisms, in this case scales, to facilitate survival of mature plants which rapidly recover after rain. The inrolled thalli (flattened plant body) of these species had protective scales and were visible in some quadrats during the November 2003 sampling. *Gongylanthus scariosus, Lethocolea pansa and Enigmella thallina* all produce spores in capsules that develop under the soil in elaborated stem tissue (marsupia). These marsupia persist in the soil after the parent plant has shrivelled or decayed (Beckmann and Scott 1989; 1992).

Mosses and lichens also took advantage of the availability of moisture (Fig. 4c). Moss cushions of *Rosulabryum camylothecium, Barbula calycina, B. crinita* and *Campylopus introflexus* all showed evidence of new growth. These species possess morphological characteristics (e.g. hyaline (colourless) leaf tips, leaf cell papillae (thickenings on cell wall), twisting and rolling of leaves) (Scott 1982, Eldridge and Tozer 1996) that enable them to tolerate arid and semi-arid environmental conditions. During dry conditions, moss cushions often are partially inundated by sand and brown in colour (Fig. 4a). After significant rain, cushions rehydrate and growth begins (Fig. 4b). Recruitment of new plants was particularly evident in *Eccremidium* sp., which had been recorded in only four quadrats during the November 2003 fieldtrip (Fig. 5b).

The overall abundance and diversity of invertebrates in the soil crusts of the Little Desert was low. This tends to confirm the observation that, as soil crusts are dry and inhospitable for much of the year, there is unlikely to be a suite of invertebrates specifically inhabiting the soil crusts. Rather, invertebrates are making use of the soil crust as a temporary refuge and food resource when the crusts are hydrated and cryptogam coverage is greater. Larvae appear to be from species that lay their eggs and pupate in the soil, and then use the soil crust as habitat. The results from this preliminary study support the conclusions of Whitford (1996) who reviewed studies of soil invertebrates in arid and semi arid regions and noted that total diversity is lower in arid ecosystems.

From these observations it is recommended that future work on the study of soil crusts involve sampling during the wetter months to attain a more accurate picture of the contribution of the various groups that make up soil crusts. However, surveying overall crust cover in the drier months is valuable in determining which species are more tolerant to desiccation and, to observe the dynamic nature of the soil crusts.

Acknowledgements

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A pictorial representation of peristomal architecture

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Abstract

The terminology associated with the use of peristomes in the identification and classification of mosses is cumbersome and difficult to understand. This paper provides a pictorial explanation of peristomal architecture with its associated terminology, such as nematodontous and arthrodontous peristomes, and the division of the latter into diplolepideous and haplolepideous peristomes. (*The Victorian Naturalist* **123** (4), 2006, 203-211)

The moss plant normally seen and recognised is referred to as a gametophyte as it produces the gametes, i.e. egg and sperm. When the sperm fertilizes the egg a sporophyte develops. The sporophyte is ephemeral and essentially remains dependent on its gametophyte parent (Fig. 1), i.e. nutrients are obtained from the gametophyte parent through the basal foot of a stalk-like structure (the seta) that remains embedded within the parental gametophyte tissue. A spore capsule terminates this seta (Fig. 1).

Many mosses have one or more rings of teeth around the mouth of the capsule (Fig. 2). The teeth collectively are referred to as the peristome (Fig. 1) and are protected by an operculum or lid (Fig. 1), which falls off when the spores are mature. However, not all mosses have peristomes.

The outer ring of teeth (exostome) in double peristomes (Fig. 2) may exhibit hygroscopic movement in response to changes in humidity by bending backwards and forwards (Proctor 1984). The movement provides a gentle catapulting action for launching spores a short distance into the air, where they may be caught by a gentle breeze and dispersed to an environment suitable for germination. Subsequent to germination, spores will develop into another gametophyte generation. Hygroscopic movement of the exostome may be particularly relevant in closed forest situations where opportunities for air transport of spores needs to be maximized. The inner ring of teeth (endostome) (Fig. 2) may regulate spore dispersal by gradually sifting the spores.

As spore dispersal mechanisms in mosses, peristomes are specialised, intricate and architecturally elaborate. Adaptive trends of morphological characters have resulted

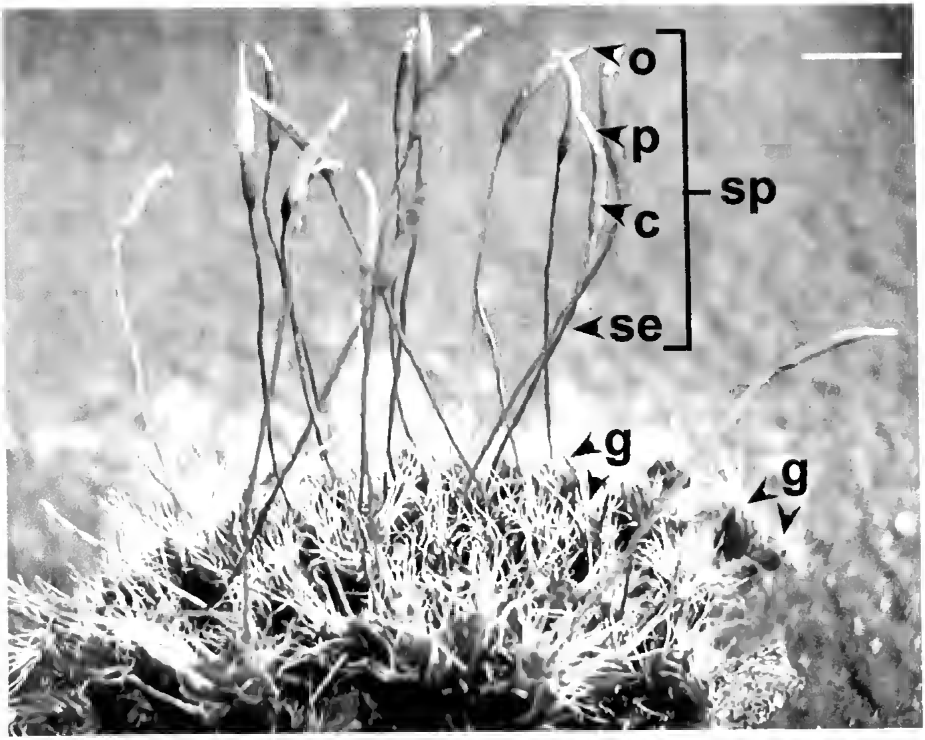

Fig. 1. Colony of *Tortula antarctica* (Hampe) Wilson. Leafy gametophyte (g) with dependent sporophyte (sp) bearing a mature capsule (c) terminating a seta (se). A peristome (p) of long teeth occurs at the mouth of the capsule. This peristome initially is covered by an operculum (o) which is shed when spores become mature. Scale bar is 3.5 mm.

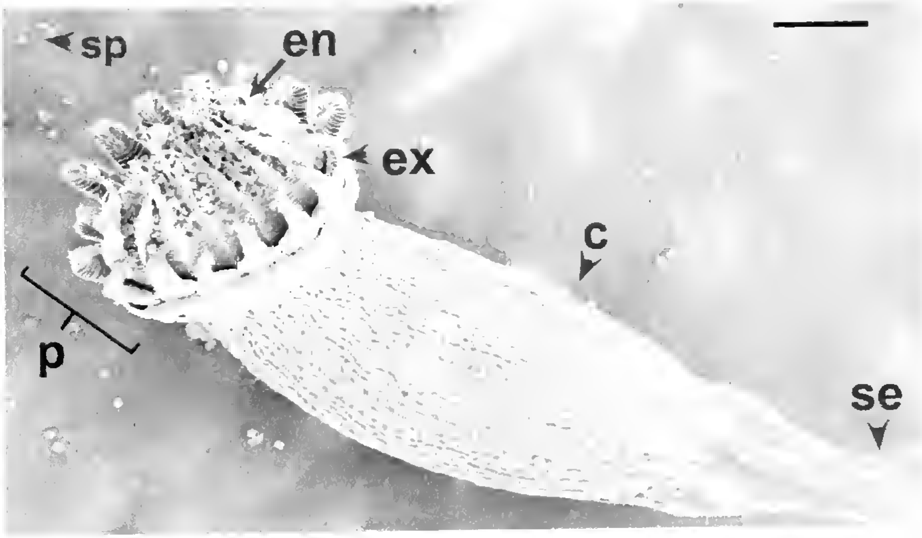

Fig. 2.. Capsule (c) of *Hypnum cupressiforme* Hedw. with peristome (p) showing an outer row of teeth, the exostome (ex), and an inner row of teeth, the endostome (en). Spores (sp). Scale bar is 200 μm.

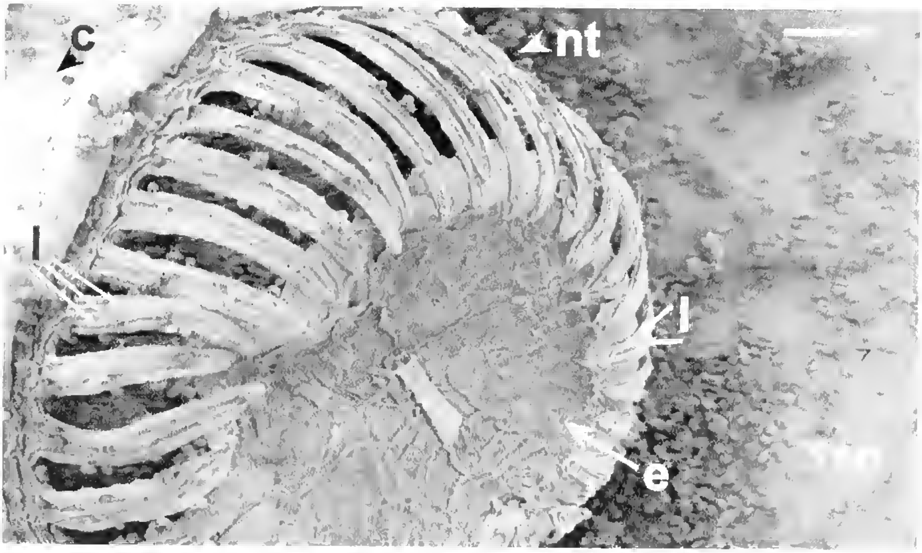

Fig. 3.. Nematodontous teeth (nt) of *Atrichum androgynum* (Müll. Hal.) A. Jaeger. Teeth are made up of layers (l) of whole cells. Tips of teeth attach to the disc-like epiphragm (e). Slight air movement causes release of spores between the teeth. Capsule (c). Spores (sp). Scale bar is 100 μm.

in different peristomal configurations that have been used as important tools in higher level classification of mosses for over 150 years (Vitt 1999). Three peristomal characters are vital to classification. These are cell structure of the teeth, the arrangement of the outer teeth relative to the inner teeth (where present), i.e. whether the outer teeth are alternate or opposite the inner teeth, and the initial cell alignment (Goffinet *et al.* 1999).

In the first instance, peristomes are divided into two types, nematodontous and arthrodontous peristomes. In terms of peristomal architecture, this division is as important as the division between monocotyledons and dicotyledons in flowering plants, although the distinction is at a lower classificatory level for the mosses than for the flowering plants.

Nematodontous peristomes have teeth composed of whole, dead and 'mostly elongate cells in one or more layers' (Crum 2001) with walls thickened uniformly (Shaw *et al.* 1989). However, arrangement of the cells can vary from species to species. Figure 3 details layers of whole cells which occur in nematodontous teeth. In the species depicted, *Atrichum androgynum* (Müll. Hal.) A. Jaeger, the tips of the teeth are attached to a disc-like epiphragm that releases spores with the help of a little air movement. In essence, spores are released via a pepper shaker effect. *Dawsonia superba* Grev. var. *pulchra* (Fig. 4) shows another method of spore dispersal where the nematodontous teeth take the form of multicellular filaments forming a twirled 'brush'. When the spores mature, the 'brush' untwists, allowing gradual release of the spores.

Arthrodontous peristomes have teeth composed of thickened cell wall remnants of squat cells occurring in two or three cell layers (Crum 2001) involving the outer, primary and inner peristome layers, i.e. OPL, PPL and IPL respectively. This means that during development of the teeth, cell wall plates located parallel to the capsule rim (periclinal), become differentially thickened, while much of the cross-wall and radially vertical cell wall material perpendicular to the capsule rim (anticlinal) becomes reabsorbed (Buck and Goffinet 2000). Ninety percent of true mosses are classified as arthrodontous (Crum 2001).

Arthrodontous peristomes are further divided into diplolepideous and haplolepideous peristomes. Diplolepideous peristomes usually have a double layer of teeth,

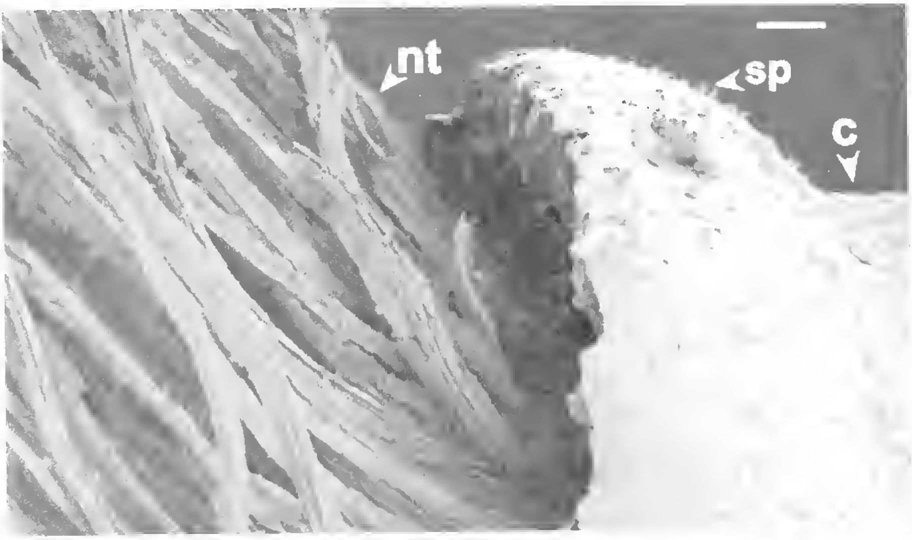

Fig. 4. The brush-like nematodontous teeth (nt) of *Dawsonia superba* Grev. var. *pulchra* Zanten facilitates spore release as it untwists. Capsule (c). Spores (sp). Scale bar is 50 µm.

the exostome forming the outer teeth and the endostome forming the inner teeth. It is the outer row that is of vital importance to classification, principally because the inner row of teeth may be reduced to nothing more than a fragile collar-like basal membrane (Fig. 5). However, more typically the endostome consists of this basal membrane with 16 teeth (also referred to as segments) which are keeled, perforated and alternate with cilia (in groups of one to four) in many species (Fig. 6) (Magombo 2003).

The exostome generally consists of 16 teeth (Shaw and Renzaglia 2004), which

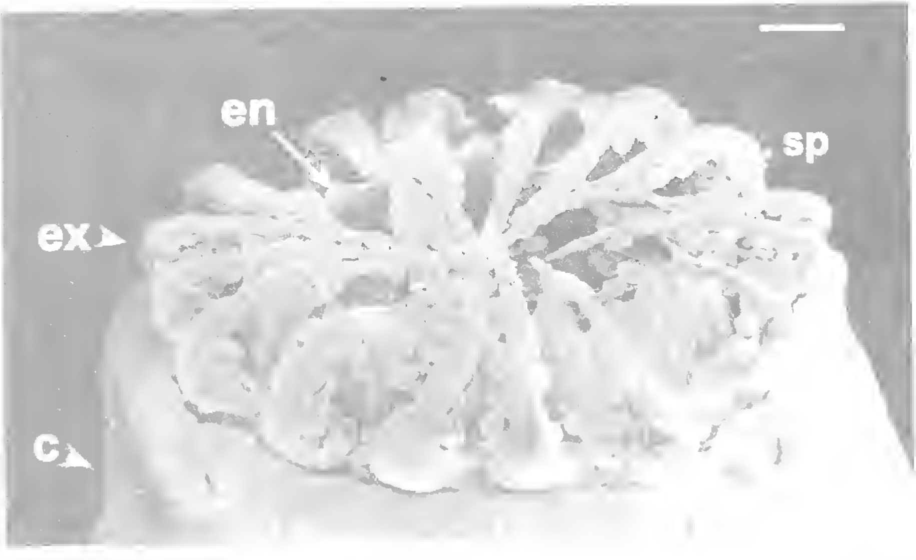

Fig. 5. Diplolepideous peristome of *Glypothecium sciuroides* (Hook.) Hampe showing 16 outer teeth constituting the exostome (ex). The exostome is vitally important to classification as the inner teeth or endostome (en) may be reduced to a collar-like basal membrane, as depicted in this figure. Capsule (c). Spores (sp). Scale bar is 50 µm.

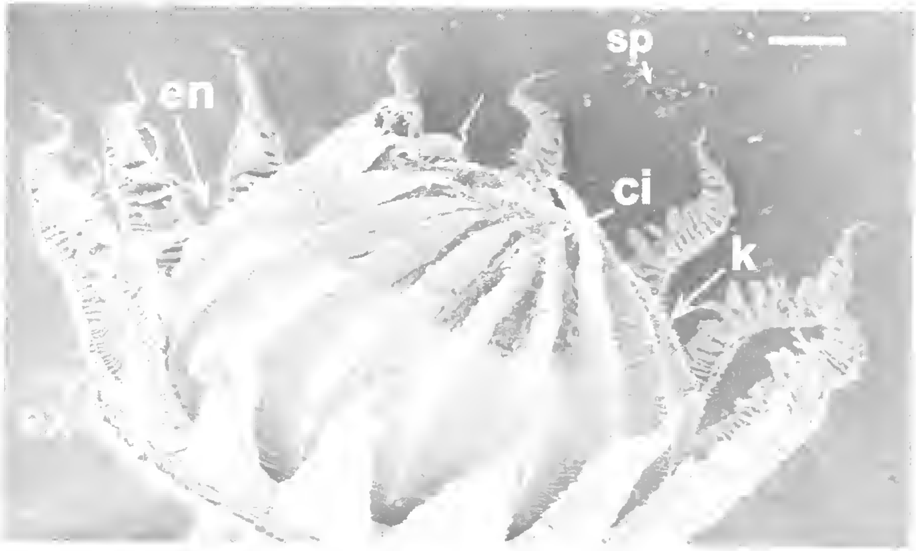

Fig. 6.. Elaborate diplolepideous peristome of *Ptychomnion aciculare* (Brid.) Mitt. showing exostome (ex) of 16 teeth, and endostome (en) of basal membrane with 16 keeled teeth (also known as segments). Perforations occur along the upper section of each keel (k) and two cilia (ci) alternate with each segment. An endostome showing a basal membrane with teeth is more typical of a diplolepideous peristome than the reduction of the endostome to just a collar-like basal membrane. Spores (sp). Scale bar is 100 µm.

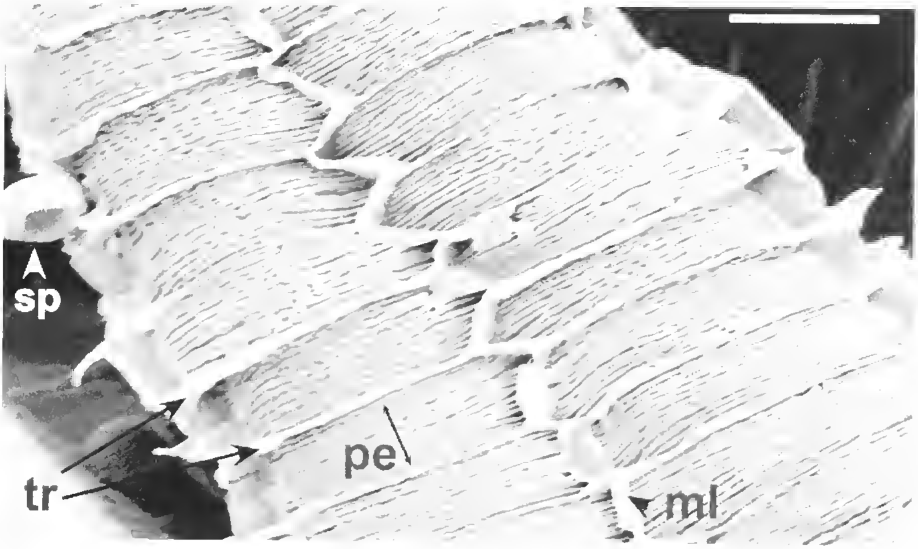

Fig. 7.. Diplolepideous exostome tooth of *Hypnodendron vitiense* Mitt. showing the outer face consisting of two columns of periclinal (parallel to the capsule rim) cell wall plates (pe) of former cells. The trabeculae (tr) derived from cross-walls on the outer face of each exostome tooth and the zig-zag median line (ml) reflect the two columns of cells that form each tooth, i.e. the trabeculae and median line represent anticlinal (perpendicular to the capsule rim) cell wall remnants and border the periclinal cell wall material. The term 'diplolepideous' refers to this twin column formation. Spores (sp). Scale bar is 20 µm.

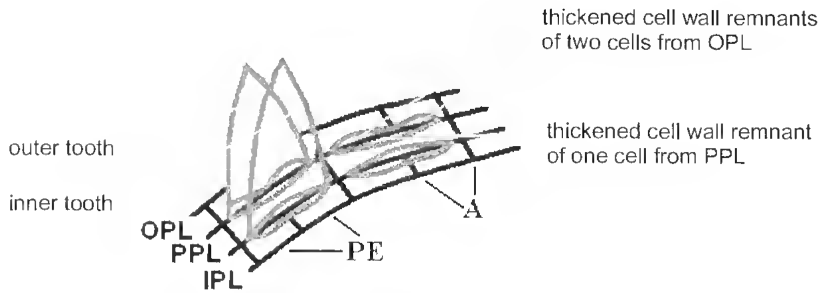

Fig. 8.. Diagram of a diplolepideous peristome (after Buck and Goffinet 2000) showing exostome (outer teeth) and endostome (inner teeth) opposite each other. Much of the anticlinal cell wall material perpendicular to the capsule (A) becomes reabsorbed. Periclinal walls (PE). Outer peristomal layer (OPL). Primary peristomal layer (PPL). Inner peristomal layer (IPL).

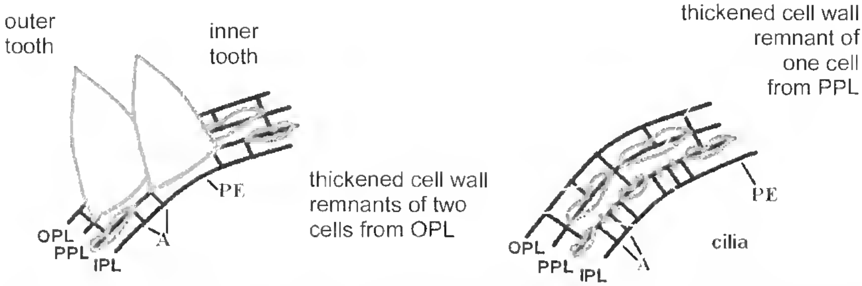

Fig. 9.. Diagram of a diplolepideous peristome (after Buck and Goffinet 2000) showing alternate exostome (outer teeth) and endostome (inner teeth). Much of the anticlinal cell wall material (A) perpendicular to the capsule becomes reabsorbed. Periclinal walls (PE). Outer peristomal layer (OPL). Primary peristomal layer (PPL). Inner peristomal layer (IPL).

have an outer face of two columns and an inner face of a single column (OPL + PPL), each column consisting of a stack of periclinal cell wall plates of former cells. The horizontal lines (trabeculae) derived from cross-walls (Fig. 7) on the outer face of each exostome tooth, and the zig-zag median line, reflect the structure of the two columns of cells occurring side by side (Edwards 1984; Shaw *et al.* 1989). The term diplolepideous refers to this twin column formula (Fig. 7).

Diplolepideous peristomes may be configured with an 'opposite' peristome cell pattern (Fig. 8) or an 'alternate' peristome cell pattern (Fig. 9), i.e. with the exostome and endostome teeth opposite or alternate to each other respectively. Figure 10 shows the exostome teeth opposite endostome teeth while Fig. 11 shows *Hypnum cupressiforme* Hedw., with exostome teeth alternating with endostome teeth. From an evolutionary point of view, the 'opposite' arrangement of the endostome and exostome is considered more primitive (Vitt 1984).

Haplolepideous peristomes have teeth with an outer face of one column consisting of wall remnants of a stack of cells and an inner face of two columns (PPL + IPL) consisting of wall remnants of two stacks of cells. Haplolepideous peristomes usually consist of a single layer of 16 teeth (Shaw and Renzaglia 2004). The term haplolepideous refers to the outer face consisting of wall remnants of the single stack of cells. The horizontal lines (trabeculae) (Fig. 12) correspond to the top and bottom plates. Figure 13 represents the haplolepideous configuration. It is thought that the haplolepideous peristome (Fig. 14) is

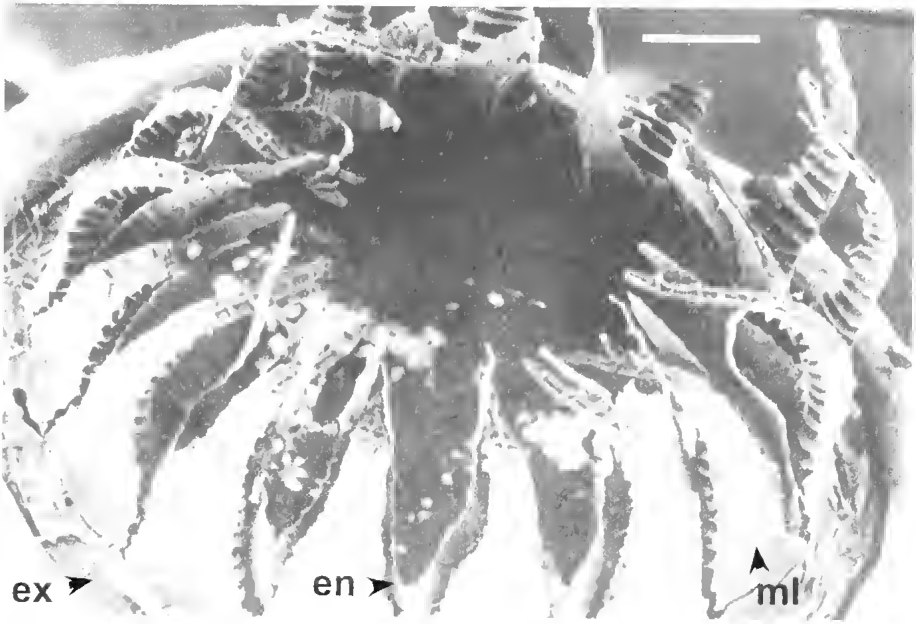

Fig. 10.. Funaria-type diplolepideous peristome showing 'opposite' tooth arrangement. Exostome of outer teeth (ex). Endostome of inner teeth (en). Zig-zag median line (ml). In evolutionary terms, the 'opposite' arrangement of outer and inner teeth is considered more primitive than the alternate tooth arrangement shown in Fig. 11. Scale bar is 40 µm.

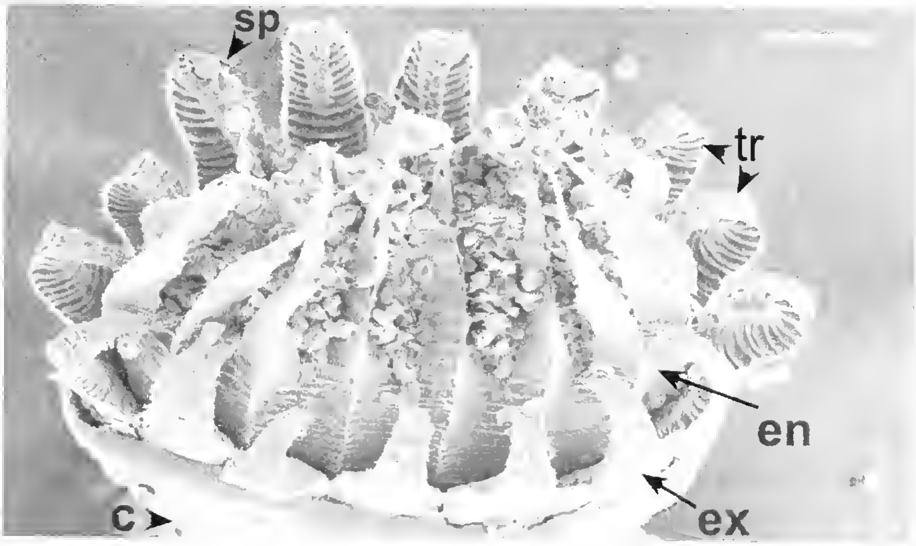

Fig. 11.. Diplolepideous peristome of *Hypnum cupressiforme* Hedw., showing 'alternate' tooth arrangement. Exostome of outer teeth (ex). Endostome of inner teeth (en) with basal membrane and keeled, perforated teeth (segments). Cilia alternate with segments, but are obscured by spore mass. Exostome teeth are trabeculate (tr) on both the outer face and inner face but the inner face is deeply trabeculate. Capsule (c). Spores (sp). Scale bar is 100 µm.

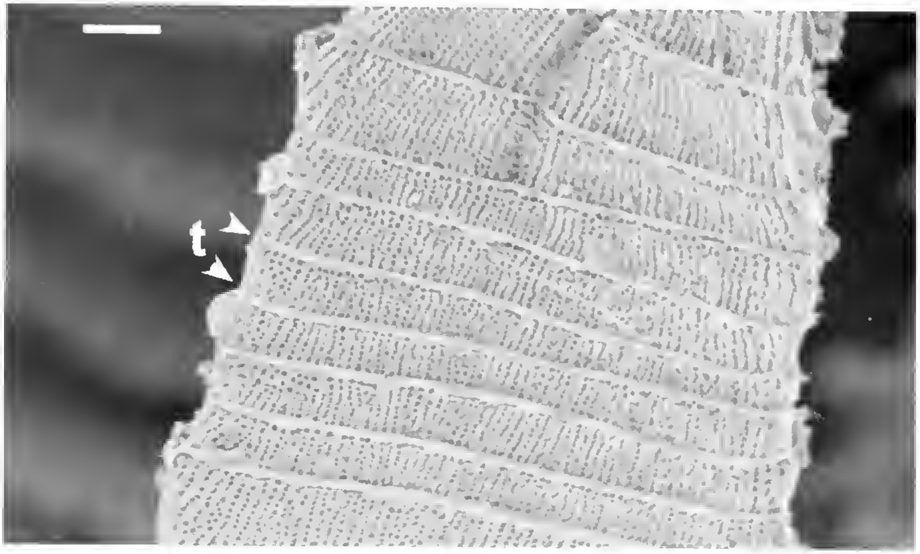

Fig. 12.. Outer face of haplolepideous teeth of *Dicranoloma menziesii* (Taylor) Renauld showing trabeculae (t) reflecting the wall material of a single column or stack of cells that forms each tooth, contrasting with the two columns of diplolepideous teeth shown in Fig. 7. The trabeculae correspond to the top and bottom cell wall plates which are anticlinal, i.e. perpendicular to the capsule rim. The material seen between the trabeculae is the periclinal cell wall remnants, i.e. cell wall remnants parallel to the capsule rim. Scale bar is 10 µm.

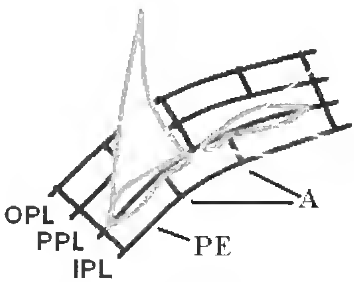

Fig. 13.. Diagram of haplolepideous peristome (after Buck and Goffinet 2000). Much of the anticlinal wall material (A) perpendicular to the capsule becomes reabsorbed. Periclinal walls (PE). Outer peristomal layer (OPL). Primary peristomal layer (PPL). Inner peristomal layer (IPL).

derived from the diplolepideous peristome with opposite endostome and exostome, and is homologous with endostomal segments (Buck and Goffinet 2000; Magombo 2003; Newton and Cox 2000; Shaw and Renzaglia 2004; Vitt 1981).

Peristomal terminology does not end here, but the above detail provides readers with an introduction to this cumbersome language belonging to the intricate, elaborate and beautiful world of peristomal architecture, moss identification and classification. Study of these ancient plants and their reproductive innovations is crucial to understanding the evolution of land plants (Shaw and Renzaglia 2004).

Acknowledgements
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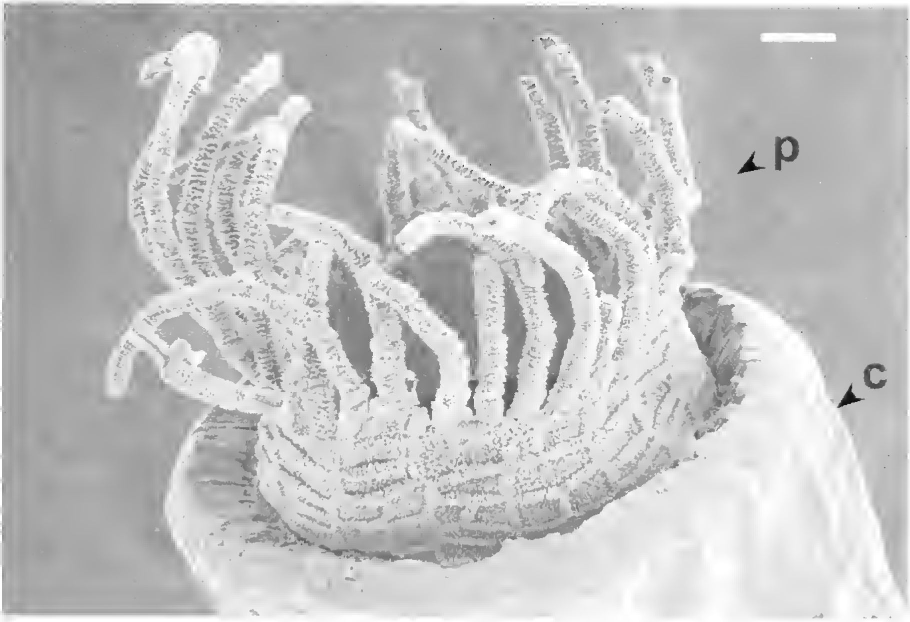

Fig. 14.. *Tortula recurvata* Hook. showing haplolepideous peristome (p) consisting of basal membrane and 32 tubular teeth. Capsule (c). The haplolepideous peristome is believed to be derived from the diplolepideous peristome with opposite exostome and endostome as depicted in Fig. 10, and that it is homologous with endostomal segments. Scale bar is 40 µm.

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Studies on Victorian bryophytes 4. The genus *Fabronia* Raddi

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Abstract

Fabronia australis Hook. is the only species of the moss genus *Fabronia* in Victoria. This species is described, its distribution in Victoria is delineated, and its conservation status is assessed. Victorian records of *F. hampeana* Sond. are rejected. (*The Victorian Naturalist* **123** (4), 2006, 212-215)

Introduction

Fabronia Raddi is the nominate genus of the family Fabroniaceae. Six species of *Fabronia* have been reported from Australia, and another has been reported from New Guinea. *Fabronia australis* Hook. has been reported from all states and territories except the Northern Territory (Streimann and Klazenga 2002), and from New Zealand (Beever *et al.* 1996). *Fabronia hampeana* Sond. has been reported from Western Australia, Victoria and New South Wales (Scott and Stone 1976, Streimann and Klazenga 2002).

Description

Fabronia australis Hook., *Musci Exotica* **2**: 160 (1819)

Plants delicate, usually rather silky, pale to dark green, with short branches arising from a creeping leafy stem anchored to the substratum by rhizoids. **Rhizoids** in fascicles, arising from the primary stem and branches, reddish brown, smooth. **Leaves** narrowly to widely ovate, up to 1.1 x 0.4 mm on the stems, slightly smaller on branches, flat to slightly concave, weakly spreading from the stem and mostly turned to the dorsal side of the stem, apex ciliate with a long terminal cell, margins usually strongly dentate or ciliate but sometimes entire (Fig. 1a and d). **Costa** weak, single, ending at or above mid-leaf. **Cells** in mid to upper leaf thick-walled, ± rhomboid and often slightly sigmoid, becoming rectangular towards the leaf base, extremely variable in size, 30–190 x 8–12 µm but mostly of a similar size in each plant; alar cells quadrate, typically in about four rows but often many more and reaching a long way along the margin and almost to the costa.

Dioecious. **Sporophytes** on specialised branches at base of current year's growth; seta straw-coloured, about 5 mm long and 50–80 µm in diameter. **Capsule** hemispherical to conical, up to about 1.0 mm long; operculum flat, with a small apiculus in the centre; peristome single, fragile, pale yellow to pale brown, strongly recurved when dry, of 16 paired teeth, strongly striate-papillose, the striations oriented in various directions (Fig. 1b). **Spores** brown to greenish brown, 12–20 µm in diameter, warty-papillose. **Perichaetial leaves** (bracts) similar to the vegetative leaves but slightly larger and colourless.

Habitat: on dry, shaded soil in rock crevices and on ledges and cliffs, and on the bark of trees and cycads in sclerophyll forest.

Known distribution: WA, SA, Vic, Tas, NSW, ACT, Qld; also in NZ. In Victoria, occurs in a wide band across the state (Fig. 2), mainly in dry sclerophyll forest.

Selected Victorian specimens: MELU 7402 Whitfield, Mar 1970; MUCV 1960 Billy Goat Bend, Mitchell River, Apr 1973; MUCV 2537 Natural Bridge, Mt Eccles NP, Oct 1974.

Similar taxa

Once the marginal cilia are noted the genus is obvious, and then only the species is in question. In New Zealand, *Catharomnion ciliatum* (Hedw.) Wils. also has ciliate margins, but it is a larger species with rather flattened shoots and grows only on bark, and the leaves usually have a distinct margin of elongate cells (Beever *et al.* 1996). *Ischryodon lepturus*, *Brachythecium albicans* and *Hypnum cupressiforme* var. *mossmanianum* have a similar overall appearance to *Fabronia australis* but lack marginal teeth or cilia. Other taxa that have been mistaken for *F. australis* in Australian collections are *Brachythecium rutabulum* and *Hypnum cupressiforme* var. *cupressiforme*.

Discussion

All specimens of *Fabronia* from Victoria seen in this study are referable to *Fabronia australis*. It is a widespread species but does not seem to tolerate very dry or very wet environments. Most records are from dry sclerophyll forest or dry, rocky grassland or woodland. Under the current IUCN criteria (Hallingbeck *et al.* 2000), *F. australis* must be classified as 'least concern' (LC) in Victoria and Australia, because it occurs in many widespread localities, including numerous conservation reserves. It appears to have declined slightly as a result of urbanisation. For example, its only known present-day locality close to Melbourne is in the more or less undisturbed environment of Warrandyte State Park.

There is a great deal of confusion about other Australian 'species', and a thorough review is needed. Specimens in MEL named *F. baileyana* Müll. Hal. seem to be a form of *F. australis* with a long hair-point. In *F. brachyphylla* Müll. Hal., reported from New South Wales, the ACT and Queensland, the leaf apex is usually acuminate, without a hairpoint or elongated apical cell, and the leaf margins are

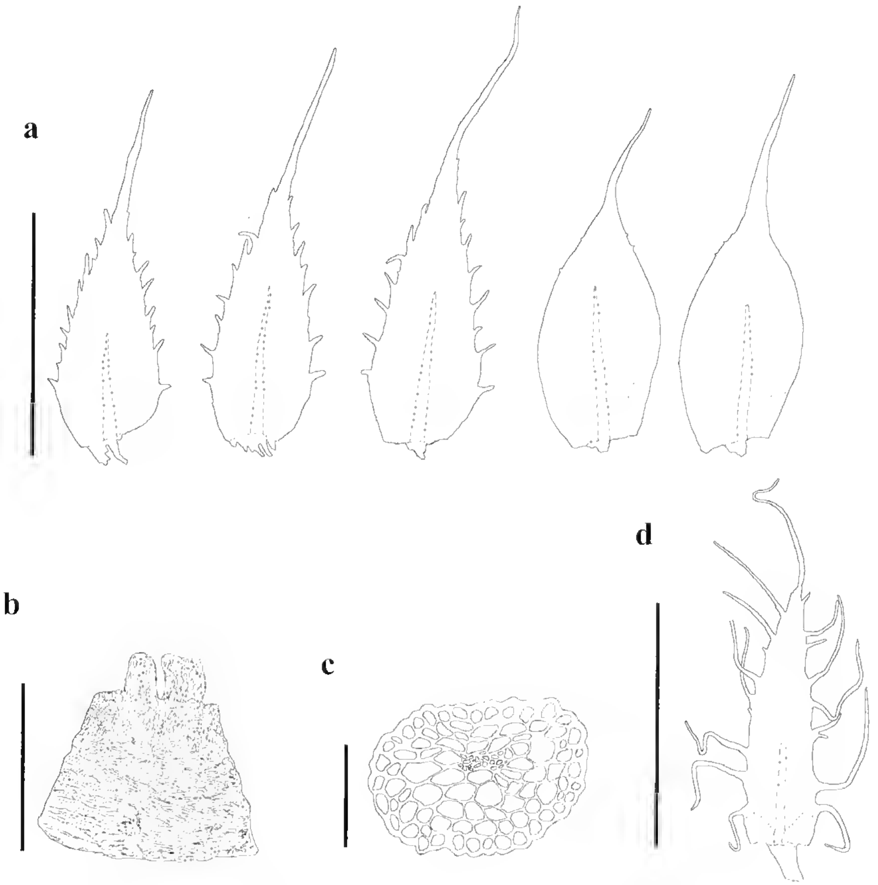

Fig. 1.. *Fabronia australis*. **a.** Leaves: three typical on left, two atypical on right. **b.** Peristome tooth. **c.** Cross-section of stem. *Fabronia hampeana* **d.** Typical leaf. Scale bars: a, d = 0.5 mm, b, c = 0.1 mm. a-c drawn from GAM Scott s.n., Alum Cliffs, near Launceston, Tasmania (MUCV 701), except two entire leaves, drawn from GAM Scott s.n., Millstream Falls, Qld (MELU 1606). d drawn from IG Stone 6296, Esperance, WA (MUCV 1631).

Fig. 2. Known distribution of *Fabronia australis* in Victoria. Open circles indicate records more than 50 years old.

entire or weakly toothed. But whether these characters are enough to separate *F. brachyphylla* from *F. australis* is very doubtful. Specimens in MEL given the names *F. novaevalesiae* Müll. Hal. and *F. obtusoacuminata* Müll. Hal. (both invalid names because they were published without a Latin diagnosis) seem to be identical to *F. brachyphylla*. Scott and Stone (1976) noted that *F. brachyphylla* has broad, obtuse leaves on most shoots, and that *F. scottiae* Müll. Hal. has acuminate leaves (i.e. lacking a ciliate hairpoint). Such a difference hardly seems enough to warrant separation as species, given the great variation seen in leaf form that occurs in *F. australis*. Furthermore, Scott and Stone (1976) suggested that *F. australis* might be a form of *F. ciliaris* (Brid.) Brid., a widespread species of the northern hemisphere.

The entire margins in a small number of specimens of *F. australis* could cause confusion, but when capsules are present the unusual pattern of striations on the peristome teeth is diagnostic. Scott and Stone (1976) described the seta as about 80 µm in diameter and the spores as green and about 12 µm in diameter, but specimens examined in this study have much narrower setae and spores are greenish-brown when mature and up to 20 µm in diameter.

Fabronia hampeana has a very woolly appearance when dry because of the more ciliate and narrower leaves (Fig. 1d), but when moist it looks similar to *F. australis*. Furthermore, some narrow-leaved and very ciliate forms of *F. australis* (e.g. MUCV 1614, from Cambewarra Mountain in NSW) can closely resemble *F. hampeana*. In such cases, sporophytes are the best means of separation. The operculum in *F. hampeana* is rounded-conical and the seta is rather shorter (2 mm) and thicker (up to 100–115 µm). Other differences, such as cell size and strength of the costa, seem weak characters given their variability in *F. australis*. Of the numerous specimens called *F. hampeana* from various regions of Australia in MEL and MELU, only those from Western Australia are that species, so that it seems indeed to be endemic to that state. *F. australis* also occurs in Western Australia, but seems to be rare there.

The only other species recorded in Australasia is *F. curvirostris* Dozy and Molk., an Asian species reported from New Guinea by Norris and Kopönen (1990), who also rejected a record of *F. secunda* Mont. from there. *F. curvirostris* differs from other Australasian species in having papillae on at least some teeth and on the apical cell.

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Melbourne's Marvellous Mosses

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Abstract

The State Botanical Collection in the National Herbarium of Victoria (MEL) includes more than 49,000 mosses. MEL's Australian moss collection has been databased and curated and contains representatives of all Victorian taxa and 76% of Australian taxa. A timeline of MEL's Australian moss collections shows that during the 1940s-80s, the collection has benefited from the activities of three significant collectors – JH Willis, AC Beauglehole and IG Stone. Australia's Virtual Herbarium project provides access to MEL's moss data via the Royal Botanic Gardens website. (*The Victorian Naturalist* **123**, (4), 2006, 215-221)

MEL's moss collection

The National Herbarium of Victoria (MEL) houses the State Botanical Collection which comprises approximately 1.2 million plant specimens including more than 49,000 mosses. There are currently 43,557 Australian moss specimens, with 44% of these from Victoria. There are more than 5,500 moss specimens collected from outside Australia, the majority of which are yet to be accessioned and curated. Numerous collections from New Zealand, the sub-Antarctic Islands, Indonesia and Canada have been curated and databased.

The diversity of the Australian moss collections at MEL may be investigated, as they have been databased. When comparing the taxa known from Australia with the taxa represented at MEL (Table 1), as one might expect MEL has the best representa-

Table 1. Number of Australian moss taxa per state (Streimann and Klazenga 2002) and number represented at MEL.

	# Taxa	MEL coll'ns	% of taxa represented at MEL
WA	209	177	84.6
NT	111	726	4.9
SA	189	140	74.1
QLD	522	444	85.1
NSW	537	399	74.3
LHI	113	80	70.8
ACT	199	93	46.7
Vic	447	447	100.0
Tas	383	255	66.6
MI	85	42	49.4
Australia	1035	798	77.1

tion of Victorian taxa, with all known Victorian taxa found amongst the MEL collection. More than 84% of Queensland and Western Australian taxa are represented at MEL. The taxa of New South Wales are well represented with 74.3%. Only 65.8% of Tasmania taxa are found at MEL and the Australian Capital Territory has the lowest representation of taxa from any of the Australian states or territories at 46.7%. Overall MEL has representatives of 77.1% of all the Australian taxa. In order to enhance and develop a comprehensive Australian moss collection at MEL, further collections from Tasmania and the ACT should be made.

Amongst the 19,000 Victorian moss collections at MEL, the family Pottiaceae is the most numerous, with 13.7% of specimens from this family. The families Bartramiaceae (6.3%), Bryaceae (5.9%) and Ditrichaceae (5.6%) are also prominent amongst the Victorian moss collection at MEL. The following genera are well represented amongst the MEL collection also: *Fissidens* (Fissidentaceae), *Campylopus* (Leucobryaceae), *Tortula* (Pottiaceae), *Bryum* (Bryaceae) and *Dicranoloma* (Ditrichaceae).

Although the National Herbarium of Victoria was founded in 1853, MEL holds moss collections from the early 1800s, with the earliest Australian moss specimen, *Ptychomnion aciculare*, collected in NSW by FW Sieber in 1823 (Fig. 1). This specimen was collected during Sieber's

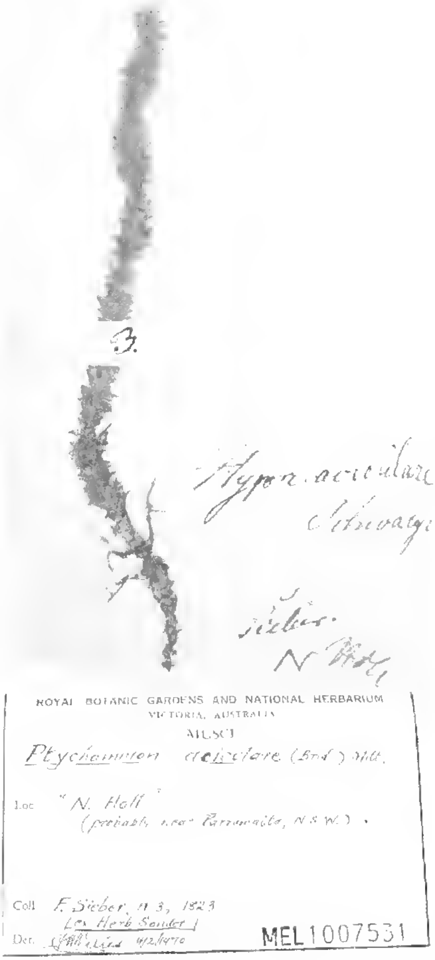

Fig. 1. MEL's earliest Australian moss specimen.

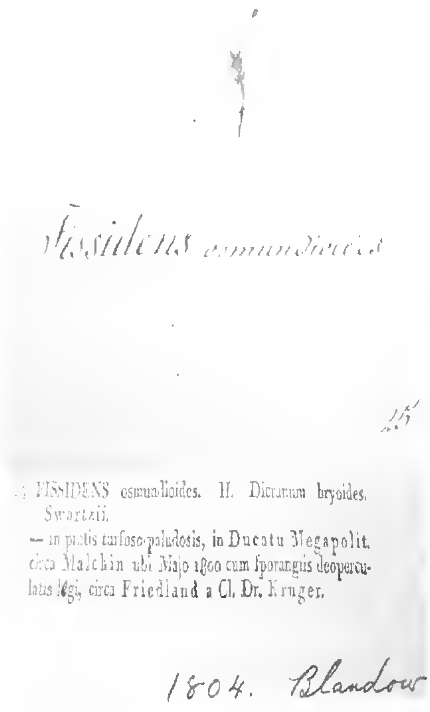

Fig. 2. MEL's earliest foreign moss specimen.

trip to Port Jackson, NSW, between June and December 1823. The earliest known foreign moss specimen, *Fissidens osmundoides*, is from Germany and was collected by Dr Kruger in May 1800 (Fig. 2). This specimen is presumed to be from Blandow's herbarium as it has his name and a date on the original label. The location of Blandow's herbarium is unknown. Otto Blandow (1778-1810) was a German pharmacist, notary and bryologist in Mecklenburg (Stafleu and Mennega 1993).

Some of the earliest moss collections at MEL were made by Baron Ferdinand von Mueller in the 1850s (Fig. 3). Mueller was Victoria's first Government Botanist and founder of the National Herbarium of Victoria. He undertook extensive collecting trips throughout Victoria and NSW, and gradually developed a network of collectors and correspondents (Orchard 1999). Mueller's personal collections and those of his correspondents formed the basis of Australia's 'largest and historically most important herbarium (MEL)' (Orchard 1999).

During the 1880s and 1890s there was a significant increase in the collecting of mosses, as shown from the MEL collection. This was primarily due to the activities of RA Bastow, as well as other early collectors including FM Reader, T Whitelegge, WA Weymouth and D Sullivan. Richard Austin Bastow was an architectural draughtsman by profession and a naturalist in his leisure. Bastow was an avid collector, collecting primarily in Victoria and Tasmania (Fig. 4). He contributed an important collection of cryptogams – including mosses, liverworts, lichens and algae – to MEL. His original notebooks with their tiny detailed drawings, his manuscript of Australian mosses, a folio of illustrations and a reference set of Australian mosses accompanied his personal herbarium, which is held at MEL. Of particular interest is the original copy of Bastow's *Illustrated Key to the Tasmanian Mosses* on wax paper with watercolour drawings, which is held in the RBG library.

Between 1900 and 1940 few mosses were added to MEL's collection (Fig. 3). After Mueller's death in 1896, 'the Herbarium languished in the doldrums and there were few accessions to the collections' (Cohn 2003). From the 1940s through to the 1980s there was a large increase in the number of mosses lodged at MEL. This was due to the activities of three significant collectors – JH Willis, AC Beauglehole and IG Stone (Fig. 5).

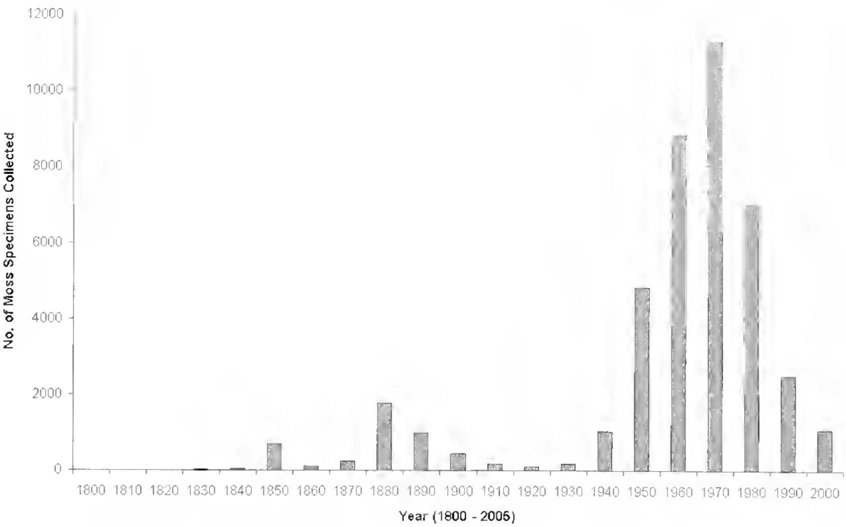

Fig. 3. Australian moss specimens at MEL.

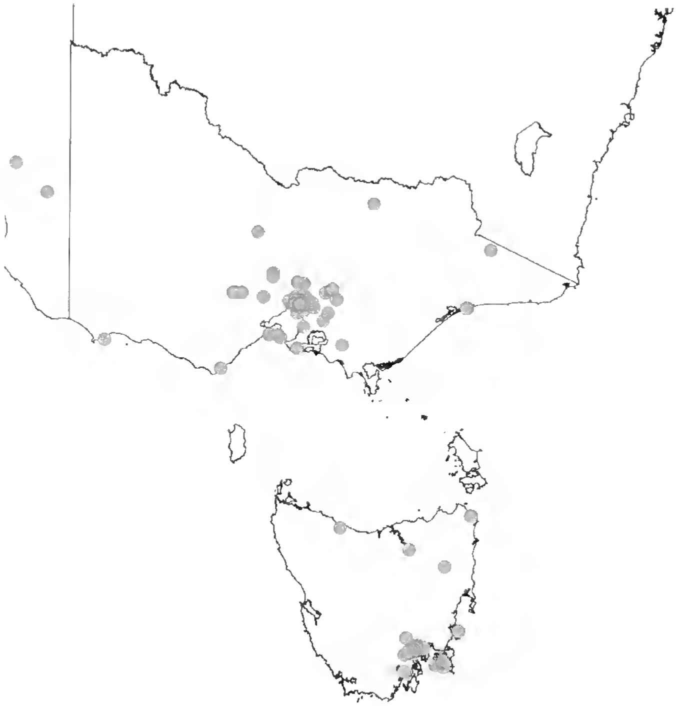

Fig. 4. Distribution map of RA Bastow collections.

James Hamlyn Willis (1910-1995)

Jim Willis was a forestry officer before he joined the National Herbarium of Victoria as a taxonomic botanist in 1937. He worked at MEL for 34 years until his retirement in 1972 (Aston 1996). Willis's botanical collections extend over a long period and over most of Australia (Fig. 6). He researched and published on both vascular and non-vascular plants. His '*A Handbook to Plants in Victoria*' was described by Aston (1996) as a 'milestone for botany in Victoria, as it was largely based on Jim's own meticulously gathered, first hand observations'. In total, Willis published over 880 items including books, scientific and popular papers, pamphlets, essays and reviews (Aston 1996). Jim Willis was described by Aston (1996) as 'a superb all-round naturalist and one of the greatest Australian botanists of the 20th Century'. He contributed a total of 19 151 specimens to MEL, of which 3340 were bryophytes. Willis' moss collections were well prepared, annotated and high quality specimens.

Alexander Clifford Beauglehole (1920-2002)

Cliff Beauglehole was a farmer from Portland who is best remembered for his enormous herbarium (>90 000 specimens), which he collected during plant surveys of the whole of Victoria. There are currently 65 809 specimens of Beauglehole's databased at MEL, including 5859 bryophytes. He collected all over Australia (Fig. 7); his interests were not only in plants, both vascular and cryptogams, but also birds, bees and other insects (Corrick 2002). Corrick described Beauglehole as having 'boundless energy and enthusiasm and his wide knowledge of the environment was exhilarating'. Ilma Stone named the moss *Phascum beauglehole* after him (Corrick

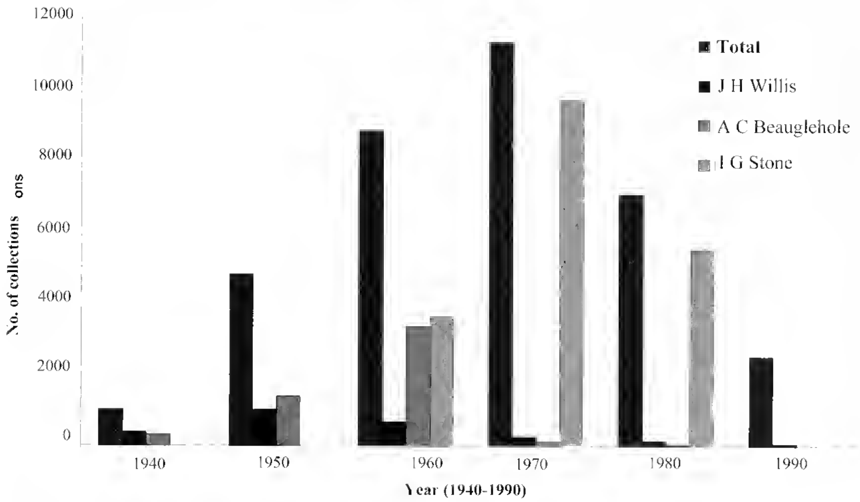

Fig. 5. Significant collectors of Australian mosses at MEL.

2002). Beauglehole's moss collections were made whilst undertaking surveys of the Victorian flora, using his unique grid system. Due to the nature of this work, his collections are not accompanied by detailed notes, but he collected mosses from the whole of the state, often from areas where few other collections have been made.

Ilma Grace Stone (1913-2001)

In an obituary on Ilma Stone, Seppelt *et al.* (2002) comment that 'Australian Bryology came of age in the 1960s-70s through the influence of Ilma Stone, George Scott, David Catcheside and James Willis, and the publication of the Mosses of Southern Australia' (Scott and Stone 1976). It is this publication that best reminds us of Ilma. However, Ilma also published more than 70 bryological papers, the first of which was published when Ilma was 48 (Beever 2001). From 1969 Ilma's research concentrated on mosses (Seppelt *et al.* 2002). Her earlier work focused on ferns. As shown in Figure 8, Ilma was a prolific collector. In fact she contributed the greatest number of moss collections (over 19 000) to MEL between the 1960s and 1980s. Ilma's collections were also extraordinary in that they came from some of the most extreme habitats in Australia. Ilma collected from tropical far north Queensland to the very dry parts of Southern Australia (Fig. 8) (J Milne 2005 pers. comm.). There are five bryophytes named in honour of Ilma Stone: *Stonea oleaginosa*, *Stoneobryum bunyaense*, *Stoneobryum minum*, *Macromitrium stoneae* and *Syrrhopodon stoneae* (Seppelt *et al.* 2002).

Australia's Virtual Herbarium (AVH) – the Future

The AVH project aims to bring together and database Australia's entire collection of scientific plant specimens. It is a collaborative project between all major Australian herbaria, which will make available the records of six million specimens. This information is available via the Internet, and may be accessed via any of the participating herbaria's websites. At this point, each herbarium links to a central database, which consolidates the data available from all of the herbaria MEL's moss data (as well as other cryptogamic and vascular plant data is currently available via the link at: http://www.rbg.vic.gov.au/avh/ (accessed 1 June 2005). These data have many uses: botanists, environmentalists, land managers and members of the public may access the distribution records of species which are based on the records from herbarium specimens over a long period of time. For example, the City of Melbourne made a request recently for moss data for specimens collected prior to the urbanization of Melbourne.

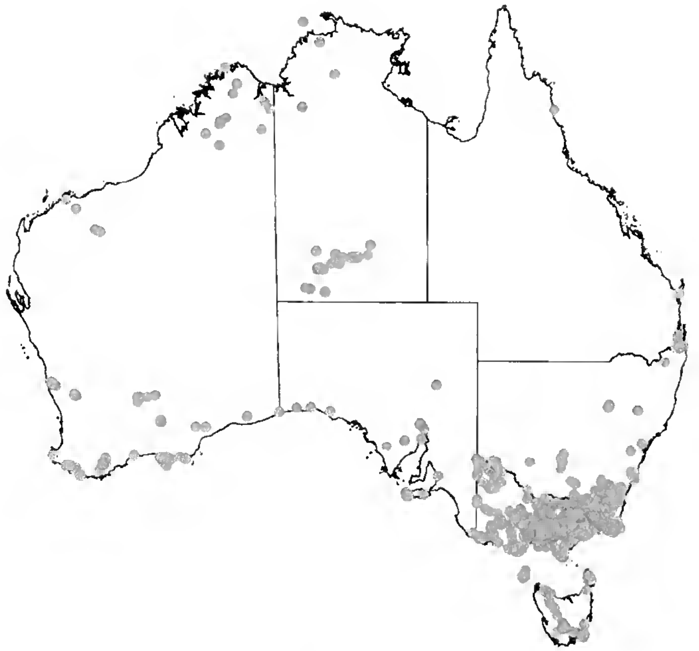

Fig. 6. Distribution map of JH Willis collections.

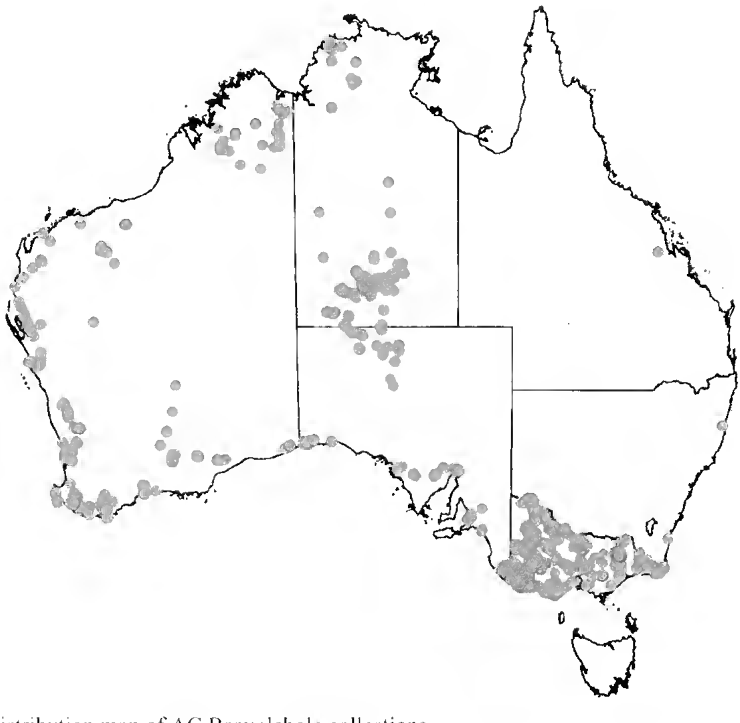

Fig. 7. Distribution map of AC Beauglehole collections.

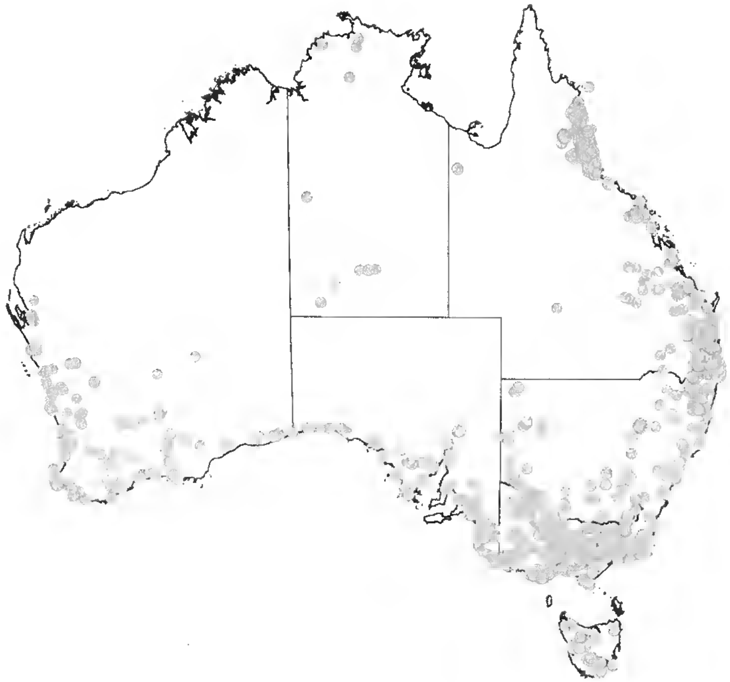

Fig. 8. Distribution map of IG Stone collections.

Acknowledgements

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Epiphytes on *Nothofagus cunninghamii* and *Eucalyptus regnans* in a Victorian cool temperate rainforest

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Abstract

This study investigated the epiphytic communities on Myrtle Beech *Nothofagus cunninghamii* (Hook.) Oerst. and Mountain Ash *Eucalyptus regnans* F.Muell. trees in a pocket of Cool Temperate Rainforest in the Yarra Ranges National Park, Victoria, Australia. Twenty species were identified growing on *N. cunninghamii*, with nine species found on *E. regnans*. The dominant epiphytes were the moss *Dicranoloma menziesii* on *N. cunninghamii*, and the liverwort *Bazzania adnexa* var. *adnexa* on *E. regnans*. (*The Victorian Naturalist* **123** (4), 2006, 222-229)

Introduction

Cool Temperate Rainforests are unique environments that support a diversity of plants and animals. Their distribution in Victoria has become very fragmented due to deforestation, recurrent wildfires and, more recently, Myrtle Wilt has been identified as a disease affecting Myrtle Beech *Nothofagus cunninghamii* (Hook.) Oerst. (Peel 1999). In the Central Highlands Cool Temperate Rainforests, the canopy is dominated by *N. cunninghamii* and interspersed with Mountain Ash *Eucalyptus regnans* F.Muell. and Sassafras *Atherosperma moschatum* Labill. (Peel 1999) There is a notable abundance and diversity of bryophytes and lichens from the forest floor through to the canopy branches. While many of these cryptogams are found in other habitats, they are most abundant in rainforests. Indeed, cryptogams attain their greatest diversity in rainforests, often exceeding more than 35 species (Ashton and McCrae 1970; Dickinson *et al.* 1993; Jarman and Kantvilas 1995a; Louwhoff 1995; Milne and Louwhoff 1999; Franks 2000; Franks and Bergstrom 2000; Ford and Gibson 2000; Morley and Gibson 2004, Dalton 1998 cited in Roberts *et al.* 2005). The trunks of the two dominant tree species, *N. cunninghamii* and *E. regnans*, provide a diversity of microhabitats for epiphytic bryophytes and lichens, thus a complex array of species may coexist (Ashton and McRae 1970; McQuillan 1993). Milne and Louwhoff (1999) recorded 64 epiphytic species (28 bryophytes and 36 lichens) on just one fallen *N. cunninghamii* tree. Epiphytes are not confined just to overstorey species within rainforests. Large tree-ferns *Cyathea cunninghamii* Hook. f., *C. australis* and *Dicksonia antarctica* Labill., major components of the understorey of rainforests, also provide suitable substrata (Ford and Gibson 2000; Roberts *et al.* 2003, Roberts *et al.* 2005). In Tasmania, bryophytes, particularly mosses, comprise most of the species on tree ferns (Roberts *et al.* 2003, Roberts *et al.* 2005). In Victoria, lichens also are common on *Dicksonia antarctica* (Ford and Gibson 2000).

The distribution of epiphytes can be affected by host species, age of host tree, the physical characteristics (texture, porosity, thickness, stability), chemical characteristics (pH) and the nature of the plant substratum as well as many environmental factors including changes in the relative humidity, temperature and light regimes (Gimingham and Birse 1957; Gough 1975; Ashton 1986; Franks and Bergstrom 2000; Ford and Gibson 2000; Morley and Gibson 2004).

The aim of this study, which forms part of a larger investigation examining invertebrate assemblages in epiphytes (Kellar 1999), was to assess the vertical distribution of epiphytes to a height of 1.5 metres on *N. cunninghamii* and *E. regnans* in a Cool Temperate Rainforest, and to compare epiphyte diversity between the two tree species.

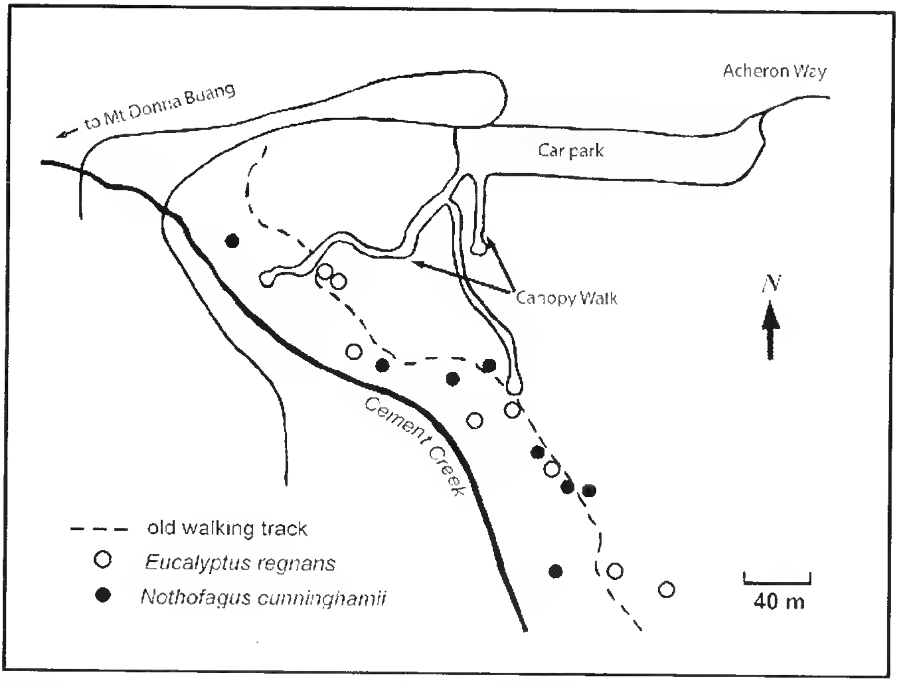

Fig. 1. Location of study site at Cement Creek, Yarra Ranges National Park, Victoria, Australia.

Methods

Study Site

This study was conducted in Cool Temperate Rainforest at Cement Creek in the Yarra Ranges National Park, Victoria (37° 41' S, 145° 42' E) (Fig. 1). The site is situated on the southern slopes of the Great Dividing Range and is 660 m above sea level. Cement Creek rises on the slopes of Mount Donna Buang, flows through the rainforest at the study site and down to the Yarra River. Temperatures range from -0.5 to 26.6 °C and the average annual rainfall is 1300 mm. Snow falls are fairly common at Cement Creek, with an average of six falls per year. The soils are volcanic in origin and contain rock fragments together with silt along the creek. The site is dominated by *N. cunninghamii*, and a number of *E. regnans* and *A. moschatum* are scattered throughout. The understorey consists of the tree-fern species *Dicksonia antarctica* and *Cyathea australis* (R.Br.) Domin, and the ground layer comprises a variety of ferns including *Hypolepis* sp. and *Blechnum wattsii* Tindale.

Data Collection

Two field collections were carried out, one in summer (February 1999) and one in autumn (May 1999). To minimise variability in tree size and age, only living trees of *N. cunninghamii* with a circumference between 2.5 and 3.5 m and *E. regnans* with a circumference between 6 and 8 m were selected for sampling. Eight trees of each species were sampled, as this was the maximum number of trees found in the area that were within the specified size range. Epiphytes were sampled at three heights: 0.5, 1 and 1.5m (Fig. 2). Four samples 5 x 5 cm were collected from each trunk, within a 45° arc either side of due south. The four samples collected at each height were amalgamated and treated as one bulk sample for each height. Epiphyte species in each of the samples were identified and cover abundance estimated. Taxonomic nomenclature follows Streimann and Klazenga (2002) for mosses, and McCarthy (2003) for liverworts.

Data Analysis

Statistical analysis was undertaken using the statistical package SYSTAT version 10 (Wilkinson, 1990) and PRIMER 5 (Clarke

Table 1. Epiphytes present and Mean % Cover abundance on *Nothofagus cunninghamii* and *Eucalyptus regnans* at Cement Creek, Victoria (n = 48 samples for each host tree species).

Taxon		*N. cunninghamii*	*E. regnans*
Liverworts			
Acrobolbaceae	*Marsupidium surculosum* (Nees) Schiffn.	0.08	
Lepidolaenaceae	*Gackstroemia weindorferi* (Herzog) Grolle	0.02	
Lepidoziaceae	*Bazzania adnexa* (Lehm. and Lindenb.) Trevis. *var. adnexa*	7.56	74.22
	Kurzia compacta (Steph.) Grolle		0.45
Metzgeriaceae	*Metzgeria furcata* (L.) Dumort.	0.02	
Plagiochilaceae	*Plagiochila fasciculata* Lindenb.	0.8	
	Thallose liverwort sp. 1	0.007	
Mosses			
Aulacomniaceae	*Lepthotheca gaudichaudii* Schwägr.	0.55	
Dicranaceae	*Dicranoloma menziesii* (Taylor) Renauld	56.15	
	Dicranoloma platycaulon Dixon	1.23	
Hypnaceae	*Hypnum cupressiforme* Hedw.	2.01	
Rhizogoniaceae	*Rhizogonium pennatum* Hook. f and Wilson	2.06	7.71
Sematophyllaceae	*Wijkia extenuata* (Brid.) H.A.Crum	17.52	1.27
Lichens			
Cladiaceae	*Cladia aggregata* (Sw.) Nyl.	1.55	3.23
Deuteromycotina	*Lepraria* sp.	0.12	
Lobariaceae	*Pseudocyphellaria* sp.	0.17	
	Foliose sp. 1	0.24	0.098
Ferns			
Grammitidaceae	*Grammitis billardieri* Willd.	1.34	0.19
Hymenophyllaceae	*Hymenophyllum rarum* R.Br.	1.21	8.02
	Fern sp. 1	0.01	
	Fern sp. 2		0.002
Fungi			
	Fungus sp. 1	0.05	

and Warwick, 1994). Cover abundance and richness were tested using double within-subject repeated measures ANOVAs with tree species as the between factor, and season and height the within factors. An Arcsine transformation was performed on cover abundance of the three dominant species of epiphytes and a log transformation was performed on species richness to improve the normality and heterogeneity of variances.

Non-metric multi-dimensional scaling (NMDS) was applied to the cover abundance of epiphyte species using the software package PRIMER (Plymouth Routines in Multivariate Ecological Research). The procedure was carried out on epiphyte abundance to generate a Bray-Curtis similarity matrix. Separate two-dimensional ordination plots were generated for summer and autumn using replicates for the cover abundance of epiphytes. Two-way analyses of similarities (ANOSIM) were used to test the hypothesis that there were no differences in assemblages between trees and height.

Results

A total of 22 species of epiphytes was found in this study. Mosses and liverworts were the dominant epiphytes on both host trees. Twenty species of epiphytes were recorded on *N. cunninghamii* while only nine species were recorded for *E. regnans* (Table 1). *Nothofagus cunninghamii* had an overall higher cover of epiphytes than *E. regnans*. The dominant epiphytes found on *N. cunninghamii* were the mosses *Dicranoloma menziesii* (56%) and *Wijkia extenuata* (17.5%), and the liverwort *Bazzania adnexa var. adnexa* (7.5%) (Table 1). Other species found occurred in low abundance. In contrast *B. adnexa var. adnexa* (74%), the filmy fern *Hymenophyllum rarum* (8%) and the moss *Rhizogonium pennatum* (7.71%) were the most dominant epiphytes on *E. regnans* (Table 1).

The patterns of distribution shown by the dominant epiphyte species were significantly different between the tree species. The species fall into three distinct

Table 2. Presence of epiphyte species in different trees/height samples. Numbers represent the number of samples in which each species was found (Total samples at each height for each tree species = 16).

Cryptogam	*Nothofagus cunninghamii*			*E. regnans*		
	0.5 m	1 m	1.5 m	0.5 m	1 m	1.5 m
GROUP A						
Dicranoloma menziesii	16	16	15			
Hypnum cupressiforme	5	5	10			
Dicranoloma platycaulon		5	5			
Leptotheca gaudichaudii		5	7			
Plagiochila fasciculata		2	2			
Lepraria sp.		1	1			
Pseudocyphellaria sp.		1	1			
Fungus sp. 1	1	1				
Marsupidium surculosum	1					
Metzgeria furcata			1			
Gaekstroemia weindorferi			1			
Liverwort (thallose) sp. 1		1				
Fern sp. 1	1					
GROUP B						
Rhizogonium pennatum	1	4	5	11	6	8
Hymenophyllum rarum	5	6	7	8	6	8
Bazzania adnexa var. *adnexa*	12	15	15	16	16	16
Lichen (foliose) sp. 1	3	3	4	1	2	3
Cladia aggregata	6	7	6	8	9	10
Grammitis billardieri	5	3	2	3	1	
Wijkia extenuata	15	14	16	3	2	
GROUP C						
Kurzia compacta				1	2	1
Fern sp. 2				1		
Total	12	16	16	9	8	6

Table 3. Results of doubly within-subject repeated measures ANOVA for bryophyte species richness on *Nothofagus cunninghamii* and *Eucalyptus regnans*.

Source of Variation	Species Richness		
	Df	MS	F
Between subjects			
Tree Species	1	0.227	30.971***
Error	14	0.007	
Within Subjects			
Season	1	0.001	0.289
Season x Tree Species	1	0.022	6.668*
Error (Season)	14	0.003	
Height	2	0.002	0.979
Height × Tree species	2	0.016	6.769**
Error (Height)	28	0.002	
Season × Height	2	0.004	0.148
Season × Height × Tree Species	2	0.005	0.126
Error (Season × Height)	28	0.002	

Significance of F-ratios: *P <0.05; **P <0.01; ***P <0.001

Table 4. Results of doubly within-subject repeated measures ANOVA for the mean % cover abundance of the dominant epiphytes species.

Source of Variation	Df	*Bazzania adnexa* var. *adnexa* MS	F	*Dicranoloma menziesii* MS	F	*Wijkia extenuata* MS	F
Between subject							
Tree Species	1	58610.585	119.086***	56611.228	140.302***	9873.760	20.586***
Error	14	492.169		403.496		479.645	
Within Subjects							
Season	1	34.099	0.261	0.085	0.001	178.668	2.799
Season × Tree Species	1	100.618	0.770	0.085	0.001	5.015	0.079
Error (Season)	14	130.735		114.250		63.842	
Height	2	29.804	0.286	303.712	2.339	115.557	0.842
Height × Tree Species	2	11.214	0.108	303.712	2.339	234.691	1.710
Error (Height)	28	104.121		129.853		137.268	
Season × Height	2	113.608	2.079	19.362	0.173	212.491	2.766
Season × Height × Tree Species	2	91.144	1.668	19.362	0.173	303.964	3.957*
Error (Season × Height)	28	54.648		111.897		76.813	

Significance of F-ratios: *P <0.05; **P <0.01; ***P <0.001

assemblages (Table 2). Group A includes all those epiphyte species specific to *N. cunninghamii*. Group C all those specific to *E. regnans* while Group B comprises 'cosmopolitan' species widespread on both *N. cunninghamii* and *E. regnans* (Table 2). On *N. cunninghamii*, total epiphyte species richness increased with height from 12 species at 0.5 m to 16 species at 1.5 m (Table 2), while on *E. regnans* there was a reduction in total species richness from nine species to six at 0.5 m and 1.5 m respectively. This interaction between tree species and height was statistically significant (P <0.01). Although the difference in species richness between the two host tree species was significant (P <0.001), height and season were not the significant factors influencing epiphyte distribution (Table 3).

The mean percentage cover abundance of each of the three dominant epiphytes on the two host tree species was found to differ significantly (P <0.001); however, height from ground and season were not significant influences on the pattern of distribution of these three epiphytes on the two host tree species (Table 4). For both seasons, the NMDS plot (Fig. 2) and the ANOSIM results indicate there were differences in epiphyte community structure between *N. cunninghamii* and *E. regnans* (summer: P = 0.001, global R = 0.938; autumn: P = 0.001, global R = 0.969). There was, however no difference in community structure in relation to height up the trunk (summer: P = 0.486, global R = 0.003; autumn: P = 0.951, global R = 0.049).

Discussion

The epiphyte communities on the two dominant tree species of the forest at Cement Creek were found to be distinct, with *N. cunninghamii* having a different assemblage of cryptogam species as well as a higher epiphyte species richness and cover abundance than *E. regnans*. There was a distinct assemblage of cryptogams on trunks of both host species. Lichens were not present in high abundances as they are-

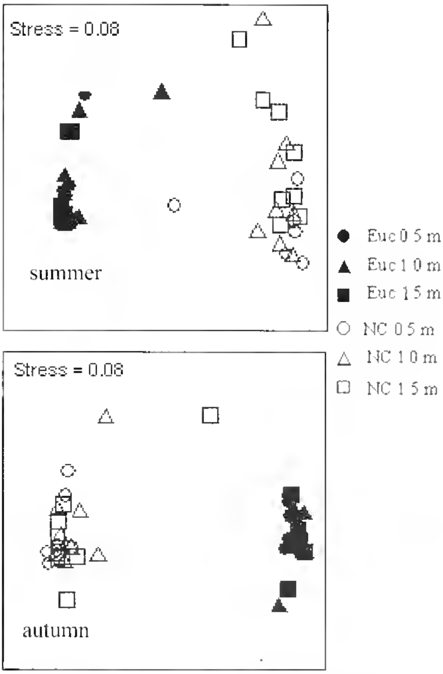

Fig. 2. Non-metric multi-dimensional scaling ordinations for epiphytes present at different heights (0.5, 1, 1.5 m) on *Nothofagus cunninghamii* (NC) and *Eucalyptus regnans* (Euc) in summer and autumn.

less tolerant to the damp andfitered light conditions at the trunk heights sampled in this study, and are more likely to occur higher up the tree where there is greater light (Kantvilas *et al.* 1985; Kantvilas 1988; Louwhoff 1995; Milne and Louwhoff 1999). The moss *D. menziesii* was dominant on *N. cunninghamii* while the liverwort *B. adnexa var. adnexa* was dominant on *E. regnans*. This supports the findings of Ashton and McCrae (1970) and Tyshing (2003) that *D. menziesii* is the dominant species on *N. cunninghamii*, and Ashton's (1986) study in which he found *Bazzania* to be the most dominant on *E. regnans*.

There are many factors that influence the distribution of epiphytes, with the most significant being characteristics of the substratum (Jarman and Kantvilas 1995b; Eldridge and Tozer 1997; Morley and Gibson 2004). The different properties of bark, such as texture, pH, age, ability to fissure, and moisture retention can all affect the distribution of epiphytes. The bark of *N. cunninghamii* is rigid, stable and corrugated, thus creating many different microhabitats for epiphytes to establish (Ashton and McCrae 1970). Within these corrugations there also is an accumulation of humus, which improves the likelihood of spore germination and the establishment of gametophytes. The bark of *E. regnans* is subfibrous in the butt area from 0-3m while the trunk above is smooth, with strips that are shed periodically. The instability of *E. regnans* bark is a factor likely to affect epiphyte species with the outermost layers known to flake off in dry periods and in heavy rain (Ashton 1986). Only the more hardy and faster growing epiphytes therefore would be expected to establish. In contrast, the sub-fibrous acidic nature and high water content of the butt suggests that it is particularly suitable for epiphyte establishment, especially liverworts such as *B. adnexa var. adnexa* (Ashton 1986).

Light intensity and humidity also affect epiphyte distribution. The different growth forms of the two trees influence light penetration and air flow onto their trunks. *Nothofagus cunninghamii* has many lateral branches that occur all along the tree, with many small leaves that are horizontally positioned and hence reduce the sunlight filtering through as well as restricting air movement. *Eucalyptus regnans* is much taller with lateral branching high in the canopy, and leaves positioned vertically, allowing more sunlight and air to pass to the lower trunk and litter beneath. The large number of epiphyte species found only on *N. cunninghamii* possibly were unable to tolerate the higher light and lower air humidity of *E. regnans*.

The increase in diversity of epiphytes with increasing height on *N. cunninghamii* may be due to the reduction of the dominant species *D. menziesii*, which is less tolerant to desiccation (Milne and Louwoff 1999). Jarman and Kantvilas (1995b) suggest that the epiphytes that survive higher up the trunk are those tolerant to desiccation. Franks and Bergstrom (2000) observed that moisture availability influenced the composition of epiphytic bryophytes on *Nothofagus moorei* (F.

Muell.) Krasser, with some bryophytes species being restricted to the basal trunk and other species (e.g. *Wijkia extenuata*) showing no restriction in vertical distribution. The reduced abundance of *D. menziesii* would encourage establishment of more tolerant epiphytes, thus increasing diversity. The decrease in species numbers up the trunk of *E. regnans* would be due to *B. adnexa* var. *adnexa* outcompeting other species and preventing their establishment. Presence of greater species richness at the base of the trunk may also be due to the local topography of the *E. regnans* butt with its many ridges, which would offer different degrees of protection and concentration of trunk water flow.

Interspecific competition is especially prevalent in plant communities (Begon 1996) and may also be a contributing factor determining epiphyte community structures on *E. regnans* and *N. cunninghamii*. *Bazzania adnexa var. adnexa* appears to outcompete and in fact exclude the establishment of other epiphyte species on *E. regnans* (Ashton 1986). This is likely to be due to the growth form of *B. adnexa* var. *adnexa* being a thick, dense mat, which does not allow the spores of other species to establish. While it still grows on *N. cunninghamii* it is possibly limited by suboptimal conditions (such as lower light) preventing it from out-competing other species. No species appears to be excluding other species on *N. cunninghamii*, allowing high species richness to be maintained. *Dicranoloma menziesii*, the dominant species on *N. cunninghamii*, has an open turf growth form, allowing other species (e.g. small liverworts) to grow between the shoots and hence enabling a wide variety of epiphytes to establish.

This study showed that vertical zonation does not occur on either of the two host tree species in the first 1.5 m of the trunk. However, the differences found between epiphyte communities are significant and illustrate the importance of maintaining not only a diversity of host tree species, but also the integrity (i.e. moisture and light regimes) of the rainforest.

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Epiphytic bryophytes of *Dicksonia antarctica* Labill. from selected pockets of Cool Temperate Rainforest, Central Highlands, Victoria

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Abstract

Epiphytic bryophytes of the Soft Tree-fern *Dicksonia antarctica* Labill. were examined in four Cool Temperate Rainforest pockets of the Central Highlands of Victoria. Thirty-two species, 17 mosses and 15 liverworts, were noted. There was no distinction in species assemblage between the north and south side of tree-ferns although bryophytes occurred on the south side of more tree-ferns than they did on the north side. (*The Victorian Naturalist* **123** (4), 2006, 229-235)

Introduction

Victorian Cool Temperate Rainforest is restricted to small pockets and ribbons found in gullies and along ridge tops (Howard and Ashton 1973; Busby 1986). These pockets are dominated by Myrtle Beech *Nothofagus cunninghamii* (Hook.) Oerst. with smaller trees such as Blackwood *Acacia melanoxylon* R.Br. and Southern Sassafras *Atherosperma moschatum* Labill. forming the understorey along with the Soft Tree-fern *Dicksonia antarctica* Labill. and Rough Tree-fern *Cyathea australis* (R.Br.) Domin. (Howard and Ashton 1973; Jarman and Brown 1983). The Soft Tree-fern (Fig. 1) is much more common than the Rough Tree-fern and frequently has a luxuriant cover of bryophytes (Cameron 1992; Jarman *et al.* 1986; Ough and Murphy 1996; Peacock 1994; Roberts *et al.* 2003), but only one published study has documented the bryophytes of tree-ferns. Roberts *et al.* (2003) listed 81 bryophytes on Soft Tree-ferns and fifty-two on Rough Tree-ferns in Tasmania.

This study examined the bryophytes of Soft Tree-ferns in selected Cool Temperate Rainforest pockets in Victoria.

Methods

Four pockets of Cool Temperate Rainforest from the Central Highlands of

Fig. 1. Soft Tree-ferns in Cool Temperate Rainforest are common, and potentially provide much surface area for epiphyte growth.

Victoria were examined between April and September in 1999. Three pockets (Lady Talbot Drive, Bellell Creek and Mount Donna Buang) were located within the Yarra Ranges National Park, while the fourth pocket (Mount Erica) was located in the Baw Baw National Park (Fig. 2). All sites were dominated by *N. cunninghamii*; however, Mountain Ash *Eucalyptus regnans* F Muell. was emergent in some areas. The understorey consisted of *A. melanoxylon*, Hazel Pomaderris *Pomaderris aspera* Sieb. ex DC, *A. moschatum* (Mt. Donna Buang only), *D. antarctica* and *C. australis*. The sparse ground cover was a combination of Hard Water-fern *Blechnum wattsii* Tindale and Mother Shield-fern *Polystichum proliferum* (R.Br.) Presl.

At each site, three transects were placed from the roadside edge of each pocket running the complete length of the pockets. Transects were not of equivalent length as pockets of Cool Temperate Rainforest in Victoria are small and of uneven shape. Quadrats of 10 m by 5 m were sampled at 15 m intervals along each transect. All Soft Tree-ferns that were 40 cm or more in circumference were sampled in each quadrat.

Quadrats of 20 cm by 20 cm were placed every 50 cm along transects running up the northern and southern aspect of each tree-fern up to a height of 2 m, this being the limit of accessibility. The old maxim that moss grows only on the south side of trees suggests that different species may occur on the two sides, albeit less on the north side, so both aspects were examined to ensure collection of as many species as possible. Percentage cover of each bryophyte was determined in each quadrat. All bryophytes were identified to species level. Mosses were identified using Scott and Stone (1976) and Beever *et al.* (1992), while liverworts were identified using Scott (1985). Revised taxonomic nomenclature followed that of Streimann and Klazenga (2002) for mosses and McCarthy (2003) for liverworts. Samples of each species are held by the Plant Ecological Research Unit at Deakin University, Burwood.

Non Metric Multidimensional Scaling (NMDS) was applied to the frequency data to determine species assemblage patterns at the various sites, with aspect and with height

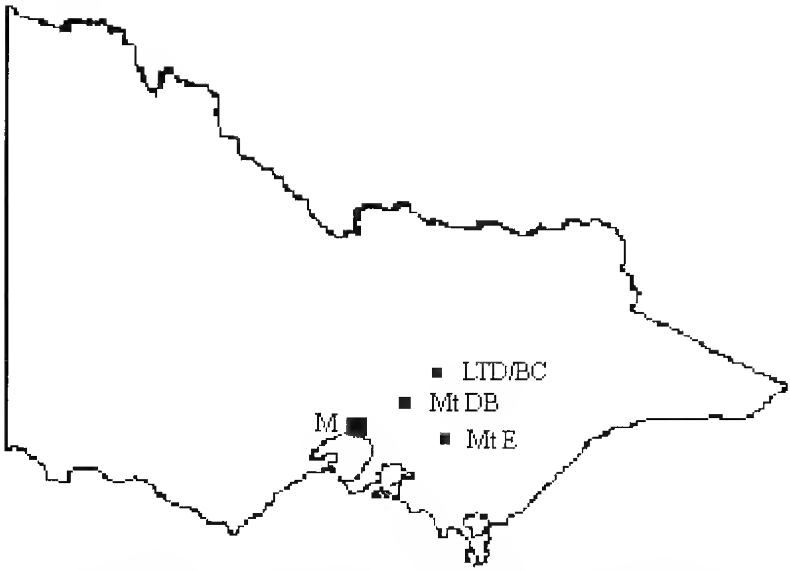

Fig. 2. Map showing general location of surveyed areas, relative to Melbourne (M). Lady Talbot Drive (LTD), Mount Donna Buang (Mt DB), Mount Erica (Mt E) and Bellell Creek (BC)

on the host. The software package PRIMER (Plymouth Routines in Multivariate Ecological Research) was used. This was based on a Bray-curtis similarity matrix.

Results

One hundred and seven Soft Tree-ferns were sampled, of which 83 had epiphytic bryophytes (Table 1). A total of 32 bryophyte species were recorded from the trunks of the tree-ferns (Table 1), of which seventeen were mosses, while 15 were liverworts (Table 2). Twenty-one species occurred at Mount Donna Buang, 20 at Lady Talbot Drive, 11 at Bellell Creek and nine at Mount Erica. No species occurred at all four sites although 10 species occurred at each of three sites. Thirteen species occurred at only one site: seven at Mount Donna Buang, three, two and one species at Lady Talbot Drive, Bellell Creek and Mount Erica respectively. Lady Talbot Drive and Mount Donna Buang had 29 of the total 32 bryophyte species between them but had only 12 species in common. NMDS showed they had two quite distinct assemblages of bryophytes (Fig. 3).

Bryophytes were found in only 214 of the total 982 quadrats examined on the trunks of the tree-ferns. Most abundant were the liverworts *Metzgeria furcata* (L) Dumort. and *Heteroscyphus fissistipus* (Hook.f. & Taylor) Schiffn. occurring in 46 and 39 quadrats respectively (Fig. 3). The most common moss was *Cyathophorum bulbosum* (Hedw.) Müll.Hal. which was found 33 times (Fig. 4). Only 10 species occurred 10 or more times. Fifteen species occurred less than five times.

Table 1. Distribution of bryophytes epiphytic on Soft Tree-ferns of the Central Highlands (LTB - Lady Talbot Drive, MDB – Mt Donna Buang, ME – Mt Erica, BC – Bellel Creek).

	LTB	MDB	ME	BC	Total
number of tree-ferns examined	65	24	7	11	107
number of tree-ferns with bryophytes	47	20	6	10	83
number of tree-ferns with bryophytes on south side	38	16	6	8	68
number of tree-ferns with bryophytes on north side	25	13	1	4	43
number of bryophyte species	20	21	9	11	32
number of bryophyte species on south side	16	18	7	9	28
number of bryophyte species on north side	14	13	4	6	24

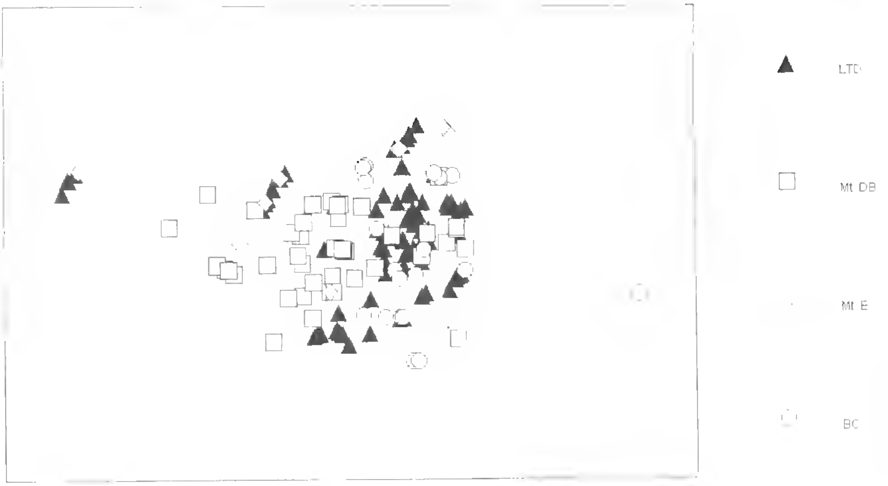

Fig. 3. NMDS showing distribution of epiphytic bryophytes. Lady Talbot Drive (LTD), Mount Donna Buang (Mt DB), Mount Erica (Mt E) and Bellell Creek (BC). Stress = 0.05

Bryophytes occurred on the south side of 68 tree-ferns but on the north side of only 43 tree-ferns. This pattern occurred at each site. At Lady Talbot Drive, 38 tree-ferns had bryophytes on the south side while only 25 tree-ferns had bryophytes on the north side, i.e. 80% compared to 53% of the total tree-ferns (with bryophytic epiphytes) respectively. Indeed, at each site, bryophytes occurred on the south side of 80% or more of the tree ferns with bryophytic epiphytes (Table 1). NMDS, however, showed no distinction between the two aspects.

Overall, there were slightly more species on the south side than north side of tree-ferns, i.e. 28 compared to 24 species respectively (Tables 1 and 2). This pattern was reflected at each site (Table 1). Seven species occurred only on the south side (*Thamnobryum pumilum*, *Catagonium nitens*, *Fissidens curvatus* var. *curvatus*, *Trachyloma planifolium*, *Distichophyllum crispulum*, *Kurzia hippurioides* and *Chiloscyphus semiteres* var. *semiteres*) while three species occurred only on the north side (*Plagiochila fasciculata*, *Tylimanthus tenellus* and *Dicranoloma billarderi*) (Table 2).

No distinction occurred between species distribution and their height on the trunk of tree-ferns.

Discussion

The much lower number of bryophytes found on Soft Tree-ferns in this study compared to the Tasmanian study (Roberts *et al.* 2003) is to be expected. Ten sites were examined in Tasmania while only four were investigated in this study. Also, Cool Temperate Rainforest in Tasmania is far more extensive, 563 000 hectares (Hickey *et al.* 1993), than in Victoria, 13 270 hectares (Adam 1992). Also, Victorian forests occur in small pockets or ribbons and thus are more prone to drying and fire than Tasmanian forests.

Old fronds of tree-ferns remain attached and form a skirt around the upper portion of trunks. This prevents light from penetrating this region of the trunk and protects this area of trunk from rain, forming a darker and drier region that would inhibit the colonisation of epiphytes. Short tree ferns, therefore, would have few if any bryophtes. Page and Brownsey (1986), Ough and Murphy (1996) and Ford and Gibson (2000) all reported few epiphytes on tree-ferns less than 2 m in height. This study included all tree-ferns of 40 cm or more in circumference but some were shorter than 2 m in height, contributing to some of the difference in bryophyte numbers of this study compared to the study of Roberts *et al.* (2003), where only tree-ferns

Table 2. Bryophytes of Soft Tree-ferns in Cool Temperate Rainforests of the Central Highlands. + indicates presence. Lady Talbot Drive (LTD), Bellell Creek (BC), Mount Donna Buang (MDB) and Mount Erica (ME).

Species	LTD	MDB	BC	MTE	N	S
Acrophyllum dentatum (Hook.f. & Wilson) Vitt & Crosby	+	+	+		+	+
Chiloscyphus muricatus (Lehm.) J.J.Engel & R.M.Schust.	+	+		+	+	+
Cyanolophocolea echinella (Lindenb. & Gottsche) R.M.Schust.	+	+			+	+
Cyathophorum bulbosum	+	+	+		+	+
Dicranoloma billarderi (Brid. ex Anon) Paris		+			+	+
Heteroscyphus coalitus (Hook.) Schiffn.	+				+	+
Heteroscyphus fissistipus (Hook.f. & Taylor) Schiffn.	+	+			+	+
Lepidozia ulothrix (Schwaegr.) Lindenb.	+	+	+		+	+
Leptophyllopsis laxus (Mitt.) R.M.Schust.	+					+
Leptostomum inclinans R.Br.	+			+	+	+
Leptotheca gaudichaudii Schwägr.	+	+	+		+	+
Metzgeria conjugata Lindb.	+	+			+	+
Metzgeria furcata (L.) Dumort.	+	+	+		+	+
Paracromastigum longiscyphum (Taylor) R.M.Schust. & J.J.Engel	+	+		+	+	+
Plagiothecium lamprostachys (Hampe) A.Jaeger	+		+		+	+
Rhaphidorrhynchium amoenum (Hedw.) M.Fleisch	+		+	+	+	+
Rhynchostegium tenuifolium (Hedw.) Reichardtvar. *tenuifolium*	+		+		+	+
Thamnobryum pumilum	+	+		+		+
Thuidiopsis sparsa (Hook.f. & Wilson) Broth.	+				+	+
Wijkia extenuata (Brid.) H.A.Crum	+	+		+	+	+
Catagonium nitens (Brid.) Cardot subsp. Nitens		+	+			+
Fissidens curvatus Hornsch var. *curvatus*			+			+
Trachyloma planifolium (Hedw.) Brid.			+			+
Bazzania involuta (Mont.) Trevis.		+			+	+
Dicranoloma dicarpum (Nees) Paris		+			+	+
Dicranoloma menziesii (Taylor) Renauld		+			+	+
Distichophyllum crispulum (Hook.f. & Wilson) Mitt.		+				+
Kurzia hippurioides (Hook.f. & Taylor) Grolle		+				+
Lepidozia laevifolia var. *laevifolia* (Hook.f. & Taylor) Taylor ex Gottsche, Lindenb. & Nees		+		+	+	+
Plagiochila fasciculata Lindenb.		+			+	
Tylimanthus tenellus (Hook.f. & Taylor) Mitt.		+			+	
Chiloscyphus semiteres var. *semiteres* (Lehm. & Lindenb.) Lehm. & Lindenb.				+		+

over 2 m in height were examined. It also explains why so few quadrats on the tree-fern trunks had bryophytes.

Roberts *et al.* (2003) concluded that Soft Tree-ferns were an important host for bryophytes in Tasmania. They found that the number of bryophyte species on tree-ferns were much higher than the number on *N. cunninghamii* found in similar forests, i.e. 81 compared to 55. In Victorian Cool Temperate Rainforest, Floyed (1999) found 46 bryophyte species on *N. cunninghamii*,

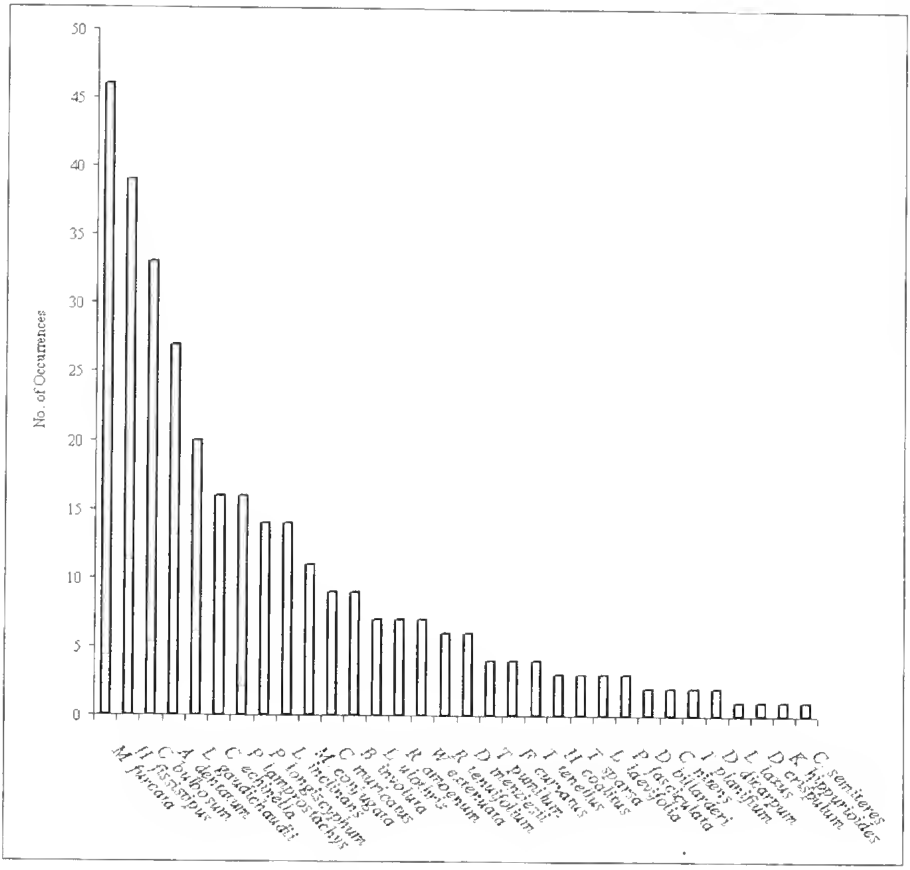

Fig. 4. The number of occurrences (quadrats) of bryophytes on Soft Tree-ferns of the Central Highlands.

43 on fallen logs, 33 on rock, 27 on *A. melanoxylon*, 25 on soil, 16 on *E. regnans*, eight on *A. moschatum* and only six on *Pomaderris aspera* Sieb. ex DC. Thus, Soft Tree-ferns in Victorian Cool Temperate Rainforest also are an important substratum type for bryophytes and their diversity, supporting 32 bryophyte species, but not as important as some other substrata. Also, the number of bryophyte species supported by a particular substratum can vary from place to place. In Victorian Cool Temperate Rainforest *N. cunninghamii* supports more bryophytes than Soft Tree-ferns, whereas the converse occurs in Tasmania.

A number of papers have shown that there are distinct differences in epiphyte species composition between aspects (Pike *et al.* 1975; Kantvilas and Minchin, 1989; Peck *et al.* 1995). Kantvilas and Minchin (1989) suggested differences in composition were caused by trunks leaning towards canopy gaps, resulting in the formation of a dry and wet side. They studied lichens but their findings are pertinent in that bryophytes tend to grow in more moist conditions than lichens, so it would be expected that more bryophytes would occur on the wet side regardless of whether it was the north or south aspect. This study did not examine moisture levels of the two aspects but shows that while there are more tree-ferns with bryophytes on the south side than on the north side, there is no distinction in species assemblage between the two aspects. Similarly, Franks and Bergstrom (2000) looked at the effects of aspect on bryophytes growing on Antarctic Beech *Nothofagus moorei* (F Muell.) Krasser in south-east Queensland. They noted that although there were slightly fewer species of both mosses and liverworts on the southern aspect compared to the northern aspect of trees, there was no statistical difference.

Generally, Soft Tree-ferns make comparatively good hosts for bryophytes; however, their importance as a substratum can vary from place to place. In Tasmania, Soft Tree-ferns support more bryophytes than *N. cunninghamii* but this is not so in Victoria. This study also found quite a variation in the number of bryophytes supported by Soft Tree-ferns from place to place. This has important implications for conservation of bryophytes and the concept of vascular plants being useful as surrogates to determine which areas should be conserved to maintain bryophyte diversity. One host cannot be considered more important than another as the number of species supported by it can vary from place to place. Therefore the use of surrogacy must be used with caution when determining whether one area may be more important than another and so have conservation priority. In order to determine an area's importance for bryophyte conservation it is important to ascertain which bryophytes live there.

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Studies on Victorian bryophytes 5. Key to leafy liverworts

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Abstract
A new key to the genera and many species of leafy liverworts in Victoria is provided. (*The Victorian Naturalist* **123** (4), 2006, 236-247)

Introduction

In the mid 1970s George Scott produced the first key to Victorian liverworts, mainly for botany students at Monash University (Scott 1975). He later expanded this key for his *magnum opus* on southern Australian liverworts (Scott 1985), providing botanists for the first time with an authoritative key for identifying our hepatic flora.

In the time since that publication, many additions, deletions and renamings of species have occurred. This new key is based on Dr Scott's original keys, but includes new genera and new names for existing genera. Allowance is also made for common errors, especially with characters that may be variable or difficult to distinguish. Thallose liverworts with a leafy form are included in the key for completeness.

Although this is mainly a key to genera, many couplets lead to a single species, and Group B is keyed to species throughout. Full keys to species in various genera will be published progressively in later papers in this *Studies* series. In the meantime, the treatments of genera in Scott (1985) are still more than adequate.

In using this key, keep in mind that our knowledge of the Victorian bryophyte flora is still very incomplete, and species and genera presently known only from Tasmania, New Zealand or other parts of the world might still be found here. The key is also valid for South Australia and southern Western Australia and for most genera encountered in Tasmania and New South Wales.

Of the taxa in this key, only *Andrewsianthus cuspidatus* and *Triandrophyllum subtrifidum* are not described or illustrated in Scott (1985) or Meagher and Fuhrer (2003). Both are well illustrated in Schuster (2002).

Names of taxa follow the current national checklist (McCarthy 2006).

A basic glossary of terms used in this key, and in the key to thallose liverworts and hornworts (*Studies* 6) that follows, is included at the end of this paper. For a complete and beautifully illustrated glossary of bryological terms, see Malcolm and Malcolm (2000).

Key to groups

1 Leaves complicate-bilobed: folded, keeled, or with an inflated ventral sac .. **Group A**
Leaves not complicate-bilobed 2

2 Leaves densely hairy or ciliate, the leaf lamina hard to distinguish .... **Group B**
Leaves ciliate or not, but lamina always easily distinguished 3

3 Underleaves absent or not visible.......... **Group C**
Underleaves present 4

4 Leaves inserted incubously on stem; i.e. when viewed from the dorsal side, each leaf overlaps one closer to the shoot apex (or would do so if they were close enough) .... **Group D**
Leaves inserted succubously, i.e. when viewed from the dorsal side, each leaf overlaps one farther from the shoot apex (or would do so if they were close enough); or inserted transversely 5

5 Leaves without lobes or marginal teeth .... **Group E**
Leaves with 2 or more lobes, or with marginal teeth .... **Group F**

Group A
Leafy liverworts with complicate-bilobed leaves

1 Leaves with a keel running longitudinally along the leaf; lobules absent 2
Leaves not keeled; lobules present 3

2 Underleaves present ..... ***Schistochila lehmanniana***
Underleaves absent ..... ***Paraschistochila tuloides***

3 Lobule dorsal 4
Lobule ventral 6

4 Plants thick, fleshy, brittle, bright green ..... ***Treubia tasmanica***
Plants delicate, not at all fleshy, dull green to yellow, often tinged chestnut 5

5 Underleaves present ..... ***Balantiopsis***
Underleaves absent ..... ***Diplophyllum***

6 Underleaves (as well as leaves) with saccate lobules ..... ***Heteroscyphus cymbaliferus***
Underleaves without saccate lobules 7

7 Lobules complex, forming an inflated claw or sac, very narrowly connected to the stem 8
Lobules simple, consisting of the inrolled or folded ventral margin of the leaf, inflated or not, usually widely connected to stem 9

8 More than 1 lobule per leaf ..... ***Gackstroemia weindorferi***
Only 1 lobule per leaf ..... ***Frullania***

9 Underleaves absent 10
Underleaves present 11

10 Rhizoids absent or arising from lobules; habitats various, rarely if ever epiphyllous ..... ***Radula***
Rhizoids in bundles on stem in the position of missing underleaves; mainly epiphyllous plants on leaves in rainforest ..... ***Cololejeunea***

11 Underleaves entire ..... ***Acrolejeunea securifolia***
Underleaves lobed or shallowly notched at apex 12

12 Lobule an inflated sac, appearing to be unattached to leaf 13
Lobule formed by a simple rolling or folding of the ventral leaf margin 14

13 Leaves with long, ciliate marginal teeth, at least in part ..... ***Gackstroemia weindorferi***
Leaves entire ..... ***Frullania***

14 One underleaf for each lateral leaf 15
One underleaf for each pair of lateral leaves 16

15 Cells with high papillae ..... ***Colura***
Cells mamillose, never papillose ..... ***Diplasiolejeunea plicatiloba***

16 Leaves very narrow at base, attached to stem by 1 or 2 cells 17
Leaves widely attached to stem, by several cells 18

17 Leaf apex rounded; lobule with 3–4 teeth ..... ***Siphonolejeunea nudipes***
Leaf apex pointed; lobule with 1 tooth ..... ***Nephelolejeunea hamata***

18 Oil bodies 1 or 2 per cell, each resembling a cluster of grapes; apical tooth of lobule ± at right angles to stem; hyaline papilla on inner side of apical tooth of lobule ..... ***Cheilolejeunea mimosa***
Oil bodies several per cell, not grape-cluster type; apical tooth of lobule ± parallel to stem; hyaline papilla on outer side of apical tooth of lobule 19

19 Leaf base with 1 or 2 enlarged cells, each almost filled by an oil body ..... ***Harpalejeunea latitans***
Leaf base without such cells ..... ***Lejeunea***

Group B
Leafy liverworts with densely hairy or spiny leaves

1 Lobules present, either dorsally or ventrally **2**
Lobules absent **4**

2 Small, helmet-shaped ventral lobules present .... ***Gackstroemia weindorfei***
Ventral lobules not present **3**

3 Lobule formed by keeling of leaf .... ***Schistochila lehmanniana***
Lobule formed by folding of leaf margin .... ***Balantiopsis diplophylla***

4 Leaves with long, single-celled spines bent ± parallel to stem, pointing to the stem apex .... ***Psiloclada clandestina***
Leaves not as above (if spines pointing to the apex, then not single-celled) **5**

5 Leaves almost wholly divided into lobes and hairs, so that leaf lamina is not evident; stems with paraphyllia **6**
Leaf lamina evident, although bordered by hairs or spines; paraphyllia absent **7**

6 Cilia of leaves distinctly papillose; in dry sclerophyll forest .... ***Trichocolea rigida***
Cilia of leaves not papillose; in wet forest or rainforest .... ***Trichocolea mollissima***

7 Hairs 1-celled, bristle-like; plant of dry heathland or woodland .... ***Chaetophyllopsis whiteleggei***
Hairs many-celled; plants of dry to wet sclerophyll forest or rainforest **8**

8 Shoots bipinnate, at least in widest part of plant; leaf hairs 1 cell wide at base .... ***Telaranea pulcherrima* var. *mooreana***
Shoots simple or 1-pinnate; leaf hairs several to many cells wide at base **9**

9 Shoots long, fawn to yellow, epiphytic in wet forest or other cool, moist habitats; leaves bifid, each lobe also bifid, the tips extended into hyaline hairs .... ***Lepicolea scolopendra***
Shoots and leaves not as above **10**

10 Shoots distinctly golden brown, terrestrial on clayey soil .... ***Temnoma townrowii***
Shoots yellow-brown to yellow-green, epiphytic on trees and rotting wood* .... ***Lepidozia ulothrix***

* Most specimens keying to here will be *Lepidozia ultothrix*, but another species resesmbling *L. hirta* of New Zealand is present in Victoria. *L. ulothrix* often has the lobes further divided; the other species does not.

Group C
Leafy liverworts without underleaves, or underleaves not apparent

1 Leaves with a ventral lobule 2
Leaves without a ventral lobule 3

2 Rhizoids absent or arising from lobules; habitats various, rarely epiphyllous .... ***Radula***
Rhizoids in bundles on stem in the position of missing underleaves; often epiphyllous .... ***Cololejeunea***

3 Although appearing leafy and lettuce-like, plant thallose, without a clearly defined stem 4
Plants truly leafy, leaves arising from a clearly defined narrow stem (stem may be obscured by leaves) 5

4 Rhizoids hyaline or brown, never crimson; thallus a wide rosette up to 20 mm in diameter, the lobe ruffled and lamellate on dorsal surface; mature capsule enclosed in a bulbous central involucre .... ***Petalophyllum preissii***
Rhizoids usually crimson; thallus not lamellate; mature capsule raised on translucent stalk .... ***Fossombronia/Austrofossombronia***

5 Leaves with lobes, teeth or spine-like hairs 6
Leaves rounded, entire or crenulate, or tapering to a single sharp point 22

6 Margins of leaves with 2 or more slender spine-like hairs 7
Margins of leaves without teeth, or teeth broad at base, not spine-like 9

7 Plants terrestrial, clearly anchored to the soil by rhizoids along the length of the stem .... ***Goebelobryum unguiculatum***
Plants terrestrial or not, but if so then without rhizoids, or rhizoids confined to stem base 8

8 Margins of leaves with 2 widely spaced ± parallel spines, swept backwards .... ***Adelanthus bisetulus***
Margins of leaves with many short teeth .... ***Plagiochila***

9 Plants densely papillose over stems and leaves 10
Plants papillose or not, but papillae not on stems 11

10 Stems hairy with short, stiff, papillose bristles; shoots 2–3 mm wide .... ***Marsupidium setulosum***
Stems papillose but lacking bristles; shoots mostly less than 1 mm wide .... ***Acrobolbus cinerascens***

11 Plants minute, thread-like, prostrate or erect, almost invisible to the naked eye; leaves bilobed, sometimes also toothed (seee couplet 4 Group F) .... ***Cephaloziella***
Plants small to large, shoots easily visible to the naked eye; leaves variously lobed or toothed 12

12 Oil bodies conspicuous, dark brown in transmitted light 13
Oil bodies often inconspicuous, not dark brown (usually transparent) 14

13 Outer cells of stem similar to inner cells; marsupium at base of stem .... ***Marsupidium surculosum***
Outer cells of stem small and thick-walled, forming a distinct 2–3-layered cortex; marsupium at the shoot tip .... ***Tylimanthus***

14 Leaves with more than 2 lobes or teeth 15
Leaves bilobed or with 2 large apical teeth, otherwise with entire margins 17

Group C cont'd

Leafy liverworts without underleaves, or underleaves not apparent

15 Stems green or brown[A] .... ***Plagiochila***
Stems black **16**

16 Shoot tips often curved over like a walking stick; leaves opposite, finely toothed ± all round margin; leaf cells without trigones .... ***Calyptrocolea falcata***
Shoots tips erect; leaves alternating along stem, coarsely toothed or lobed along apical margin; leaf cells with very large trigones .... ***Acrochila biserialis***

17 Leaves tightly and evenly pressed against stem **18**
Leaves spreading from stem, at least in one direction **19**

18 Plants greyish; leaves obvious, overlapping; stem hidden by leaves; on soil .... ***Gymnomitrion incompletum***
Plants very dark green to black, appearing leafless but with minute widely spaced leaves; stem clearly visible; on rocks in flowing water .... ***Cephalomitrion aterrimum***

19 Leaves bifid to halfway; plant aquatic or semi-aquatic .... ***Allisoniella nigra***
Leaves bifid but never to halfway; plant not aquatic or semi-aquatic **20**

20 Leaves wrapped around stem; epiphytic in wet forest or rainforest .... ***Anastrophyllum schismoides***
Leaves spreading widely from the stem; not epiphytic **21**

21 Leaves longer than wide, ± oblong; on soil at low elevations[A] .... ***Andrewsianthus cuspidatus***
Leaves wider than long, ± oval, on rock at higher elevations .. ***Marsupella sparsifolia***

22 Shoots prostrate, with many rhizoids along much of the stem **23**
Shoots erect or ascending, attached to the substrate only at the base **31**

23 Leaves with papillose cuticle, at least in lower half of leaf........ **24**
Leaves smooth or striolate, never papillose **26**

24 Epiphytic in wet forest or rainforest, or on rocks in subalpine to alpine areas; capsule developing in perianth .... ***Jamiesoniella colorata***
On soil in drier habitats (rarely aquatic); not in alpine areas; capsule in a buried marsupium **25**

25 Plants yellowish to deep green, sometimes tinted chestnut; oil bodies large, brownish, few per cell; leaf cuticle papillose only towards apex .... ***Lethocolea pansa***
Plants silvery white to whitish green, not tinted chestnut; oil bodies small, colourless, up to 14 per cell; leaf cuticle usually papillose all over .... ***Gongylanthus scariosus***

26 Leaves ± opaque, cells almost filled by brownish oil bodies ... ***Acrobolbus concinnus***
Leaves translucent, oil bodies pale (brownish only in *Lethocolea pansa*) **27**

27 Plants minute; leaf and stem cells all similar, bulging; leaves few-celled .... ***Zoopsis***
Plants small to large, leaf and stem cells not bulging, leaf cells distinctly different from stem cells; leaves many-celled **28**

28 Leaves tongue-shaped, ending in an acute point .... ***Cuspidatula monodon***
Leaves with widely rounded apex, not at all pointed **29**

29 Leaf insertion succubous, orientation ± longitudinal; leaves ± flat; epiphytic in rainforest or subalpine woodland[B] .... ***Pedinophyllum monoicum***
Leaf insertion ± transverse; leaves flat to concave; terrestrial or aquatic **30**

Group C cont'd
Leafy liverworts without underleaves, or underleaves not apparent

30 Outer cells of stem enlarged and translucent, forming a distinct hyaloderm; leaves 2–3 cells thick in middle near the base; stolon-like stems present; plants of subalpine and alpine areas .. ***Hygrolembidium acrocladum***
Outer cells of stem not differentiated as a hyaloderm; leaves 1 cell thick throughout; stolon-like stems not present; plants in various habitats .... ***Solenostoma* (*Jungermannia*)**

31 Leaves tightly and evenly appressed to stem **32**
Leaves spreading from stem, at least in one direction **33**

32 Cells of leaf margin thick-walled, with peg-like projections; leaves densely papillose, especially in basal half ...... ***Nothogymnomitrion erosum***
Cells of leaf margin thin-walled; leaves smooth or finely striate, not papillose .... ***Herzogobryum teres***

33 Erect branches arising from creeping stolon-like stems; plants small, leaves deeply concave; in subalpine or alpine areas .... ***Hygrolembidium acrocladum***
Stolon-like stems not present; leaves concave or not, but never deeply; habitats various **34**

34 Stems mostly erect and unbranched, forming low dense turf on soil; capsule formed in tubular perianth, or in a marsupium **35**
Stems usually branched, not forming low dense turf; capsule formed in tubular or flattened perianth **37**

35 Male and female branches at end of shoot; oil bodies always pale .... ***Solenostoma* (*Jungermannia*)**
White male branches and marsupia carried at base of stem; oil bodies clear brown, rarely pale **36**

36 Plants green, robust; leaves 1–2 mm wide; leaf cells without trigones .... ***Marsupidium surculosum***
Plants usually brownish, small; leaves < 1 mm wide; leaf cells with distinct trigones .... ***Jackiella curvata***

37 Leaves dark green, brown or black, margins entire; in montane to alpine areas in or next to water .... ***Cryptochila grandiflora***
Leaves yellowish, green or greenish brown, margins usually toothed; in various habitats but mostly montane or lower .... ***Plagiochila***

[A] Species of *Lophozia*, a genus not yet formally reported for Victoria but undoubtedly present here, could key out at couplet 16 or 22.

[B] *Jamesoniella tasmanica*, doubtfully recorded for Victoria, would key to here. It has yellowish or brown concave leaves and the perianth tapers to a narrow mouth; *Pedinophyllum monoicum* is always green and the perianth expands to a wide mouth.

Group D
Leafy liverworts with underleaves and incubous leaves

1 Leaves with ventral lobules .... **Group A**
Leaves without ventral lobules **2**

2 Most leaves on main stems 4-lobed **3**
Most leaves on main stems 3-lobed, 2-lobed or not lobed **5**

3 Leaves inserted almost longitudinally; leaf cells in regular rows .... ***Telaranea centipes***
Leaves clearly incubous to transverse; leaf cells not in regular rows **4**

4 Leaves nearly transverse; tiny plants creeping over clay soil, often in dense mats .... ***Kurzia***
Leaves clearly incubous, leaves densely overlapping on most parts of shoot .... ***Lepidozia***

5 Leaves divided almost to the base, each lobe consisting ± of 4–6 elongated cells in a row .... ***Paracromastigum longiscypha***
Leaves not divided almost to the base, segments not as above **6**

6 Ventral flagella absent **7**
Ventral flagella present **9**

7 Leaves constantly 3-lobed, never with extra teeth; underleaves minute, entire to shallowly 3-lobed; plant minute .... ***Drucella integristipula***
At least some leaves 2-lobed or entire; underleaves large, distinctly 2-lobed or 3-lobed; plants small to large **8**

8 Both leaves and underleaves variably and deeply 2-lobed and 3-lobed; leaf insertion clearly incubous; leaf surface distinctly striolate .... ***Triandrophyllum subtrifidum***
Leaves and underleaves shallowly 2-lobed or entire, sometimes with small accessory teeth, never 3-lobed; leaf insertion ± transverse; leaf surface not striolate (but may be papillose) .... ***Isotachis***

9 At least some leaves 3-lobed; ventral flagellum arising from axil of underleaf.. ***Bazzania***
All leaves 2-lobed or entire; ventral flagellum replacing half of underleaf .... ***Acromastigum***

Group E

Leafy liverworts with underleaves and succubous to transverse leaves without lobes

1 Leaves with a lobule on the ventral side .... **Group A**
Leaves without a lobule on the ventral side 2

2 Plants minute, cells inflated and glistening; leaves consisting of
a few relictual cells topped by smaller oblique cells .... ***Zoopsis***
Plants small to large, cells not inflated and glistening; leaves
consisting of many cells 3

3 Although appearing entire, apex of leaves with 2 small
closely spaced lohes .... ***Saccogyuidium decurvum***
Leaves without lobes 4

4 Leaves deeply concave, more or less fleshy; in
alpine habitats .... ***Hygrolembidium acrocladum***
Leaves not deeply concave, never fleshy; in various habitats 5

5 Plants somewhat to distinctly dorso-ventrally flattened;
with brownish pigments; perianths ± laterally compressed,
basically 2-lipped, the ventral lobe much reduced in length;
rhizoids not confined to underleaf bases .... ***Leptoscyphus expansus***
Plants usually lacking brownish pigments; perianth
trigonous to trigonous inflated, the mouth equally or
subequally trilobed; rhizoids confined to underleaf bases 6

6 Underleaves always joined to leaves on both sides,
usually strongly; sex organs always on short specialised
intercalary shoots; androecia on narrow leafless branches;
leaf cells often with large trigones .... ***Heteroscyphus***
Underleaves joined to leaves on 1 side only, or weakly joined to
leaves on both sides; sex organs all or mostly on unspecialised
leafy shoots; androecia usually on leafy branches; leaf cells
without trigones, or trigones small to medium, never large 7

7 Plants stoloniferous; leaves transverse to succubous; leafy branches
erect, without flagella* .... ***Hepatostolonophora paucistipula***
Plants not stoloniferous, leaves succubous; leafy branches usually prostrate 8

8 Leaves with irregular fragile teeth on margin, often broken off,
giving leaves a ragged appearance; cuticle with a distinct
rainbow sheen .... ***Leptophyllopsis laxa***
Leaves without such marginal teeth; cuticle without a distinct rainbow sheen 9

9 Leaves moderately to deeply concave; underleaves plane,
convex, or cucullate .... ***Clasmatocolea***
Leaves plane or convex; underleaves sometimes strongly
concave, especially near shoot apices .... ***Chiloscyphus***

* I have found no legitimate material of *H. rotata* from Victoria, and therefore discount it at present from the Victorian flora. It has symmetrical leaves with recurved margins,and might well turn up in subalpine and alpine areas.

Group F

Leafy liverworts with underleaves and lobed or toothed succubous to transverse leaves

1 Leaves densely hairy or spiny, leaf lamina hard to distinguish .... **Group B**
Leaves not densely hairy or spiny, leaf lamina clearly visible **2**

2 Plants minute: leaves consisting of a few cells topped by smaller oblique cells .... ***Zoopsis***
Plants minute to large; leaves consisting of many cells **3**

3 Plants minute, thread-like; leaves hardly visible under hand lens: underleaves minute or absent **4**
Plants small to large, not thread-like, leaves clearly visibly under hand lens; underleaves always present **5**

4 Leaf margins entire .... ***Cephaloziella exiliflora***
Leaf margins raggedly toothed .... ***Cephaloziella hirta***

5 Stems dark, densely covered in pale hair-like paraphylls; leaves and underleaves 2-lobed, underleaves usually also ciliate or toothed .... ***Chandonanthus squarrosus***
Stems variously coloured, lacking paraphylls; leaves variously lobed **6**

6 Leaves divided to beyond half way **7**
Leaves not divided beyond half way **9**

7 Leaves divided into 3–4 narrowly triangular lobes, usually with 2 extra teeth on the side; lobes spreading away from stem ..... ***Temnoma palmatum***
Leaves divided into 4 long narrow lobes; lobes parallel to stem **8**

8 Leaf lobes spine-like, bent in centre; leaves succubous .... ***Psiloclada clandestina***
Leaf lobes narrowly to widely triangular; leaves ± transverse .... ***Kurzia***

9 Underleaves always joined to leaves on both sides, usually strongly .... ***Heteroscyphus***
Underleaves joined to leaves on 1 side only, or not joined at all **10**

10 Leaves with irregular fragile teeth on margin, often broken off, giving leaves a ragged appearance; cuticle with a distinct rainbow sheen .... ***Leptophyllopsis laxa***
Leaves without such marginal teeth; cuticle without a distinct rainbow sheen **11**

11 Leaves ± transverse, 4-lobed to almost half way; stolons present; rare plant of subalpine woodland .... ***Pseudocephalozia paludicola***
Leaves clearly succubous, not deeply 4-lobed; stolons not present **12**

12 Sporophyte developing in perianth on short lateral branch; underleaves usually joined to leaves on 1 side, sometimes narrowly; leaves ± circular to tongue-shaped .... ***Chiloscyphus***
Sporophyte developing in marsupium on short branch on underside of stem; underleaves clearly not joined to leaves: leaves various **13**

13 Leaves ± oblong, deeply lobed at apex; underleaves divided to the base into 2 diverging lobes* .... ***Geocalyx caledonicus***
Leaves ± triangular-ovate, entire or very shallowly lobed at apex; underleaves almost circular, shallowly notched at apex .... ***Saccogynidium***

* Species of *Lophozia*, a genus not yet formally reported for Victoria but undoubtedly present here, could key out at couplet 13.

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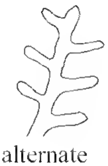
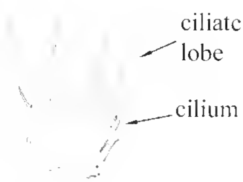
Glossary of liverwort terms

Alternate With branches alternating from one side to another along stem or thallus, so that the branches are not opposite.



Bipinnate Branched pinnately, and each branch also branched pinnately.

Ciliate With long hair-like processes (cilia).



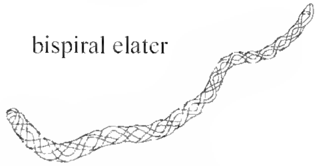
Complicate-bilobed Consisting of two seemingly separate segments (lobe and lobule, or double lamina and keel), very different in their size and shape; the segments are joined, but sometimes very narrowly. See *keel*, *lobule*.

Dissected Notched at the apex; if the notch is so deep that the two sides touch or overlap at their tips, then the term 'deeply dissected' is used.

Dioecious Having the male and female organs on separate plants.

Dorsal On the upper side of the thallus or shoot, i.e. farthest from the substratum.

Elater Elongated cell with spiral or bispiral internal structure, present in most liverwort and some hornwort capsules; involved in spore dispersal.



Entire Without teeth, spines or other projections (but may be lobed).

Epiphyllous Growing on the leaf or frond of another plant.

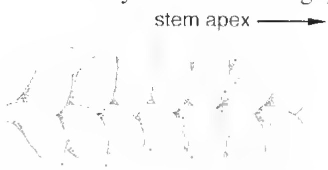
Epiphytic Growing on another plant (usually on bark).

Flagellum A ventral branch with minute leaves, usually anchoring the plant to the substratum.

Gemma A multicelled propagule capable of growing into a new plant; often formed in a specialised organ but also often arising from leaves, thallus margins or other plant parts.

Hyaline Transparent and colourless.

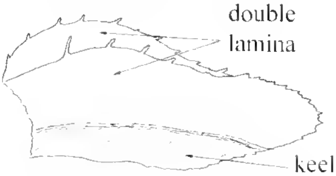
Incubous Arranged so that, when viewed from the dorsal side, each leaf overlaps the one nearer the stem apex (or would if they were close enough).



Intercalary branch A branch produced by an outgrowth from within the stem, rather than from the stem apex. Intercalary branches have a tiny 'collar' of stem cortex cells at their base.

Involucre A cylindrical structure surrounding the male organs (sometimes female organs) in some thallus liverworts.

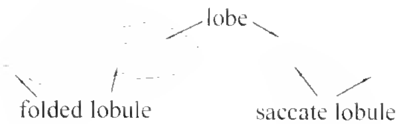
Keeled Having a double lamina in one section of the leaf, the two halves fused along a longitudinal line that meets the stem at the leaf base, so that the other part of the leaf resembles a keel.



Lamellate Having wing-like projections arising from the thallus.

Lamina The thinner parts of a thallus, as distinct from the midrib.

Lobe Segment of a leaf or thallus, formed by growth of separate apical cells. See *lobule*.



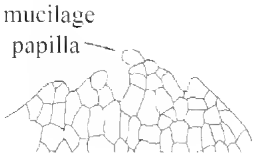
Lobule Segment of a leaf or thallus formed by rolling or folding of the leaf or thallus, rather than growth from separate apical cells.

Marsupium A fleshy, root-like and usually hairy organ buried in the soil, containing the developing sporophyte in some liverworts.

Midrib A narrow thickening along the centre-line of a thallus.

Monoecious Having male and female organs on the same plant.

Mucilage papilla Small club-shaped cells formed at or near apex of thallus or leaf; often not persisting when dry.

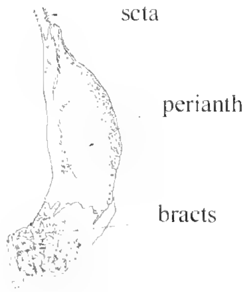


Oil body Globule within a cell, containing lipids and other fatty substances; often useful for distinguishing genera or species.

Palmate Branching from a central point, like the fingers of a hand or the spokes of a wheel.

Papilla Pimple-like thickening of the outer cell wall.

Perianth A fleshy, usually cylindrical structure in which the sporophyte develops.



Pinnate Branched on each side of the stem or thallus at more or less regular intervals, so that the branches are more or less in opposite pairs.

Pseudoelater Elater-like multicellular structure in the capsules of some hornworts.

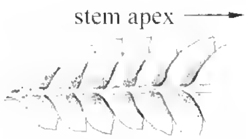
Rhizoid A hair-like growth on the ventral side of the plant, usually anchoring it to the substratum.

Seta Translucent stem on which capsule is raised.

Sporophyte The seta and capsule together.

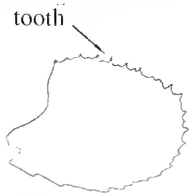
Striolate Marked by fine lines or linear structures.

Succubous Arranged so that, when viewed from the dorsal side, each leaf



overlaps the one farther the stem apex (or would if they were close enough).

Tooth Small, tapering projection on margin of leaf or thallus, consisting of one or a few cells, or formed by an extension of a cell wall.

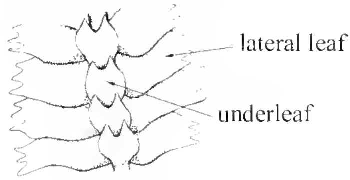


Transverse Having the join between the leaves and stem running sideways across the stem, not angled.

transverse leaves

Trigone Triangular to cordate thickening at the point where three cells join.

Underleaves Leaves of a different size (usually much smaller) and shape than the lateral leaves, and attached on the ventral side of the stem.



Ventral On the underside of the thallus or shoot, i.e. closest to the substratum.

Studies on Victorian bryophytes 6. Key to thallose liverworts and hornworts

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Abstract

A new key to the genera and many species of thallose liverworts and hornworts (except *Fossombronia* and *Riccia* species) in Victoria is provided. (*The Victorian Naturalist* **123** (4), 2006, 247-254)

Introduction

This artificial key complements the key to the genera of leafy liverworts in this volume. It is based on the key to southern Australian liverworts in Scott (1985), but is substantially updated and revised to take into account taxonomic changes and additions to the Victorian flora in the last 20 years. Common mistakes are allowed for in the main key and group keys.

The key can be used to identify specimens to species level, except for species of *Fossombronia* (which are very difficult to identify without detailed analysis) and *Riccia* (which is under review in Australia and is likely to undergo substantial changes). Also keep in mind that species and genera presently known only from Tasmania, New Zealand or other parts of the world might still be found in Victoria. This key is not valid for other regions of Australia.

Most of the thallose liverworts and hornworts in Victoria are described and illustrated in Scott (1985) and Meagher and Fuhrer (2003).

Names of taxa follow the current national checklist (McCarthy 2006).

A basic glossary of terms used in this key is included in the key to leafy liverworts (*Studies* 5 in this issue). For a complete and beautifully illustrated glossary of bryological terms, see Malcolm and Malcolm (2000).

Key to thallose liverworts and hornworts

1 Thallus leafy, or with leaf-like lobes on either side of a central axis 2
Thallus lobed or unlobed, but not leafy 5

2 Rhizoids crimson .... **Fossombroniaceae (Group A)**
Rhizoids not crimson, or absent, or not seen..........................3

3 Lobes pinnate or alternate, arranged all along the central thallus; or plant leafy or lettuce-like 4
Lobes palmate, the lobes radiating or bifurcating (Y-branching) from a central point; or thallus arising from a narrow, ± upright stalk 11

4 Thallus bright grass-green, thick and fleshy, rather brittle; rare plant.......................... **Treubiaceae (*Treubia tasmanica*)**
Thallus green or not; not thick and fleshy, not brittle; common plants .... **Fossombroniaceae (Group A)**

5 Thallus one cell thick (except midrib) 6
Thallus mostly several cells thick in part 8

6 Thallus narrow throughout (< 3 mm), lobes pinnate, alternate or bifurcated 7
Thallus wide, at least in part (usually > 4 mm), often palmately divided .... **Pallaviciniaceae (Group C)**

7 Growing on wet or dried soil, commonly mud (either saline or fresh); lobe pattern usually not obvious .... **Sphaerocarpales (Group D)**
Growing on trees or rocks, never on mud; lobes bifurcating (Y-branching) .... **Metzgeriaceae (Group E)**

8 Chloroplasts usually 1 or 2 per cell; capsule erect, needle-like, splitting gradually down from tip; large cavities containing dark cyanobacteria often evident in thallus .... **Anthocerophyta (Group B)**
Chloroplasts several to many per cell; capsule ovoid to globose, not needle-like; cavities in thallus (if present) not containing dark cyanobacteria . 9

9 Thallus half-buried in soil, firmly anchored by copious rhizoids; capsule formed in marsupium buried in soil .... ***Enigmella thallina***
Thallus on or above soil, or not on soil, anchored or not by rhizoids; capsule not formed in marsupium buried in soil 10

10 Thallus surface without pores, upper surface homogeneous, without pores; rhizoids all smooth 11
Plants surface with pores, often opening to the upper surface by air pores; rhizoids normally of two sorts: one smooth and the other with internal peg-like thickenings 15

11 Midrib conspicuous; lamina 1 cell thick in outer parts 12
No midrib; lamina never 1 cell thick, except sometimes at the very edge 13

12 Plants on bark or rock, never on soil; pale yellow-green, never rose-tinted; prostrate; fine hairs present on ventral surface and usually also on thallus margins .... **Metzgeriaceae (Group E)**
Plants on soil or rotting logs, also epiphytic in humid habitats; mid to dark green, often rose-tinted, often arising from a narrow, ± upright stalk; ventral surface and margins lacking hairs (but may be toothed) .... **Hymenophytaceae / Pallaviciniaceae (Group C)**

13 Plants with regular, few-celled lobes in the position of leaves and underleaves .... **miskeyed *Zoopsis* or eroded leafy liverwort**
Plants usually irregularly lobed; lobes many-celled **14**

14 Sporophyte needle-like; chloroplasts usually 1 or 2 per cell; cavities in thallus containing dark cyanobacteria often present ... **Anthocerophyta (Group B)**
Sporophyte not needle-like; chloroplasts usually several to many per cell; cavities in thallus containing dark cyanobacteria never present ....**Aneuraceae (Group F)**

15 Gemma cups circular or crescent-shaped, obvious on upper surface of thallus .... **Marchantiaceae (Group G)**
Gemma cups lacking **16**

16 Upper surface of thallus spongy, often whitish **17**
Upper surface of thallus firm, usually green **18**

17 Plants usually forming complete or partial rosettes on the ground, or else free-floating; not in salt pans .... **Ricciaceae (Group H)**
Plants not forming rosettes; in salt pans or on compacted soil .... **Sphaerocarpales (Group D)**

18 Upper surface of thallus flat, not furrowed; sporophytes carried outside the thallus **19**
Upper surface furrowed, V-shaped at least at apex; sporophytes embedded in thallus .... **Ricciaceae (Group H)**

19 Thallus usually > 7 mm wide; many long, free rhizoids on ventral surface .... **Marchantiaceae (Group G)**
Thallus usually < 6 mm wide; never with rhizoids as above .... **Aytoniaceae and Targioniaceae (Group I)**

Group A
Fossombroniaceae

1 Plants aquatic or semi-aquatic; thallus erect, up to 30 mm tall .... *Austrofossombronia australis*
Plants not aquatic or semiaquatic (but may be on drying mud); thallus prostrate, < 10 mm tall **2**

2 Rhizoids hyaline or brown, never crimson; Thallus ± as long as wide, ruffled and lamellate on dorsal surface .... *Petalophyllum preissii*
Rhizoids usually crimson; thallus usually much longer than wide, not lamellate .... *Fossombronia*

Group B
Anthocerophyta

1 Chloroplasts 2 or more per cell; capsule with spirally thickened and unsegmented elaters 2
Chloroplasts usually 1 per cell; capsule with irregular segmented pseudo-elaters 3

2 Thallus < 25 mm long .... *Megaceros gracilis*
Thallus 35–50 mm long .... *Megaceros pellucidus*

3 Thallus with a rough and cavernous surface, usually pale green with crisped margins; spores blackish .... *Anthoceros punctatus*
Thallus with smooth upper surface, usually dark green with margins rarely crisped; spores yellowish 4

4 Plants dioecious .... *Phaeoceros laevis*
Plants monoecious .... *Anthoceros brotheri*

Group C
Hymenophytaceae and Pallavicinaceae

1 Plants with sex organs 2
Sex organs lacking or not visible 8

2 Sex organs on specialised short branches at base or on underside of frond 3
Sex organs on upper side of frond, not on specialised branches 4

3 Sexual branches at base of frond; thallus simple or sparsely branched, not palmate .... ***Podomitrium phyllanthus***
Sexual branches on underside of frond; thallus palmately divided above .... ***Hymenophyton flabellatum***

4 Sporophyte base encased in a thick, fleshy tube bearing archegonia near apex; male plants with scales overlapping midrib dorsally 5
Sporophyte base surrounded by a long tubular pseudoperianth, not fleshy; male plants with scales in 2 rows down each side of midrib 6

5 Thallus branched, margins coarsely toothed .... ***Symphyogyna podophylla***
Thallus unbranched, consisting of broad and narrow sections, margins entire .... ***Symphyogyna interrupta***

6 Margins strongly toothed with conspicuous teeth, several cells long .... ***Pallavicinia xiphoides***
Margins generally entire or with teeth of only 1 or 2 cells 7

7 Thallus ± flat, the margins rarely if ever flexed upwards* .... ***Pallavicinia lyelli***
Thallus commonly concave, the margins flexed upwards .... ***Pallavicinia rubristipa***

8 Frond margins toothed, at least near apex 9
Frond margins entire or nearly so 10

9 Margins with teeth of only 1 or 2 cells** .... ***Pallavicinia lyelli***
Margins with teeth several cells long .... ***P. lyelli / S. interrupta*** **(inseparable)**

10 Thallus, commonly concave, the margins flexed upwards .... ***Pallavicinia rubristipa***
Thallus ± flat, the margins rarely if ever flexed upwards 11

11 Fronds borne on erect stalks; plant completely green .... ***Hymenophyton flabellatum***
Fronds prostrate; plant may have a rose-pink tinge 12

12 Stalk rose-pink, at least near base .... ***Pallavicinia lyelli***
Stalk completely green .... ***Podomitrium phyllanthus***

* Schuster (1991) gave the name *Pallavicinia pseudolyellii* to Australasian material of '*P. lyellii*' and gave a Latin diagnosis, but did not validate the name by nominating a type.

** *Jensenia connivens*, discounted from the Australian flora by Schaumann *et al.* (2004), would key to couplet 9; it has fronds borne on erect stalks but is tinged rose red below.

Group D
Sphaerocarpales

1 Thallus ± circular, usually almost covered by inflated, bottle-like involucres 2
Thallus elongated, consisting of a stem with a wing along one side,
spore-bearing involucres at the edge and tip 3
2 Thallus bubble-like, with a single pore on top;
in saline habitats .... ***Monocarpus sphaerocarpus***
Thallus flat, with several involucres together;
not in saline habitats .... ***Sphaerocarpos texanus***
3 Monoicous; on freshwater mud; spines on spores 12 µm long .... ***Riella spiculata***
Dioicous; on saline mud; spines on spores 4–5 µm long .... ***Riella halophila***

Group E
Metzgeriaceae

1 Thallus with hairs on both dorsal and ventral surfaces* .... ***Metzgeria* sp. A**
Thallus without hairs on dorsal surface 2
2 Thallus lobed and saccate .... ***Metzgeria saccata***
Thallus flat, not lobed or saccate 3
3 Hairs weakly to distinctly falcate, mostly paired; midrib covered
by 2–3 cells on dorsal side .... ***Metzgeria leptoneura***
Hairs not falcate, paired and/or single; midrib covered by 2–4 cells on dorsal side ... 4
4 Thallus tapered to a narrow apex on most lobes .... ***Metzgeria consanguinea***
Thallus rarely if at all tapered, most lobes with an obtuse, rounded apex 5
5 Midrib covered by 3(–4) cells on dorsal side, 4–6 on ventral side..... ***Metzgeria rigida***
Midrib covered by 2(–3) cells on dorsal side, 2-4 on ventral side 6
6 Midrib covered by 2 cells on ventral side** .... ***Metzgeria decipiens***
Midrib covered by (3–)4 cells on ventral side .... ***Metzgeria furcata***

Notes:
Cells covering the costa should be counted about half way between one thallus branch and the next.

* *Metzgeria* sp. A from Carlisle State Park seems closest to *M. follicola* of Melanesia.

** So (2002) followed Grolle (2002) in reducing *M. decipiens* to a synonym of *M. furcata*, based on the variability in the number of cells covering the midrib on the dorsal side of the thallus. However, the number of cells on the ventral side seems to distinguish the two clearly. Until a full assessment of the two taxa is made, I prefer to maintain them as separate entities.

Group F
Aneuraceae

1 Thallus U-shaped in cross-section, at least near lobe tips **2**
Thallus flat or slightly curved in cross-section, never U-shaped **4**

2 Thallus margins plane; lobe apices spoon-shaped, often yellowish and bearing gemmae .... ***Riccardia cochleata***
Thallus lobes flexuose to crispate; lobe apices not as above **3**

3 Thallus > 7 mm wide; margins strongly crisped; aquatic plant of alpine or subalpine streams .... ***Aneura* sp. A**
Thallus < 6 mm wide; margins flexuose to slightly crisped; not aquatic .... ***Aneura rodwayi***

4 Apex of thallus not dissected **5**
Apex of thallus dissected **8**

5 Plant dendroid or semi-dendroid; thallus differentiated into a central stem and branches; lateral branches with evident central strands; cuticle papillose .... ***Riccardia eriocaula***
Thallus without an erect stem; lateral branches without a central strand; cuticle smooth **6**

6 Thallus branches with a wing 1 cell thick; mucilage papillae lateral and ventral only, persisting; shoot calyptra smooth .... ***Riccardia minima***
Thallus branches not winged; mucilage papillae dorsal as well as lateral and ventral, not persisting; shoot calyptra crowned with hyaline hairs **7**

7 Thallus lens-shaped in cross-section .... ***Riccardia aequicellularis***
Thallus circular in cross-section .... ***Riccardia alcicornis***

8 Cuticle striolate or papillose **9**
Cuticle smooth **10**

9 Cuticle striolate .... ***Riccardia crassa***
Cuticle papillose .... ***Riccardia colensoi***

10 Thallus mean width > 2 mm (usually 3–6 mm); apex deeply dissected .... ***Aneura alterniloba***
Thallus mean width < 2 mm; apex shallowly divided **11**

11 Thallus mean width < 1 mm; often with prostrate main branches and erect, pinnately branched (almost palmate) secondary branches; monoecious .... ***Riccardia wattsiana***
Thallus mean width > 1 mm; branches prostrate; dioecious.......... **12**

12 Branching often appearing palmate; mucilage papillae not persisting; stolons present .... ***Riccardia rupicola***
Branching always clearly pinnate; mucilage papillae persisting; stolons absent .... ***Riccardia bipinnatifida***

Note:
Aneura sp. A is an undescribed species known from the Bogong High Plains, Baw Baw Plateau and Kosciuszko National Park. It is probably also present in New Zealand.

Group G
Marchantiaceae

1 Gemma cups (if present) crescent-shaped; pores on upper surface of thallus not surrounded by polygonal shapes .... ***Lunularia cruciata***
Gemma cups (if present) circular; pores on upper surface surrounded by polygonal shapes 2

2 Ventral scales forming a narrow crimson stripe down the centre of the underside of the thallus; archegoniophore lobes flat, rectangular .... ***Marchantia foliacea***
Ventral scales colourless, covering underside of thallus; archegoniophore lobes rod-like 3

3 Colour of upper surface of thallus evenly green; surface with a glossy sheen; marginal scales not projecting beyond thallus edge .... ***Marchantia berteroana***
Colour of upper surface of thallus uneven, with a dark zone down the middle; surface without a glossy sheen; marginal scales projecting slightly beyond thallus edge ...... ***Marchantia polymorpha* var. *aquatica***

Group H
Ricciaceae

1 Plants free-floating 2
Plants on soil or mud 3

2 Ventral scales conspicuous, purplish .... ***Ricciocarpos natans***
Ventral scales not evident, not coloured .... ***Riccia duplex* var. *duplex***

3 Thallus heart-shaped; on drying mud; ventral scales purplish, in bunches .... ***Ricciocarpos natans***
Thallus heart-shaped or not; on various substrates; ventral scales variously coloured but not in bunches 4

4 Dorsal surface of thallus with compact tissues forming narrow vertical air chambers, without specialised pores; epidermal cells hyaline .... ***Riccia* subgenus *Riccia***
Dorsal surface of thallus with loosely arranged (often spongy) tissues forming polyhedral or large and irregular air chambers with well-defined pores; epidermal cells chlorophyllose except around pores .... ***Riccia* subgenus *Ricciella***

Group I
Aytoniaceae and Targioniaceae

1 Side branches originating from underside of thallus; capsules formed in black spherical pouches beneath apices of thallus .... ***Targionia hypophylla***
Side branches originating from margin or upper surface of thallus; capsules formed in umbrella-like streutures (archegoniophores) ... **(Aytoniaceae) 2**

2 Sex organs always present, in 2 or more receptacles down the midline of the thallus .... ***Plagiochasma rupestre***
Sex organs absent, or scattered receptacles usually on the margin or apex of the thallus **3**

3 Epidermal pores surrounded by 4 or more rings of cells; perianth (involucre) hemispherical, with one slit beneath .... ***Reboulia queenslandica***
Epidermal pores surrounded by 1–3 rings of cells; perianth conical, opening with numerous vertical slits .... ***Asterella* 4**

4 Thallus crimson underneath, generally 5–7 mm wide; perianth with 12–14 slits* .... ***Asterella drummondii***
Thallus green underneath, generally 3-4 mm wide; perianth with about 8 slits .... ***Asterella tenera***

**Asterella conocephala*, *A. tasmanica* and *A. whiteleggeana* are almost certainly conspecific with *A. drummondii* or *A. tenera*.

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One hundred and nineteen years ago

MOSSES OF VICTORIA, WITH BRIEF NOTES
BY D. SULLIVAN

'*Where to look for them.* On and in the crevices of rocks, on logs, about the bases and roots of trees, on banks of watercourses, lakes, lagoons, and waterholes, on the ground, from the low lands to the summits of our highest mountains – both in wet and dry localities, but more especially in the former. … I would recommend Melbourne collectors to search well about the Yarra, Dandenong, You Yangs, Mount Macedon, Riddle's Creek, Lancefield (Deep Creek), Sunbury, Gisborne, etc. September, October, and November are the best months for the dry localities, and December, January, and February for the higher mountains and moist forest country. Mosses may be found in certain localities throughout the year, but in winter, except in rare cases, they are not in a fit state for detailed examination, having lost both the calyptras and operculums parts, which are sometimes of great value in deciding specific distinctions.'

From *The Victorian Naturalist* **IV** (1887-8), pp. 109-110

Bryophyte distribution in Blackwood forests of the Otway Ranges, Victoria

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Abstract.
Tracheophyte and bryophyte distribution was surveyed in nineteen Blackwood–dominated sites of two different origins in the Otway Ranges. Nine sites were placed in sheltered gullies and ten sites were placed in upslope stands. Fifty-one tracheophyte taxa, 49 moss taxa and 39 liverwort (including hornwort) taxa were recorded in total. Bryophyte species richness was significantly higher in gully sites. The most frequent bryophyte taxa varied between gully and upslope sites. The percentage occurrence of certain substrates was shown to be an important determinant of bryophyte species richness and composition. Decaying wood and soil supported the greatest number of bryophyte taxa compared with all other substrates. (*The Victorian Naturalist* **123** (4), 2006, 255-268)

Introduction

Bryophytes are a visually dominant component of forests dominated by Blackwood *Acacia melanoxylon* R.Br. in the Otway Ranges in southwest Victoria. Despite this, however, bryological research in these forests has been minimal. Although still in its early stages, investigation of bryophyte distribution with regard to forest type (e.g. Pharo and Beattie 2002) and substrate variables is proceeding for south-eastern Australian forests. Most research to date examines bryophyte dependence on a range of spatial and habitat variables within eucalypt forest and/or rainforest. Many bryophyte taxa show preferences for some substrate types over others (Jarman and Kantvilas 2001b; Turner and Pharo 2005) with species richness (Pharo and Beattie 2002) and composition (Ashton 1986; Kantvilas and Jarman 1993; Pharo *et al.* 2004) shown to be dependent on substrate type. Accordingly, some species of host tree support particular bryophyte communities (Jarman and Kantvilas 1994), with species richness shown to be associated with trunk girth (Ashton and McCrae 1970) and species richness and composition associated with trunk height (Milne and Louwhoff 1999; Jarman and Kantvilas 1995) and aspect (Franks and Bergstrom 2000). Bryophytes show significant small-scale spatial distribution patterns even on a single substrate, for example stream rocks (Carrigan and Gibson 2004).

The state of decomposition in coarse woody substrates has been shown to significantly affect bryophyte composition in some forest types (Rambo and Muir 1998a), but not others (Pharo and Beattie 2002). Rather, Pharo and Beattie (2002) found that level of decomposition explained low but significant bryophyte species richness. Some soil chemical and soil texture variables have been associated with the distribution of bryophytes in semi-arid eastern Australia (Eldridge and Tozer 1997). Brasell and Mattay (1984) demonstrated that time since fire affects soil bryophyte presence and dominance with significant changes in the first three years of succession. Time since major disturbance and the associated effects on bryophyte substrate relationships are further explored by Turner and Pharo (2005).

Pharo *et al.* (2004) examined landscape context classes alongside substrate variables of which the latter were found to be more important in explaining species richness and composition in remnant eucalypt forests and *Pinus radiata* D. Don plantations. Bryophyte composition and relative frequency was shown by Franks (2000) to be significantly different between isolated sites, despite sampling being undertaken on the same species of tree. There is much scope for further investigation of landscape effects on bryophyte distribution in south-eastern Australia. Research on bryophyte distribution with regard to substrate variables has a longer history in the Northern

Hemisphere with many of the same causal factors proposed at various taxonomic levels (e.g. Shacklette 1961; McAlister 1995; Peck *et al.* 1995; Reese 2001).

The broad aim of this research was to provide a description of bryophyte distribution within Otway Blackwood forests, in turn contributing to a greater understanding of bryophyte ecology within southeastern Australian forests. The results presented in this paper are not intended to be exhaustive and there is much opportunity for further bryophyte research within the study area.

Methods

Study area

The study area was confined to the Great Otway National Park and adjacent Aire Valley Softwood Plantation between Cape Otway in the south and the Otway Main Ridge between Wyelangta, Beech Forest and Olangolah in the north, 140–170 km southwest of Melbourne. Mean monthly rainfall at Forrest State Forest is lowest in January (44 mm) and highest in August (128.7 mm). Mean daily maximum temperature is lowest in July (11.7°C) and highest in January (24.5°C) (Bureau of Meteorology 2004)

Vegetation

Acacia melanoxylon is one of the widest ranging tree species in eastern Australia (Entwisle *et al.* 1996). In the Otway Ranges, *A. melanoxylon* occurs as a dominant canopy tree forming mostly closed forest. General floristics of Otway Blackwood forests are discussed by Howard and Ashton (1973), Parsons *et al.* (1975), Earl and Bennett (1986) and Cameron (1992).

Parsons *et al.* (1975) noted 'secondary scrub' dominated by *A. melanoxylon* on slopes where Mountain Ash *Eucalyptus regnans* F.Muell. had been cleared. This community was described and mapped by Roberts (1988) along with a gully Blackwood community of a different origin. Gully stands are found from 130–320 m above sea level and generally occur where natural fire disturbance precludes the full development of mature Cool Temperate Rainforest (Peel 1999) dominated by Myrtle Beech *Nothofagus cunninghamii* (Hook.) Oerst. Pannell (1992) described Blackwood Swamp Forest in northwestern Tasmania with close structural and floristic affinity to the Otway gully community. Naturally-occurring gully stands intergrade with mature stands of Otway Cool Temperate Rainforest (in the sense of Peel 1999) where *A. melanoxylon* co-dominates with, or is replaced by, *N. cunninghamii*. The secondary scrub occupies higher slopes generally >300 m above sea level where *A. melanoxylon* may co-dominate with Satinwood *Nematolepis squamea* (Labill.) Paul G. Wilson subsp. *squamea* . The secondary scrub community is a product of extensive land clearing in the late 1800s and, associated with this, frequent bushfires were reported from 1886–1939 (Williams 1977; Mortlock and Dargavel 1989). Fire and/or mechanical soil disturbance may stimulate mass germination of soil-stored *A. melanoxylon* seed (Harris 1989; Jenning and Dawson 1998) which, unlike eucalypt seed, retains its viability for many decades. These factors have no doubt contributed to the exclusion of eucalypts in the secondary scrub community.

Tracheophyte (vascular plant) nomenclature follows Ross and Walsh (2003). Bryophyte nomenclature follows Streimann and Klazenga (2002) and McCarthy (2003). The term liverwort is used hereafter to include hornworts. Authorship for each taxon recorded within a quadrat is provided within Appendix 1 and 2.

Sampling

Forty candidate survey sites were selected using unpublished *Hardwood Stand Class* and *Rainforest Dominant Structural Overstorey* maps (Victorian Department of Conservation, Forests and Lands c. 1981, 1988). No sites were selected south of 38° 48' 30" due to limited access within the national park and the increasing patchiness of the target plant communities. A random number generator was used to select 19 sites comprising 16 within the Great Otway National Park and three within the Aire Valley Softwood Plantation. The 19 sites were examined to ensure they did not contain the dominant trees of Wet Forest (*E. regnans*) or Cool Temperate Rainforest (*N. cunninghamii*). Of the 19 sites, 10 were selected within gullies and the remainder on upper slopes. Gully sites were included in the study only if they lacked evidence of recent logging or fire (e.g. snig tracks, cut eucalypt trunks or charcoal). Upslope sites were selected away from major drainage lines and often contained younger Blackwoods with small crowns on top of tall slender trunks (a low crown / stem ratio). Larger Blackwood stands were sampled in preference to smaller patches where possible.

Sampling was undertaken in November 2002 and was confined to 20 m x 20 m quadrats at each site (following Cameron and Turner 1996). Quadrats were placed in the centre of a selected gully site and at least 30 m from any obvious edge, such as adjoining eucalypt forest, in upslope sites. All tracheophytes recorded within each quadrat were assigned to an estimated projective foliage cover/abundance interval using the Braun-Blanquet (1965) scale. In addition, nine 2 m x 2 m sub-plots were placed within each quadrat to sample bryophyte, tracheophyte and substrate presence, with one sub-plot in each corner, one half way along each side and one at the centre of the quadrat. Sub-plots were used to obtain a measure of the frequency of occurrence of each plant taxon and substrate type. They were also used to estimate average percentage cover of bare soil to the nearest 10% (negligible cover was recorded as 1%). Bryophytes were separated during collection according to the 11 substrate types on which they were found: eight vascular plant taxa (up to 2 m from the ground), soil, rock and decaying wood. The number of bryophyte samples was no less than 45 for any one substrate across all sites. Decaying wood included any species that developed stems greater than three centimetres in diameter which were in a sufficient state of decomposition that the characteristic surface texture of that species was lost. The presence of substrates was recorded in each sub-plot regardless of bryophyte occupancy. Recently fallen branches from the tree canopy were not sampled. Large Blackwood trunks on the ground were included as decaying wood where there was evidence that they had not recently fallen. Other environmental data were collected for each quadrat including projective canopy cover (to the nearest 10%), slope and aspect. Aspect was assigned to 22.5 degree intervals weighted in favour of east (east 2, north and south 1, west 0) and south (south 2, east and west 1, north 0).

Data Analysis

T-tests or Mann-Whitney U tests were used to compare means of percentage occurrence (frequency) for plant taxa, substrates and other environmental variables in each forest type. Data were arcsine transformed where necessary for the former. Ordination of sites was performed on percentage occurrence of plant taxa using Multidimensional Scaling of log transformed data using the Bray-Curtis coefficient. Analysis of Similarity was used to test differences in the percentage occurrence of plant taxa between forest types. Similarity Percentages were generated to identify important floristic differences between each forest type. Multiple Regression Analysis was used to determine any significant relationship between bryophyte species richness and a number of predictor variables. Following examination of the data, including predictor variables and their linearity with bryophyte species richness, a selection of variables was chosen to be included in the model. These were slope, vascular species richness, number of substrates and the incidence of *A. melanoxylon*, Soft Tree-fern *Dicksonia antarctica*, decaying wood and soil with predictor variables added using the forward method. Examination of the spread of regression residuals indicated that a linear model was appropriate for the data. Cluster Analysis was performed on presence/absence data for bryophyte taxa on each substrate using the Bray-Curtis coefficient. Multiple Regression Analysis and univariate analyses were undertaken using SPSS version 14.0.1. Other multivariate analyses were undertaken using PRIMER version 5.2.0.

Results

A total of 88 bryophyte taxa was recorded across all sites compared with 51 tracheophyte taxa. The bryophyte taxa represent 66 genera and 40 families (Appendix 1). The most commonly represented moss family was Hookeriaceae and the most commonly represented liverwort family was Lepidoziaceae. Seven taxa (7.7%) found in upslope sites were not found in gully sites compared with 20 taxa (22%) found exclusively in gully sites. Sub-plots were not used for replication of samples, as within-sub-plot group similarity of bryophyte presence was considered too strong (Global R = 0.329, $p = 0.01$). Gully sites had a greater mean species richness, for all taxa, than upslope sites (t = 3.645, df = 17, $p = 0.002$). This pattern was also demonstrated for bryophytes alone (t = 3.226, df = 17, $p = 0.005$) but not for tracheophytes (U = 27, $p = 0.138$). Tracheophyte species richness was significantly lower than bryophyte species richness in gully (U = 0, $p = <0.01$) and upslope sites (t = 8.548, df = 18, $p = <0.001$) (Table 1). Moss species richness was significantly higher in gully sites than upslope sites (t = 2.595, df = 17, $p = 0.019$), as was liverwort species richness (t = 2.615, df = 17, $p = 0.015$).

Table 1. Plant species richness in each forest type. Values = mean (standard deviation).

	Gully		Upslope	
	4m²	36m²	4m²	36m²
Total flora	20.3 (4.12)	56.3 (8.2)	17.4 (3.68)	44.8 (5.96)
Bryophyte	13.2 (3.6)	38.6 (6.06)	10.8 (3.13)	30.1 (5.36)
Tracheophyte	7.1 (2.23)	17.7 (3.16)	6.6 (1.68)	14.7 (3.4)

Decaying wood supported a total of 72 bryophyte taxa throughout the study area (Fig. 1). This was the highest number recorded for any substrate, followed by soil (54), *D. antarctica* (50) and *A. melanoxylon* (42). The total number of bryophyte taxa recorded for any other substrate was less than 35. For each substrate type, more species of moss were recorded than liverworts.

Analysis of Similarity based on the percentage occurrence of tracheophyte taxa showed some discrimination between forest sites (Global R = 0.367, $p = 0.02$) with bryophytes contributing further towards explaining floristic differences (Global R = 0.497, $p = 0.001$). Combining both groups resulted in the clearest separation of sites according to forest type (Global R = 0.544, $p = 0.001$) as illustrated in Fig. 2.

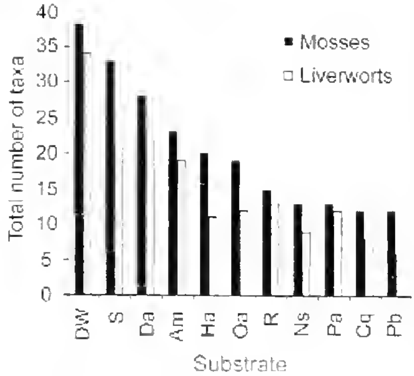

Fig. 1. Total number of moss and liverwort taxa recorded on each substrate for all sites. DW – Decaying Wood, S – Soil, Da – *Dicksonia antarctica*, Am – *Acacia melanoxylon*, Ha – *Hedycarya angustifolia*, Oa – *Olearia argophylla*, R – Rock, Ns – *Nematolepis squamea*, Pa – *Pomaderris aspera*, Cq – *Coprosma quadrifida*, Pb – *Pittosporum bicolor*.

An analysis of Similarity Percentages of bryophyte species frequency in each forest type revealed ten moss taxa and eight liverwort taxa that contributed to 50% of the cumulative percentage dissimilarity (Table 2). Greater than 90% of these taxa were present in more than 20% of all subplots. The equivalent analysis on tracheophytes revealed 11 taxa of which five were ferns and the remainder flowering plants. An analysis of Similarity Percentages of tracheophyte species cover/abundance with

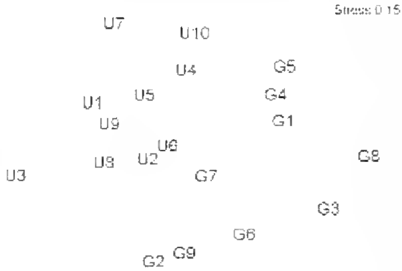

Fig. 2. Multidimensional Scaling of sites based on percentage occurrence of all plant taxa. G – Gully, U – Upslope.

Table 2. Similarity Percentages of bryophyte and tracheophyte species based on percentage occurrence in each forest type.

Av. Diss = 45.89	Gully	Upslope			
Bryophyte species	Average % abundance	Average % abundance	Average Dissimilarity	Contribution%	Cumulative %
Thuidiopsis sparsa	59.26	17.78	1.92	4.18	4.18
Achrophyllum dentatum	69.14	27.78	1.87	4.08	8.27
Plagiochila fasciculata	48.15	85.56	1.74	3.79	12.06
Lopidium concinnum	39.51	70	1.42	3.09	15.14
Metzgeria furcata	35.8	64.44	1.29	2.81	17.96
Heteroscyphus argutus	34.57	6.67	1.29	2.8	20.76
Podomitrium phyllanthus	34.57	10	1.27	2.77	23.53
Camptochaete arbuscula	62.96	38.89	1.27	2.76	26.29
Cyathophorum bulbosum	34.57	44.44	1.21	2.64	28.94
Calyptrochaeta brownii	4.94	28.89	1.2	2.6	31.54
Radula buccinifera	60.49	84.44	1.15	2.51	34.05
Ptychomnion aciculare	43.21	43.33	1.12	2.45	36.5
Heteroscyphus fissistipus	51.85	50	1.1	2.4	38.9
Weymouthia mollis	53.09	56.67	1.1	2.39	41.29
Frullania falciloba	11.11	30	1.06	2.32	43.61
Wijkia extenuata	65.43	48.89	1.04	2.28	45.88
Chiloscyphus muricatus	38.27	43.33	1.03	2.25	48.13
Weymouthia cochlearifolia	17.28	28.89	1.02	2.22	50.35

Av. Diss = 44.15	Gully	Upslope			
Tracheophyte species	Average % abundance	Average % abundance	Average Dissimilarity	Contribution%	Cumulative %
Blechnum wattsii	17.28	40	2.8	6.34	6.34
Polystichum proliferum	55.56	61.11	2.45	5.55	11.88
Dicksonia antarctica	70.37	62.22	2.33	5.27	17.16
Coprosma quadrifida	53.09	42.22	2.21	5.01	22.17
Olearia argophylla	59.26	35.56	2.09	4.73	26.91
Nematolepis squamea	0	28.89	2.08	4.71	31.62
Asplenium bulbiferum	38.27	40	2.04	4.63	36.25
Hedycarya angustifolia	16.05	23.33	1.86	4.21	40.46
Clematis aristata	38.27	30	1.8	4.07	44.53
Pomaderris aspera	24.69	0	1.75	3.96	48.49
Grammitis billardierei	14.81	27.78	1.64	3.72	52.21

the same cumulative cut-off identified the same species (with one exception) although they were ordered differently.

The three most frequently occurring bryophyte taxa were different in each forest type (Fig. 3). These taxa contribute to 50% of the cumulative percentage dissimilarity in Table 2 except for *Rhaphidorrhynchium amoenum* which had very similar percentage occurrence in each forest type.

The mean number of substrates did not vary between forest types (t = -0.901, df = 17, p = 0.38). Substrate composition was relatively consistent across forest types although results were not significant (Global R = 0.071, p = 0.141). Analysis of Similarity between the percentage occurrence of substrate types indicated some significant variation between forest types (Global R = 0.324, p = 0.002). Percentage occurrence was significantly higher for three substrates, decaying wood (t = 3.319, df = 17, p = 0.004). *D. antarctica* (t = 2.994, df = 17, p = 0.008) and soil (t = 2.1788, df = 17, p = 0.044), in gully sites. Estimated cover of soil was significantly higher in gully sites (t = 4.669, df = 17, p<0.001). The percentage occurrence of *A. melanoxylon* was significantly higher in upslope sites (U = 14.5, p = 0.011). Two substrates in upslope sites, *N. squamea* and *Pittosporum bicolor*, were not recorded in any gully sub-plots. Percentage occurrence of remaining substrate types was not significantly different between forest types (p>0.05). Canopy cover was not significantly different between forest types (t = -1.973, df = 17, p = 0.065).

Multiple Regression Analysis revealed the percentage occurrence of soil (Fig. 4) and decaying wood substrates as significant predictors of species richness for bryophytes (adjusted r^2 = 0.739, $F_{1,17}$ = 21.238, p<0.001 - Standardised Beta Coefficient for soil 0.558, p = 0.002, Standardised Beta Coefficient for decaying wood 0.466, p = 0.006). All other predictor variables were removed from the model.

Table 3 compares mean percentage occurrence of substrates between sites where the listed bryophyte taxa are present and sites where they are absent. Bryophyte taxa were chosen from a SIMPER analysis of presence/absence data between forest types and are sorted in descending order of contribution to dissimilarity (down to 50%). Those with <6 replicates were discarded. Analysis of Similarity between forest types based on bryophyte presence/absence data revealed at least some significant composition differences (Global R = 0.28, p = 0.006). Greater than

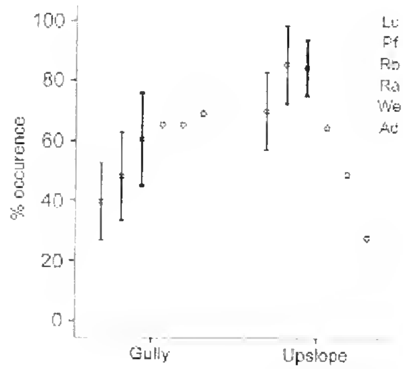

Fig. 3. The three most frequently occurring bryophyte taxa in each forest type (error bars show 1 SE). *Lc* - *Lopidium concinnum*, *Pf* - *Plagiochila fasciculata*, *Rb* - *Radula buccinifera*, *Ra* - *Rhaphidorrhynchium amoenum*, *We* - *Wijkia extenuata*, *Ad* - *Achrophyllum dentatum*. Percentage occurrence in each forest type was significantly different for each except *Ra* and *We* (p<0.05) reported relationships.

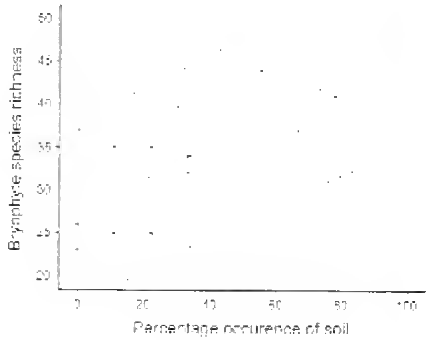

Fig. 4. Relationship between species richness and the percentage occurrence of soil at the quadrat (400 m^2) level. Outer lines show 95% confidence intervals.

Classification of substrates (Fig. 5), based on the composition of bryophyte taxa, revealed the greatest dissimilarity between rock and all other substrate types. Flowering plant substrates showed clear separation from all other substrate types at approximately 60% similarity.

Discussion

At first sight, Otway Blackwood forests are relatively homogeneous in species richness and composition of understorey tracheophytes. Understorey composition of gully stands, in particular, has close affinities with Otway Cool Temperate Rainforest (Cameron 1992; Peel 1999). The Analysis of Similarity results for tracheophyte percentage occurrence provide independent corroboration of these reported relationships.

The overwhelming contribution of bryophytes and other non-vascular cryptogams to species richness in rainforest has been reported from floristically and physiognomically similar vegetation within Victoria (Cameron and Turner 1996; Milne and Louwhoff 1999). Significant differences between tracheophyte and bryophyte species richness might therefore be anticipated in the Blackwood forests of the Otways. The present study revealed that species richness for bryophytes was almost twice that for tracheophytes. Differences observed in bryophyte species richness between forest types parallel those of Ford *et al.* (2000) for lichens in the Otway Ranges. These authors reported greater species richness in Cool Temperate Rainforest gullies with *N. cunninghamii* than in *A. melanoxylon*-dominated forest, although the difference was not statistically significant. Lichens share similar substrate types to bryophytes. Bryophyte species composition is difficult to assess visually in the field but becomes apparent through the analysis of subplot data. For example, rock bryophytes were well separated in the Cluster Analysis of substrates based on bryophyte presence across all sites. This is explained by the predominance of pluriverous taxa and the relative absence of species demonstrating a high fidelity to rock substrates.

The number of substrate types was not identified as an important predictor for bryophyte species richness. Pharo *et al.* (2004) found that there was significantly higher bryophyte species richness where there were more substrate types in drier forests of southern New South Wales. The importance of decaying wood as habitat for bryophytes and other cryptogams is well documented (Lindenmayer *et al.* 1999; Grove and Meggs 2002). In this study, we found that decaying wood provides suitable habitat for the great majority of taxa observed although, for some rare taxa, the association is based on very few samples. The range of decomposition states in decaying wood may explain the high species richness observed, particularly where decomposition is well advanced and the woody debris is developing the properties of soil. As a consequence, differences in lignicolous communities were not well defined. Soil was an important substrate for bryophytes, supporting over half of all taxa recorded. Percentage occurrence of soil was identified as the most significant predictor of bryophyte species richness. Humicolous bryophytes often extended onto the lower caudex of *D. antarctica*. These three substrates accounted for all but

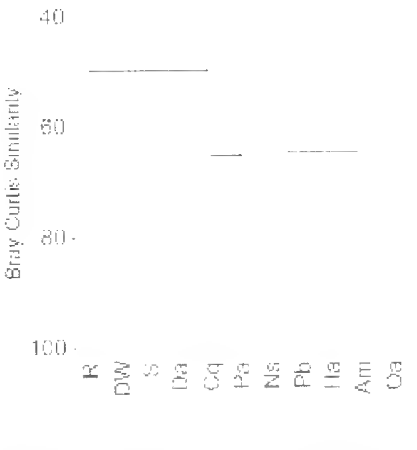

Fig. 5. Classification of substrates based on the composition of bryophyte taxa. R – Rock, DW – Decaying Wood, S – Soil, Da – *Dicksonia antarctica*, Cq – *Coprosma quadrifida*, Pa – *Pomaderris aspera*, Ns – *Nematolepis squamea*, Pb – *Pittosporum bicolor*, Ha – *Hedycarya angustifolia*, Am – *Acacia melanoxylon*, Oa – *Olearia argophylla*.

Table 3. Substrate distribution within sites based on the presence of selected bryophyte species. Absence of a symbol = the species was not found on that substrate, 0 = no significant difference, + = significantly more frequent in sites where the species was present, – = significantly less frequent in sites where the species was present ($p<0.05$).

	Greater presence	Percentage of gully or upslope sites where present.	Decaying Wood	Rock	Soil	*Acacia melanoxylon*	*Olearia argophylla*	*Dicksonia antarctica*	*Nematolepis squamea*	*Coprosma quadrifida*	*Pittosporum bicolor*	*Pomaderris aspera*	*Hedycarya angustifolia*
Goniobryum subbasilare	G	78	0		+			+					0
Aneura alterniloba	G	67	+	0	0								0
Hypnodendron vitiense	G	67	0		+			+					
Heteroscyphus argutus	G	100	+		0	0	0	0					
Rhizogonium distichum	G	89	+		0	0	0	0					
Calyptrochaeta otwayensis	G	67	+		0	0		0		0			0
Calyptrochaeta brownii	U	60	0		0	0	0	0					0
Zoopsis argentea	G	67	+		+	–		+					0
Chiloscyphus semiteres	U	80	0	0	0	0		0	0			0	0
Hypnum cupressiforme	U	60	0				0		0				
Leucobryum candidum	G	56			0	–	0	0			0		0
Paracromastigum longiscyphum	G	56	0		0			0					
Rosulabryum billarderi	G	56			0	0	0	0					
Rhynchostegium tenuifolium	G	67	0		0	0	+	0	0	0			0
Trachyloma planifolium	G	33	0		0	0		0	0	0		0	0
Megaceros gracilis	G	78	0	0	0	0	0	0					0
Podomitrium phyllanthus	G	78	0	0	0	0		0				0	0
Bazzania involuta	G	44	0			0	0	0	0				
Cheilolejeunea mimosa	U	40	0			0				0		0	
Fissidens pallidus	U	40			0								

a few taxa that were recorded in only a small number of samples. While this result suggests a parallel overlap in the habitat preferences of corticolous and humicolous species, it is likely to reflect the unique morphology, and hence physico-chemical properties, of the *Dicksonia* caudex. Variation in the percentage occurrence of any of these three substrate types has a significant influence on bryophyte species richness and composition. Soil availability has been identified as an important determinant of bryophyte species richness and composition elsewhere (Pharo and Beattie 2002). Ashton (1986) noted well developed soil bryophyte communities in Cool Temperate Rainforests of the Victorian Central Highlands.

Landscape variables associated with bryophyte distribution often include parameters such as mean annual rainfall (Fensham and Streimann 1997). Bryophyte distribution is also affected by site variables including canopy characteristics (Rambo and Muir 1998b). The two Blackwood forest types in the Otways are, by definition, separated topographically and by their contrasting disturbance histories. Canopy trees in upslope sites belonged to a single readily identifiable age class. Canopy trees in gully sites were lower branching, appeared older and there was more evidence of tree fall (possibly due to the swampy conditions). Natural disturbance caused by tree fall may contribute to the greater percentage occurrence of bare soil and decaying wood and the inferred microclimatic variability within the gully sites. It may also contribute to the quantitative reduction in the percentage occurrence of *A. melanoxylon*. Further investigation of the effects of middlestorey structure on bryophyte distribution may be useful in these forests. We found that middlestorey cover (from observation and cover/abundance values of relevant taxa) varied considerably between sites. In some sites where *A. melanoxylon* cover was relatively low, Austral Mulberry *Hedycarya angustifolia*, Musk Daisy-bush *Olearia argophylla* and *D. antarctica* compensated to provide almost complete shade for bryophyte habitats near the ground.

A significant proportion of the bryophyte taxa encountered can be regarded as truly pluriverous with samples taken from more than half the available substrate types. The three most frequently recorded taxa in each forest type are, not surprisingly, pluriverous. They are also ubiquitous geographically, with one or more of these taxa often reported as common or ubiquitous in a range of wet forests of southe-astern Australia (Scott and Stone 1976; Scott 1985; Jarman and Kantvilas 2001a, 2001b; Meagher and Fuhrer 2003). Despite being ubiquitous, the percentage occurrences of four of these taxa are significantly affected by habitat variation or microclimatic differences (or both) between the two forest types. The rarer bryophyte taxa include those less likely to tolerate major habitat disturbance as well as those with a narrow environmental amplitude. These include species listed in Table 3. The eight species with the highest contribution to compositional dissimilarity in Table 3 are present wherever the percentage occurrence of certain substrate types is significantly different from those sites where each species is absent. The substrates contributing to this pattern were also those with a significantly different percentage occurrence in each forest type.

There is convincing evidence to conclude that the two Blackwood forests are significantly different in their bryofloras. The percentage occurrences of soil, decaying wood, *D. antarctica* and *A. melanoxylon* were shown to be important factors influencing bryophyte distribution in the Blackwood forests of the Otways. More detailed investigation of the relationship between forest structure, microclimatic variables and habitat variables in Otway Blackwood forests is recommended following this preliminary study.

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Appendix 1.. Bryophyte census of Otway Blackwood Forests indicating distribution according to substrate types.

		Decaying Wood	Rock	Soil	*Acacia melanoxylon*	*Olearia argophylla*	*Dicksonia antarctica*	*Nematolepis squamea*	*Coprosma quadrifida*	*Pomaderris aspera*	*Pittosporum bicolor*	*Hedycarya angustifolia*
Bryophyta (Mosses)												
Amblystegiaceae	*Acrocladium chlamydophyllum* (Hook. f. & Wilson) Mull. Hal. & Broth.	+										
Brachytheciaceae	*Rhynchostegium tenuifolium* (Hedw.) Reichardt	+		+	+	+	+	+	+			+
Bryaceae	*Rosulabryum billarderi* (Schwaegr.) J. R. Spence			+								
Catagoniaceae	*Catagonium nitens* (Brid.) Cardot subsp. *nitens*										+	
Dicranaceae	*Dicranoloma billarderi* (Brid. ex Anon.) Paris	+		+			+					
	Dicranoloma menziesii (Taylor) Renauld	+	+		+	+	+			+	+	+
Fissidentaceae	*Fissidens curvatus* Hornsch.			+								
	Fissidens pallidus Hook. f. & Wilson			+								
	Fissidens serratus Mull. Hal var. *serratus* .	+		+								
	Fissidens taylorii Mull. Hal.		+	+								
	Fissidens tenellus Hook. f. & Wilson			+								
Hookeriaceae	*Achrophyllum dentatum* (Hook. f. & Wilson) Vitt & Crosby	+	+	+	+	+	+		+	+	+	
	Calyptrochaeta brownii (Dixon) J.K. Bartlett	+		+	+	+	+					+
	Calyptrochaeta otwayensis Streimann	+		+	+		+		+			+
	Distichophyllum crispulum (Hook. f. & Wilson) Mitt.	+	+	+								
	Distichophyllum microcarpum (Hedw.) Mitt.	+	+									
	Distichophyllum pulchellum (Hampe) Mitt.	+										
Hypnaceae	*Hypnum cupressiforme* Hedw.	+				+		+				
Hypnodendraceae	*Hypnodendron spinnervium* subsp. *archeri* (W. Mitt.) A. Touw	+	+	+			+					+
	Hypnodendron vitiense subsp. *australe* A. Touw	+		+			+					
Hypopterygiaceae	*Cyathophorum bulbosum* (Hedw.) Mull. Hal.	+	+	+	+	+	+	+	+		+	+
	Hypopterygium rotulatum spp. agg.	+		+			+					
	Lopidium concinnum (Hook.) Wilson	+	+	+	+	+	+	+	+	+	+	+

Appendix 1. (cont.) Bryophyte census of Otway Blackwood Forests indicating distribution according to substrate types .

Family	Species	Decaying Wood	Rock	Soil	*Acacia melanoxylon*	*Olearia argophylla*	*Dicksonia antarctica*	*Nematolepis squamea*	*Coprosma quadrifida*	*Pomaderris aspera*	*Pittosporum bicolor*	*Hedycarya angustifolia*
Lembophyllaceae	*Camptochaete arbuscula* (Sm.) Reichardt var. *arbuscula*	+	+	+	+	+	+	+	+		+	+
	Lembophyllum divulsum (Hook. f. & Wilson) Lindb.	+		+			+			+		
	Weymouthia cochlearifolia (Schwagr.) Dixon	+		+	+	+	+		+	+		+
	Weymouthia mollis (Hedw.) Broth.	+	+	+	+	+	+	+	+	+		+
Leucobryaceae	*Leucobryum candidum* (Brid. ex P. Beauv.) Wilson	+		+	+	+	+				+	+
Meteoriaceae	*Papillaria flavolimbata* (Mull. Hal. & Hampe) A. Jaeger	+			+							
Mitteniaceae	*Mittenia plumula* (Mitt.) Lindb.			+			+					
Neckeraceae	*Thamnobryum pumilum* (Hook. f. & Wilson) Nieuwl.		+	+			+					
Orthotrichaceae	*Macromitrium* sp.	+		+						+		
	Zygodon intermedius Bruch & Schimp.	+	+	+	+	+	+	+		+	+	+
Plagiotheciaceae	*Isopterygium limatum* (Hook. f. & Wilson) Broth.	+		+	+	+	+	+			+	+
Pottiaceae	*Barbula* sp.				+							
	Calyptopogon mnioides (Schwägr.) Broth.	+			+							
Pterobryaceae	*Trachyloma planifolium* (Hedwig) Brid.	+		+	+		+	+	+	+		+
Ptychomniaceae	*Ptychomnion aciculare* (Brid.) Mitt.	+		+	+	+	+	+		+	+	+
Racopilaceae	*Racopilum cuspidigerum* var. *convolutaceum* (Mull. Hal.) Zanten & Dijkstra	+	+	+						+		
Rhizogoniaceae	*Goniobryum subbasilare* (Hook.) Lindb.	+		+			+					+
	Hymenodon pilifer Hook. f. & Wilson		+	+	+	+	+					
	Leptotheca gaudichaudii Schwagr.			+								
	Pyrrhobryum mnioides subsp. *contortum* (Wilson) Fife	+										
	Pyrrhobryum paramattense (Mull. Hal.) Manuel	+		+								
	Rhizogonium distichum (Sw.) Brid.	+		+	+	+	+					
Sematophyllaceae	*Rhaphidorrhynchium amoenum* (Hedw.) M. Fleisch.	+		+	+	+	+	+	+		+	+
	Wijkia extenuata (Brid.) H.A. Crum	+		+	+	+	+	+	+	+	+	+
Thuidiaceae	*Thuidiopsis furfurosa* (Hook.f. et Wilson) M. Fleisch.	+										
	Thuidiopsis sparsa (Hook. f. & Wilson) Broth.	+	+		+	+	+	+	+	+	+	+

Hepatophyta (Liverworts / Hornworts)

Schistochilaceae	*Schistochila lehmanniana* (Lindenb.) Steph.	+										
Acrobolbaceae	*Tylimanthus diversifolius* E.A. Hodgs.						+					
	Tylimanthus tenellus (Hook. f. & Taylor) Mitt.						+					
Adelanthaceae	*Adelanthus bisetulus* (Steph.) Grolle	+										
Aneuraceae	*Aneura alterniloba* (Hook. f. & Taylor) Taylor & Hook. f.	+	+	+								+
Anthocerotaceae	*Phaeoceros* sp.	+	+	+			+					
	Megaceros gracilis (Reichardt) Stephani	+	+	+	+	+	+					+
Frullaniaceae	*Frullania deplanata* Mitt.	+						+	+	+		
	Frullania falciloba Taylor ex Lehm.	+			+	+	+	+	+	+	+	
Geocalycaceae	*Cyanolophocolea echinella* (Lindenb. & Gottsche) R. M. Schust.	+	+				+					
	Chiloscyphus muricatus (Lehm.) J.J. Engel & R.M. Schust.	+	+	+	+	+	+	+	+	+	+	+
	Chiloscyphus semiteres (Lehm. & Lindenb.) Lehm. & Lindenb.	+	+	+	+		+	+		+		+
	Chiloscyphus sp.	+										
	Heteroscyphus argutus (Reinw., Blume & Nees) Schiffn.	+		+	+	+	+					
	Heteroscyphus coalitus (Hook.) Schiffn.	+		+								
	Heteroscyphus fissistipus (Hook. f. & Taylor) Schiffn.	+	+	+	+	+	+	+		+	+	+
Hymenophytaceae	*Hymenophyton flabellatum* (Labill.) Dumort. ex Trevis.	+		+	+							
Lejeuneaceae	*Cheilolejeunea mimosa* (Hook. f. & Taylor) R.M. Schust.	+			+				+	+		
	Lejeunea drummondii Taylor					+						+
	Lejeunea sp.	+		+	+					+		
	Nephelolejeunea hamata Grolle	+		+	+		+		+	+		
Lepidoziaceae	*Acromastigum colensoanum* (Mitt.) A. Evans ex Reimers						+					
	Bazzania involuta (Mont.) Trevis.	+			+	+	+	+				
	Kurzia hippurioides (Hook.f. & Taylor) Groll	+										
	Lepidozia glaucophylla (Hook. f. & Taylor) Taylor ex Gottsche	+		+		+	+					
	Lepidozia sp.	+		+	+	+						
	Paracromastigum longiscyphum (Taylor) R.M. Schust. & J.J. Engel	+		+			+					
	Psiloclada clandestina. Mitt. var. *clandestina*	+		+	+		+					
	Telaranea centipes (Taylor ex Gottsche et al.) R.M. Schust.	+										
	Zoopsis argentea (Hook. f. & Taylor) Hook. f. ex Gottsche	+		+	+		+					+
Metzgeriaceae	*Metzgeria furcata* (L.) Dumort.	+	+	+	+	+		+	+	+	+	+
	Metzgeria sp.		+		+							
Pallaviciniaceae	*Podomitrium phyllanthus* (Hook.) Mitt.	+	+	+	+		+			+		+
	Symphyogyna podophylla (Thunb.) Mont. & Nees	+	+	+			+					
Plagiochilaceae	*Plagiochila fasciculata* Lindenb.	+	+	+	+	+	+	+	+	+	+	+
	Plagiochila strombifolia Taylor ex Lehm.	+										
Pseudolepicoleaceae	*Temnoma* sp.	+										
Radulaceae	*Radula buccinifera* (Hook. f. & Taylor) Taylor ex Gottsche	+	+	+	+	+	+	+	+	+	+	+
Trichocoleaceae	*Trichocolea mollissima* (Hook. f. & Taylor) Gottsche	+					+					

Appendix 2. Tracheophyte census of Otway Blackwood Forests.

Pteridophyta (Ferns)

Aspleniaceae	*Asplenium bulbiferum* subsp. *gracillimum* (Colenso) Brownsey
	Asplenium flabellifolium Cav.
	Asplenium flaccidum G. Forst. subsp. *flaccidum*
Blechnaceae	*Blechnum cartilagineum* Sw.
	Blechnum chambersii Tindale
	Blechnum fluviatile (R. Br.) E. J. Lowe ex Saloman
	Blechnum nudum (Labill.) Mett. ex Luerss.
	Blechnum wattsii Tindale
Cyatheaceae	*Cyathea australis* (R. Br.) Domin
Dennstaedtiaceae	*Histiopteris incisa* (Thunb.) J. Sm.
Dicksoniaceae	*Dicksonia antarctica* Labill.
Dryopteridaceae	*Polystichum proliferum* (R. Br.) C. Presl
	Rumohra adiantiformis (G. Forst.) Ching
Grammitidaceae	*Ctenopteris heterophylla* (Labill.) Tindale
	Grammitis billardierei Willd.
Hymenophyllaceae	*Crepidomanes venosum* (R. Br.) Bostock
	Hymenophyllum australe Willd.
	Hymenophyllum cupressiforme Labill.
	Hymenophyllum flabellatum Labill.
	Hymenophyllum rarum R. Br.
Polypodiaceae	*Microsorum pustulatum* (G. Forst.) Copel. subsp. *pustulatum*

Magnoliophyta (Flowering plants)

Liliopsida (Monocotyledons)

Cyperaceae	*Carex appressa* R. Br.
	Lepidosperma elatius Labill.
	Uncinia tenella R. Br.
Orchidaceae	*Pterostylis pedunculata* R. Br.
	Sarcochilus australis (Lindl.) Rchb. f.
	Chiloglottis cornuta Hook f.
Poaceae	*Tetrarrhena juncea* R. Br.

Magnoliopsida (Dicotyledons)

Apiaceae	*Hydrocotyle hirta* A. Rich.
Apocynaceae	*Parsonsia brownii* (Britten) Pichon
Araliaceae	*Polyscias sambucifolia* (Sieber ex DC.) Harms
Asteraceae	*Bedfordia arborescens* Hochr.
	Olearia argophylla (Labill.) Benth.
	Olearia lirata (Sims) Hutch.
Caprifoliaceae	*Sambucus gaudichaudiana* DC.
Mimosaceae	*Acacia melanoxylon* R. Br.
Monimiaceae	*Hedycarya angustifolia* R. Cunn.
Oleaceae	*Notelaea ligustrina* Vent.
Pittosporaceae	*Pittosporum bicolor* Hook.
Proteaceae	*Lomatia fraseri* R. Br.
Ranunculaceae	*Clematis aristata* R. Br. ex Ker Gawl
Rhamnaceae	*Pomaderris aspera* Sieber ex DC.
Rosaceae	**Rubus polyanthemus* Lindeb.
Rubiaceae	*Coprosma quadrifida* (Labill.) B.L. Rob.
Rutaceae	*Correa lawrenceana* var. *latrobeana* (F. Muell.ex Hannaford) Paul G. Wilson
	Nematolepis squamea (Labill.) Paul. G. Wilson subsp. *squamea*
Solanaceae	*Solanum laciniatum* Aiton
Thymelaeaceae	*Pimelea axiflora* F. Muell. ex Meisn. subsp. *axiflora*
Urticaceae	*Australina pusilla* subsp. *muelleri* (Wedd.) Friss & Wilmot-Dear
	Urtica incisa Poir. in Lam.
Winteraceae	*Tasmannia lanceolata* (Poir.) Baill.

Plagiochila strombifolia is a common epiphytic liverwort of wet forests and other damp habitats. The leaves are fan-shaped as the lower edge of each is rolled under. They smell like parsnip when crushed. This species is mentioned in the papers by Dell and Jenkins, and Carrigan. Photograph by Matthew Dell.

Dicranoloma billarderi is a moss characteristic of wet forests. The long, slender leaves characteristically curve to one side. Sporophytes are common. This species is mentioned in several papers in this issue: by Carrigan, Dell and Jenkins, and Floyed and Gibson. Photograph by Matthew Dell.

The sexual reproduction and phenology of *Atrichum androgynum* (Müll.Hal.) A.Jaeger

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Abstract
Two populations of *Atrichum androgynum* (Müll.Hal.) A.Jaeger from differing habitats were investigated. Within both populations perichaetia were observed more frequently than perigonia, although the number of antheridia was greater than the number of archegonia. A clear seasonality in the sequence and timing of sexual reproduction occurred, with little variation due to habitat. Antheridia began development in spring, after sporophytes had reached maturity. Initiation of archegonial development occurred approximately one month later. Spores were isosporic and 3 µm in diameter. Release of mature spores peaked in spring. The sporophyte maturation cycle of *A. androgynum* was 12 months. (*The Victorian Naturalist* **123** (4), 2006, 270-278)

Introduction

There was little quantitative research on the developmental stages of gametangia and sporophyte production (Forman 1965; Mishler 1988) until Greene (1960) produced the concept of the Maturation Index, which was later modified by Longton and Greene (1969a). This provided a single means of comparison for the sequence and timing of developmental stages for both gametangia and sporophyte production (Forman 1965; Greene 1960), making assessment of the reproductive cycle of mosses easier. A number of studies have used Greene's Maturation Index or a modified version of it (Hancock and Brassard 1974; Imura 1994; Longton and Greene 1969a and b; Mishler 1991). Modification can be necessary depending on the nature of the moss under investigation. The Maturation Index also provides ways to compare species from selected geographical areas (Greene 1960; Longton and Greene 1969a and b) and within single habitats, allowing detailed examination of environmental factors affecting populations and individual gametophytes under field or laboratory conditions (Longton and Greene 1969a).

Atrichum androgynum is a cosmopolitan moss found in south-east Australia, New Zealand, South Africa and Central and South America (Nyholm 1971; Scott and Stone 1976). It grows on shaded forest floors and moist embankments in Wet Sclerophyll Forest and Cool Temperate Rainforest (Beever *et al.* 1992; Nyholm 1971) although it occasionally occurs in more open areas such as along creek margins and in canopy gaps (Jarman and Fuhrer 1995). *Atrichum androgynum* is an erect moss ranging from four to eight centimetres in height. It is polysetous with an average of one to five sporophytes (Nyholm 1971; Scott and Stone 1976).

Atrichum androgynum belongs to the family Polytrichaceae, which has 24 genera and approximately 300 species world wide. In Australia there are eight genera and 23 species, 10 of which are endemic (Streimann and Klazenga 2002).

In this study the reproductive biology and phenology of *A. androgynum* was investigated within a Cool Temperate Rainforest in Victoria. The aims of the study were to investigate the sequence and timing of the sexual reproductive cycle and to determine the male to female stem ratio.

Methods

Two populations were investigated at Cement Creek Turntable, situated in the Yarra Ranges National Park, 69 km north-east of Melbourne. The park consists of about 75 000 hectares of relatively unmodified bushland and is surrounded by state forest. The creek transects the park and contains Wet Sclerophyll Forest with pockets of Cool Temperate Rainforest, dominated by *Eucalyptus regnans* F.Muell. and *Nothofagus cunninghamii* (Hook.)

Oerst. *Dicksonia antarctica* Labill. and *Cyathea australis* R.Br. make up the understorey, while ground cover principally consists of *Blechnum watsii* Tindale and various species of *Hypolepis* Bernhardi.

Site one was within a canopy gap of mature rainforest and consisted of three loosely connected colonies of *A. androgynum*, with one colony prone to flooding after rain. Site two was a single but exceptionally large and dense colony beneath a closed canopy. The colony occurred at the base of a small embankment and stayed moist through seepage.

Climatic conditions in the Yarra Ranges National Park are influenced by topography and altitude: 652.8 mm of rain was experienced from the beginning of 2002 until September 2002. The highest rainfall recorded was in July 2002, at 126.7 mm, with the lowest rainfall occurring in March 2002. However, there was a significant decrease in rainfall from 2001 to 2002.

Within the Yarra Ranges National Park summers are often dry, and the danger of fire is common with irregular north-westerly winds (Maxwell 1997). Mean summer temperatures in 2002 were approximately 21 °C with the highest temperature occurring during summer at 21.9 °C. Snow often falls during winter, although it does not last long (Maxwell 1997). The lowest winter temperature recorded was 5 °C (August 2002).

Sixty stems from each site were sampled randomly at fortnightly intervals beginning 21 March 2002 until 27 February 2003. Specimens from each site were placed into labelled envelopes and stored in a refrigerator at 4 °C for one to four days until examined.

Each stem was examined for the presence of perichaetia (groups of specialized leaves surrounding the female reproductive organs) and perigonia (groups of specialized leaves surrounding the male reproductive organs). If present they were counted and excised, and archegonia (female reproductive organs) and antheridia (male reproductive organs) dissected from them. The number of archegonia and antheridia per perichaetium and perigonium respectively were counted and assigned a maturation stage and index value using a modified version of Longton and Greene's (1969b) Maturation Index for gametangia and sporophytes (Table 1 and Fig. 1). From this a population average maturation index value was determined each fortnight for both the antheridia and archegonia. Antheridia and archegonia that were aborted or from a previous cycle were noted but not included in the population average. When present, sporophytes also were assigned a maturity index value and a population average was determined. Sporophytes that were aborted or persistent from the previous cycle also were recorded but not included in the population average. Stems were examined for any specialized asexual propagules, for example gemmae, rhizoidal gemmae, brood bodies and fragments from stems or caducous leaves.

Results

Stems normally exhibited either the male or female sexual state (Fig. 2), however, four out of nearly 3000 stems were bisexual. Male and female stems were identical in form and therefore could not be distinguished unless they were fertile. Male and female stems occurred at both populations; however, female stems were dominant. Within site one, 664 female stems were observed compared to only 116 male stems. 703 stems were of unknown sexuality as they were not fertile. At site two, the number of female stems was slightly lower than at site one, with 603 female stems. The number of male stems in site two was similar to site one with 120 stems, a difference of only four stems. At site two 713 stems were of unknown sex.

The number of antheridia per perigonium ranged from one to 100 in site one and one to 80 in site two (Table 2). At site one, 21–30 antheridia per perigonium were common, compared to 11–20 antheridia per perigonium at site two. Site one had a higher number of perigonia with a total of 118, while site two had 83 perigonia. Perigonia had been noted since the beginning of the study but these were from a previous cycle and were empty except on one occasion in August 2002. The antheridium present was brown with a ruptured apex. Antheridia in the Juvenile stage were first observed in Septemher 2002. Progression of the initial stage was rapid (Fig. 3) and Immature antheridia were observed within two weeks at both site one

Table 1. Stages of gametangial and sporophyte development (Modified version of Longton and Greene 1969b).

Phenostage value	**Index**	**Description**
Gametangia		
(J) Juvenile	1	Gametangia become visible
(I) Immature	2	Gametangia reach half length of dehisced gametangia
(M) Mature	3	Apices of gametangia rupture. Archegonia become receptive for fertilisation and liberation of antherozoids begins
(D) Dehisced	4	Development of brown colouration begins in gametangia at ruptured apices
(A) Aborted	#	Development of brown or hyaline colouration begins in gametangia with unruptured apices in J or I stages
Sporophytes		
(SV) Swollen venter	1	Venter of archegonium begins to swell
(ESV) Elongated swollen venter	2	Venter is elongated with apex still attached
(ECP) Early calyptra in perichaetium	3	Calyptra visible within perichaetium bracts
(LCP) Late calyptra in perichaetium	4	Calyptra becomes half exserted from perichaetial bracts
(ECI) Early calyptra intact	5	Calyptra becomes fully exserted from perichaetial bracts
(LCI) Late calyptra intact	6	Swelling of capsule begins
(EOI) Early operculum intact	7	Operculum green in colour
(OI) Operculum intact	8	Operculum becomes brown in colour
(LOI) Late operculum intact	9	Capsule becomes brown in colour
(OF) Operculum fallen	10	Operculum falls
(EF) Empty and fresh	11	75% of spores have been shed
(A) Aborted	#	Apex of sporophyte withers prior to spore formation usually in ECP, LCP or ECI

and two (October 2002). Development slowed for a period of two and a half months at site two and three months at site one (October to December 2002), until maturity was reached. Antheridia took approximately five months to mature.

The number of archegonia per perichaetium was much lower than that of antheridia per perigonium. The range of archegonia per perichaetium was from one to 34, although one archegonium per perichaetium was more common. Fertile perichaetia of site one had considerably more archegonia than those at site two, where one to seven archegonia per perichaetium was common, compared to one to four for site two (Table 3).

Archegonial development began later than antheridial development, with Juvenile and Immature archegonia first recorded in October 2002, at both site one and site two. Mature archegonia were first recorded in site two in early December 2002, approximately six weeks after Immature archegonia were first observed. At site one, Mature archegonia occurred two months (late December 2002) after the initiation of Immature archegonia. Maturation of archegonia took approximately four months, from late spring to summer (Fig. 4).

Fifty-five percent of stems bore sporophytes in site one, as opposed to 45% in site two. Polysety was common within both populations but occurred to a greater extent at site one, where one to 32 sporophytes per perichaetium occurred although only one to six was common (Table 4). Site two had only one to six sporophytes per perichaetium but only one to three was common (Table 4). The occurrence of a single sporophyte per perichaetium, however, was more common than polysety in either site. Site one had 174 gametophytes with one sporophyte, while in site two 290 gametophytes were observed with one sporophyte (Table 4).

The sequence and timing of sporophyte development was similar for each site (Table 5). At the beginning of the study, sporophytes at the young phenostages (Early Calyptra Intact, Late Calyptra Intact, Early Operculum Intact and Operculum Intact) were observed. In site

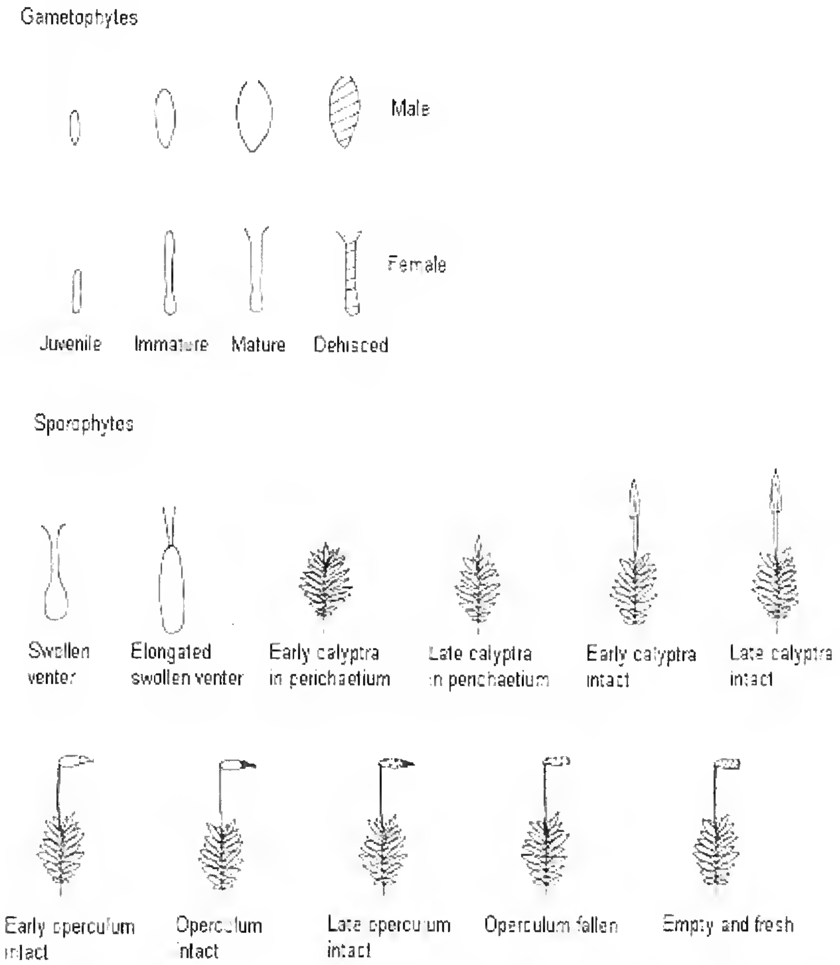

Fig. 1. Diagrammatic version of gametangial and sporophytic maturation table (based on the concept of Longton and Greene, 1969b).

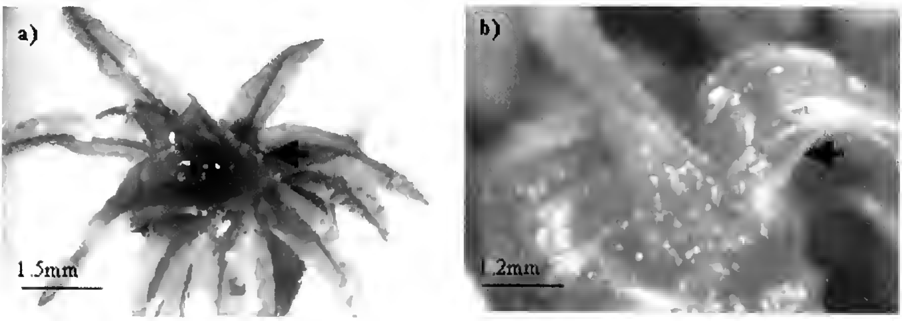

Fig. 2. a. Perigonial leaves (arrowed) and **b.** perichaetial leaves (arrowed) of *Atrichum androgynum*.

Table 2. Variation in the number of antheridia per perigonium in *Atrichum androgynum*, Cement Creek, Victoria.

Number of antheridia per perigonium	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	Total
Site 1	12	20	22	20	15	10	9	7	2	1	118
Site 2	14	25	21	12	5	5		1			83
Total	26	45	43	32	20	15	9	8	2	1	

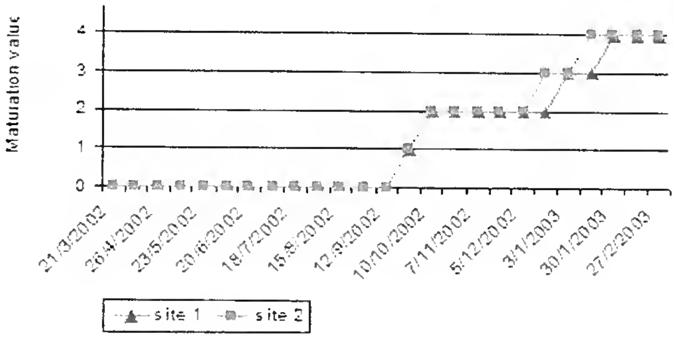

Fig. 3. Antheridial development in *Atrichum androgynum* at Cement Creek, Victoria, 2002-2003.

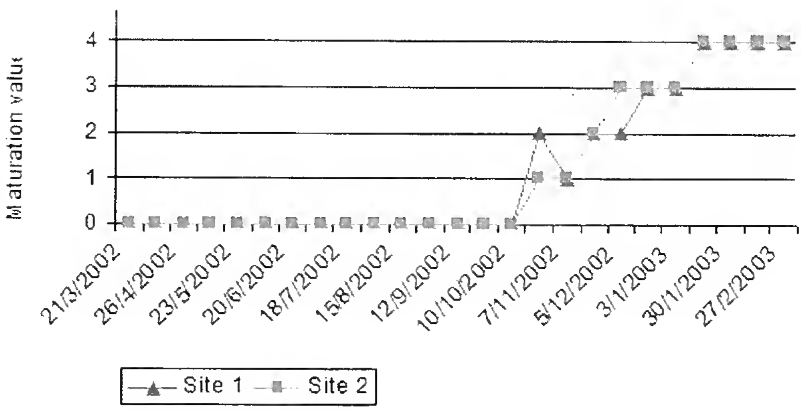

Fig. 4. Archegonial development in *Atrichum androgynum* at Cement Creek, Victoria, 2002-2003.

Table 3. Variation in the number of archegonia per perichaetium in *Atrichum androgynum*, Cement Creek, Victoria.

Number of archegonia per perichaetium	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15-19	20-24	25-29	30-34	Total
Site 1	72	72	62	51	61	45	35	23	17	11	8	9	3	4	1	3		1	478
Site 2	117	83	53	28	13	13	10	6	2	4		1	1		1				332
Total	189	155	115	79	74	58	45	29	19	15	8	10	4	4	2	3		1	810

Table 4. Variation in the number of sporophytes per perichaetium in *Atrichum androgynum*, Cement Creek, Victoria.

Number of sporophytes per perichaetium	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	32	Total
Site 1	174	139	76	56	39	26	16	10	4	8	3	3	1	2		1	1	1	560
Site 2	290	152	40	17	7	7													513
Total	464	291	116	73	46	33	16	10	4	8	3	3	1	2		1	1	1	1073

one, young sporophytes occurred during autumn, while in site two, young sporophytes occurred from late summer – autumn (2002). Mature sporophytes (Late Operculum Intact, Operculum Fallen and Empty and Fresh) were observed from winter to early summer at site one and late autumn to early summer (2002) at site two. Immature sporophytes (Early Swollen Venter, Early Calyptra in Perichaetium and Late Calyptra in Perichaetium) were not present until 2003; development occurred during the summer months. Progress of one phenostage to the next slowed with development. For example, Early Calyptra Intact and Late Calyptra Intact lasted for only two weeks. Early Operculum Intact lasted for two to four weeks. Operculum Intact lasted for four to six weeks and Late Operculum Intact lasted for ten weeks. Overall, sporophyte development took 12 months.

Only one spore size occurred. These spores were approximately 3 µm in size and had wart-like protruberances (Fig. 5). Spore release occurred via the peristome teeth and epiphragm (see Fig. 3 in Tyshing and Gibson, this issue), which slow down dispersal, allowing spore release over a longer period of time compared to spore release en masse via explosive expulsion. Spore release in *A. androgynum* began in winter and ended in spring, lasting approximately three months.

No specialised form of asexual reproduction was observed within either population.

Discussion

It is not surprising that *Atrichum androgynum* showed seasonality in the sequence and timing of gametangial and sporophytic development as this is known for many mosses (Longton and Greene 1969a and b; Miles *et al.* 1989; Stark 1985). Even specimens of a single species from two extremely diverse environments, such as polar (sub-arctic and sub-antarctic) and temperate habitats, showed little variation in the timing of events (Miles *et al.* 1989). Other Australian species also demonstrate defined seasonal patterns of development for gametangia and sporophytes, e.g. *Dicranoloma billardierei* (Brid. ex Anon.)

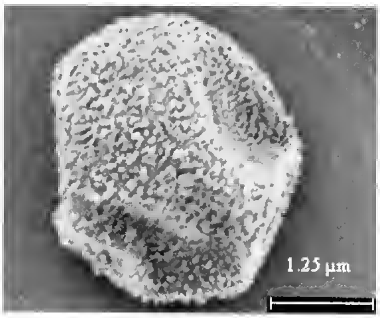

Fig. 5. Spore of *Atrichum androgynum* with wart-like protuberances.

Table 5. Seasonal events of the sexual reproductive cycle of *Atrichum androgynum*. I = initiation of antheridia/archegonia, M = mature antheridia/archegonia, YS = young sporophytes, MS = mature sporophytes and SD = spore dispersal.

	Spring	Summer	Autumn	Winter	Spring	Summer
Site one	I ♂, ♀ I	♂ M, ♀ M	YS	MS	SD	
Site two	I ♂, ♀ I	♂ M, ♀ M, YS	MS		SD	

Paris, *D. platycaulon* Dixon and *D. menziesii* (Taylor) Renauld (Milne 2001), and *Wijkia extenuata* (Sinclair 1999; Sinclair and Gibson 2000). In some species, e.g. *Grimmia pulvinata* (Hedw.) Sm. and *Tortula muralis* Hedw., the sporophytic cycle is seasonal, while the gametangial cycle is not (Miles *et al.* 1989). In these species, Juvenile, Immature and Dehisced stages of gametangia occur throughout the year, and although archegonia are fertilised throughout the year. sporophyte development is strictly seasonal (Miles *et al.* 1989). Other species such as *Funaria hygrometrica* Hedw. show no seasonality in either gametangial or sporophytic development (Longton 1976; B Sinclair and M Gibson pers. obs.), but this is a fugitive species and can produce sporophytes at any time of the year (B Sinclair and M Gibson pers. obs.).

In *A. androgynum*, antheridial development was seasonal with no antheridia noted until spring, when they occurred at the juvenile and immature stages in large numbers. In many species, archegonia begin development after antheridia (Miles *et al.* 1989), with antheridial development taking considerably longer. This also was the case with *A. androgynum*.

The reasons that antheridia often develop over considerably longer periods than archegonia are twofold. Firstly, perigonia often produce larger numbers of antheridia compared to the numbers of archegonia produced by perichaetia, especially in species with separate male and female stems (Longton and Greene 1969a and b; Stark 1997; Stark *et al.* 2000). This is not surprising as perichaetial leaves are usually smaller than perigonial leaves (Wyatt 1977), thus cannot contain as many archegonia compared to antheridia in perigonia. The higher number of antheridia per perigonium would result in higher sperm numbers and so would aid in maximizing the number of archegonia fertilised within a colony. The reverse, however, does occur. Milne (2001) found that *D. billarderi* and *D. menziesii* produced more archegonia per perichaetium than antheridia per perigonium and attributed this to the absence of specialised structures, such as splash cups, to aid in sperm transfer. *Atrichum androgynum* does not have the well-developed splash cups of *Polytrichum juniperum* Hedw., for example, but the perigonial leaves are arranged in such a way that they provide a good facsimile of a splash cup, and facilitate sperm transfer in the same manner. The second reason that antheridia often take longer to develop than archegonia is that there is a greater number of cells produced within antheridia than within archegonia (Stark 1997), i.e. many sperm occur within antheridia and the sperm cell is quite complex (Imura 1994).

Sporophytic development of *A. androgynum* showed seasonal trends. This was not unusual as other species also have shown seasonal patterns of sporophyte development (e.g. Imura 1994; Miles *et al.* 1989; Milne 2001). The sporophyte development of *A. androgynum* occurred over a 12 month period. There is much variation in length of time required for sporophyte development from a matter of months to years so, again, this is not unusual. *Dicranoloma billarderi* takes 20 months for sporophytes to mature, *Pleurozium schreberi* (Brid.) Mitt. 13 months (Longton and Greene 1969a), *D. menziesii* 10-12 months (Milne 2001), *Wijkia. extenuata* (Brid.) Crum. nine months (Sinclair 1999), and *F. hygrometrica* less than two months (B Sinclair and M Gibson pers. obs.).

Many species produce large numbers of archegonia within each perichaetium, and although many can be fertilised, usually only one sporophyte reaches maturity (Stark and Castetter 1995). Similarly, although *A. androgynum* is polysetous, the majority of sporophytes at the swollen venter stage abort. Further loss of sporophytes occurs with subsequent development. This is common in many polysetous mosses (Stark 1983).

Spore dispersal can occur over a long period of time. In *Syntrichia inermis* Brid., spores were dispersed over a one-year period (Stark 1997). In *Dicranoloma* species it continued for several months (Milne 2001). In *A. androgynum* spore release began in winter and peaked in late spring.

Often, studies do not indicate whether specialised forms of vegetative propagation have occurred, and those that do simply state the form of asexual reproduction but not how it varies with time and/or season.

This study examined each stem of *A. androgynum* collected to determine whether any specialised forms of asexual reproduction occurred, but none was found. Asexual reproduction is important for colony expansion and gap-filling within colonies (Kimmerer 1991). The latter is particularly important as gaps within colonies can result in the death of the colony.

Phenological studies on bryophytes are few, especially within Australia. Knowledge of the reproduction of bryophytes aids in understanding their survival strategies in environments that are continually changing and becoming more fragmented, a constant problem in Australia and elsewhere. Knowledge of the reproductive biology of bryophytes aids in correct conservation management and the long-term sustainability of a species.

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Stream bryophytes in Victorian rainforest streams

Stream bryophytes potentially constitute a major part of the autotrophic biomass in stream ecosystems. They are generally more abundant in cool streams with a strong current as many require carbon dioxide, which is available in an adequate supply due to turbulence, for photosynthesis. Bryophyte abundance is higher in streams that have a uniform and stable substratum. On stream rocks, bryophyte species richness is variable, with areas submerged having quite low species richness. The area at and just above the water line has a sharp increase in bryophyte species richness and consists mainly of facultatively aquatic species.

Stream bryophytes are common in Victorian rainforest streams (Fig. 1), occurring on rocks, logs and sediment. However, research into stream bryophytes is limited compared to the amount of research dealing with their terrestrial counterparts. This is surprising considering their abundance and diversity, especially in

Table 1. Preliminary list of bryophyte species identified in Victorian rainforest streams.

Bryophyta

Achrophyllum dentatum (Hook.f. & Wilson) Vitt & Crosby
Atrichum androgynum (Müll.Hal.) A.Jaeger
Camptochaete arbuscula (Sm.) Reichardt var. *arbuscula*
Catagonium nitens (Brid.) Cardot subsp. *nitens*
Cyathophorum bulbosum (Hedw.) Müll.Hal.
Dicranoloma billarderi (Brid. Ex Anon.)Paris
Dicranoloma menziesii (Taylor) Renauld var. *menziesii*
Fallaciella gracilis (Hook.f. & Wilson) H.A. Crum
Fissidens dietrichiae Müll.Hal.
Fissidens rigidulus Hook.f. & Wilson var. *rigidulus*
Fissidens taylorii Müll.Hal.
Fissidens tenellus Hook.f. & Wilson
Hypnodendron comosum (Labill.) Mitt. var. *sieberi* (Müll.Hal.) Touw
Hypnodendron spininervium (Hook.) A.Jaeger & Sauerb. subsp. *archeri* (Mitt.) Touw
Hypnodendron vitiense Mitt. subsp. *australe* Touw
Hypopterygium tamarisci (Sw.) Brid. ex Müll. Hal.
Mesochaete undulata Lindb.
Pseudoleskiopsis imbricata (Hook.f. & Wilson) Thér.
Ptychomnion aciculare (Brid.) Mitt.
Pyrrhobryum mnioides (Hook.) Manuel subsp. *contortum* (Wilson) Fife
Racopilum cuspidigerum (Schwägr.) Ångstr. var. *convolutaceum* (Müll.Hal.) Zanten & Dijkstra
Rosulabryum billarderi (Schwägr.) J.R. Spence
Sematophyllum homomallum (Hampe) Broth.
Thamnobryum pumilum (Hook.f. & Wilson) Nieuwl.
Thuidiopsis furfurosa (Hook.f. & Wilson) M.Fleisch.
Wijkia extenuata (Brid.) H.A.Crum

Hepatophyta

Aneura alterniloba (Hook.f. & Taylor) Taylor & Hook.f.
Bazzania adnexa (Lehm. & Lindenb.) Trevis.
Chiloscyphus semiteres (Lehm. & Lindenb.) Lehm. & Lindenb. var. *semiteres*
Geocalyx caledonicus Steph.
Heteroscyphus coalitus (Hook.) Schiffn.
Heteroscyphus fissistipus (Hook.f. & Taylor) Schiffn.
Heteroscyphus planiusculus (Hook.f. & Taylor) J.J.Engel
Hymenophyton flabellatum (Labill.) Dumort. ex Trevis.
Lepidozia laevifolia (Hook.f. & Taylor) Taylor ex Gottsche, Lindenb. & Nees var. *laevifolia*
Lepidozia ulothrix (Schwaegr.) Lindenb.
Lunularia cruciata (L.) Dumort.
Marchantia berteroana Lehm. & Lindenb.
Marchantia foliacea Mitt.
Metzgeria furcata (L.) Dumort.
Plagiochila fasciculata Lindenb.
Plagiochila retrospectans Nees
Plagiochila strombifolia Taylor ex Lehm.
Podomitrium phyllanthus (Hook.) Mitt.
Radula buccinifera (Hook.f. & Taylor) Taylor ex Gottsche, Lindenb. & Nees
Riccardia aequicellularis (Steph.) Hewson
Riccardia crassa (Schwaegr.) Carrington & Pearson
Schistochila lehmanniana (Lindenb.) Steph.
Symphyogyna podophylla (Thunb.) Mont. & Nees

Anthocerophyta

Megaceros gracilis (Rebdt.) Steph.

mountain streams. As part of my PhD I am looking into the ecology, reproduction and genetics of stream bryophytes in Victorian rainforest streams, encompassing Cool Temperate, Warm Temperate and Gallery Rainforest pockets. So far, a total of 18 streams have been investigated and 50 species identified. This preliminary list of stream bryophytes is presented in Table 1.

Mosses were more abundant than both liverworts and hornworts, with 26, 23 and one species identified respectively. Among the species identified, *Achrophyllum dentatum*, *Hypnodendron spininervium*, *Hypnodendron vitiense*, *Wijkia extenuata*, *Heteroscyphus coalitus*, *Heteroscyphus planiusculus* and *Riccardia aequicellularis* were most commonly represented. These species also are common in wet forest and rainforest on substrata such as soil, tree bases, rock and tree-ferns. *Achrophyllum dentatum* and *W. extenuata* are among the most common species in this habitat, and this is reflected in the streams. Species such as *Catagonium nitens*, *Fallaciella gracilis*, *Hypnodendron comosum*, *Mesochaete undulata*, *Pseudoleskiopsis imbricata*, *Geocalyx caledonicus* and *Lunularia cruciata* were least commonly represented, with examples being identified in only one or two streams. However, some of these species are common elsewhere; for example, *L. cruciata* is extremely common in areas that are disturbed or man-made, *P. imbricata* is fairly common on dry, exposed boulders and *Catagonium nitens* is a common terrestrial species in wet forest. *Hypnodendron comosum*, although not a rare species in rainforest, is much less abundant than either *H. vitiense* or *H. spininervium*. This, again, is reflected in streams, with *H. comosum* occurring in only one stream but *H. spininervium* and *H. vitiense* occurring in most streams. In the case of *G. caledonicus* and *F. gracilis* it is presumed that they are more common than thought (Scott and Stone 1976; Scott 1985; Meagher and Fuhrer 2003), but are seldom collected due to *G. caledonicus* bearing a strong resemblance to some *Chiloscyphus* species and *F. gracilis* having a rather nondescript appearance.

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Fig. 1. Stream Bryophytes in a Victorian Cool Temperate Rainforest.

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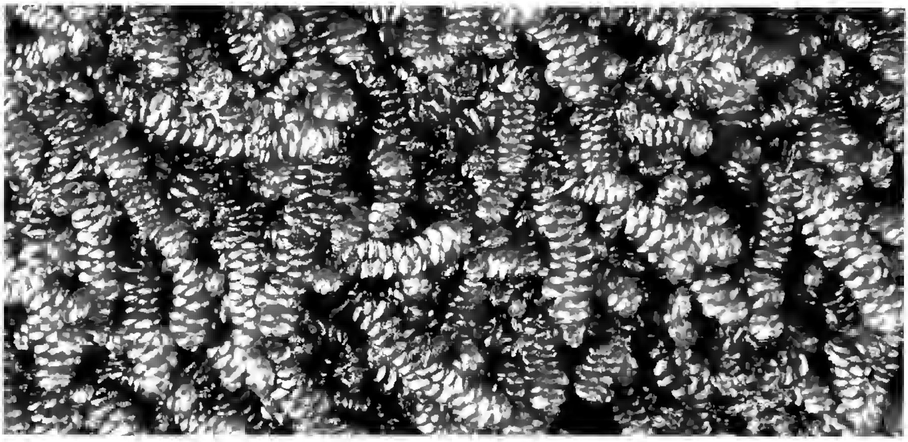
Fissidens oblongifolius is a moss with leaves that lie in one plane. Species of *Fissidens* are distinguished easily in the field as they have a 'hand-like' appearance. *Fissidens oblongifolius* is mentioned in the paper by Dell and Jenkins. Photograph by Matthew Dell.



Frullania falciloba is an epiphytic liverwort commonly found in the canopy of forests. Leaves occur in three rows. Leaves of the lateral rows consist of a lobe and smaller lobule. *Frullania* is one of the genera included in Meagher's key to leafy liverworts. Dell and Jenkins mention the species in their paper. Photograph by Matthew Dell.

Glossary

This glossary defines some of the terms used throughout this issue. Definitions are simplified and based on Malcolm and Malcolm (2000) and Scott and Stone (1976), to which readers are referred for more detailed definitions.

Acuminate tapering to a long narrow point.

Alar cells specialized cells at the corners of moss leaf bases. These are different from other leaf cells in size, shape, colour, thickness or wall ornamentation.

Anticlinal perpendicular to the surface.

Antheridium (plural antheridia) male reproductive organ containing sperm (antherozooids).

Apiculus (plural apiculi) an abrupt, short point at a tip or apex.

Archegonium (plural archegonia) flask-shaped female reproductive organ consisting of an elongated neck and swollen basal region (the venter) supported on a stalk. The venter contains an egg.

Bracts modified leaves surrounding the reproductive organs

Brood bodies any structures that function as vegetative propagules

Caducous falling off readily, deciduous

Calyptra a membranous or hairy cap formed from the wall of the archegonium after fertilization of the egg by a sperm. It protects the embryonic sporophyte and aids in control of its development.

Capsule the spore-bearing component of the sporophyte, i.e. the sporangium, consisting of a sterile base, a fertile spore case and usually, in mosses, a sterile lid, the operculum. The capsule is simpler in liverworts than mosses.

Cilium (plural cilia) a delicate hair or tooth-like structure at a margin or on a surface, or alternating with the endostomal teeth.

Conical cone shaped

Costa (plural costae) the thickened midrib or nerve of a leaf

Cryptogam plants that do not produce flowers or seeds and have their reproductive parts in what once were considered hidden structures. Cryptogams include the mosses, liverworts, hornworts, fungi and algae, as well as ferns and fern-allies.

Dentate having unicellular or multicellular teeth that are outward facing.

Dorsal said of the upper surface of a prostrate stem, the outer surface of a peristome tooth, the lower surface of a leaf, and the upper surface of a thallose liverwort or hornwort

Endostome found in many mosses, the inner peristome, normally arising from a basal membrane and consisting of segments alternating with cilia

Epiphragm (plural epiphragmata) a circular membrane attached to the tips of the peristome teeth, and partially closing the capsule mouth after the operculum has fallen off.

Exostome the outer peristome of mosses consisting of one or more rows of teeth that usually are split in two towards the tip.

Fascicles a bundle or cluster of structures, e.g. leaves, branches, propagules.

Gametophyte the haploid multicellular gamete producing generation.

Gemma (plural gemmae) a type of vegetative propagule composed of only a few cells.

Hairpoint a hair-like leaf tip in mosses formed by a costa projecting well beyond the end of the leaf blade, or by a protracted tapering of the blade tip.

Hyaline colourless and transparent or nearly so.

Hygroscopic readily absorbing moisture, said of moss peristome teeth that bend in and out in response to humidity.

Marsupium (plural marsupial) a swollen and elongated pouch-like structure enclosing the sporophyte.

Obtuse blunt with the sides making an angle of more than 90°.

Operculum (plural opercula) in mosses, the lid that covers the capsule mouth; in liverworts, the apical portion of the sporangium which opens during dehiscence.

Ovate egg-shaped.

Papilla (plural papillae) a local thickening of the cell wall or a mucilage-secreting cell in some liverworts.

Perichaetium (plural perichaetia) a cluster of bracts surrounding the archegonium and later the base of the seta.
Periclinal parallel orientation to the surface.
Perigonium (plural perigonia) a cluster of bracts surrounding the antheridium.
Peristome the ring or rings of teeth inside the mouth of the capsule.
Pluriverous able to occur on a wide variety of subtrates.
Polysetous a state in mosses where more than one sporophyte at the apex of a single branch each with its own calyptra.
Protonema (plural protonemata) branched algal-like filaments or plate-like growths arising from the spores and from which erect shoots form.
Recurved curved backward or downward, as in leaves.
Rhomboid of cells, quadrilateral in surface view or nearly so, with the lateral angles obtuse.
Seta the stalk or structure of the sporophyte carrying the capsule.
Sigmoid relating to cell outlines tht have a slight s-twist; curved in opposite directions at the two ends of the cells.
Sporophyte the diploid multicellular spore producing generation.
Soil crust crust-like covering on the soil that maintains landscape stability. Usually comprised of bryophytes, lichens, algae and fungi.
Spiral arranged in the pattern of a snail shell or corkscrew
Thallus a plant body formed as a flat plateor sheet of tissue.
Trabeculae cross bars or projections on the back of a tooth of the exostome or the slender support strands that prevent air-chambers from collapsing in a number of thalloid liverworts.
Tracheophyte vascular plant.
Venter swollen basal structure of the archegonium, contains the egg.
Warty having small protuberances

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Scot GAM and Stone IG (1976) The Mosses of Southern Australia. (Academic Press: New York)

One hundred and fourteen years ago

DESCRIPTION, COLLECTION, AND PRESERVATION OF MOSSES
BY R.A. BASTOW

'...The great natural order of mosses is ever at our side. On almost every wall top these tiny plants rear their capsules, holding them aloft to inhale the passing breeze or to reap the benefit of the maturing sun-ray; as we wander through the fields they are under our feet, forming a carpet far more luxurious than that of any Oriental loom; they are over our heads as we thread our way through the bush; they throw a gentle mantle over their brethren of larger growth, and who have succumbed to the stormy blast, that none may mock the dead; they enlighten the storm-beaten cliff of sombre grey; they glisten on the sides and roof of the cavern; they twirl in the purling stream; and form a glad luxuriance of humble beauty in niche, on bank, on rock, and everywhere.'

'COLLECTION OF MOSSES. – In the autumn and winter months the mosses in low-lying localities will generally be found in their greatest perfection, whilst in the spring and summer months those growing in more or less mountainous districts are at their best, and it is probable that Victoria is as highly favoured as any country in the world for its vast profusion of mosses. Extensive plains, alpine and sub-alpine heights, damp forests, and fern-tree gullies are characteristic of the colony; there is, therefore, every inducement to make a closer acquaintance with such delightful forms. A necessary equipment for such excursions consists of a good pocket lens, a large knife, capacious pockets, a piece of carpet or oilcloth, and some papers cut in squares to wrap each specimen in.'

From *The Victorian Naturalist* **IX** (1892-3), pp. 123-124

The Victorian Naturalist

Volume 123 (5) October 2006

Published by The Field Naturalists Club of Victoria *since 1884*

From the Editors

In a number of respects, this issue of *The Victorian Naturalist* can be seen to focus attention in several directions. In the concluding half of the paper by Mansergh, Anderson and Amos, the view is clearly to the future; at the same time, the article by Hewish looks at something from the past. This diversity is continued in the other papers presented here, with articles on the ecology of particular areas of vegetation, reptiles, and mammals. The numerous book reviews published here also encompass a wide range of topics of interest to naturalists.

This diversity of subject matter points to one of the more intreresting and, perhaps, appealing aspects of this journal – the practice that has developed over many years, of publishing papers that focus not only on natural science but also on the history of natural science, including that of its practitioners. This is not a common feature of many journals but it is one that has long been a feature of *The Victorian Naturalist*. Readers may be comfited to know that this practice will continue indefinitely.

Given the range of material in this issue, the Editors feel certain that readers will find much to enjoy in the following pages.

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The Victorian Naturalist

Volume 123 (5) 2006 October

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Front cover: Common Dunnart *Sminthopsis murina*. Photo by Alicia McCormack. See article on p 317.

Back cover: Huntsman spider *Delena cancerides*. Photo by Wendy Clark. See book review on p 342.

Victoria's living Natural Capital — decline and replenishment 1800 - 2050
Part 2. The new millennium: replenishment

Ian Mansergh, Heather Anderson and Nevil Amos

Department of Sustainability and Environment
PO Box 500, East Melbourne 3002, Victoria

Abstract

Colonial and post-colonial views of 'europeanising' the landscape have evolved to a new sense of place which embraces native biodiversity. Victoria's economy has diversified and new drivers of change in land use, not based on the primacy of intensive agricultural production, are apparent across large areas of Victoria. Past science and technology (agronomy and engineering) is being challenged by emerging sciences, and new concepts such as ecosystem services can be combined to replenish the natural capital. The inevitability of global warming and the necessity to maximise the capacity of our biodiversity to adapt will be important drivers. Replenishment will happen through changing community values; the availability of adequate space and habitat; and the increase in pertinent and applied knowledge. (*The Victorian Naturalist* **123** (5), 2006, 288-313)

Introduction

A history of land use and environmental effects (pre-1800 to present) was presented in Mansergh *et al.* (2006)[1]. Over the last 30 years, a range of factors have deepened our understanding of the ways we have managed land and water use. These include the progressive appreciation of our climate, the uniqueness of our natural capital (and its decline), a diversifying economy based less on agricultural production, and our affluence. In addition to such factors, emergent global imperatives, a new sense of place, new knowledge and tools, and opportunities provided by socio-economic trends, will affect the trajectories of land use changes. It is by getting the right mix of these factors working in the direction of improved biodiversity conservation, that Victoria's natural capital will achieve some replenishment. Although some problems remain intractable, there is reason for hope because many positive trends are already evident. Much purposeful work remains to be done. As we envisage landscapes inherited by the next generations it is useful to reflect upon the positive changes over the last generation (see Box 1).

Of necessity, the general large-scale view of Victoria's environment (landscape, ecosystem, modelling etc.) offered in this paper does not detail the particular (i.e. individual species). However, increasing understanding of the particular is a vital component of ecology. Before examining socio-economic trends and new developments in science it is important to examine changes in the underlying value society places on indigenous natural capital and landscapes. It is the 'sense of place' that determines the context in which these and other drivers operate and evolve.

Sense of place

In contrast to a history of 'europeanising' the landscape (Part 1) our 'sense of place' is increasingly based on the natural environments, with value placed on the assets bequeathed to future generations. Christian views of 'nature' held by pioneers (Part 1) were challenged by Roberts (1986) who suggested a Christian Land Stewardship Ethic for Australia. Twenty years later, an international body of the Anglican Church 'declared the wilful destruction of the environment to be a sin' (*Sydney Morning Herald*, 2 July 2005, p 8; Falvey 2005). Tangible expressions of such evolution in community values include the dramatic increase in the area of the reserve system, and >130 000 ha of conserved habitat on private land (Part 1 Fig. 6). Native flora and fauna are integral to this new sense of place. Ethics of increased respect and recognition of existence rights for native species have replaced acclimatisation, consumption and destruction. This can be seen in legislation (quarantine regulations, Flora

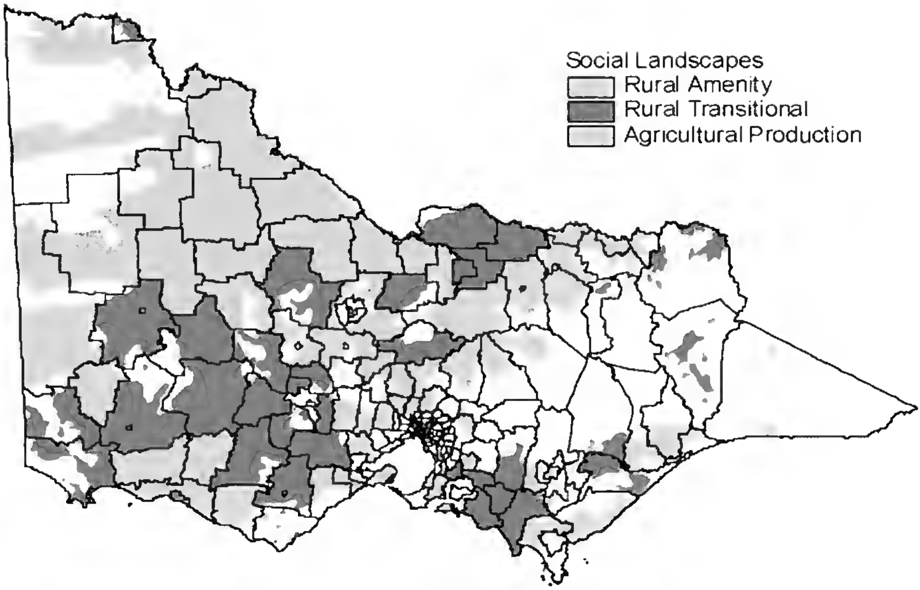

Fig. 1. Socio-economic trajectories of landscapes of Victoria – amenity, transitional and production. Public land is shown as white (Source: Barr 2005).

Box 1

In 1970 who would have thought:

- the LCC would be initiated and the conservation estate would subsequently rise from 1.2% in 1975 to 17% in 2005, including a series of marine parks (5% of the marine area);
- the campaigns to preserve Lake Pedder (1970s) and the Franklin River (early 1980s) would become national issues;
- in 1987, the Brundtland Commission would promote the concepts of ecologically sustainable development and intergenerational equity). In 20 years, the world community would produce an 'Earth Summit' and produce a Convention on the Conservation of Biodiversity — having a more rapid take up of signatory nations of than any prior Convention;
- El Niño - La Niña would be found to be a major climatic driver bringing periodic droughts, and science would be much clearer on greenhouse global warming and its effects (IPCC 2001a, 2001b). [we use global warming rather than climate change as this more accurately reflects the phenomena];
- Victoria's sheep flock would shrink from 35 million in 1970 to 21.3 million in 2002 (ABS 2002).
- the High Court, in the 1992 Mabo case, would determine that Australia was not *terra nullius* when European settlers arrived;
- the water catchments of Melbourne would be conservatively valued at $0.5 – 1 billion (Young 2003);
- commitments to restore an environmental flow to Snowy River would be made;
- cattle grazing would be removed from the Alpine National Park in 2005-6;
- it would become possible to use a computer at home or work to view a high-resolution satellite image of any place on the globe. (http://worldwind.arc.nasa.gov/; http://earth.google.com/).

and Fauna Guarantee Act 1988), policies (e.g. national ban on whaling) and on-going community debates over issues such as old growth forest, duck hunting, river health, native vegetation and biodiversity.

We do not suggest that attitudes to biodiversity and this new sense of place are universally held, but they are certainly held by both urban and rural Victorians, as shown by the success of Land For Wildlife (5500 properties), Landcare (900 groups) and Coastcare (20 000 volunteers) (DSE 2005a). Volunteers alone contributed working hours to the value of $180 million in 2001 to selected natural resource management programs (DSE 2005a). This does not include the work of community-based organisations such as Field Naturalists Club of Victoria (FNCV), Victorian National Parks Association (VNPA), Trust for Nature (TfN) etc.

The High Court Mabo decision of 1992 showed that a fundamental premise of European settlement (*terra nullius*) was erroneous[2]. This prompts, if not necessitates, a new and more inclusive paradigm than the one that had underpinned treatment of the land, its people and their knowledge. Re-evaluations are already occurring, with works such as *Lie of the Land* (Carter 1996) and *This Whisper in Our Hearts* (Reynolds 1998). *In Sunshine or in Shadow* provides an excellent example of how Victorian Koori elders and experiences influence the appreciation of the European past and world view of the present and future (Flanagan 2002). A new 'sense of place' and 'treatment of place' have replaced colonial views where the natural environment was unlimited. William Deane, former Governor-General, believes we must open ourselves to this land and 'live in harmony and reconciliation with the land and its original inhabitants' (quoted in McKernan 2005). Our shared home is here, without dreaming of, or recreating, Devon (see Part 1).

Whilst the 'greenhouse debate' compels a global view on climate. Australians now realise that we live on the driest inhabited continent on earth. Historically droughts (and our responses) have had major effects on Victorians, and lessons of land and water use have been slowly learnt (Keating 1992; McKernan 2005). 'Drought denial' and 'drought proofing' are being replaced by an appreciation of water as a limiting factor of the environment. In 1983, the year the last major dam was finished (Part 1), dust storms brought the 'mallee' to Melbourne as a result of inappropriate land use, soil erosion and drought (Keating 1992). Drought preparedness is now recognised as an economic message to adopt appropriate land use (Productivity Commission 2004). Further, as knowledge of the 'El Niño' phenomenon and drought prediction increases, 'exceptional circumstances' prompting drought relief should be less frequent and ethical questions as to magnitude of 'foreseeable' stock death from starvation and thirst could be addressed (McKernan 2005). Future availability of water and allocations for people and the environment have become major national issues (Wentworth Group 2003), with the Murray and Snowy River debates related to water, rivers and land use (Miller 2005; Close 1990). Global warming is likely to exacerbate water availability as a societal imperative (Howe *et al* 2005; Pittock 2003) and our sense of place will condition adaptation and future land use.

Changing drivers of land use change in agricultural areas

Policies

From the viewpoint of the values that drove it, the consumption of natural capital to gain wealth from forestry, mining and agriculture has been successful. It has helped make us affluent, urbanised and well fed. It also has led to the development of a capital base for broader development (e.g. manufacturing, services). However, the relative economic importance of agriculture has declined. Australian agriculture is most profitable over a relatively small percentage of the area allocated to it[3], and has left a legacy of natural resource degradation problems and over-allocation (NLWRA 2002). Over the past 20 years, governments have initiated, with varying success, a multitude of programs and strategies to address the decline in parts of the natural capital, for example One Billion Trees, Natural Heritage Trust (NHT). In the case of NHT, public financial capital accumulated over generations (Telstra) was used in an attempt to restore components of natural capital, including biodiversity (http://www.nht.gov.au/index.html). The point here is not success or otherwise of these initial programs, but the national change to valuing and endeavouring to restore natural capital.

A series of 'policy visions' directly related to Victoria's future natural capital have been published (see www.dse.vic.gov.au). These include: *Victoria's Biodiversity* (Government of Victoria 1997) 'net gain in

Table 1 Land use and native vegetation in Victoria, the past and future scenarios.

Period	Direction	% of Victoria	Source
1899-1974	Permanent clearing of tree cover @ 1050 km² p.a.	60%	Gilbee 1999
1975-2005	Permanent clearing of tree cover @ > 70 km² p.a.	1-2%	Woodgate and Black 1989; Gilbee 1999; NRE 2002
2006	**Victorian Planning Provisions - zone Groups**	**Total**	
	Business, residential, industrial, special purpose	1.86%	Victorian Planning Provisions
	Commonwealth land	0.24%	
	Environmental	1.50%	
	Green wedge	1.35%	
	Public land	33.88%	
	Rural \ Farming	61.17%	
	Grand Total	100.00%	
Future trends			
	Amenity landscapes c.25% of agricultural land	15%	Barr 2005
	Transitional landscapes c.32% of agricultural landscapes	20%	
	Production and irrigation c.44% of agricultural landscapes	c. 30%	
early 2000s	'net gain in the extent and condition of native vegetation'	Statewide	NRE 1997
by 2015	Revegetation of recharge zones (40-60%)		NRE 2000
by 2020	Agricultural production uses 30% less land	c. 18%	Kefford 2002; ORL 2002
	Mosaic landscape accommodates a 40% coverage of native vegetation	*	VCMC 2002
	Revegetation along rivers and streams (90%), health of remnants, revegetation and biolinks		NRE 1997; VCMC 2002

* Of Victoria's 10 CMAs, the following have less than 40% native vegetation coverage: North Central 12%, Wimmera 16%, Glenelg Hopkins 20%, Corangamite 23%, Port Phillip and Westernport 29%, Goulburn Broken 30% and Mallee 34%. Currently Victoria has 36% native vegetation coverage. (Source: DSE GIS corporate library 2006)

condition and extent of native vegetation'; in 2020 agricultural production will require '30% less land and 20% less water' (Kefford 2002; ORL 2002); 'the mosaic landscape accommodates 40% native vegetation coverage' in catchments in 2020 (Victorian Catchment Management Council (VCMC 2002); and the statewide salinity plan (NRE 2000) seeking '40 to 60 percent' of 'critical recharge areas revegetated by 2015'. These visions, perhaps cognisant of socio-economic drivers, have quantified some areas available for replenishment.

Socio-economic

The agricultural sector and its landscapes are changing. In the colourful but insightful words of Barr (2005), traditional farmers face several new realities: 'Get big or get out' and 'There's only so much more a consumer can eat'. The mean age of farmers is increasing (Barr 2005), populations in parts of rural Victoria are predicted to decline by 2020 (DOI 1996), and in other parts the land value exceeds its value for agricultural products (Part 1 Fig. 15). These economic and demographic trends indicate that changes in land ownership and land use patterns can be envisaged in the next years. Through extensive analysis

Fig. 2. Two scenes visualising scenarios for red gum forest and surrounding landscapes along the Murray near Cobram. Tree positions and heights are based on laser altimetry data. (Courtesy Alex Lau, DSE).

of current trends. Barr (2005) concluded that the future trajectory of Victorian rural landscapes can be differentiated into zones of rural amenity, rural transitional, agricultural production and irrigation (Fig. 1). In the first two (55%), intensification for commodity production will have a lessening effect, and new landscapes will evolve. Analysis of Land for Wildlife (LFW) data (number of properties, area of habitat by

Fig. 3. Visualising future landscapes: virtual reality of Mt Buller showing (upper) 'actual' view reconstructed from laser altimetry and other data showing existing forest; (lower) a view with forests converted to farmland, a further scenario not recommended. (Courtesy Alex Lau, DSE).

zone) strongly support this analysis. Rural amenity zones cover c.23% of private land, yet have 58% of LFW properties and 33% of habitat area. Production zones (c.45% of private land) have 13% of LFW properties and 18% of habitat (X^2=4608.6 p<.001).

Rural amenity and transitional landscapes

The percentage of 'agricultural – private land' in rural amenity zones and the rural transitional zones is substantial (c. 55%) and approximates the current area of public

Box 2

Landscape preferencing (modelling)*

A new area of endeavour is landscape preferencing, which combines technology (GIS, computers) with ecological knowledge (Wilson *et al.* 2005). Functioning models now exist (and will doubtless be improved) in which priority is given to restoration, improving patch size and connectivity. Ecological algorithms such as home range, forage range, seral stage, habitat condition and resilience can be added to incorporate and maximise conservation outcomes at any scale.

Habitat reconstruction and revegetation in the existing and future landscape can now be purposefully designed, using transparent assumptions. Careful consideration can be given not only to the proportion of the landscape, but also the specific parts of the landscape that are required and are most resilient. Restoration of the natural capital can be optimised, for itself, or in concert with a range of other socio-economic variables where trade-offs can be made. Victorian models and experiments are already looking at optimising a range of outcomes (e.g. salinity, water quality, biodiversity outcomes) for public investment (DSE and DPI 2005).

Victoria needs to achieve landscape results that do not unconsciously and adversely affect other natural capital (e.g. plantations or revegetation affecting water flows and budgets). Areas that become available (e.g. retirement from agriculture) might not be an optimum use, nor even a moderately efficient use, in landscape restoration for biodiversity conservation. Wise use of preferencing models and planning is essential.

* Spatially explicit models for prioritising landscape restoration (biodiversity perspective)

land (Fig. 1). Replenishment of natural capital in 25% of the area of these zones provides an equivalent to half the area of the current reserve system. Apart from the extent of these zones their position is important for adaptation to global warming (see Global warming – page 304).

For rural amenity zones, Barr (2005) concluded that

> the bright future depends on the *protection of the amenity features* and landscapes that attract migrants. The *management of public lands and planning schemes that embrace amenity values* will be crucial for the future, lest the migrants it attracts help destroy the very features that draw them ...

(our emphasis). For rural transitional landscapes, he found that 'aspirations varied from niche production to bush renovation'. Current biodiversity assets are a crucial part of the amenity of these landscapes, and their enhancement will increase amenity value. Natural revegetation of recharge areas increases amenity whilst resource degradation (e.g. salinisation) lowers amenity and other values (NRE 2000). Further, some ecological resilience (e.g. potential for natural regeneration of native tree cover) persists, but the window of opportunity for this restoration regeneration is limited (Dorrough and Moxham 2005). It appears that 'space' and capacity is becoming available for the restoration of natural capital in parts of these zones.

Production and irrigated landscapes

In the production and irrigation landscapes of the future, further industrialisation of agriculture can be expected (high capital, energy and external inputs, concentration of production, specialisation and tendency to monoculture; for examples see Part 1 Fig. 13). If inappropriately managed, this will take its toll on localised and regional natural capital. However, there is an emerging community trend for ecologically sustainable rural industries (House of Representatives Standing Committee on Environment and Heritage 2001; ORL 2002). Consumer and industry awareness, along with the potential for a clearer definition of 'duty of care', of landholders

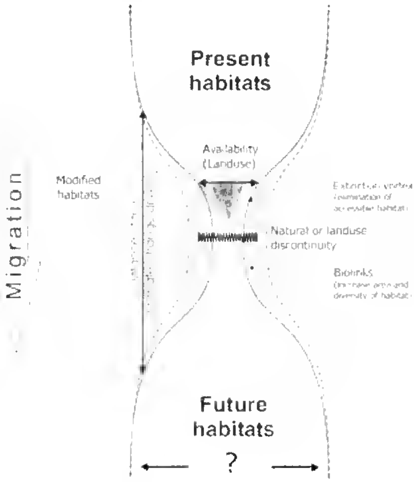

Fig. 4. Idealised view of population bottlenecks under changing distribution of habitat.

Box 3

An Emerging biolink?

Some of the above themes can be demonstrated in an area west of Benalla (North central Central Victoria) which was originally part of the inland grassy woodlands, an ecosystem and related biota now threatened (Robinson and Traill 1996; Ford *et al.* 2001). This area is within an amenity landscape and a biolink zone (Fig. 1; Fig. 5) and parts are emerging from the binary production / other landscapes of the past. Of the > 6,000 dryland farming properties in the Goulburn Broken catchment 84% are classified as sub-economic (< 250 ha) (Goulburn Broken Catchment and Land Protection Board 1997) and almost all of the catchment is zoned rural.

The area around Upotipotpon was originally cleared for sheep and intensive grazing (alienated in late 19th century) and pastures were improved during the wool boom (Fig. 6). Tree cover within a 10 km radius (320 km²) has been reduced to about 7.5% and now persists in small blocks (< 50 ha) and roadsides (Fig. 6; Fig. 7). Over the last decade, a series of corridors to augment roadside woodland vegetation for the threatened Grey-crowned Babbler *Pomatostomus temporalis* have been established (> 30 km concentrated around Benalla – Violet Town). A 128 ha former sheep property (Fig. 6; Fig. 7) has been part of that network and approximately 7 years after fencing / planting / a new seral stage and additional micro habitats have been created. Initially the reservoir tree cover on the property was about 45% but the current owners, mainly through natural regeneration are increasing this to 85% (Kate Stothers and Lance Williams 2006 pers. comm.). Over 137 native fauna species have been recorded on the property (Appendix 1), including the Yellow-footed Antechinus *Antechinus flavipes*. Of the bird species, 13 % are regarded as threatened woodland taxa (Appendix 1) and the increase in habitat should benefit a range of species (Radford *et al.* 2004, 2005). This property will be a connected node with additional micro habitats and seral stages developing over the decades, some of which will be available to incoming species. As part of a revolving fund (purchase, convenant, resale) TfN has purchased a 146 ha property in close proximity (D. Robinson, pers. comm. August 2006).

Such activities across the biolink zone provide habitat and living space: for biota; native vegetation regeneration; and, potential colonisation of species in response to changing climate. Naturally regenerating eucalypt will be selected to survive in a climate 0.7°C warmer than their centruy-old parents.

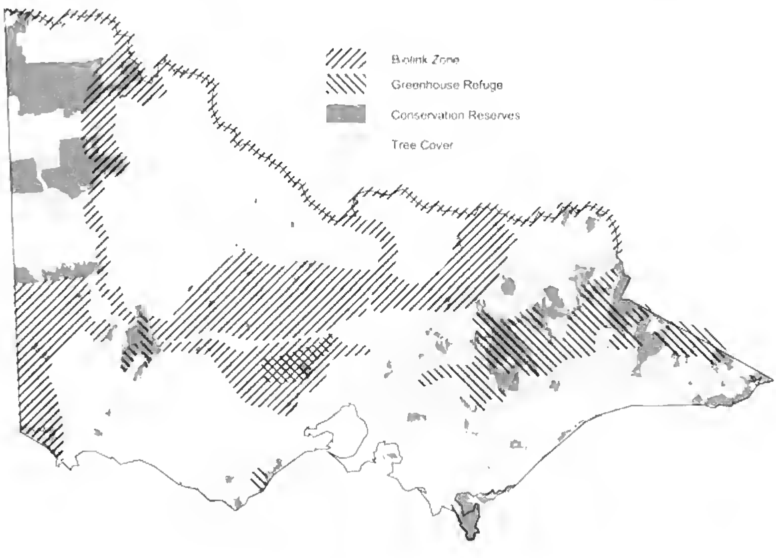

Fig. 5. Greenhouse refugia and Biolinks. (Modified from DCE 1992; Brereton *et al.* 1995)

(Raff 2004), should ameliorate environmentally adverse effects.

Markets for products influence production. Consumer demand promotes mechanisms that ensure quality standards (e.g. pesticide residues, GM-free food) leading to the development of accreditation and quality control mechanisms (e.g. Environmental Management Systems (EMS))[4].

Anderson *et al.* (2001) demonstrated how biodiversity can be incorporated into an EMS at the farm scale, and this is being investigated at the national level (NRMMC

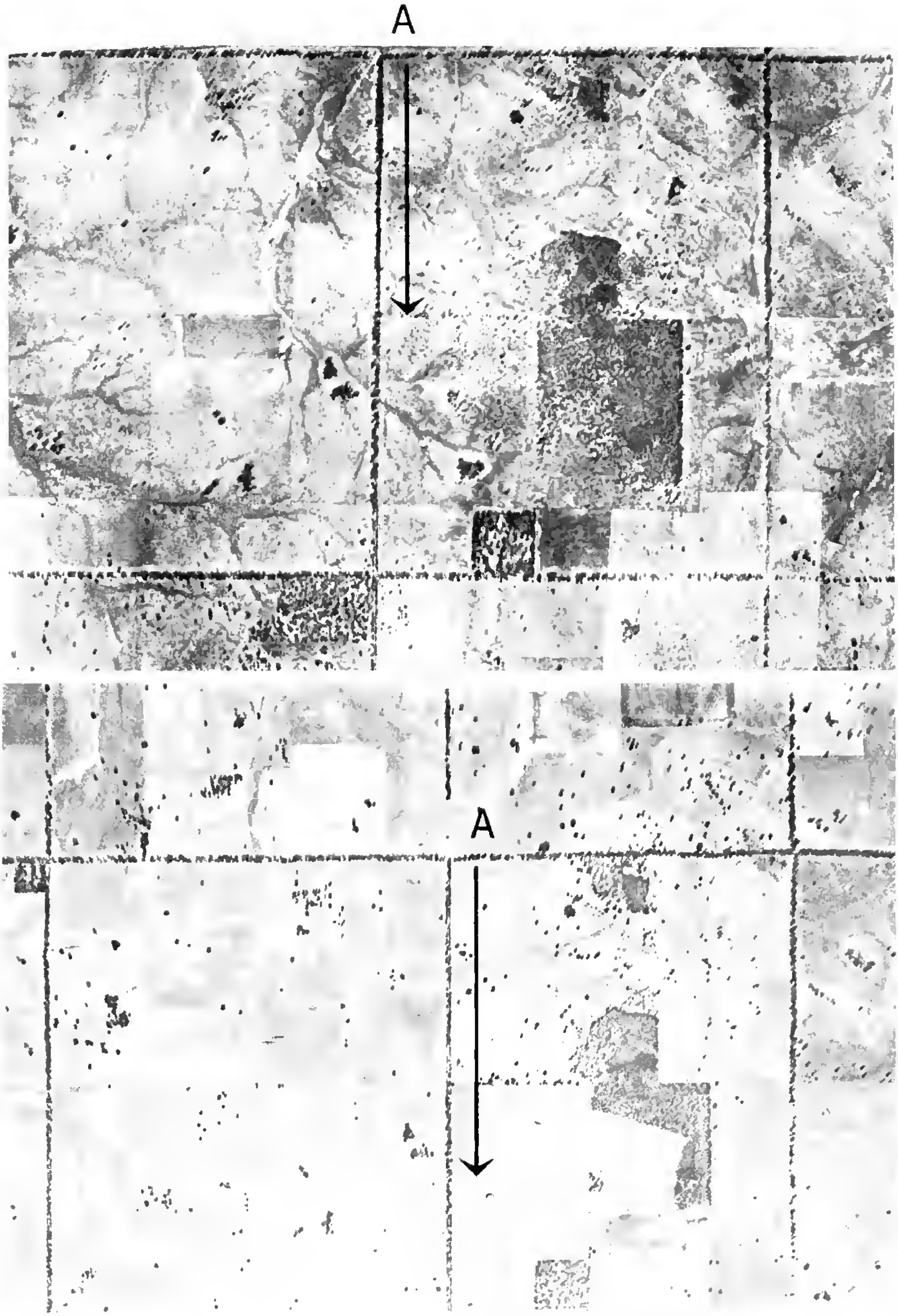

Fig. 6. Aerial photographs of property at Upotipotpon (west of Benalla); (upper) 1941: predominantly cleared; native tree cover remnants and public roadsides, clearing (across drainage lines) and non ploughing of paddocks, predominantly native pasture; (lower) 1971: peak of area under sheep in Victoria – pasture 'improved', farm dams, less trees, recent clearing and windrowed trees (x). Point A is the same as in Fig. 7. (Photos courtesy DSE Benalla).

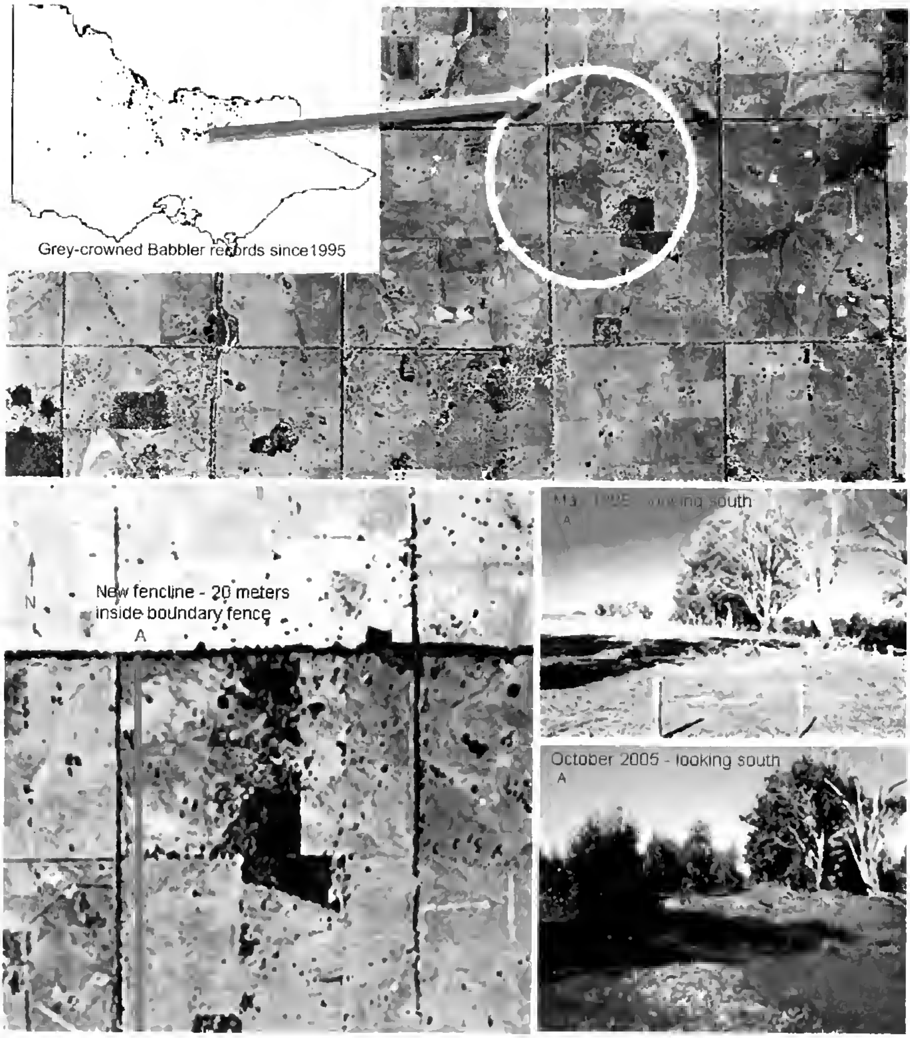

Fig. 7. An emerging biolink - aerial photograph (1995) of property at Upotipotpon, Victorian distribution of Grey-crowned Babbler habitat and on-ground corridor. Point A is the same as in Fig. 6. (Aerial photo/map DSE; landscape photograph - Kate Stothers).

2002). Some agricultural groups are promoting improved biodiversity outcomes as an active part of their enterprises within a landscape approach (e.g. Birchip Cropping Group, www.bcg.org.au).

Loss of vegetation through the intensification of agriculture is visually obvious at the site level (Part 1 Fig. 4, Fig. 13). Other ramifications also have depleted natural capital both on- and off-site. Excess phosphorus and nitrogen changes soil chemistry on site and contributes to off-site eutrophication of rivers and wetlands, the biota and function of which are already stressed, past erosion effects 10 000 km of waterways in the Murray Darling Basin (Koehn and O'Connor 1990; NLWRA 2001). Nutrient management (soils and water), is a critical concern of Australian agriculture, and externalities (soils and rivers) must be addressed to reach emerging community standards of ecological sustainability[5]. Acidification degrades our soils at an economic cost estimated in 2000 to be

> $1 billion, >5 times that of lost agricultural production from salinity (Goldie and Furnass 2005).

Private and public land dichotomy

The vast majority of Victoria's private land was historically alienated (66%) and cleared (62%) for agricultural production with the conservation reserve system essentially arising from what remained (Part 1 Fig. 6), and a range of private versus licenses on public land. The starkness of this dichotomy is changing (Mansergh and Anderson 2006). Rights and responsibilities of property ownership change over time, as does government allocation of property rights (Part 1; Bromley 1991; Raff 1998, 2004). Industry's 'licence to operate' changes and is qualified over time. Examples include: pollution controls; cessation of alpine grazing; scallop dredging in Port Phillip Bay and logging in the Otways. Local government planning schemes, through democratic processes reflecting community values, are able to plan land use zones and development and protection overlays, e.g. environmental significance. The large area of the rural zone (Table 1) reflects past land use. Current and emergent trends are provided in (Part 1 Fig. 15), (Fig. 2).

The area of private land managed for conservation is increasing (Part 1). In 1997, Birds Australia (formerly the RAOU) directly purchased 'Gluepot' station in South Australia through community and business donations, and implemented the idea of conservation organisations owning and managing large and strategically important properties. Trust for Nature purchased Ned's Corner, the largest single property in Victoria (29 800 ha). More recently, Bush Heritage also purchased properties for conservation. In a study of conservation on the private estate Fitzsimmons (2004) concluded that multi-tenure reserve networks can make a contribution to biodiversity conservation:

> ...The high level of enthusiasm from private landowners to participate in a national reserve system provides an important stimulus to strengthen the co-ordination of activities between public and private conservation lands at a national level.

Public land

Public land remains after the primary alienation (allocation) of the Crown to private property (Part 1, Table 1). Over the last 30 years there has been a trend toward the allocation of uses and management of broad areas of public land (predominantly parks and forests in the terrestrial landscapes) toward more conservation-orientated uses (Part 1). The development of management planning and codes of practice complement this allocation. Recent decisions suggest that this trend will continue. Examples include creation of marine parks, cessation of logging in the Otways (in 2008) and removal of cattle grazing from the Alpine National Park. Some commodities traditionally harvested from the public estate are increasingly being produced privately, e.g. forest products (Part 1) and emerging aquaculture. Some landscape-scale threatening processes are being addressed. Examples include: removal of scallop dredging in Port Phillip Bay; lessening grazing pressure (rabbits and kangaroos) and regeneration of vegetation communities (Hattah Lakes National Park); fox predation (Southern Ark – East Gippsland) and fire regimes (Fire Ecology Working Group 2004, see below). The extent and condition of native vegetation in the public estate will be a key environmental attribute in future.

Outside these broad-acre areas, the public estate includes vital areas for biodiversity for linkages, reservoirs of genetic diversity and critical resources (e.g. tree hollows, see below). Such areas include: road and rail easements (including unused); streamside and coastal reserves; and smaller reserves (e.g. Flora and Fauna, cemeteries). Apart from their intrinsic value, the broad ecological significance of these areas is that some traverse landscapes and thus conserve reservoirs (even if depleted) from a cross section of the original vegetation. Combined, the area of these is substantial, e.g. roadsides support an equivalent area three times that of Wilsons Promontory National Parks. In many landscapes a high proportion of existing mature trees, which are vital ecological attributes (see below) survive on roadsides (Matt White, DSE pers. comm.). VicRoads (2002) has developed a roadside conservation strategy, the CMAs and local governments have developed codes and management manuals to protect and manage native vegetation on the roadsides. Many of these features are critical to the increasing value, landscape amenity, and the appropriate management is required and is evolving. Crown river frontages are a significant part of the public estate that has been grossly degraded (Part 1). Willows are no longer planted and are now actively eradicated, and between 2002 and 2005 > 1457 km existing riparian vegetation has been fenced, protecting an estimated 5835 ha of riparian vegetation with > 0.5 million native plants established to enhance riparian zones. Bank stabilisation works have been undertaken along 80 kms (Rod Taylor, DSE pers.comm.). The Mallee CMA (undated) has Frontage Action Plans for 733 km of Murray River frontage. However, to attain a 90% restoration of riparian vegetation by 2020 (NRE 1997) much work needs to be done across Victoria.

Systematic knowledge of the ecological condition of the estate and thus key management priorities for restoration (see metric below) are critical and will assist in quantifying the value of the natural capital for the ecosystems services public lands provide. New and increased pressures (e.g. various recreation pursuits) will require appropriate management. However, trends already evident should lead to replenishment of the natural capital over the next decades.

Changing economic value

Biodiversity assets

Biodiversity assets were initially protected for their novelty or intrinsic worth but many of Victoria's natural assets have increasing economic value, as the following two examples show. Firstly, the Fairy Penguin (*Eudyptula minor*) Parade at Phillip Island, an important tourist site bringing economic wealth to regional Victoria, could have been destroyed by trampling in the 1960s. To be maintained, knowledge and protection of the penguins' feeding grounds is required, thus affecting management beyond Phillip Island. Secondly, since the 1880s, various catchments have been closed to protect Melbourne's water supply and now support old growth forests (e.g. Mountain Ash *Eucalyptus regnans*). A treatment plant following loss of the forests capacity to produce high quality water would cost $ 0.5-1 billion (Young 2003). This figure does *not* include the loss of a quantity of water to regrowth forests which consumes much more water in transpiration than the mature forest (O'Shaughnessy and Jayasuriya 1987).

Ecosystem services

In contrast to the intrinsic, ethical or scientific value, living natural capital is being increasingly valued for the utilitarian 'ecosystem services' it provides (World Commission on Environment and Development 1987; Daily 1997; Cork 2001). Such services include water quality and quantity, soil fertility and stability, pollination, pest and salinity control, and amenity. Important environmental initiatives in Victoria's history such as the Soil Conservation Authority (1940s), Environment Protection Authority (1970s), and Land Conservation Council (1980s) can be seen as early attempts to protect aspects of ecosystem services. However, historically the contribution of these services to well-being and the economy was not costed into production ('free' and limitless). Valuing ecosystem services is a way to include the costs of degradation of the assets and ecological functions into the economy. A classic example of the value of ecosystem services comes from the American state of New York, where it was found to be significantly cheaper and better to buy and restore catchments than to build an 'engineering' solution to water quality issues (Cork and Shelton 2000). Reconstituted surrogates for natural wetlands are examples in which natural processes may be cheaper and have broader benefits than purely engineering solutions. Our increased understanding of salinity at the landscape scale shows how past clearing of recharge areas has adversely effected discharge areas (NRE 2000). Revegetation of recharge areas provides ecosystem services elsewhere in the landscape whilst it may initially consume more water.

Native biodiversity is a fundamental ecosystem service, as well as the source from which some others are derived. In practical application (e.g. payments and

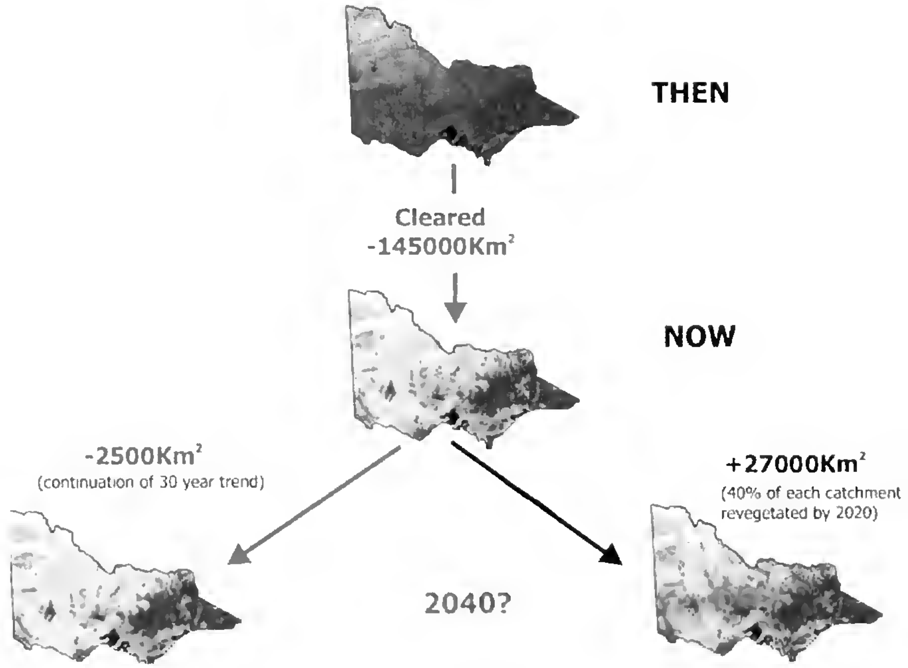

Fig. 8. Land use decisions which we make now will determine future landscapes. Satellite images of Victoria's past, present, and future scenarios. Future scenarios are: continuation of past 30 year trend of depletion (lower left), catchments with 40% mosaic coverage of native vegetation (lower right) and revegetation of biolink areas (5% in production, 10% in transitional and 20% in amenity zones, see text).

transfers) it is important to take a balanced and holistic view to ensure that sites 'providing' some ecosystem services are not also contributing to on-going dis-services to other elements (e.g. fertiliser leakage). Exotic species may also provide some ecosystem services; however, Victoria has numerous examples of exotic species that rapidly provided 'ecosystem dis-services' (rabbits, blackberries, willows, Phalaris) at great environmental and economic cost. As a concept, ecosystem service provides new perspectives and opportunities for biodiversity conservation as the 'stocks and flows' of environmental assets would be quantified. Ecosystem services must be quantifiable and thus the extent and condition of the natural assets (and their contribution to services) measurable.

Existing and emerging science and technology

Environmental metrics

'Habitat hectares' provides a method for measuring (a metric) the condition of native vegetation, including fragmentation status, based on variance from a benchmark (Parkes *et al.* 2003; also see Part 1 Fig. 4). (Ecological Vegetation Class (EVC) benchmarks by bioregion, and benchmarks for wetlands, are available at www.dse.vic.gov.au.) This metric allows a robust ecological measure of the condition of native vegetation and, by inference, what management actions are needed for improvement or offsets (NRE 2002). The same logic is being used in metrics for wetlands, and improvements to the Index of Stream Condition (Ladson *et al.* 1999; DSE 2005b).

Vegetation condition throughout Victoria is being mapped and modelled using this metric (ARIER *et al.* 2004; David Parkes 2005 pers. comm.). This will allow vegetation condition and its improvement to be related to other ecosystem attributes and services, e.g. water quality and quantity. Appropriate environmental metrics provides for better accounting and investment (from national to local scale) and a means for incorporating biodiversity and other elements into the economic and land use decision making. The first national attempt by Australian Bureau of Statistics (ABS 2002) at 'Triple bottom line' (economic, social, environmental) reporting indicated the need for environmental metrics. The power of metrics and thresholds in public debate is discussed below (Miller 2005).

Knowledge base – species and landscape

Both the science and questions asked of science are reflected in *The Victorian Naturalist* (Watkins 1984; Archer 2005) and a few themes relevant to Victoria will be discussed here from this broad field. Knowledge of species and genetics has expanded exponentially, assisted by the legislative focus of the Victorian *Flora and Fauna Guarantee Act* 1988 and the national *Environment Protection and Biodiversity Conservation* Act 1999. The pace of change may not be as fast as some would like, but the trend is impressive. The expanded knowledge base erodes one of the fundamental drivers of past degradation — ignorance. It has taken generations to appreciate droughts as an environmental feature (Keating 1992; McKernan 2005; see Box 1) as early settlers had no meteorological records and did not avail themselves of Koori knowledge. Ecological studies following the 2003 alpine fires (summarised in DSE 2005c) indicate that opportunities are now taken to expand our knowledge base following significant environmental events (cf. 1939 and 1983 fires).

Beyond studies of specific species, the rise of landscape ecology and restoration ecology as disciplines is significant (Archer 2005), as this allows issues and processes to be viewed at an appropriate scale for landscape change, restoration and conservation (Templeton *et al.* 2004). Important ecological issues can be scientifically identified and investigated; these include connectivity (Soule *et al.* 2004) and ecological thresholds (Huggett 2005; Lindenmayer *et al.* 2005; Lindenmayer and Luck 2005; Radford *et al.* 2004, 2005). There is a trend from describing problems (e.g. 'fragmentation') to formulating solutions; for example, Radford *et al.* (2004) asked, 'How much habitat is enough?' This knowledge can be integrated with other disciplines at the landscape level to achieve a more holistic view of future desirable landscapes. Importantly these questions of science are qualitively different from the engineering (civil, water) and agronomy issues that dominated landscape change in the 20th century (Funtowicz 1991).

There still remain large neglected areas of investigation, some of which are critical to ecological processes. Soil biodiversity and invertebrates (which in combination support the majority of terrestrial species) and, perhaps the related and emerging understanding of resilience (Dorrough and Moxham 2005; Dorrough *et al.* 2006) stand out as major gaps. The FNCV and *The Victorian Naturalist* have an important role in some of these areas, for example the study of fungi (May 2005).

Remote sensing and computers

Remote sensing (satellite imagery and laser altimetry), geographic information systems and related computer modelling allow more sophisticated and accurate monitoring of our living natural capital at a variety of scales (Graetz *et al.* 1993; Gilbee 1999). Recent advances in remote sensing technology, especially the combination of laser scanning and high-resolution multi-spectral images, open new possibilities in capturing, monitoring and modelling changes in landscapes. Laser scanning makes it possible to map terrain under tree canopies with an accuracy previously unattainable (Hyyppä *et al.* 2001). Laser altimetry also can be used to define individual tree height, crown shape and trunk location (Lim *et al.* 2001; Pyysalo and Hyyppä 2002; Watt *et al.* 2003).

These novel techniques enable us to visualise the structure of a forest in three dimensions (Fig. 2). Repeating these measurements over time enables us to model spatial growth of a tree, a stand or a landscape. This could eventually underpin multi-scale landscape planning, allowing us to see future 'virtual landscapes' under various management regimes (Lau *et al.* 2001; Fig. 3). These techniques could allow us to model the appearance and function of future landscapes that will be the result of our conscious management decisions, and could therefore inform and drive debate about implications of the choices made. Remote sensing and spatial modelling also can be used to assess fragmentation status (Ferwerda 2003) and, most significantly, vegetation condition as shown by ARIER *et al.* (2004) in modelling and mapping parts of northern Victoria. This will be completed statewide in 2008 (Matt White, DSE pers. comm.).

New programs

Although in their infancy, new biodiversity enhancement programs are combining economic and ecological theory to invest in ecological improvements. Through information exchange between landholders and governments, programs such as BushTender have sought to create a market for improvement in native vegetation while obtaining the best price for the service (BushTender, on DSE web site). The habitat hectare assessment, referred to above, has been critical for such programs. The model has nurtured several hybrids, such as PlainsTender (Western Basalt Plains grasslands) and CarbonTender (carbon credits for restoration of native vegetation, 'storing carbon' at sites that will assist biodiversity to adapt to global warming). This concept has recently been combined with other environmental outcomes to provide multiple-benefit results [EcoTender (DSE and DPI 2005)].

In future the scope of such auction-based tools and associated metrics could provide an alternative income stream for novel management practices, while allowing scarce funds to be directed to areas that will produce the greatest environmental benefits. What is common and important in all these programs is the ability to quantify environmental gains that should result from changes to site management. Investment is made on improved functioning of assets rather than activity. Such programs improve ecological outcomes, transparency and landholder satisfaction.

Ecological resilience

Resilience is the capacity to recover from disturbance. The capacity for natural regeneration of vegetation at a site is related to the history of land use and management (e.g. time since clearing, cropping, fertiliser regime and proximity to remaining vegetation). Natural regeneration is probably the most cost-effective mechanism for replenishment and realisation of the resilience (Greening Australia 2003). A survey in grazing properties in central Victoria (Dorrough and Moxham 2005) found that

> under current patterns of tree cover (2.7%), 40% of the total area has high probability of supporting natural regeneration in the absence of livestock grazing ... reduced to 18% ... if no action is taken in next 30 years

Such research work is of vital importance for the insights into both ecosystem resilience and the 'natural' window of opportunity within which the community can promote cost-effective land use and management change. Conversely, the restoration of landscapes with little natural resilience (high resistance) would require additional resources and may prove futile in the end. Availability of genetic capacity (e.g. seeds) is important. However, it is probable that the health / resilience of soils will be a fundamental functional constraint – resistance due to compaction, chemistry and most importantly biological activity (see Part 1 Fig. 4; Dorrough *et al.* 2006).

The depletion of mature forest (and trees) has been a feature of our historic land use (Part 1). Tree hollows occur in older age trees (> 100–150 years) and are critical for persistence and resilience of many species (Vesk and McNally 2006). Bat species represent > 25% of Australia's mammalian fauna and are important for pollination, seed dispersal and predation of invertebrates. Verpertilionid bats are the dominant group in South-eastern Australia where no bat species is yet known to have become extinct (Lumsden and Bennett 2000). In fragmented woodland and forest environments bats utilise paddocks with scattered trees and appear to have a higher capacity to persist (Lumsden and Bennett 2000, Lumsden and Bennett 2003), relative to other mammals and some birds (Robinson and Trail 1996). However, the bats' continued persistence and resilience is dependent on long-term availability of roosting and maternity sites (hollow bearing trees). Lumsden *et al.* (2002a, 2002b) found in the Murray floodplain forests that Lesser Long-eared Bat *Nyctophilus geof-*

froyi and Gould's Wattled Bat *Chalinlobus gouldi* required (respectively) both dead and living large-diameter trees for roosting and maternity sites. The suite of hollow-dependent arboreal mammals and birds may face a bottleneck (of supply) in rural areas (Vesk and McNally 2006: see also Fig. 4) around 2050. Lessening the bottleneck requires revegetation to begin as soon as possible (Vesk and McNally 2006). Large old trees are products of the past, and future availability of tree hollows requires conscious nurturing of a range of age classes across the landscapes, for this critical feature to remain resilient for hollow-dependent species and invertebrates utilising differently aged trees.

Species and habitat resilience also is facilitated by understanding variations of habitat quality and identification of landscape refugia, such as mesic gullies in fragmented dry forest landscapes (e.g. Soderquist and Mac Nally 2000). In other more 'intact' landscapes better understanding of ecological inter-relationships facilitates better management for resilience and persistence. The role of mycophageous marsupials in dispersing mycorrhizal fungi is now better appreciated (Claridge 1992). The endangered Long-footed Potoroo *Potorous longipes* feeds on over 30 species of fungi (sporocarps, hypogeal and sub-hypogeal) many of which are thought to have symbiotic relationships with forest trees and shrubs and thus vegetation health (DSE 2003b). Knowledge of specific symbiotic relationships of a range of orchids with fungi and pollinators has been used to replenish populations (A Pritchard 2006 pers. comm.).

Practical techniques for restoration and enhancement

Increased empirical and theoretical knowledge is being practically applied to restoration and amelioration for threatening processes. Extensive guidelines for re-establishing native vegetation in Victoria are readily available (Greening Australia 2003), as is information to assist landholders on specific issues, for example tree hollows and bats (Lumsden and Bennett 2003). Research suggests there is 'considerable potential for the large scale restoration of herbaceous plant communities using direct seeding' (UniNews 2005) which could facilitate replenishment of depleted lowland grasslands. Practical amelioration techniques for threatening processes to the rivers are being used and developed (Koehn and O'Connor 1990), [for example establishment of ecological flow regimes for rivers and streams]. The fish passage at Dights Falls, on the Yarra River at Collingwood, restored access to c. 2000 kms of waterways for 80 % of the diadromous freshwater species (migrating between fresh and estuarine/marine) that had been inhibited for over a century (Zampatti *et al.* 2003). Over the last decade > 5000 kms of river length has been re-opened for fish passage on about 40 rivers at approximately 80 sites (P Bennett 2005 pers. comm.). Conversely, exclusion barriers and removal of trout upstream has conserved populations of the endangered Barred Galaxias *Galaxias fuscus* from predation (Raadik 2002). These installations require periodic maintenance to provide ongoing benefits. De-snagging our rivers has rightly declined and re-snagging for fish habitat and breeding is now a proven and active technique in river management (Koehn 2004; Nicol *et al.* 2002; MDBC 2004) assisting threatened species such as the Murray Cod *Maccullochella peelii peelii*.

Threatened species can be recovered. With the Koala recovery, Victoria led the world in species restoration from early/mid 20th century (Part 1). In Victoria, endangered populations have been successfully replenished through captive breeding - release, e.g. the Helmeted Honeyeater *Lichenostomus melanops cassidix* at Yellingbo (Smales *et al.* 1999), or relocation, e.g. Black-eared Miner *Manorina melanotis* into Murray Sunset National Park from Bookmark Biosphere reserve (Clarke *et al.* 2002) and the Eastern Barred Bandicoot *Perameles gunni* (Clark *et al.* 1995). Macquarie Perch *Macquaria australasica* were released (outside their range) into the Yarra River from 1912 to the 1940s and this population, following the rapid decline of the species in the Murray Darling Basin (from the 1970s), is highly significant (e.g. potential for restocking) for this nationally endangered fish (Minister for Water 2006).

A population of the Eastern Quoll *Dasyurus viverinnus* presumed extinct on the mainland (last Victorian record in 1950s) has been established from Tasmanian stock within a fox-proof fenced area near the You Yangs (Richard Woods 2005 pers. comm.). Although these animals may not be genetically appropriate to re-establish a free-ranging population, the knowledge from husbanding will assist future efforts. Habitats and social organisation of the threatened species can be restored, e.g. endangered Mountain Pygmy-possum *Burramys parvus* and a tunnel corridor (Mansergh and Scotts 1989). Restoration, even of some species 'extinct' to Victoria, can now be realistically envisaged (Mansergh and Seebeck 1992). Many successful efforts integrate science within the broader socio-economic context, an important concept brought to the fore in Victoria by Clark *et al.* (1995).

Major threatening processes to biodiversity are addressed at the landscape scale. Under a predator control program over the last decade, Western Shield, Western Australian populations of 18 mammals, three birds, two reptiles and one amphibian, have been translocated (= introductions, re-introductions and re-stocking (IUCN 1987)) with the success rate twice that of failure (Mawson 2004). Preliminary results from Southern Ark, a landscape-scale fox control program in East Gippsland, suggests that recovery of small to medium sized mammals (e.g. Long-nosed Potoroo *Potorous tridactylus*) can be expected (DSE 2003a). A major potential pest in the marine environment, the Northern Pacific Sea Star *Asterias amurensis*, has been eradicated from Venus Bay, Inverloch, by a community-based program (Ingrid Holiday, DSE pers. com.). Management of fire regimes across public land in Victoria now seeks improved ecological outcomes including the provision of 'conditions necessary for the persistence of biota' (Fire Ecology Working Group 2004). Key life history features of the flora which determine how a species lives and reproduces, its vital attributes, are used to inform ecological burning regimes, thus actively using fire to achieve ecological outcomes.

Major 21st century threat — global warming

Accelerated global warming caused by the human-induced increase in atmospheric carbon dioxide and other 'greenhouse gases' is the major threatening process to global biodiversity in the 21st century (IPCC 2001a, 2001b). A 'globally coherent fingerprint of global warming impacts across natural systems' (Parmesan and Yohe 2003), and 15 to 37% of species are 'committed to extinction' (Thomas *et al.* 2004; Brereton *et al.* 1995). Changes in clinal genetic variation in an eastern Australian fruit fly *Drosophila melanogaster* over the last 30 years, have been recorded, and are equivalent to a shift of 4° latitude southward in response to global warming (Umina *et al.* 2005). The theoretical risks of global warming as set out by Peters and Darling (1986) were presented in *The Victorian Naturalist* by Mansergh and Bennett (1989). Subsequent modelling of distributions (bioclimatic envelopes) and future climatic scenarios have supported the theoretical predictions (Bennett *et al.* 1992). Global warming will induce changes in the distribution and abundance of biota at an unprecedented rate across eastern Australian landscapes where habitats have been eliminated, fragmented and modified (Mansergh *et al.* 2005a, 2005b). Current species distribution reflects survival from past climate change and migration and adaptation to 'recent' climate. Modified environments have constricted habitat availability (in terms of both quality and quantity) that will produce genetic/population bottlenecks, or extinction of populations that are unable to persist as the current distribution of habitat is altered through climate change (Fig. 4; Opdam and Wascher 2004). Water budgets and weeds also are predicted to be affected by global warming (Pittock 2003), with predictions of increased fire-weather risks and a shifting and narrowing of the time window available for prescribed burning in south-eastern Australia (Hennessy *et al.* 2005). In the context of global warming, recent works by influential authors indicate that environmental problems, including the loss of biodiversity and our living capital, are not only critical but urgent and demand action at all levels of community (Flannery 2005; Lowe 2005).

Amelioration (lessening greenhouse gas emissions) was the primary debate of the 1990s. However, with the IPCC report (2001a, 2001b) indicating that global warming is happening, adaptation must be included within a rational response. Biodiversity was the first sector to develop a national adaptation action plan (NRMMC 2004). Key responses include: an increase and refinement of knowledge and predictive capacity; making existing native vegetation (including expanded reserves) as resilient as possible (to use biological inertia of systems); and to establish ecologically viable connections between areas that will maximise evolutionary potential for movement. These connecting zones have been termed 'biolinks' (Bennett *et al.* 1992; DCE 1992) and are much broader than traditional wildlife corridors (Mansergh *et al.* 2005b). Biolinks aim to ameliorate the effects of population bottlenecks induced by global warming (Fig. 4). From early modelling, Bennett *et al.* (1992) identified both climatic refugia and biolinks for Victoria and this achieved policy recognition (DCE 1992; Fig. 5). There is a high co-incidence of biolinks (Fig. 5) and amenity/transitional zone (Fig. 1) although each was derived independently from different data sources. Within these zones some landholders are *already* managing land that will assist these efforts (see Box 3). It has been suggested, perhaps optimistically (Mansergh *et al.* 2005a, 2005b), that 'the production metric' in these landscapes may evolve from DSE (Dry Sheep Equivalent – see Part 1) to habitat hectares.

Refugia for flora and fauna exist across the landscape and operate at different spatial and temporal scales under different environmental changes or events (fire, drought, climate change). Future studies will refine our knowledge.

Refugia are associated with the availability of critical resources (e.g. water) and microhabitat diversity (e.g. elevated areas, high fertility). The Grampians, Great Dividing Range and environments associated with the Murray River are Victorian examples that also will be important under global warming scenarios (Emison 1982; Brereton *et al.* 1995). Planning for biolinks needs to be cognisant of this at the macro scale (of what they were linking) and the micro scale, i.e. diversity of habitats (fertility and topography) (Soderquist and Mac Nally 2000). In Victoria, crown land along water frontages, locality of recharge areas, the marginality of steep hill country for grazing (Crosthwaite *et al.* 2006), and changes in socio-economic trajectories (Fig. 1), indicate that opportunities exist for innovative changes to land use and management throughout Victoria. We suggest that focusing additional resources in biolink areas (progressively defined) is a worthwhile approach.

The imperatives of adaptation to global warming will become increasingly apparent and important to society and community values (Lowe 2005; Flannery 2005). Part of the adaptation for biodiversity conservation will include 'biolinks' (NRMMC 2004), within and through previous agricultural landscapes. Although the importance of connectivity is increasingly well known to science (Soule *et al.* 2004) it is not widely adopted in land use and management. As society adapts to climate change, the concept of biolinks provides a long-term 'intergenerational' purposefulness for restoration. This reflects at least two (of the three) pillars of ecologically sustainable development (World Commission on Environment and Development 1987). Our language should change, as 'remnants' of pre-European vegetation become 'reservoirs' for future landscapes. As noted above, enlarging and ecologically linking through large scale revegetation should begin as soon as possible and the legacy of old trees should be protected.

Visualising 'sustainability' in Victorian landscapes

This paper and the original presentation on which it is based use reconstructed sequences of images and aerial photos to visualise historic changes at a state-wide scale, landscape and site level (Fig. 1, Fig. 2 – Part 1) (Fig. 2; Fig. 3; Fig. 6; Fig. 7; Fig. 8). These techniques, at an appropriate scale, offer a new and powerful tool for understanding historic changes in the natural environment and for exploring future options for its replenishment.

Any form of sustainability must involve restoration of landscape and ecosystem function and services. Linking some of the above evidence with the move toward a 'sustainable state', it seems logical to use technology to 'envision future landscapes' (Mansergh and Parkes 2003). Given the landscape debt, it is also imperative that we can visualise from where we have come (Part 1), and land use history is a critical aspect of resilience resistance (Dorrough *et al.* 2006). The first comprehensive aerial photographic survey of Victoria (RAAF in late 1930s and 40s) is the earliest statewide photographic benchmark (Fig. 6). Vandersee (1988) used some of the 1941 photo series to show changes of Victorian saltmarsh communities and the potential effects of global warming. Accurate time series of land use history maps/photographs for all areas of the state would provide the ideal benchmark for better understanding the spatial expression of some of the ecological issues we have inherited and must confront / resolve in future. This would provide a basis from which future land use change could be designed and debated. Policy 'visions' could be translated from their current verbal form to a visual and spatial form, giving clearer substance to land use changes. Visualisation of these potential changes will allow better appreciation of future options, and may help to communicate or decide the magnitude of the changes. Continuation of the 30-year trend in depletion may be contrasted to two revegetation scenarios (from data in Table 1) and preference to biolinks in Figure 8. It would be a significant tool for Catchment Management Authorities, local government, scientists and citizens to advance biodiversity conservation and other issues of land use change as we move toward sustainability. Technologically we can visualise future landscapes from the present. We would argue that a benchmark from the past provides the critical third point on any 'trajectory graph'. Absence of this perspective risks ignoring both the extinction debts embedded in the landscape and the identification of more potentially resilient areas.

The Snowy River: a recent issue

Elements of the recent Snowy River debate demonstrate how some of the emerging themes identified above are expressed and combined in our society. The Snowy Scheme was a national icon that sought to 'green' the inland through irrigation. Ninety-nine percent of the montane flows of the Snowy River were diverted to inland irrigation and electricity production (Part 1; Seddon 1994; Miller 2005). In the 1990s, community groups along the Snowy River sought to restore 'ecological flows', which were seen by others as a threat to water entitlements in the Murray and Murrumbidgee irrigation areas.

At a public rally on the steps of Victoria's Parliament in April 1999, Lady Southey (of the Myer Foundation) asserted that 'science is on the side of the river' (Miller 2005). This alludes to the Enlightenment belief of science being 'true', but the science here was the environmental flow study (Pendlebury *et al.* 1996) that stated that 28% of the original flow was the minimum required to restore river health; i.e. metrics and thresholds had been set for the natural capital (the river). This science was not available a few years previously, and at the time of the original decision to proceed with the scheme (1949) it would have been inconceivable to even contemplate the need to measure the effects on the river ecosystem. The dominant 'sciences' of that time in relation to the use and allocation of land and water were engineering and agronomy. Tom Burlinson (the actor who played Jim Craig in *The Man From Snowy River*) said 'It was shameful legacy to leave to our children and our grandchildren. Now is the time to listen to the experts the Snowy River must flow again' (quoted in Miller 2005). In such expressions of public sentiment a new 'sense of place' is seen, supported by new science and metrics (environmental flow), and pleas for intergenerational equity in terms of living natural capital. Diverting this from natural capital almost completely to irrigation and the generation fo electricity had become unacceptable to the community' Our sense of place is a more holistically-valued native biodiversity.

The responses of several Aboriginal elders who attended the initial re-instalment of part of the Snowy River's flow, were recorded as significant. Ngarigo elder Aunty Rae Stewart (quoted in Miller 2005):

> The spirit of the elders of this area will be free at last with the flowing of the river.

Gunai elder Uncle Albert Mullet (quoted in Miller 2005):

> White people are beginning to learn to care for country, and if its not too late, they might learn something.

These perspectives (and increased flow, possibly to 28% in the long term) indicate that some fundamental perceptions and values that have driven past land and water use are changing in our society.

Conclusion

The legacy of our past land use is stark. Victoria has the highest concentration on the continent of bioregions under high landscape stress (Part 1 Fig. 3). The consciousness and valuing of the natural capital that has been lost, what remains, and what may still be lost provide a major cultural driver for future land use and management. Our sense of place has changed. Business as usual is not an option, and replenishment of our natural capital is a prerequisite, if we are to become a 'sustainable state'.

The future cannot be predicted with any certainty. However, a future can be envisaged in which the historical trend of broadscale, almost relentless, depletion of natural capital and decline in ecological processes and ecosystem services is reversed. Attempts to change toward this direction can be seen at the national, state and local levels. In substantial Victorian landscapes, socio-economic drivers of land use change will assist this trend. The value of environmental assets is increasing, as are concepts and tools that incorporate them into the modes of production. New knowledge and ecological insights will, perhaps inevitably, assist this process of change and overcome some of the 'ignorance' over past use of our living natural capital. The appreciation of past radical depletion, of the new 'sense of place', of how we confront and adapt to greenhouse in the 21st century, and of intergenerational equity, are converging issues. These provide common ground to replenish our living natural capital as a societal aspiration that can be realised. The future landscapes of Victoria will reflect our view of what is important to us as a community. We can and must learn from the past, in relation to our living natural capital — 'caring for country' demands replenishment.

Footnotes

[1] Mansergh *et al.* 2006 will be referred to as Part 1 from here on.

[2] The negligible amount of Victorian land managed by Koories (Part 1 Table 1, SAMEIV 2002) requires redress. See also Aboriginal and Torres Strait Islander Heritage Protection Act 1984 (Commonwealth). Recently, Justice Merkel (Clarke v State of Victoria [2005] FCA 1795) in a recent legal decision concerning the Wimmera stated, 'the tide of History has not washed away all entitlements to native title in South-Eastern part of Australia'. The issue will not be discussed here.

[3] In the national context, Victorian agriculture remains economically important (DPI 2005). NLWRA (2001 and 2002) found that 26% of Australia's agricultural production and 50% of profits comes from irrigated land — just 1% of the landscape dedicated to agriculture. Eighty percent of agricultural profits come from less than 1% of the area used: and 10% of farm establishments produce between 40 and 50% of Australia's gross agricultural income (NLWRA 2002). The agricultural industries have progressively moved away from 'subsidies' and Productivity Commission (2004) suggests that 'measured assistance to most agricultural activities remains low'. There remains a need to remove 'perverse incentives' (Young *et al.* 1996).

[4] EMS monitor processes for improvement. It is cautionary to note that the starting point or baseline is important (see Figures in Part 1). Starting from a vastly depleted system improvement may be marginal or at worst illusionary.

[5] The 'sub and super' (1940-60s) period (Part 1) and the doubling of nitrogenous fertilisers during the 1990s have resulted in soil acidification becoming a major problem in agricultural landscapes (NLWRA 2001).

[6] McCoy and Young (2005) discussed structural changes, including environmental flows and buyback of water, for the Murray catchment that would enable the majority of the Snowy water to continue to flow.

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and the October 2005 meeting, convinced us that the words and analysis may find resonance and have meaning to a wide readership.

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Part 1 Errata

Page 20. NRE 1997 established net gain in condition and extent of native vegetation as policy. NRE (2002) articulated the hierarchy of avoid, mitigate, offset.

Page 22. Correctly referenced, however, more accurate figures for Victoria are – freehold 66%, public 34%.

Appendix 1. Terrestrial vertebrate fauna species from property at Upotipotpon 'pootong pootong', west of Benalla (Data supplied by Lance Wiliam)

Common Name	Scientific Name	Common Name	Scientific Name	Common Name	Scientific Name
Frogs					
Common Eastern Froglet	*Crinia signifera*	Eastern Banjo Frog	*Limnodynastes dumerilii*	Peron's Tree Frog	*Litoria peroni*
Plains Froglet	*Crinia parinsignifera*	Sloane's Froglet	*Crinia sloanei*	Spotted Grass Frog	*Limnodynastes tasmaniensis*
Reptiles					
Bearded Dragon +	*Pogona barbata*	Eastern Blue-tongued	*Tiliqua scincoides*	Eastern Brown Snake	*Pseudonaja textilis*
Lace Monitor +	*Varanus varius*	Marbled Gecko	*Christinus marmoratus*	Robust Ctenotus	*Ctenotus robustus*
South-eastern Morethia Skink	*Morethia boulengeri*	Southern Rainbow-skink	*Carlia tetradactyla*	Wood Gecko	*Diplodactylus vittatus*
Birds					
Australasian Grebe	*Tachybaptus novaehollandiae*	Australian Hobby	*Falco longipennis*	Australian Magpie	*Gymnorhina tibicen*
Australian Owlet-nightjar	*Aegotheles cristatus*	Australian Pipit	*Anthus australis*	Australian Raven	*Corvus coronoides*
Australian Shelduck	*Tadorna tadornoides*	Australian White Ibis	*Threskiornis molucca*	Australian Wood Duck	*Chenonetta jubata*
Barn Owl	*Tyto alba*	Black Falcon +	*Falco subniger*	Black Honeyeater	*Certhionyx niger*
Black Kite	*Milvus migrans*	Black-chinned Honeyeater ^	*Melithreptus gularis*	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*
Black-fronted Dotterel	*Elseyornis melanops*	Blue-faced Honeyeater	*Entomyzon cyanotis*	Brown Falcon	*Falco berigora*
Brown Goshawk	*Accipiter fasciatus*	Brown Songlark	*Cincloramphus cruralis*	Brown Treecreeper ^	*Climacteris picumnus*
Brown-headed Honeyeater ^	*Melithreptus brevirostris*	Budgerigar	*Melopsittacus undulatus*	Bush Stone-curlew +^	*Burhinus grallarius*
Cockatiel	*Nymphicus hollandicus*	Common Bronzewing	*Phaps chalcoptera*	Crested Pigeon	*Ocyphaps lophotes*
Crimson Rosella	*Platycercus elegans*	Diamond Firetail +^	*Stagonopleura guttata*	Dusky Woodswallow	*Artamus cyanopterus*
Eastern Rosella	*Platycercus eximius*	Eastern Shrike-tit	*Falcunculus frontatus*	Eastern Yellow Robin	*Eopsaltria australis*
Fairy Martin	*Hirundo ariel*	Flame Robin	*Petroica phoenicia*	Fuscous Honeyeater ^	*Lichenostomus fuscus*
Galah	*Cacatua roseicapilla*	Grey Butcherbird	*Cracticus torquatus*	Grey Fantail	*Rhipidura albiscapa*
Grey Shrike-thrush	*Colluricincla harmonica*	Grey-crowned Babbler +^	*Pomatostomus temporalis*	Hooded Robin ^	*Melanodryas cucullata*
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*	Jacky Winter ^	*Microeca fascinans*	Laughing Kookaburra	*Dacelo novaeguineae*
Little Corella	*Cacatua sanguinea*	Little Eagle	*Hieraaetus morphnoides*	Little Friarbird	*Philemon citreogularis*
Little Lorikeet ^	*Glossopsitta pusilla*	Little Pied Cormorant	*Phalacrocorax melanoleucos*	Little Raven	*Corvus mellori*
Magpie-lark	*Grallina cyanoleuca*	Masked Lapwing	*Vanellus miles*	Masked Woodswallow	*Artamus personatus*
Mistletoebird	*Dicaeum hirundinaceum*	Nankeen Kestrel	*Falco cenchroides*	Noisy Friarbird	*Philemon corniculatus*
Noisy Miner	*Manorina melanocephala*	Olive-backed Oriole	*Oriolus sagittatus*	Pacific Black Duck	*Anas superciliosa*

Common Name	Scientific Name	Common Name	Scientific Name	Common Name	Scientific Name
Birds (cont.)					
Painted Button-quail ^	*Turnix varia*	Painted Honeyeater +^	*Grantiella picta*	Pallid Cuckoo	*Cuculus pallidus*
Pied Butcherbird	*Cracticus nigrogularis*	Pied Currawong	*Strepera graculina*	Pied Honeyeater	*Certhionyx variegatus*
Pink Robin	*Petroica rodinogaster*	Rainbow Bee-eater	*Merops ornatus*	Red Wattlebird	*Anthochaera carunculata*
Red-rumped Parrot	*Psephotus haematonotus*	Restless Flycatcher	*Myiagra inquieta*	Rufous Songlark	*Cincloramphus mathewsi*
Rufous Whistler	*Pachycephala rufiventris*	Sacred Kingfisher	*Todiramphus sanctus*	Scarlet Robin	*Petroica multicolor*
Southern Boobook	*Ninox boobook*	Southern Whiteface	*Aphelocephala leucopsis*	Spotted Nightjar	*Eurostopodus argus*
Spotted Pardalote	*Pardalotus punctatus*	Straw-necked Ibis	*Threskiornis spinicollis*	Striated Pardalote	*Pardalotus striatus*
Sulphur-crested Cockatoo	*Cacatua galerita*	Superb Fairy-wren	*Malurus cyaneus*	Swift Parrot +^	*Lathamus discolor*
Tawny Frogmouth	*Podargus strigoides*	Tree Martin	*Hirundo nigricans*	Varied Sittella	*Daphoenositta chrysoptera*
Wedge-tailed Eagle	*Aquila audax*	Weebill	*Smicrornis brevirostris*	Welcome Swallow	*Hirundo neoxena*
Western Gerygone ^	*Gerygone fusca*	Whistling Kite	*Haliastur sphenurus*	White-bellied Cuckoo-shrike	*Coracina papuensis*
White-bellied Sea-Eagle +	Haliaeetus leucogaster	White-browed Babbler	*Pomatostomus superciliosus*	White-browed Woodswallow	*Artamus superciliosus*
White-faced Heron	*Egretta novaehollandiae*	White-fronted Chat	*Epthianura albifrons*	White-necked Heron	*Ardea pacifica*
White-plumed Honeyeater	*Lichenostomus penicillatus*	White-throated Needletail	*Hirundapus caudacutus*	White-winged Chough	*Corcorax melanorhampos*
White-winged Triller	*Lalage sueurii*	Willie Wagtail	*Rhipidura leucophrys*	Yellow Thornbill	*Acanthiza nana*
Yellow-billed Spoonbill	*Platalea flaveolens*	Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	Eurasian Blackbird *	*Turdus merula*
Common Starling *	*Sturnus vulgaris*				
Mammals					
Chocolate Wattled Bat	*Chalinolobus morio*	Common Brushtail Possum	*Trichosurus vulpecula*	Common Ringtail Possum	*Pseudocheirus peregrinus*
Eastern Grey Kangaroo	*Macropus giganteus*	Gould's Wattled Bat	*Nyctophilus gouldii*	Koala	*Phascolarctos cinereus*
Lesser Long-eared Bat	*Nyctophilus geoffroyi*	Little Forest Bat	*Vespadelus vulturnus*	Short-beaked Echidna	*Tachyglossus aculeatus*
Southern Freetail Bat	*Mormopterus* sp. (long penis form)	Squirrel Glider +	*Petaurus norfolcensis*	White-striped Freetail-bat	*Tadarida australis*
Yellow-footed Antechinus	*Antechinus flavipes*	Brown Hare*	*Lepus capensis*	Cat *	*Felis catus*
Fox *	*Vulpes vulpes*	Rabbit *	*Oryctolagus cuniculus*		

+ threatened in Victoria
^ species listed in the FFG Woodland Bird Community as woodland dependent
* introduced

Historical notes on Charles and Thomas Brittlebank, pioneer naturalists in the Werribee Gorge district, west of Melbourne

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Abstract

Early FNCV members, the brothers Charles and Thomas Brittlebank pursued their varied interests in natural history in the Werribee Gorge district in the late 19th and early 20th centuries. They compiled one of the first comprehensive bird lists for the area. Charles was a renowned artist and contributed illustrations of birds and their eggs, insects, fungi and mistletoes for pioneering works on thoise subjects by AJ Cambpell, JA Leach, Charles French, Daniel McAlpine and himself. He published widely and was considered an authority on the evidence for glacial action in Werribee Gorge. Thomas was a skilled egg collector, bird observer, landscape artist and contributor to his brother's and AJ Campbell's studies. Together they helped to lay the foundations of natural history study in Victoria. (*The Victorian Naturalist* **123** (5), 2006, 314–317)

Thomas (1865[?]–1948) and Charles Brittlebank (1863–1945) were pioneers in studying the natural history of the district immediately west of Melbourne, Victoria. They were brothers, born in the village of Winston in Derbyshire, England. In the 1870s, the family moved to the New Hebrides, and from there to Queensland, where their father Andrew and another son Louis died, probably of typhoid. The two younger sons and their mother Ellen later moved to Tasmania and then to Spring Vale (location unknown). Ellen bought a house and property, Dunbar, at Myrniong near Bacchus Marsh, on the northern side of Werribee Gorge. EE Pescott (1946) gave the date of arrival at Myrniong as 1893, but it was probably considerably earlier. A report in 1890 referred to an FNCV excursion to Werribee Gorge and stated that the Brittlebank brothers were present and the party started from Dunbar (Anon 1890). The previous owner of the property, William Dunbar, died in 1884 (Bacchus Marsh and District Historical Society 2003). When Charles married, he continued to live at Dunbar, while Thomas and his wife built a new house, Bonsall. The property was used for mixed farming until 1919 or 1920, when it was sold. Charles then worked for the Department of Agriculture. Thomas became the headmaster of the Migrant Training Centre at Elcho near Geelong, where migrants were trained in Australian agricultural methods, and was later involved in agricultural education at Warrnambool (Anon 1945; Pescott 1946; Anon 1948; Whittell 1954; Bacchus Marsh and District Historical Society 2003; Marion Taylor, pers. comm.).

While they were living near Werribee Gorge, the brothers became interested in the natural history of the area. They must have been inspired by the beautiful setting of Dunbar, overlooking the rugged Werribee River valley, and with panoramic views of Melbourne, the Dandenong Ranges, the You Yangs and Mount Blackwood. Charles leaned more towards geology and Thomas towards ornithology, but they both had wide interests. Charles became the better known of the two, because of his work as Plant Pathologist and Biologist-in-charge of Science at the Department of Agriculture, his scientific publications in geology, botany, mycology, entomology and ornithology, and his illustrations in pioneering works in Australian natural history. However, Thomas was also a talented artist and naturalist (Pescott 1946; Anon 1948).

Charles and Thomas were active and popular members of the Field Naturalists' Club of Victoria. Naturally, they became particularly associated with Werribee Gorge, and many club excursions to the area were led by one or both of the brothers. Perhaps naturalists were also attracted by the friendly welcome, the late breakfasts and the sumptuous evening meals prepared by Mrs Brittlebank at Dunbar (Campbell 1891; Barnard 1894). In early excursions, members were attracted by the possibilities for bird-watching in the area.

A report published in *The Victorian Naturalist* in 1890 was devoted mainly to birds, and included a complete bird list (Anon 1890). The gorge was famous for its nesting Wedge-tailed Eagles. AJ Campbell's book, *Nests and Eggs of Australian Birds* (1900), shows a photograph (facing page 10) of an intrepid climber standing in a rather casual attitude beside an eagle's nest in Werribee Gorge. The tree appears to be projecting outwards from a mountainside with the nest suspended over an alarming void. Later in the 1890s, the focus gradually shifted to the geology of Werribee Gorge, which became famous for its evidence of glacial action and a former ice-age, partly because of work by George Sweet, Charles Brittlebank and Professor Edgeworth David. However, there was some confusion over priority for the observations of glacial rocks and a dispute over the interpretation of the geological studies (Officer and Balfour 1893; Sweet and Brittlebank 1893; Hall 1894).

Few illustrators have contributed so much to so many fields of natural history as Charles Brittlebank. He produced most of the plates of insects for five volumes of Charles French's *A Handbook of the Destructive Insects of Victoria* (1891-1911); 14 plates for Volume I; 22 for Volume II; 20 for Volume III; 17 for Volume IV; and 10 for Volume V. He prepared the plates for Volume VI, but the book was not issued. He painted six plates for his own paper on the Harlequin Mistletoe (1908), and produced dozens of coloured plates and hundreds of microphotographs for books on fungi by Daniel McAlpine (e.g. McAlpine 1899). Paintings of orchids by Charles Brittlebank were donated to Museum Victoria by his family. He is best known by bird-watchers for his detailed and exquisite watercolours of eggs in AJ Campbell's *Nests and Eggs of Australian Birds* (1900), the first work to delineate the eggs of more than 200 Australian species (pure-white eggs were not illustrated). He used many eggs from the collection of his brother Thomas as models. There is a letter in the AJ Campbell collection in Museum Victoria, in which Charles Brittlebank agrees to paint 202 eggs for AJ Campbell for a fee of £27 (McEvey 1966). Charles was described as an exacting artist. His work became world-famous for its 'beauty of delineation and accuracy of detail', achieved with the aid of a large magnifying lens (Pescott 1946).

Charles Brittlebank's paintings of birds were not as successful as his renditions of insects and eggs. In Allan McEvey's opinion (1966), the posture and the birds' legs were 'often unconvincing'. However, the paintings are of considerable historical interest. Charles Brittlebank provided several illustrations of insectivorous birds with explanatory notes for Charles French's work on insects: birds were delineated by him in eight plates in Volume III, 14 plates in Volume IV, and four plates in Volume V. AJ Campbell's book includes one of his bird paintings, a pair of Rose Robins at a lichen-covered nest containing their pale-green spotted eggs (facing page 142); he provided five illustrations in JA Leach's *An Australian Bird Book* (1911); and there are four original colour plates of birds (petrels, Red-capped Robin, Flame Robin, Eastern Yellow Robin) in the collection of Museum Victoria. The plate of the petrels was used, either as a study or as the final plate, for the illustrations of these species in Leach's book (McEvey 1966).

The Brittlebank brothers are especially known for their work in Werribee Gorge. However, they observed birds over a wide area west of Melbourne. In AJ Campbell's book, they contributed many records from Bacchus Marsh, Lerderderg Gorge, Yaloak, Mount Wallace, the Werribee Plains, Mount Cottrell, Wyndham, Werribee and the mouth of the Werribee River. But perhaps their greatest contribution to local ornithological knowledge was a paper on the birds of Myrniong published in *The Victorian Naturalist* (Brittlebank 1899a). This paper, written by Charles, listed every bird species which he and Thomas had recorded in the district between 1893 and 1899: 158 species in all, 108 of them with breeding records. Several rarities, vagrants, and birds now declining or locally extinct were on the list, including Square-tailed Kite, Letter-winged Kite, Rainbow Lorikeet, Spangled Drongo, Cicadabird, Hooded Robin, Black-faced Monarch, White-browed and Grey-crowned Babbler, Regent Honeyeater and Dollarbird. Lerderderg Gorge, Melton, Mount Blackwood, the Moorabool River and the northern Brisbane Ranges formed the boundaries of the district covered in this paper. An area of woodland now known as Long Forest fell within these limits. It contains an isolated occurrence of Bull Mallee *Eucalyptus behriana*, unique south of the Great Divide. The mallee woodland is mentioned in the introductory paragraph of the paper, and Thomas Brittlebank visited the area (then known as Melton) at least once. His discovery of a nest of a White-fronted Chat there was the subject of a short note in *The Victorian Naturalist* (C Brittlebank 1899). Unfortunately, however, no specific locations were given for any of the birds on the Myrniong list.

Charles Brittlebank's versatility across several disciplines in natural history, and his talent with both pen and brush, were astonishing, and yet his work was never superficial. It was always supported by the most careful observations and research, and demonstrated his patience and attention to detail. We can picture him alone, quietly working on his papers and paintings over endless hours, and yet this picture appears to be incomplete. He must have been a sociable person. He was well liked in the FNCV. An affectionate and generous friend, his home was always open and became the centre for Werribee Gorge excursions over many years. He always enjoyed sharing his knowledge (Pescott 1946). For his friend, Charles French, he prepared as a gift a series of drawings of beetles, commemorating every species that bore French's name. These covered seven large sheets of drawing paper (Pescott 1946). To balance his quieter pursuits, Charles Brittlebank was very active and possessed great stamina. EE Pescott, one of his obituarists, noted that he was an amateur boxer in his youth. Reports of Werribee Gorge excursions in the 1890s spoke of scrambling down the riverbed, scaling precipitous slopes, pushing through hilltop scrub, and negotiating huge stones, fallen masses of rock and thorny thickets. To traverse 16 kilometres took up to 10 hours of walking over an actual distance of 40-45 km. This was all described as 'rather violent exercise' (Anon 1890; Barnard 1894). This difficult country was Charles' patch, and he knew every inch of it.

Because Thomas left little published work under his own name, he is a more shadowy historical figure than Charles. Like his brother, he was a talented artist, producing many landscape paintings (Marion Taylor, pers. comm.). His observational skills were at least the equal of Charles'. He was a partner, sometimes a silent one, in some of his brother's endeavours. Many of the eggs delineated in AJ Campbell's book and the records in Charles' paper on the birds of Myrniong originated with Thomas (T Brittlebank 1899; Campbell 1900). Like his brother, Thomas was at home in rugged Werribee Gorge, and took part in, and led, several FNCV excursions there (e.g. Hall 1894). He seemed to be the more adventurous of the two, perhaps because Charles' wife suffered from poor health (Marion Taylor, pers. comm.). In those days, all serious egg-collectors were daring tree-climbers and travellers. Thomas took part in egg-collecting expeditions to remote parts of Australia (Marion Taylor, pers. comm.), and he was the first to describe and measure the eggs of the Little Kingfisher, from a nest he found in the Cape York district of Queensland (Brittlebank 1901). His egg-collection is now at Museum Victoria.

Thomas and Charles were buried side-by-side in Bacchus Marsh (Maddingley) Cemetery, with their mother and their wives. From the grave-sites, the ridge above Werribee Gorge is visible in the distance.

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I would like to thank Bob Reid, the Bacchus Marsh and District Historical Society, and Marion Taylor, grand-daughter of Thomas Brittlebank, for information on the Brittlebank family and their property, Dunbar. The librarian and assistant librarian of the FNCV, the staff of the State Library of Victoria, and Dean Hewish assisted with the literature search.

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A record of the Common Dunnart *Sminthopsis murina* using artificial habitat

The Common Dunnart *Sminthopsis murina* inhabits mallee scrub, dry heath, dry forest and woodland within Victoria, mostly in the north and west of the state (Atlas of Victorian Wildlife). All areas where the species is found have sparse shrub and ground cover, but usually with a dense cover of ground litter (Menkhorst 1995). However, the species is no longer common and is now classed as vulnerable in Victoria. Records of the Common Dunnart exist close to Melbourne, particularly to the north east on dry slopes and ridges south of the Kinglake ranges, in the vicinity of Watsons Creek.

Fig. 1. Concrete paver used to produce nesting cavity.

In this district, the Watsons Creek Nature Conservation Link is made up of remnant habitat areas along Watsons Creek and several Crown Conservation Reserves, which join the Kinglake ranges to the north and the Yarra Valley to the south. Within this link, One Tree Hill Reserve is the largest area of reserved crown land and provides important habitat for several rare and threatened species, including the Powerful Owl *Ninox strenua*, Brush-tailed Phascogale *Phascogale tapoatafa* and Common Dunnart.

As part of a habitat enhancement program, RMIT University, in conjunction with Parks Victoria, positioned forty concrete pavers on several slopes in Dry Grassy Woodland at One Tree Hill, in habitat that was considered typical for the Common Dunnart. Each paver measured 380 mm by 380 mm and had a thickness of 45 mm (Fig. 1). The forty pavers were layed between October 2003 and March 2004. They were positioned in four lines of ten, with about ten metres between pavers. A nesting cavity was excavated under each block and dry grass was provided for nesting material.

One Tree Hill Common Dunnart record, March 2006

On 24/3/2006, staff and students from the School of Life and Physical Sciences, RMIT University, visited One Tree Hill Reserve with Mr Campbell Beardsell of Parks Victoria, principally to study the techniques and results of ecological burning. Towards the end of the day, as we were about to conclude the visit, we realised that the track leading to the easiest exit passed closely to one of the lines of pavers. It was decided to show the students some of the pavers and explain the reason for their presence in the reserve. When the second paver in the line was lifted, to our surprise, a Common Dunnart was found sheltering under the paver. The animal was subsequently captured by hand (see cover picture) and proved to be an adult male. The dunnart was released hard against the entrance to the paver, but ran directly to the next paver in the line and disappeared under it. It is interesting to note that the area from which this record was obtained was subjected to an ecological burn in March 2005, and ground cover in March 2006, was particularly sparse.

Other records exist for the Common Dunnart in this reserve which also involve the species using artificial habitat. On the 25/5/1968, the then Mammal Survey Group (now Fauna Survey Group) of the FNCV visited One Tree Hill and captured two common Dunnarts that were found under discarded galvanised iron (FNCV unpubl. data). This was six years after wildfire had burnt through the area in 1962. On 20 November 1988, Beardsell (1997) carried out a detailed ten hectare search of dense tussocks on slopes directly below the site where the Common Dunnart was found on 24/3/2006. During the search two adult female Common Dunnarts were found, both with pouched young, one in a grass tussock and the other under discarded galvanised iron.

Acknowledgements
Many thanks to Cam Beardsell, Parks Victoria, whose idea it was to use concrete pavers as habitat at One Tree Hill Reserve. Richard Francis, formerly of RMIT University, organised and supervised the laying of the pavers and numerous RMIT students helped carry the pavers down steep slopes. The specimen mentioned in this article was handled under the terms of Research Permit No. 10002492 issued by the Department of Sustainability and Environment and by RMIT Animal Ethics Committee Approval No. 315.

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Flora and Fauna Guarantee Act 1988

Final recommendations in regard to nominations for listing under the Flora and Fauna Guarantee Act 1988. The nominations for the following taxa to be listed as threatened are supported by the Scientific Advisory Committee July 2006.

Marsh Tree-moss *Climacium dendroides*
Oval Wedge-fern *Lindsaea trichomanoides*

Butterflies of the Solomon Islands: systematics and biogeography

by John Tennent

Publisher: *Storm Entomological Publications, Dereham, UK, 2002.*
413 pages 84 plates. ISBN 0954204506. RRP c. $280.00
Available from the author. Email: jt@stormemt.freeserve.co.uk

It was a delight to read this definitive work on the Solomon Islands butterflies, particularly given my interest in the Pacific region. The birdwing illustrations are eye-catching, and I think most lepidopterists delight in seeing these awe-inspiring creatures in the wild. I, like the author, have had the opportunity to see a number of birdwing taxa during travels in the Asia-Pacific region. In Guadalcanal, I gazed upon both sexes of the localised blue birdwing, *Ornithoptera priamus urvillianus* as they fed at red hibiscus in village gardens, and patrolled and perched beneath plantation canopy during the heat of the afternoon. In late afternoon, adjacent forest margins, their massive forms could be seen in silhouette, soaring above the canopy and feeding amidst treetop blossoms.

In the Solomons in recent years, butterfly collecting can still be adventurous and daring. Tennent compares how Woodford, in the 19th century had 'carried a butterfly net in one hand and a pistol in the other.' And, how, he himself, some 120 years later, required accompaniment by 'a uniformed soldier armed with a self-loading rifle' (p vii). Several years on from Tennent's expeditions, Honiara remains risky for collectors venturing far outside the urban border protection zone. There is also little tourist infrastructure, so few go there.

Tennent recognises at least 197 species in the Solomons archipelago (excluding Nissan, Buka, and Bouganville administered by PNG), with 145 species from Guadalcanal alone. In compiling this important work, Tennent spent some 18 months conducting fieldwork in the Solomons, visiting 44 islands, and in the process discovered a large number of taxa later named in his technical papers, and predicts that still more await discovery in the inaccessible interiors of some islands.

This meticulously detailed book, by a leading authority on the systematics and biogeography of the Pacific Island butterflies, is obviously 'a must have' for any butterfly enthusiast with an interest in the species in the Australasian region. It is attractively presented, hardbound, with a glossy dust jacket depicting live adults. It opens with a foreword by RI Vane-Wright, followed by a single-page preface, acknowledgement section, and clear structure diagrams of wings, with venation and wing areas labelled. There is also a species checklist that includes subspecies, and a key to 22 important abbreviations. Four large maps, covering the expanse of islands of the Southwest Pacific, the Solomon Islands chain, with enlargements of the New Georgia group and Santa Cruz group, are provided. The work then comprises the two main sections: the Introduction and Systematic Part. The twin columned text contains bold headers and species titles, enabling ease of finding information.

The introductory section commences with informative short pieces on the archipelago's geological origins, climate, and vegetation. It continues with an intriguing account on historic European presence, leading on to a focus on earlier butterfly collectors of the region and their adventures, as well as contemporary work. Attention then directs towards the butterflies themselves, with discussion of mimicry, local biogeography, generic and species distributions and endemism in the islands. Tabulations of generic and species tallies and percentage of endemism for the major islands are inset within the regions under discussion. Tabulated world generic distributions are also provided; font modification used in places for tighter fitting in compartments and space saving may have created a trade-off on aesthetics, but remains acceptable. A fifth map in this section (p 20), details presumed faunal movement between islands at an earlier geological period and is useful in understanding areas of speciation and evolution of local forms through long isolation. Within the body text there are a few black and white historical illustrations, many line drawings of genitalia, and seven colour pictures of habitat and scenery. For the faraway naturalist, idyllic locality photos, like the one of Tikopia, are always an enticement. Perhaps more could have been included, particularly showing the different habitats in which the varied species are usually encountered.

The systematic part involves a thorough appraisal of the genera, species and subspecies of five butterfly families present in the islands. Each valid name is given with sources of descriptions, type localities, and synonyms. The world range is provided at species level, and finer distribution outlined at local level. Descriptions of species pertain largely to characters used to separate each from nearest others. Each family is introduced by a table listing species and islands occupied by each. Host plants in the Solomon Islands are largely unknown, and the author draws from knowledge of populations of Australia, New Guinea and Fiji as to likely plant genera that may be utilised. These reviewed host listings will be useful guides for the visiting collector or researcher hunting early stages of various local taxa. Tennent also queries some distribution and nomenclature concerns and, where possible, resolves these or at least proposes tentative solutions, explaining any inadequacies where appropriate, and giving earlier authors' opinions.

The book concludes with a list of references, a glossary, and two appendices, 84 colour plates of species and subspecies, and an index of technical names. The illustrated adults have their island of collection provided from their label data. Appendix A is a complete database on all specimens examined by the author, including label data, from several museums in London, Oxford, Honolulu, Honiara, and Sydney. This enormously valuable compilation spanning 43 pages also includes observations by the author, who asserts that 'only records where identification is beyond doubt are included' (p 185). Appendix B is a gazetteer of three pages, comprising an alphabetically arranged list of localities, with alternative or local names for islands to prevent confusion. Both appendices are essential tools in using the book, and visiting observers/collectors will find the database an important tool to find sites for species sought after. Such a tool seems unique to this book, but in countries like Australia, the museum and collection records, numbering in the hundreds of thousands, are too numerous for listing in faunal works. This label data catalogue is foundational for a database on the local species, which in the future, collectors with a passion for this region may wish to build on electronically.

As the work has been pragmatically proofread, I found very few typographical errors, although an Australian butterfly mentioned in passing, *Phaedyma shepherdi*, has its specific epithet misspelled as 'sheperdi' (p 141). The reference section of over 700 sources seems largely complete, but random crosschecking found a couple of citations had been omitted. The glossy colour illustrations of more than 1100 lifesize butterflies (including many primary and secondary types) ease identification. Indeed, some subspecies have never been illustrated before. Finally, perhaps illustrations of live adults in places (other than those on the dust jacket) could have enhanced the book; an added touch I would have liked to see. Overall, John Tennent is to be congratulated for the production of a second faunal work of excellent quality and scholarship, his first being *The Butterflies of Morocco, Algeria and Tunisia* (1996); and this one similarly displays a high standard of readability for both expert and butterfly novice. I wholeheartedly recommend it.

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Climate change: turning up the heat

by A Barrie Pittock

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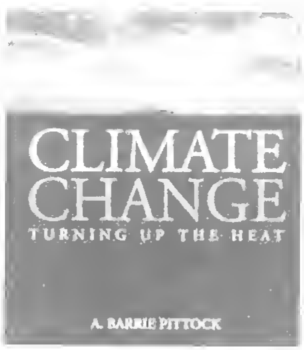

Yes, there's another book on climate change – and no wonder, it's serious stuff. Adding to the now hefty weight of literature on the climate and our future is this outstanding contribution from an expert in the field: Barrie Pittock has been a leading researcher of climate change with CSIRO and served on the Intergovernmental Panel on Climate Change (IPCC). The author's credentials give this book a unique perspective on the problems we face and how they might be addressed. It stands out as a book that offers lucid explanations of fact, uncertainty, risk and climate science. Discussed are environmental changes wrought by excessive consumption and overpopulation, and how these will affect the environment and we humans that depend on it – probably in a very inequitable way. This is also a solutions book that speaks to you and me, and policymakers.

In the chapter 'Learning from the past', the reasons for past climate changes (e.g. variations in Earth's orbit, solar output, and volcanic eruptions) and the lessons we can learn from them are discussed. These changes are often cited as a reason for complacency (*if people survived these in the past, why not in the future?*), but the author reminds us that this ignores our now very different place in the environment. For example, large populations are unable to migrate across national boundaries, and we have mass reliance on relatively few food crops; also, the 'climate change that we can expect in the next 100 years has happened before, but at a much slower rate and from a cooler starting point'.

The chapter title, 'Uncertainty is inevitable, but risk is certain', as noted in the foreword, is an erudite comment on the heart of the climate change debate; the chapter itself details why we cannot ignore the overwhelming, though to some extent uncertain, evidence of anthropogenic climate change. We deal with uncertainty every day and don't generally ignore it: we wear seatbelts to *reduce* the risk of serious injury in the *rare* event of an accident. The IPCC estimated that by 2100 global CO_2 concentrations will be 75 – 350% higher than pre-industrial values, leading to an increase in temperature of 1.4 – 5.8 °C and consequent sea-level rises of 9 – 88 cm. Because these are broad ranges, and indeed estimates, the author helpfully outlines how we estimate risk and measure climate change: e.g. how reliable are temperature measurements from within cities compared to those from satellites? The issue of uncertainty is a strong theme of the book at two levels: in science (how much climate change will there be?) and in future human and societal behaviour (how well will we cope with reducing our emissions?).

'Impacts: why be concerned?' explains why we should be deeply worried if even only the minimum estimates of temperature increase are realised. Here, Pittock quotes from the IPCC on: risks to threatened environments and biodiversity (the Great Barrier Reef already is showing signs of its likely demise – not only will we lose a cherished soul-enriching habitat, but we should remember that the reef also enriches the Australian economy by $1 to 2 billion, *each year*); risks from extreme weather events (damages to ecosystems, crops [why are our North Queensland bananas so expensive now?] and society); inequitable distribution of impacts (the poor [in low-latitude, developing countries] will suffer most as their lands become too hot and dry for habitation); risks from large-scale discontinuities such as melting of the Greenland and West Antarctic Ice Sheets (many heavily populated coastal areas would be flooded).

'Living with climate change' discusses the many things we'll have to do to adapt, and highlights the inequity of these forced adaptations. 'There are equity issues...since adaptation is necessary for people that are affected by climate change, but not necessarily for those who have caused it'. A familiar example is the Pacific islanders who will have to evacuate their submerged homelands because of the changes caused by industrialised nations: who should pay for this?

As well as *adaptation*, we must practise *mitigation* of climate change ('Limiting climate change', chapter 8) by reducing greenhouse gas emissions. This need not be expensive - huge savings can be made by being more efficient. Mitigation is especially important as, even with minimum estimates of climate change (a global rise of 2 – 3 °C before the end of this century), adaptation will be extremely costly and often impossible to implement. Most alarmingly, however, without mitigation, irreversible changes will be set in train that may not be apparent until it is too late (if it isn't already): for example, the thawing of the Arctic tundra would release huge amounts of CO^2 and methane leading to further, accelerated warming; as would the melting of the ice sheets through the consequent lack of solar reflection that these white expanses now provide.

What can we do about it? The obvious switch to non-fossil fuels is thoroughly aired, with the advantages and disadvantages of wind, nuclear, hydrogen, etc well discussed. Pittock notes that truly renewable and essentially harmless means of energy generation, such as wind power, are few; and I note that Victorian naturalists should not be quiet while dubious cases, such as that of the orange-bellied parrot, are argued against the erection of wind turbines.

Climate change is put in context with other pressing problems of fresh water, ozone, atmospheric pollution, overpopulation and security issues, and the conclusion is drawn that all are, of course, linked. Pittock points out that greenhouse gas emissions are essentially a problem of overpopulation, but with the vast burden of emissions coming from the developed countries. Thus, 'the population issue boils down to one of sustainable development'; 'population issues and climate policy need to be linked' – but, since populations generally decline over generations (long-term) urgent reductions in emissions per person (in the west) need to be enacted now.

A chapter on the politics of climate change gives a fascinating glimpse into negotiations in the IPCC and deals with much more besides, under headings such as 'what about the uncertainty?', 'how realistic are the scenarios?', 'choosing emissions targets' and 'how urgently do we need to act?'. It is noted that in choosing emissions targets and how we adapt, we face huge ethical issues around which people or fauna and flora will survive increasing temperatures, rising oceans, more intense storms etc. The author also considers how climate change will affect different countries and what specific nations can do to mitigate global greenhouse gas emissions; he looks at Canberra's reasons for not signing the Kyoto protocol and provides well-reasoned and fact-based counter arguments.

The author often quotes from literature and IPCC reports. Useful headings and bulleted summaries afford a quick grasp of the main points, or the reader can spend time with Pittock's lucid, well-referenced discussions. The 'sources of information'section cites reports, texts, papers and, importantly, categorised websites (e.g. government agencies, NGOs, renewables...). It's a little repetitive in parts, but this allows sections to be read in isolation and it can act as a useful, well-indexed reference book.

This is a disturbing book, but provides an impetus for change, and tolerance in the light of the changes we face. In the closing chapter, 'Accepting the challenge', the author adds a note of optimism: 'It is not about doom and gloom ... but exciting technologies, creating new markets, opportunities for investments ... solving several problems at once ... enjoying our relationship with nature and creating a sustainable future. It is about making life better.' My view is that we're going to need strong, honest politicians to make sure we have more than a short-term view of what's good for us, and what's right for the rest of Earth's inhabitants.

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Ecological review of the Koo-Wee-Rup Swamp and associated grasslands

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Abstract

An understanding of the ecology of the Koo-Wee-Rup Swamp was obtained from historical surveys and soil maps. The probable boundary of the former largest swamp in Victoria was determined. The immense swamp had distinct zones formed by inner and outer swamps: the inner swamp was a permanently inundated reed and rush swamp with emergent sand ridges and possibly with lake-like cells, while the fringing outer swamp was largely paperbark scrub subject to frequent flooding. Grassland and acacia woodland were locally extensive adjacent to the swamp in areas of periodic flooding. The inner swamp boundary was probably flood controlled while the outer boundary was probably fire controlled on the plain and topographically controlled by hills to the east. Rare examples of swamp scrub and grassland remain. (*The Victorian Naturalist* 123 (5), 2006, 323–334)

Introduction

The Koo-Wee-Rup Swamp, also known as the Great Swamp, the Great Marsh and Kuwirap, was the largest swamp in Victoria. Draining and clearing the immense swamp for agriculture was a major undertaking commencing in the 1870s and continuing in stages to the 1960s, imposing hardship on early settlers. It took several attempts over nearly 90 years to drain the swamp, during which time there were at least twelve floods, the last in 1952 (Roberts 1985). The swamp was destroyed without any detailed account of its original condition (Hills 1942) so what is known of its ecology is constructed from fragmentary and often indirect evidence.

The Aboriginal name Kuwirap is said to mean 'blackfish swimming', from kowe = water and wirap or werup = blackfish (Database of Aboriginal Placenames of Victoria 2002). Surveyor William Urquhart (1847) recorded the name of the swamp. His field book states that the Great Swamp was called 'Cowirrip' by the 'Natives'. The name of the swamp is spelt in several ways. Koo-Wee-Rup and Kooweerup are official historical place names. The spelling Koo-Wee-Rup was used for the swamp before and during the time of drainage and is applied here. Koo Wee Rup is now the official place name of the town on the former edge of the swamp.

Kuwirap was effectively impassable and formed part of the boundary between the inland Woiwurrung and the coastal Boonwurrung people. The northern edge was inhabited by the Bulug willam clan, meaning 'swamp dwellers' from buluk = swamp and willam = dwelling place. The southern edge was inhabited by the Yallock balug clan of the Boonwurrung, meaning 'river people' from yallock = river and bulluk = people (Clark 1990, 1996).

In order to understand this unique ecosystem and locate remnant vegetation, historical data and information are used here to map the outer boundary of the swamp. Soil mapping allows a glimpse of the inner swamp. Further analysis is in Yugovic and Mitchell (2004, 2005).

Methods

Copies of early survey plans were obtained from Land Victoria and the State Library of Victoria. Mapping was undertaken using GIS software and the Cardinia Shire Council digital base map of roads and watercourses. Plans were scanned and registered as accurately as possible, using reference points such as creek alignments, land boundaries and, in the case of Urquhart (1847), Mount Ararat and Cannibal Hill. Swamp and grassland boundaries were digitally traced and combined on one composite map.

Map data and information sources were:

Survey map of Urquhart (1847)

Map of the western and northern edge of the swamp and adjacent open plains from Tooradin to Garfield, remarkable detail with traverse points shown, valuable annotations on vegetation.

Survey map of Foot (1855)
Map of the southern swamp edge from The Inlets to Yallock, shows crown allotments allowing better resolution and registration with the base map, valuable annotations.

Survey map of Callanan (1859)
Map of the northern swamp edge from Cardinia to Pakenham, shows allotments, valuable annotations.

Plan K118 (1866)
Map of the southern swamp edge in the Yallock area, shows allotments, valuable annotations.

Plan L3335 (1866)
Map of the near-coastal swamp edge and The Inlets, shows allotments, valuable annotations.

Plan Rail 84C2 (1873)
Railway survey map of the eastern swamp edge from Garfield to Yannathan, uniquely covers a large area but relatively small scale.

Map of Torbonarach and Red Bluff (Moore & Martin's Yallock stations)(no date)
Sketch map of the Yallock area in Gunson (1968), not to scale but informative.

Map of land subsidence of Hills (1942)
A remarkable map of early land subsidence, overlaying early contours with 1914 contours. Subsidence was due to shrinkage and loss of up to about eight feet of peat from drainage, burning, wind erosion, compaction and oxidation. The distribution of the former peat deposit is assumed to indicate the extent of the inner swamp. Points where contours lines from the two surveys converge indicate no subsidence and the edge of the deposit. Coverage is not complete so the entire deposit is not indicated. The map also appears in Hills (1975).

Soil map of Sargeant et al. (1996)
The primary source on the extent of the original peat deposit and thus the inner swamp. Map units Koo-Wee-Rup peaty clay (Ko) and Koo-Wee-Rup peaty clay with sandy ridges (Ko/sr) indicate the previous extent of peat (I. Sargeant pers. comm.). These soils are developed on alluvial deposits that pre-date the swamp. Most of the deposits were below the peat layer and now incorporate residue from the peat, hence the term 'peaty' (Hills 1942, Goudie 1942).

Hills (1942) indicates a larger area of peat deposit but Sargeant *et al.* (1996) is adopted for the inner swamp boundary due to its complete coverage. However, soil map units Ko and Ko/sr may represent a minimum estimate. The present organic or peaty content of soil is expected to be lower towards the edge of the former peat deposit where the overlying peat would have been more shallow. Marginal areas of Monomeith clay loam and Narre clay loam, which have normal amounts of organic matter, may have had shallow peat although it was 'no more than a few inches', and the transition from peaty clay to clay loam is very gradual (Goudie 1942).

Swampy riparian woodland is indicated in the mapping along the Bunyip River before it enters the inner swamp and along Yallock Creek after it leaves the inner swamp. The woodland is hypothesised or modelled in order to complete the map, all other data being sourced from existing maps. The notional width of woodland is 100 m on each side of the stream, based on the example at Bayles, while the old course of the Bunyip is unclear.

Results and Discussion

Early maps and survey plans and soil mapping are combined in Figure 1 to represent the original inner and outer boundary of the Koo-Wee-Rup Swamp. Where there are discrepancies between sources, the best source in terms of resolution is given priority. Where no data is included, along small sections of the outer boundary, no line is indicated.

The scale and accuracy of the reconstructed swamp boundary varies with the source data. Source maps such as Foot (1855) are remarkably detailed and probably accurate to within tens of metres, while other maps are at smaller scales and one is not to scale. The outer swamp boundary is a compilation of historical maps and survey plans, while the inner boundary is inferred from soil mapping and is indicative only.

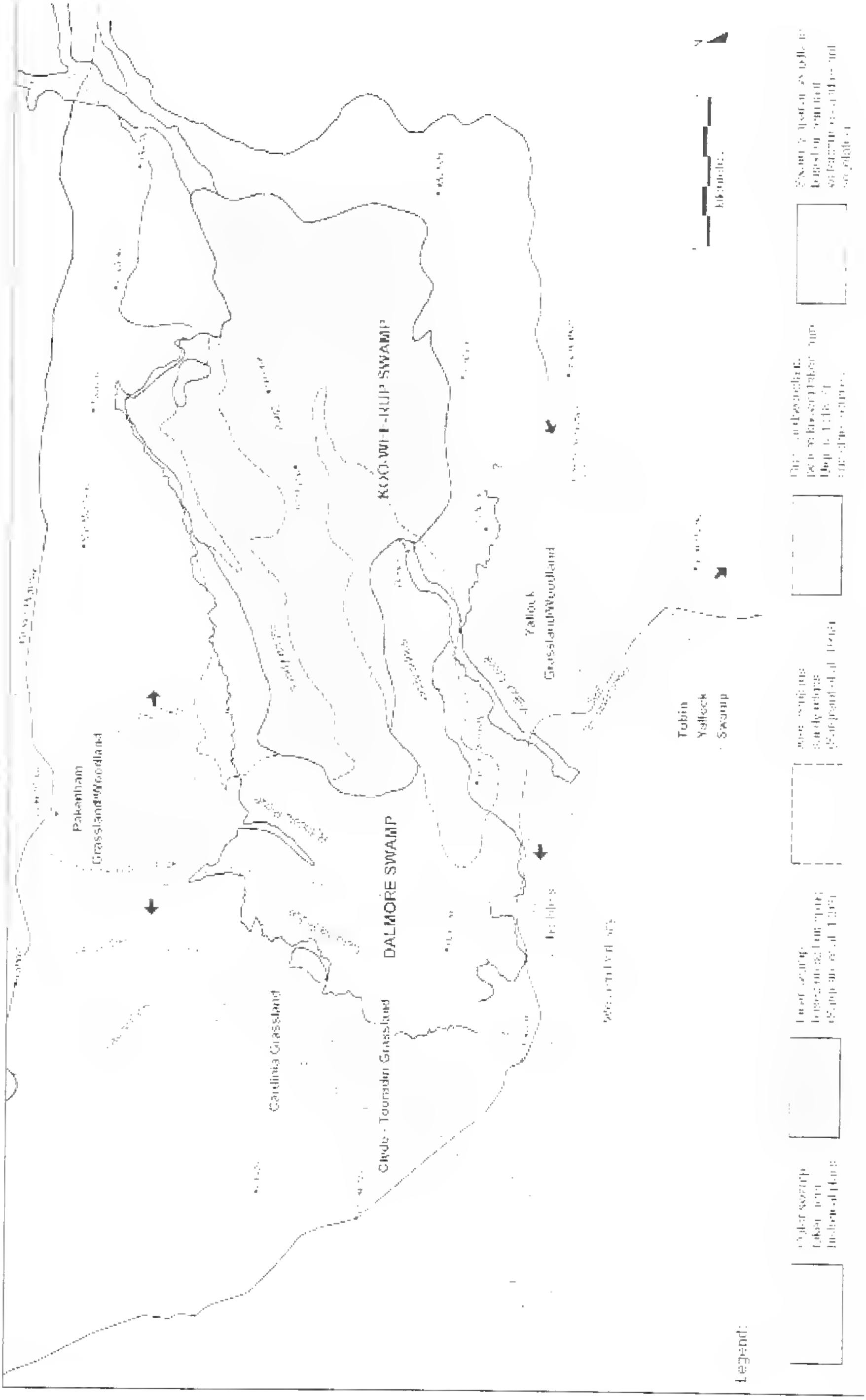

Fig. 1. Koo-Wee-Rup Swamp, reconstructed from historical plans and soil mapping.

The Koo-Wee-Rup Plain included a number of swamp complexes (Rosengren 1984):

- Koo-Wee-Rup Swamp
- Dalmore Swamp, contiguous with above, to the west
- Tobin Yallock Swamp, effectively separate from both of the above, to the south Grasslands and woodlands were locally extensive on the margins of these swamps.

Koo-Wee-Rup Swamp

The Koo-Wee-Rup Swamp was joined with the Dalmore Swamp to form a major wetland complex with an east-west orientation. With maximum dimensions of 32 km and 14 km and over 30 000 ha in area, this was the largest swamp in Victoria.

The swamp was situated on the Koo-Wee-Rup Plain, the northern and terrestrial part of the Western Port Sunkland which is a product of block faulting (Spencer-Jones *et al.* 1975). The swamp formed after the last Ice Age in what had been an arid or semi-arid landscape. A previously dry climate is indicated by wind-formed curved ridges (lunettes) on the east side of former intermittent or dry lakes (Sargeant *et al.* 1996). With climate warming there was more rainfall and permanent flow in the Bunyip River. Permanent inundation of the inner swamp initiated peat deposition which was continuous up to the time of drainage (Hills 1942).

Sea level rise following the Ice Age truncated the swamp, greatly reducing its size. Freshwater swamp deposits outcrop along the coast as low cliffs between The Inlets and Lang Lang beach (Gell 1974; Rosengren 1984). Peat deposits also have been traced below the mudflats of Western Port Bay where they are exposed in tidal channels. Peat 0.5 m above the base of the freshwater swamp deposit on the floor of the bay was dated 12 280 to 13 480 years BP. Given the age of the peat sample and its location relative to the base of the deposit, it is likely that initial deposition began around 14-15 000 years BP. Prior to the marine incursion the Koo-Wee-Rup and Tobin Yallock Swamps extended well onto the present floor of the bay where they merged to form a large swamp for several thousand years (Miles 1976).

The outer swamp consisted primarily of closed scrub 4–6 m in height and dominated by the shrub or small tree Swamp Paperbark *Melaleuca ericifolia* (Urquhart 1847 field book). The dense scrub grew on essentially mineral clay soil rather than the deeper organic peat of the inner swamp, as *Melaleuca* requires drainage and generally does not tolerate permanent inundation. *Melaleuca* may develop a shallow peaty surface layer when frequently waterlogged or may colonise peat during dry phases where water levels are lower than normal. Some areas within the outer swamp, probably mostly localised sand ridges, supported swampy woodland of Swamp Gum *Eucalyptus ovata* with *Melaleuca* understorey, the 'Gum Scrub' of Urquhart (1847). There were 'water channels in places' (Hills 1942).

The core of the swamp was a very different environment, being relatively open and dominated by reeds and rushes. 'Two transects of the swamp made in 1868 show mainly reeds, rushes, and water where peat has now been mapped, with a small area of stunted tea-tree noted on the eastern edge' (Goudie 1942). Hills (1942) thought the reeds and rushes were probably Common Reed *Phragmites australis* and a species of *Scirpus*. The early 1868 survey, which could not be located during this study, also indicates the presence of open water.

The 13 000 ha inner swamp was essentially a massive peat bog rather than a typical swamp. With an average surface slope of 1.3 m per kilometre (Hills 1975), it could not have held one continuous standing body of water. Hills (1942) suggested it consisted of relatively small lake-like cells separated by dense growths of reeds and rushes that acted as slowly permeable barriers to the flow of surface water, while Goudie (1942) referred to 'many lagoons'. A particularly large cell or 'sheet of water' with deep peat probably existed between Cora Lynn and Catani (Goudie 1942). Groundwater moved more slowly through the peat and, in effect, the swamp was a gigantic sponge with large volumes of water slowly moving through.

The fall of the swamp decreased towards the coast, as the fall of the main drain ranges from 1.9 m/km near Bunyip to 0.6 m/km in the lower reaches (Hills 1942). This is due to the shape and size of the old alluvial fan of the Bunyip River that lay under the swamp (Goudie 1942).

Permanent inundation in the centre of the swamp resulted in the deposition of 'fibrous peat, six to ten feet deep, waterlogged for the most part' (East 1935), consisting of *Phragmites* and other vegetation not fully decomposed due to anaerobic conditions. Remains of *Phragmites*, *Typha* and *Melaleuca* were found in remnant peat by Goudie (1942). The peat also included a small amount of gravel from the catchment transported into the swamp by water currents. Up to three metres of peat had accumulated over thousands of years, and since it is resistant to erosion the massive peat deposit acted as a local base level for streams (Hills 1942, 1975).

The Koo-Wee-Rup Swamp complex was fed by about ten creeks and rivers but mainly by the Bunyip River with headwaters in the cool temperate rainforests and mountain ash forests of the Central Highlands 25 km north. Before it was channelled the Bunyip River was 'about 10 feet wide and 5 feet deep' (Catani 1901). It is not clear whether levees lined the river before it entered the inner swamp, as levees are not apparent at sites 28 and 29 of Rosengren (1984). The Lang Lang River may have connected with the swamp on its southern margin; if so it then left the swamp, crossed a short distance of grassland and entered Tobin Yallock Swamp where it dissipated. With the possible exception of the Lang Lang River, all contributing streams dissipated within the swamp complex, the outlets being separate streams.

Paperbark scrub extended back along the rivers and creeks entering the Koo-Wee-Rup Swamp, making the boundary of the swamp somewhat arbitrary in places. For example, swampy vegetation east of Bunyip along the Bunyip River and its tributaries may be considered part of the larger swamp complex but is not included in this analysis. Further historical research and map compilation are appropriate east of Bunyip in particular.

About seven creeks drained the swamp complex. The main outlet was Yallock Creek which issued from the southern edge of the inner swamp at Bayles and was essentially the lower course of the Bunyip River which entered the inner swamp in the north-east (Rosengren 1984). Natural levees lining the creek supported riparian eucalypt woodland; a valuable example is the isolated remnant woodland at Bayles. Yallock Creek and its levee woodland meandered through 3 km of scrub before leaving the outer swamp and passing through woodland and grassland to the coast. According to an early survey, Yallock Creek 'runs the greater part of the year, but towards the end of summer becomes only a chain of ponds' (Foot 1855). Low flow does not necessarily mean the inner swamp was dry as the peat may have been holding water at the time. Hovell in January 1827 found the water 'exceedingly good'.

Sand ridges were reportedly used to access the swamp for stock grazing (Hills 1942). Narrow meandering sandy ridges slightly above the present surface occur in parts of the swamp area, both inside and outside the area of the former peat deposit. There are two 'sandy complexes', in the north and south of the swamp, where sand ridges occupy more than 20% of the area, and occasional ridges occur outside these areas (Goudie 1942, Sargeant *et al.* 1996, Fig. 1). Many ridges are now modified by gravel extraction (I. Sargeant pers. comm.) but they were 0.3 to 1.5 m high and from a few metres to 20 to 40 m wide (Goudie 1942). A site with one metre ridges occurs at Pakenham South (Rosengren 1984). The ridges are probably abandoned levees and bed deposits of distributary channels of a large alluvial fan made by the Bunyip River under more arid conditions prior to formation of the swamp (Hills 1942).

From the map of early land subsidence (Hills 1942), the original surface of the sandy complexes was 0.6 to 2.1 metres higher (average 1.3 metres). It follows that many but not all of the ridges were buried under the peat, which is consistent with some ridges having a peaty loam soil indicating past coverage by peat while others do not (Goudie 1942, Sargeant *et al.* 1996). It is also likely that, along the shallow edges of the peat deposit, exposed ridges in the outer swamp extended into the inner swamp before disappearing below peat.

The sandy complexes impeded drainage and influenced the distribution and size of lagoons within the inner swamp. The southern sandy complex at Bayles may have been responsible for a 'large area of standing water' between Cora Lynn and Catani. Similarly, the northern sandy complex blocked Ararat Creek forming a northern arm of the inner swamp (Hills 1942).

Two ridges appear on Urquhart's map: the 3 km Rythdale ridge and 2 km Cardinia ridge. Both are on the outer north-western edge of the swamp, are curved and have similar orientation (Fig. 1). They have state geomorphic significance due to their unusual landform (Rosengren 1984) and are lunettes (Sargeant *et al.* 1996). Formed by wind, and 5 to 8 m above the swamp surface in the case of Cardinia ridge, they are markedly different from the lower alluvial sand ridges. Both ridges were high ground in the swamp but they did not reach the inner swamp (the other high ground was the island at Tynong). From remnant vegetation, the crest of Rythdale ridge supported grassy woodland of Manna Gum *Eucalyptus viminalis*. The southern tip of the ridge was annotated 'point of timber' by Urquhart.

Vegetation patterns, particularly within the inner swamp, were probably intricate. The lake-like cells postulated by Hills probably would have supported a complex mosaic of reedswamp, aquatic sedgeland and aquatic herbland. Emergent sand ridges are likely to have supported vegetation ranging from stunted paperbark scrub to swampy woodland on higher sites. Sand ridges would also have determined vegetation patterns in the outer swamp due to more soil aeration and possibly higher fire frequency, generally favouring swampy woodland. They also impeded drainage resulting in local reedbeds and waterholes (1866 Yallock plan).

The close proximity of the inner and outer swamp boundaries for about 8 km between Nar Nar Goon and Garfield is of considerable interest. The area is likely to have been highly productive for the Woiwurrung, providing access to the inner swamp where fish and waterbirds would have been abundant. Tynong is said to mean 'plenty of fish' (O'Callaghan 1918). River Blackfish *Gadopsis marmoratus*, after which the swamp is named, is a valuable eating fish that presumably occurred in the swamp. Black Swan eggs may have been obtained in spring when most breeding occurs. On the south side of the swamp, the Boonwurrung could reach the inner swamp via the Yallock Creek levees as far as Bayles and also possibly in the Yallock to Yannathan area. Plant resources were presumably plentiful and included food plants such as Water-ribbons with edible tubers and Cumbungi with edible rhizomes, and Common Reed used for spear shafts, bags, baskets and necklace beads (Gott 1993).

An early sketch map of Western Port drawn by Assistant Protector of Aborigines William Thomas in 1840 depicts an area well inland of his coastal route with the label 'Pan-der-buit or Great Impassable Swamp' (Thomas in Cannon 1983). This may have been a name of the inner swamp, from buth/butj = 'grass in general' also referring to reeds and sedges (N Scarlett, pers. comm.).

An island in the swamp occurred at Tynong where a low granite hill had become surrounded by swamp (Fig. 1). The description on Urquhart's map is 'island heavily timbered with gum and dense scrubs' suggesting lack of fire. At Tynong there was an abrupt sequence from grassy eucalypt woodland on granite hills to reedswamp on the plain with a fringe of *Melaleuca* and swampy woodland. The extensive view from the hills over 'impenetrable scrubs of Tea Tree, Gum Scrubs and Reeds' (Urquhart 1847) included the northern arm reedswamp and the vast inner reedswamp stretching south-west to the horizon.

A specimen of Leadbeater's Possum at Museum Victoria was collected from the hollow branch of a tree being felled at 'the edge of the Koo-Wee-Rup Swamp long before the swamp was drained, about three miles due south from Tynong railway station' (Mason in Brazenor 1932). This locality is well within the original swamp but peripheral clearing may have occurred by that time. The hollow-bearing tree may have been a Swamp Gum on a sand ridge. The location suggests sand ridges outcropped above the peat south-west of the Tynong island. A sand ridge in the vicinity mapped by Rosengren (1984) may have been the collection site.

Magpie Goose is recorded from Koo-Wee-Rup and the swamp would presumably have supported large numbers of this bird which was locally abundant in south-east Australia. From the habitat preferences and behaviour of the species in northern Australia (Nye 2004), the inner swamp would have provided nesting habitat, the outer swamp roosting habitat in trees and shrubs, and the adjacent floodplain grasslands foraging habitat. The swamp area thus provided all necessary habitats for the species as well as drought refuge.

As with many swamps in Australia, Kuwirap was said to be inhabited by a large black monstrous amphibious creature with a harsh call, known as the bunyip. The Woiwurring called the creature Banib hence the place name Bunyip, while the Boonwurrung called it Tooroodun hence the name Tooradin (Database of Aboriginal Placenames of Victoria 2002).

'On the Western Port plains, there is a basin of water—never dry, even in the hottest summers—which is called Toor-roo-dun, because the Bun-yip lives in that water' (Smyth 1878), which suggests Toor-roo-dun was also a name of the inner swamp. Reputed to devour human beings, Toor-roo-dun was said to inhabit the deep waters and the thick mud beneath the waters of the swamp and to have a head and neck like an emu (Smyth 1878).

No bunyip story in Australia is recorded in detail. The story may relate to seals which sometimes visit freshwater rivers and swamps, as bunyips reported by early Europeans were apparently vagrant seals, or even to extinct megafauna such as *Diprotodon* (Flett 1999). However, the swamp formed after the megafaunal extinction and it is implausible that the coastal Boonwurrung would not have recognised seals even outside their usual habitat.

Draining and clearing the Koo-Wee-Rup and Tobin Yallock Swamps rapidly led to deep incision and channel erosion of the feeder streams upstream, due to lowering of the local base level. By 1916 the Bunyip Main Drain had deposited a layer of sediment two feet thick 1½ miles out to sea (East 1935). Bunyip Main Drain and Lang Lang River (Drain) remain by far the largest contributors of suspended sediment to Western Port Bay (Wallbrink *et al.* 2003). The slow recovery of seagrass cover since the decline of the 1970s (Ball and Blake 2001) and declining fisheries in the bay (DPI 2004) may be affected by the resulting high turbidity.

Dalmore Swamp

Before it was drained and cleared, Dalmore Swamp was fed mainly by Cardinia Creek and was known for its dense, almost impassable scrub (Goudie 1942). It occurred on mineral clay soil rather than the deep peat of the inner Koo-Wee-Rup Swamp. A continuous line of 'impenetrable scrubs' was mapped by Urquhart (1847) along the north edge of the 'Great Swamp' then consisting of both swamps in combination. Dalmore Swamp was effectively joined with the Koo-Wee-Rup Swamp, forming a western extension of the outer swamp. The swamp was drained by five tidal creeks, four at The Inlets and Sawtell Creek at Tooradin.

The central area has a layer of decomposed peat approximately 75–85 cm below the surface which may reach a thickness of 60 cm (Goudie 1942). The peat seam is valuable in market gardening due to the internal soil drainage it provides (Sargeant *et al.* 1996), the overlying black clay preventing it from being lost. Remains of club-sedge *Bolboschoenus* have been found in the peat (S Seymour pers. comm.), consistent with Goudie who identified seeds of '*Scirpus* and *Lepidosperma*' in the peat (*Bolboschoenus* was previously *Scirpus*).

The centre of the Dalmore Swamp once may have been an arm of the inner swamp until local geological uplift reduced the catchment size and stream flow of the western feeder streams, ending peat formation and leading to deposition of the overlying Dalmore clay (Hills 1942). However, soil maps indicate the Dalmore peat was not connected with the inner swamp peat (Goudie 1942, Sargeant *et al.* 1996), suggesting the past existence of two inner swamps.

Tobin Yallock Swamp

The former extensive Tobin Yallock Swamp was south of the Yallock grasslands and was fed mainly by the Lang Lang River. It consisted largely of *Melaleuca* scrub fanning out to form a 6 km length of the north-east coast of Western Port Bay. With no mangrove or salt marsh fringe and no beach, this shoreline *Melaleuca* scrub was highly unusual in Victoria.

The shore was probably cliffed and receding when mapped by Smythe, the low two metre cliff consisting of exposed freshwater swamp peat and clay. There was no single outlet, water issuing from the swamp via 'numerous rills of fresh water continually running' (Smythe 1843). 'It is possible that floodwaters spilling out in this way produced the crenulate shoreline, with waterfalls scouring out each cove' (Bird and Barson 1975).

Gum Scrub Creek drained the outer Koo-Wee-Rup Swamp at Caldermeade and was vegetated by 'Tea Tree Swamp'; it then entered Tobin Yallock Swamp and dissipated. The scrub from the two swamps almost connected via a tenuous link where the first European 'road' was situated (Smythe 1843), almost certainly following the Aboriginal path between the swamps.

A valuable 1887 Lands Department plan of Tobin Yallock Swamp, showing scrub along the coast and a mosaic of scrub and grassland further inland, is in Key (1967). The grassland is described as 'coarse pasture land very wet in winter' and 'very good pasture land'.

Further research and mapping would be worthwhile to better define the edges of the Tobin Yallock and Koo-Wee-Rup Swamps and the largely open area between them. Smythe's (1843) description of some sites as 'Tea Tree Swamp' is not consistent with surveys of Foot (1855) and Callanan (1866) who maps belts of 'Tea Tree' within 'very course pasture land timbered [with] gums & very wet in winter'. Smythe's is an exploratory survey but fire or clearing may have fragmented the scrub near Toorbinarruk Station between surveys.

Associated grasslands

The extensive grassland or open woodland on the floodplain of Yallock Creek, between the Koo-Wee-Rup and Tobin Yallock Swamps, was no doubt familiar to the Yallock balug clan. However, explorer Samuel Wright was the first European to see it, in 1826. He described it as follows (quoted in Gunson 1968):

> in point of quality ... equal to any he ever saw in the Colony, it appeared like beautiful meadows in England, very thin of timber, grass excellent

Soon after, explorer William Hovell (1827) described the same area:

> one mile from the tent [mouth of Yallock Creek], I came to a fine open level country, very thinly covered with trees, soil of a good quality, and the grass long and fresh ... the only objection to it is that I think it lies too flat to be perfectly dry in rainy seasons

The area south of Yallock Creek seen by Hovell is in Monomeith, which is an Aboriginal term meaning 'pleasant, good, pure' (Massola 1968), 'good and beautiful' (Gunson 1968) or 'pleasant, agreeable' (Blake 1977). This may have been a reference to the open and productive terrain compared to dense swamp scrub, or a reference to water quality. It is noted that 'monomeeth poath' means 'a grassy plain, a lawn' (Bunce in Smyth 1878).

'It was this natural grassland which made the Yallock area, just south of the swamp, so attractive to early squatters' (Key 1967). Smythe (1843) mapped swamp scrub and acacia woodland forming a mosaic in the local area. The description of the relatively open country between belts of 'Tea Tree Swamp' is 'Rich black soil wooded with Lightwood' and 'good grass'. Mapping of the open areas includes many series of non-random dots that may represent trees thus depicting a mosaic of grassland and acacia woodland.

On its western side, the Great Swamp had an adjacent 'open grassy plain' at Cardinia where Cardinia Creek entered the swamp (Urquhart 1847). Another 'open grassy plain' north of Tooradin about 5 by 2–3 km in size (Cook and Yugovic 2003) was described by Hovell (1827):

> I came to another open space, quite clear of trees for several miles square, but so perfectly flat that the water appears to have no possibility of draining off, consequently after rain the ground must be some time before it can absorb the whole, but at this time we could not get a drop to moisten our lips, which would have been very acceptable from it being so very hot, and which we so much required, having come upon a native path, which led in the direction I wanted to go, I kept upon it in hopes that it would lead to water

William Blandowski crossed the grassy plains during his scientific exploration of Western Port in 1855. He described it thus (1855):

> Between Lisle's station [Tooradin] and the inlets, the land is swampy, and luxuriantly

covered with excellent grass, well adapted for fattening cattle. . . Between Lisle's and Cuthbert's station [The Gurdies] the country consists of magnificent pasture grounds, the horse having to walk through thick kangaroo grass, reaching up to the girths.

Grassland and acacia woodland, essentially the same plant community, were locally extensive on alluvial plains outside the wall of *Melaleuca* scrub that defined the edges of the Great Swamp and Tobin Yallock Swamp. The major grass was moisture-demanding Common Tussock-grass *Poa labillardierei*. Also present, usually on slightly drier sites, was Kangaroo Grass *Themeda triandra*, the dominant grass of dry basalt grasslands in western Victoria. The grassland was rich in flora and fauna (Cook and Yugovic 2003) including the Aboriginal staple Murnong (Yam Daisy) *Microseris* sp. which was probably common. Southern Brown Bandicoot was probably common in less flooded areas and still occurs in grassland remnants.

Blackwood *Acacia melanoxylon* (then called Lightwood) and to a lesser extent Swamp Gum were the major trees in this grassy environment due to their resilience to flood, drought and fire. Blackwood's suckering habit enables it to survive fire. Some individuals would reach tree size and avoid grass fires, forming a woodland. The area is just beyond the range of River Red-gum *Eucalyptus camaldulensis* probably due to high rainfall. Acacia woodland on flood plains, previously a distinctive part of the landscape, is now very rare or extinct as an ecosystem. However Blackwood remains widespread, mainly on road and rail reserves.

The outer swamp boundary has no clear relationship with soil type (Sargeant *et al.* 1996) as the same soils occur on both sides of the surveyed boundary. Since *Melaleuca* tends to occupy former grassland sites today, we suggest that Koories were burning back the edges of the swamps for access and hunter gathering. All the early European explorers of Western Port noted that large areas of land were burnt (Gaughwin 1981). William Thomas noted that since the neighbouring Yowengarra clan was defunct their country had become scrubby because it was not being periodically burned (Clark 1990). Urquhart's field book refers to frequent burning reducing the *Melaleuca* on open plains 'producing good grass'. 'Many layers of burnt tea tree branches were found when the swamp was drained' (Roberts 1985). As dry peat is flammable, accumulation of the massive peat deposit in the presence of the Aboriginal fire regime presumably was due to water in the inner swamp preventing major peat fires.

Melaleuca ericifolia reproduces by root-suckering and seedlings, enabling rapid spread under suitable conditions. The Koories were probably advantaged by a natural weakness or tolerance limit of *Melaleuca*: while it was flood tolerant it was not tolerant of the high fire frequency on the swamp margin associated with drier soils and more flammable vegetation. *Melaleuca* can regenerate after fire but may be greatly reduced in cover, so the position of the swamp boundary is likely to have been a long-term response to repeated fire.

Drainage patterns indicate the floodplain grasslands and woodlands occurred on slightly higher and therefore less flooded land than the swamp. It follows the soils were more prone to dry out and crack in summer but it is unlikely soil factors alone would have controlled *Melaleuca*. A combination of soil and fire factors may have operated to confine the scrub. Both the inner and outer swamp boundaries may have been relatively stable over time, or dynamic and responsive to change in factors such as rainfall, evaporation, flooding and fire.

Fire may have been particularly important to the Boonwurrung for access purposes. Aboriginal burning is likely to have maintained the 18 km open space corridor between Tooradin and Lang Lang and the effective separation of the Koo-Wee-Rup and Tobin Yallock Swamps. The Yallock balug clan were most likely managing their grassy open landscape by regular burning, without which the land would have become dense and effectively uninhabitable scrub. In doing so they maximised both food production and biodiversity.

At The Inlets, the grassland strip passing between the inland paperbark scrub and the coastal samphire and mangrove scrub was less than 300 m wide and probably formed a vital corridor in the middle of the tribal range. Four tidal creeks draining the Dalmore Swamp and the terminal western arm of the inner swamp were in close proximity. Part of the area is described as 'good grass pasture land' on the 1866 survey plan. Remnant vegetation includes grasslands associated with various salinity regimes. Non-saline sites are mostly dominated by Kangaroo Grass, brackish sites are dominated by Common Tussock-grass (Fig. 2), while relatively saline sites beside salt marsh are dominated by Coast Tussock-grass *Poa poiformis*.

Despite the previously locally extensive occurrence of periodically wet grasslands on flood plains adjacent to swamps, recognition of this distinctive ecosystem occurred only in the 1990s (SAC 1994), reflecting early modification and loss of the grasslands before recording.

The now rare plains grassland may be predicted to occur on alluvial 'black soil' outside the margins of former swamps on the Gippsland plain. The eastern side the Great Swamp may have had little or no grassland, such as in the north-east area where foothills of the ranges formed an edge with the swamp (Garfield to Bunyip). Here *Melaleuca* evidently extended to the break of slope. However, the rail survey map with this evidence was compiled after cessation of the Aboriginal fire regime, so *Melaleuca* may have spread onto grassland.

This knowledge of the swamp boundary has been useful in locating and recognising several significant remnants of grassland such as the Clyde-Tooradin grassland (Cook and Yugovic 2003) and the Yallock grassland seen by Samuel Wright 180 years ago (Fig. 3). Similarly, extremely rare remnants of outer swamp scrub have been found, including an example with the original swamp boundary beside brackish sedgeland at The Inlets estuary.

Conclusions

The Koo-Wee-Rup Swamp was a unique ecosystem with distinct zonation formed by inner and outer swamps. The inner swamp was a permanently inundated reed and rush swamp on deep peat with localised emergent sand ridges. It is likely to have included a descending series of lake-like cells or lagoons separated by dense belts of vegetation, resulting in multiple internal water levels rather than the single water level of most swamps. The fringing outer swamp was subject to frequent flooding and supported dense *Melaleuca*, giving an impression that the scrub occurred throughout. Adjacent grasslands and grassy woodlands were occasionally flooded and were locally extensive beyond the generally sharp swamp boundary.

We suggest the inner swamp boundary was primarily flood controlled while the outer swamp boundary was primarily fire controlled on the plain and topographically controlled by hills to the east. Aboriginal burning maintained the adjacent grasslands and woodlands but had little or no influence on the core of the swamp where permanent water prevented major peat fires.

Despite the major environmental change, some of the wetland flora and fauna of the original swamp live in, visit or pass through the area today, the many drains and pastures providing modified habitat. Swamp Paperbark and Common Reed are conspicuous along many drains. In addition, some flora and fauna from the forest catchment of the Bunyip River such as Silver Wattle *Acacia dealbata* have colonised the banks of the Bunyip Main Drain.

Further historical research and field investigation would resolve these wetland and grassland ecosystems more clearly, this analysis forming a basis for further study. An understanding of historical and extant ecosystems and landscapes provides the basis for informed land management. Rare examples of scrub and grassland remain, all in need of management.

This study shows how careful interpretation of small remnants, in combination with examination of archival records, can further our knowledge of highly fragmented vegetation types such as native grasslands. It also demonstrates that existing vegetation on roads and drains may be misleading as to pre-European vegetation patterns. Similar studies may provide useful insights in other heavily cleared regions.

Fig. 2. Native grassland 200 m from the swamp edge (not in photo), The Inlets.

Fig. 3. Native grassland on the floodplain of Yallock Creek, Monomeith.

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New locality records for reptiles, including the vulnerable Swamp Skink *Egernia coventryi*, in South Gippsland, 2001 – 2005

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Abstract

Between 2001 and 2005, surveys of vertebrate fauna in three crown land conservation reserves in South Gippsland were commissioned by Parks Victoria. During these surveys new locality records were obtained for several species of small reptiles, including the vulnerable Swamp Skink *Egernia coventryi*. Incidental records were also obtained from local residents during this period, resulting in one new locality record for the Swamp Skink and two other species that had not previously been recorded in this part of southern Victoria. Habitat preference of the Swamp Skink is discussed. (*The Victorian Naturalist* **123** (5), 2006, 335–338).

Introduction

During 2001, a reptile and amphibian survey of the Wonthaggi Heathland Nature Conservation Reserve was commissioned by Parks Victoria, results of which have been published in this journal (Homan 2003). Over the following four years further surveys of reserves in South Gippsland were commissioned by Parks Victoria.

In 2002, a survey of the vertebrate fauna of the Bunurong Coastal Reserve was carried out. This reserve is located approximately 115kms south east of Melbourne, between Cape Paterson and Inverloch.

In 2003, a survey of the vertebrate fauna of part of the Kilkunda-Harmers Haven Coastal Reserve was carried out. The section of this reserve surveyed was formerly known as the Harmers Haven Flora and Fauna Reserve and adjoins the western end of Bunurong Coastal Reserve at Cape Paterson and extends along the coast for approximately four kilometres to the eastern boundary of the Wonthaggi Heathlands.

During 2004 and 2005, staff and students from the Department of Applied Science, Holmesglen Institute of TAFE, carried out vertebrate surveys of sites in the Wonthaggi Heathland Nature Conservation Reserve that had been subjected to ecological burning.

Over this five year period several local residents also provided information that produced new locality records for several species of reptiles.

The species and localities

Swamp Skink Egernia coventryi

Wonthaggi Heathland Nature Conservation Reserve

During the 2001 survey of this reserve a new locality record for the vulnerable Swamp Skink was obtained (Homan 2003).

Bunurong Coastal Reserve

A feature of this reserve is a series of rocky headlands that enclose small, sandy coves. In one such cove twenty Elliott traps (small size, Type A) were set in October 2002, principally to survey the presence of small mammals. Traps were baited with a mixture of peanut butter, 'quick' oats and honey. They were set behind a primary sand-dune, less than twenty metres from the high tide mark, at the base of a cliff. Traps were set over three days and nights (60 trap-nights) and were left open for daylight sampling, which resulted in the capture of a Swamp Skink on 10 October 2002. The site was visited again in November 2002 (using the same survey method and effort) and a further capture of a Swamp Skink occurred on 27 November 2002. Both captures measured and weighed the same (Table 1) and both had a regrowing tail, so it is assumed that this was the same animal.

The vegetation at this location consisted of Spreading Flax-lily *Dianella revoluta*, Knobby Club-sedge *Isolepis nodosa*, Coast Sword-sedge *Lepidosperma gladiatum*, Coast Tussock Grass *Poa poiformis*, Seaberry Saltbush *Rhagodia candolleana*,

Table 1. Details of Swamp Skinks recorded in Bunurong Coastal Reserve and Kilkunda-Harmers Haven Coastal Reserve, in 2002 and 2003. * indicates regrowth tail.

Location	Date	Snout-vent length (mm)	Tail length (mm)	Weight (gms)
Bunurong	10 Oct. 2002	95	95*	23
Bunurong	27 Nov 2002	95	95*	23
Harmers Haven	12 Feb. 2003	80	120	13
Harmers Haven	12 Feb. 2003	105	115	30
Harmers Haven	12 Feb. 2003	65	57*	9
Harmers Haven	17 Nov 2003	107	115	30

with some Austral Bracken *Pteridium esculentum*, Ross' Noonflower *Carpobrotus rossii*, Common Reed *Phragmites australis*, Coast Daisy-bush *Olearia axillaris* and Coast Beard-heath *Leucopogon parviflorus*.

Kilkunda-Harmers Haven Coastal Reserve

During this survey two pitfall lines were established in low-lying areas behind tertiary sand-dunes approximately 1.3 kilometres apart. Both pitfall lines consisted of ten, twenty-litre plastic buckets, spaced at five metre intervals, with a 30-centimetre-high aluminium flywire drift fence, over a distance of 60 m. The first pitfall line was in vegetation that was largely weed-free, with Coast Sword-sedge, Strand Sedge *Carex pumila*, Coast Tussock Grass, Bidgee-widgee *Acaena novaezelandiae*, some Austral Bracken and Coast Banksia *Banksia integrifolia* and a small infestation of Sweet Vernal-grass *Anthoxanthum odoratum*. The second site was in a more disturbed area, which had been a public campsite until it was fenced off about ten years previously. Vegetation at this site consisted of large areas of Sweet Vernal-grass, with some Spear Thistle *Cirsium vulgare*, Coast Tussock Grass, emerging Swamp Paperbark *Melaleuca ericifolia*, Coast Teatree *Leptospermum laevigatum* and Coast Wattle *Acacia sophorae*.

During the first trapping session on 12 February 2003, three Swamp Skinks were captured in the first pitfall line, and on 17 November 2003 one Swamp Skink was captured in the pitfall line at the disturbed site (Table 1).

Private property approximately 8 kilometres south-west of Koonwarra.

In late 2003, D and D Drummond, the owners of a property approximately eight

Fig. 1. Swamp Skink *Egernia coventryi* on mulch under pear tree.

kilometres south-west of Koonwarra, reported seeing fairly large skinks basking at several locations on their property. On 18 November 2003 I visited the property and found two Swamp Skinks, one basking on the trunk of a fallen Swamp Paperbark, amongst weeds, beside a dam, and another on mulch, under a pear tree in a small orchard (Fig. 1). The property was visited again on 28 January 2004, when another Swamp Skink was found under an old polystyrene surfboard lying on weeds beside the dam.

***Tree Dragon* Amphibolurus muricatus**

Wonthaggi Heathland Nature Conservation Reserve

No records of this species were obtained during the reptile and amphibian survey of this reserve in 2001 (Homan, 2003). However, on 11 October 2002 Ms Terri Allen, of Wonthaggi, visited the reserve and observed a Tree Dragon basking on a fence post.

The site was visited two days later on 13 October 2002, with Mr Steve Darby of Yarram, when the Tree Dragon was located again, captured by hand and photographed. Prior to this, no records for this species were available for this reserve or the Wonthaggi district (Atlas of Victorian Wildlife database). On 14 November 2003 Terri Allen also found a road-killed Tree Dragon on a public access track in this reserve.

Kilkunda-Harmers Haven Coastal Reserve

On 19 November 2003, the last day of the survey of this reserve, a juvenile Tree Dragon was caught by hand near the pitfall line located at the disturbed site mentioned above. Prior to this no records were available for this species in this reserve (Atlas of Victorian Wildlife Database). This species is readily captured in pitfall traps (FNCV, RMIT University unpubl. data); yet, despite 1327 pit-nights being completed throughout these reserves between 2001 and 2005, no individuals of this species were recorded using this survey method. This may suggest that the population of this species is low along this section of the Victorian coast.

***Black Rock Skink* Egernia saxatilis**

Private property approximately 3 kilometres WNW of Inverloch

During early 2005, B and L Teesdale, owners of a property approximately three kilometres WNW of Inverloch, noticed a lizard entering their home. The animal became a regular visitor and was photographed on 25 February 2005. The photograph was forwarded to me by Parks Victoria staff at Wonthaggi and clearly showed the lizard to be a Black Rock Skink. No records of this species were previously available for the Wonthaggi/Inverloch district (Atlas of Victorian Wildlife Database).

***Common Blue-tongued Lizard* Tiliqua scincoides**

Wonthaggi Heathland Nature Conservation Reserve

During October 2005, staff and students from Holmesglen Institute of TAFE carried out a survey of vertebrate fauna in a section of this reserve that was subjected to an ecological burn in May 1992. Elliott traps (Type A) were one of the survey methods used and were left open for daylight sampling on 12 October 2005. During this trapping session one juvenile Common Blue-tongued Lizard was captured (Snout-vent = 100mm, Tail = 40mm, Weight = 27gms). Bait used was a mixture of 'quick' oats, peanut butter and honey. The Blotched Blue-tongued Lizard *Tiliqua nigrolutea* has been recorded in this reserve (Homan, 2003) and is common in this district (Homan, unpubl. data); however, this is the first available record of the Common Blue-tongued Lizard for this reserve and for the Wonthaggi district (Atlas of Victoria Wildlife Database).

Discussion

The Swamp Skink is listed as vulnerable in Victoria and most records are from coastal regions (Atlas of Victorian Wildlife Database). The species generally inhabits low-lying areas, swamp margins, sedge-tussock vegetation and salt-marshes (Cogger 2000; Wilson and Swan 2003).

The records obtained during these surveys from Wonthaggi Heathlands, Bunurong Coastal Reserve and Kilkunda-Harmers Haven Coastal Reserve, are from areas and habitat that are considered typical for this species. However, the habitat and location of Swamp Skink records at the Koonwarra site are very different from those at the other three sites. In particular, it was unexpected to find this species in an orchard close to numerous man-made structures, well away from any low-lying areas.

The Koonwarra property, of about ten hectares, is located in coastal foothills approximately eight kilometres from the coast and is at an altitude of about 90 m. It was a dairy farm before being purchased in 1974 and is heavily infested with introduced weeds, including Sweet Vernal-grass, Yorkshire Fog *Holcus lanatus*, Cape Weed *Arctotheca calendula*, Rib Wort *Plantago lanceolata*, Rats-tail Grass *Sporobolus africanus*, Dandelion *Taraxacum* spp., and some Blackberry *Rubus fruticusos*.

Prior to settlement the property and surrounding areas would have been typical South Gippsland open-forest. Small remnant areas of this forest type survive today along roadsides in the district and in neighbouring properties, and as remnant vegetation in moist gullies. However, no low-lying, swampy habitat that could be considered typical for the Swamp Skink, exists in any nearby areas.

The only native vegetation remaining on the property in 1974 was an isolated area of about two hectares in a moist gully. Vegetation covering half of this area consisted of Soft Tree Fern *Dicksonia antarctica*, Scrambling Coral-Fern *Gleichenia microphylla*, Red-fruit Saw-sedge *Gahnia sieberiana*, Scented Paperbark *Melaleuca squarrosa*, Forest Wire Grass *Tetrarrhena juncea*, and Austral Bracken, with some Blackberry and an overstorey of Blackwood *Acacia melanoxylon*. A small remnant stand of Messmate *Eucalyptus obliqua* and some Narrow-leaved Peppermint *Eucalyptus radiata* survived south of and adjacent to the gully. This gully vegetation remains today and has been allowed to expand through natural regeneration to approximately three hectares. The other hectare consisted of an open area of Common Reed, which survives, upstream and immediately adjacent to the above vegetation.

Swamp Skinks were located about 300 m above the moist gully to the north, near the top of a wide slope. A narrow, road-side verge with Messmate, Narrow-leaved Peppermint and Swamp Paperbark and some Blackberry is located about 150 m north of the area where Swamp Skinks were found. The previous open grazing land now consists of a vineyard, poultry enclosures, an orchard, a vegetable garden, several sheds, a house, several small dams and a large native garden.

At least one previous survey has located the Swamp Skink in habitat considered atypical for this species. Clemann and Beardsell (1999), recorded the Swamp Skink in a low-lying site within heathy woodland, during a herpetofauna survey in the Enfield State Forest near Ballarat, in February 1999. During a survey of a reserve in Boronia, in March, 2000, Clemann (2000) also recorded the Swamp Skink from habitat containing an understorey of weed grasses.

Some small reptiles can be unintentionally relocated when firewood or logs are moved between sites. The Swamp Skink, however, usually shelters in burrows (Wilson and Swan 2003) and in any case large logs are not a normal component of swampy areas inhabited by the species, so it is unlikely that Swamp Skinks were accidentally introduced to this property. It therefore appears that Swamp Skinks have survived in the past, in either the remnant moist gully (perhaps in the reedy vegetation) or the roadside verge and have since colonised several areas of artificial and weedy habitat that the species apparently finds suitable.

Clemann (2000) suggests that caution should be exercised when assuming that Swamp Skinks are not present in marginal habitat or areas that appear unlikely to support the species. If Swamp Skinks have survived on this Koonwarra property, then it is possible that other isolated populations of this threatened species may exist in other parts of the South Gippsland foothills.

Acknowledgements

Surveys of the reserves mentioned in this article were carried out under Research Permit Nos. 10001200, 10001693, 10002108 and 10002377 issued by the Department of Sustainability and Environment. Staff at Parks Victoria, Wonthaggi, especially Dan Drummond, Brian Martin and Sandy Brown, provided much assistance. Terri Allen of Wonthaggi kindly shared her intimate knowledge of the Wonthaggi Heathlands. Pascale Pitot, of Holmesglen Institute of TAFE, and Richard Francis provided assistance with plant identification. D and D Drummond provided access to their property and B and L Teesdale provided photographic evidence for the Black Rock Skink record. Maryrose Morgan of Lorne provided field assistance.

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Received 8 December 2005; accepted 11 May 2006

Birds of South-eastern Australia Gould League Series revised

'Susan McInnes commemorative edition'.

Illustrations by Susan McInnes. Revised by Alan Reid.

Publisher: Overthefence Press 2005. Seven volumes, paperback, in slipcase.
ISBN 0975247204 (1-7 set)

The 'Susan McInnes commemorative edition' of *Birds of South-eastern Australia* is an attractively presented set of seven regional field guides that are clearly written, beautifully illustrated and a pleasure to use. The books stem from the series *Birds of Victoria*, published by the Gould League over 30 years ago and later expanded to include birds of the south-eastern region. Because there have been considerable changes in the status, distribution and nomenclature of bird species in Australia over the years, well-known ornithologist Alan Reid has revised and updated the original text (written by Alan Reid, Noel Shaw and Roy Wheeler) and, as in previous editions, has included additional articles by other authors.

Each book contains a dedication to the memory of the illustrator, gifted artist Susan McInnes. Her beautiful paintings show birds in lifelike poses in their habitats, and also depict the behaviour of the birds: the White-breasted Woodswallows clustered together on a dead twig, (Book 6 p 103) and the finches and sparrows on a parkland fence (Book 1 p 31) are just two of many delightful examples.

All major habitats found in south-eastern Australia are covered, - namely (1) Urban Areas, (2) The Ranges, (3) Oceans, Bays and Beaches, (4) Inland Waterways, (5) Dry Country, and (7) Farmlands – and feature the most common bird species found in these places. Book 6 (Rare) is devoted to species that are rare in the south-eastern region and, with 118 pages, is now the largest book in the set. Each general habitat type is subdivided into specific habitats; for example Book 2, 'The Ranges', features Foothills, Gullies, Denser Forests, High Plains and Heaths, and Tasmania. The latter section includes all birds endemic to Tasmania.

The colour coding used for earlier editions has been retained (e.g. brown for Urban Areas, blue for Oceans, Bays and Beaches), and is used on the spines of the books, the headings in the text, and to frame the colour plates, reducing their size a little but creating room for an easy-to-find name of a specific habitat to the right of each plate. The font is much easier to read than that used in previous editions, and the cover designs have been simplified. Appropriately, all photographs published in previous editions have been removed and replaced with drawings or text. New, clear maps harmonise perfectly with the rest of the content. The layout is excellent: no space is wasted, enabling a large amount of information to be fitted into the books without any page seeming overcrowded.

Each book has its own introduction, index, 'How to use this book', plus other informative articles and at least one map. Silhouettes of bird groups to aid recognition are included in Books 1 and 3. Those in Book 1 are placed in a very useful 5-column table, showing bird group, size, silhouette, habitat, and the page numbers where information on each group can be found. Book 1 also contains two forewords to the set (one by the Governor of Victoria at the time of publication, John Landy, and the other by the author), as well as 'Hints for bird study' and a comprehensive index to all seven books.

Descriptions of the birds cover General (appearance), Voice, Flight, Food, Nest, Behaviour, and Distribution. In some cases two or more of these categories are merged together, often under the heading 'Behaviour'. The use of colour for the headings is pleasing and much more effective than black bold type. Small pictures of plants, animals and similar bird species that live in particular bird habitats are distributed through the volumes. In the case of the animals, size is given (though 10 mm seems a little large for an aphid, Book 1 p 30). Where similar species of birds are shown, their size and the page number of the book where they appear are indicated. In each book general notes on particular groups of birds are sometimes supplied, e.g. 'Grebe characteristics'. When many birds are illustrated on a double page spread, the book and page numbers where their descriptions appear are indicated (e.g. the honeyeaters in Book 1 pp 64-65).

I have only a couple of minor criticisms. It is a pity that the colours in some of the paintings lack the vibrancy of those in earlier editions, and are, in just a few cases, misleading. For example, the Australian Reed-Warbler in this edition has inexplicably changed from brown to green (Book 1 p 51), but fortunately remains brown in Book 4. Not so obvious – unless you are comparing editions – some of the colours are 'washed out': the breeding plumage of the Cattle Egret has paled to a mustard colour (Book 4 p 51), and the scarlet on the Scarlet Honeyeater is brownish orange (Book 6 p 71). Maybe this would not have happened if it had been feasible to print the books in Australia. Typographical errors are almost non-existent, but in 'How to use this book' 'latin' should have a capital 'L'.

This is a really lovely set of books, produced with much enthusiasm, thought and care. Although soft-covered, they are sufficiently robust to withstand repeated use, their size is just right to fit into a day pack or glove box, and they come in a protective slipcase (appropriately depicting many species of birds), which is constructed so that it is easy to slide all the books in at once. The notched sides of the slipcase make it equally easy to take hold of the books and pull them out. These guides provide a marvellous introduction to over 470 birds of south-eastern Australia, and would make a wonderful gift for anyone, young or old, who is interested in learning about them.

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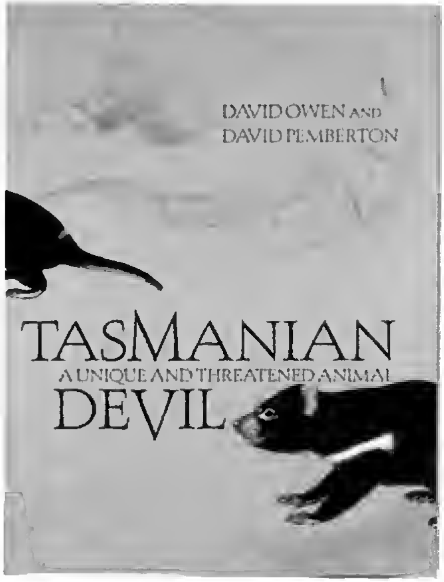
Tasmanian Devil: a Unique and Threatened Animal

by David Owen and David Pemberton

Publisher: *Allen and Unwin, St Leonards, New South Wales, 2005, 225 pages, hardback; ISBN 1741143683. RRP $35.00*



Tasmanian Devils are fascinating creatures. They became Australia's largest carnivorous marsupials following extinction of the Thylacine. They remind me of myself – shy, nocturnal, a spicy attitude when required and the ability to eat almost anything! The Tasmanian Devil has endured much prejudice, misunderstanding and persecution over the past 200 years, being labelled 'Beelzebub's pup' and, along with the Thylacine, considered responsible for destruction of livestock. However, 80 years of bounty records collected by Eric Guiler showed that the real culprits were poor management decisions and practices, along with packs of feral dogs. This did not stop the persecution of the Tasmanian Devils, as they were seen to be the bane of sheep farmers, and their perceived notoriety was the inspiration for the famous Warner Brothers' cartoon character, Taz. Recently the Devils have once more come under attack, not by humans, but by the deadly Devil Facial Tumour Disease (DFTD), mutilating the faces of hundreds of Devils and posing the threat of extinction for the species.

Tasmanian Devil: a Unique and Threatened Animal summarises the life and times of the Tasmanian Devil accurately and concisely. It covers the history of the Devil, from the evolution and radiation of the dasyurid family in Australia, the relationship of the Devil with the new settlers of Tasmania and the current threat of DFTD. Although the inclusion of some chapters is questionable (e.g. the supposed link between Errol Flynn and the development of Taz by Warner Bros) every chapter covers an important part of the Tasmanian Devil's history in detail. The particularly interesting sections are the chapters focusing on the life history and ecology of the Devil, which leave the reader thoroughly informed. Did you know that Tasmanian Devils have remained relatively unchanged in both shape and size for about 70 000 years? Or that an adult Tasmanian Devil can eat up to 40% of its body weight in one meal? It also is concerning to learn that DFTD has killed at least a third of the Tasmanian Devils.

The authors have made use of the many publications and insights by past and present researchers, ensuring the book is a valuable resource for current and potential researchers and for anyone with an interest in these beautiful creatures. Throughout the book there are also many eyewitness accounts, dating from the early 19th century. These provide humour, horror and a sense of disbelief, making the book a thoroughly interesting and entertaining read.

The layout of the book is similar to that of David Owen's book, *Thylacine: The tragic tale of the Tasmanian Tiger*, with extensive black and white photographs and drawings throughout the book as well as eight pages of colour plates at the centre. Overall this book has been the most enjoyable, understandable text I have read regarding Tasmanian Devils. I recommend this book to anyone with an interest in Tasmanian Devils or Tasmanian history.

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Spiders of Australia: an introduction to their classification, biology and distribution

by Trevor J Hawkeswood
with photographs by B Coulson, T J Hawkeswood, CJ Parker and M Peterson;
paintings by JR Turner

Publisher: *Pensoft Publishers, Sofia, Bulgaria, 2003. 264 pages, paperback. ISBN 9546421928. RRP $44*

Having long held a fascination with Australasian arthropods, particularly insects and spiders, I keenly accepted a review copy of *Spiders of Australia* from the author. A flip through the glossy photographs, depicting many live spiders in natural settings, rekindled memories of encounters during my childhood and youth. There were few introductory spider books in my primary school library when my interest in arthropods developed in the early 1970s, and had a suitable piece such as this been then available I would have read it with enthusiasm.

The work is introductory, rather than definitive. It is educative, compiled by a well-known naturalist and indefatigable writer on Australasian natural history, and seems appropriately directed towards a lay readership or the intelligent beginner observer. About 150 spider species of a national total exceeding 1800 are described and many are beautifully illustrated. The illustrations feature the live spiders in natural settings, providing a glimpse into their ability to camouflage. To enable the book to be practical as an identification guide, the 166 colour plates, comprising 139 photographs and 27 paintings, are cross-referenced to the relevant species accounts. Many common Australian spiders will be quickly recognised using the sharp colour plates, but the author points out their identification limitations, given that important characters defining species or distinguishing sibling taxa may not be visible in the photographs. The book is about half A4 sized and glossy covered, and as well as conveniently sized, its slim shape enables snug fitting into one's daypack or car glove box for quick retrieval in the field.

The preface describes the author's childhood fascination with flora and fauna, stimulating further reading. The introduction includes general information on morphology, with line drawings of dorsal and ventral surfaces of a typical spider, with external anatomical structures labelled to assist the novice. Spider diets, lifecycles, courtship and mating behaviour are described, and favoured habitats specified. The classification section covers the basics any new inquirer will need to know. Many readers will quickly turn to the short section listing the 14 genera of poisonous Australian spiders (10 of which are illustrated in the work) so as to familiarise themselves with any undesirable home visitors. Here the work wisely promotes collection of the actual biting spider for positive identification to prevent myths from mis-associations – a problem the medical profession now knows only too well since the White-tail Spider's circumstantially earned reputation became legendary during the 1980s.

The 29 spider families and representative species discussed are all listed for quick reference (pp 29–33). Family overviews (specifying species numbers at national and world levels) and selected species accounts, which comprise the bulk of the book, then follow (pp 33–163). Headed by scientific names (unlike birds and butterflies, most spiders don't have common names), one or more common representatives of each family are presented, accompanied by black and white thumb-sized photos. These are cross-referenced (by plate numbers) to the enlarged colour plates located at the rear of the book (pp 200–257, albeit those particular pages are not individually numbered). For each representative species, both sexes are usually described and adult size is given in millimetres (as the illustrations are without scale). Species' accounts often include commentary on egg sizes and quantity, egg sac structures and placements, hatching time, adult and spiderling behaviour, and common prey where known, or known to the author. Importantly, many observations by the author appear otherwise unpublished.

A five-page glossary assists readers unfamiliar with technical terms, but usually the author keeps jargon to a minimum in the body text, enhancing its appeal to a lay field-naturalist audience. A list of 11 Australian spider books introduces the Reference section (comprising bibliographic rather than cited sources), and includes brief annotations on earlier generalist works spanning from 1935 to 1996, including comment on their availability should readers wish to supplement their personal library. For advanced reading, many journal papers are listed on a family by family basis. Artistic credits are given on (unnumbered) p 257; most photographs having been taken by the author. The guide then concludes with arthropod and plant indexes of both common and scientific names.

Although perhaps of limited concern to the novice or hobbyist observer, the guide does contain a sprinkling of inaccuracies which spider specialists will detect, as well as a few other limitations. *Lampona* is listed as a member of the Gnaphosidae on p 27, but in the main text is under Lamponidae (p 67). Distribution data are defined to State level only, and some appears a little conservative. For example, the St Andrews Cross spider (*Argiope*, presumably *A. keyserlingi*, the common species illustrated) occurs in Melbourne, but Victoria is not listed (p 116). I found the black and white inset photo placement above (rather than below) each species' name a little ambiguous for groups where several species are present in sequence. And, given my biogeographical faunal interests, small range-fill maps for each species seem conspicuous by their absence.

Readability suffers in places due to the variable print quality. In my review copy the text font within the species accounts on pp 34-35, 39, 42-43, 46-47 are unfortunately finely shadowed or double imaged. In addition, a small number of grammatical or typographical errors, or word omissions are present (pp 61, 67, 73, 94, 96, 123, 157). A preposition is missing on p 112 (fourth line), a verb is omitted on p 147, insects is rendered 'inspects' (p 150), and Myanmar has been misspelled twice (p 46). The adjective 'tropical' (p 162) in reference to rainforests in south eastern Queensland is latitudinally inappropriate. Structurally, a paragraph on red-back spiders (pp 141-143) is lengthy and might have been better topically split. Selected species have been described as 'interesting' (e.g. p 99), and no doubt these are to the author, but perhaps further explanation is needed to convince readers or spider enthusiasts as to why. The author frequently mentions the lack of information available for various species, and a generic statement to this effect might have been well placed in the introduction to avoid repetition across sections.

Because of my pragmatic interests, I would have liked to see in-text citation of books and papers in support of some specifics and to enable rapid sourcing and checking of important facts for quality assurance purposes in line with the growing trend towards evidence-based literature in recent decades. However, in a guidebook written for general public readership or middle secondary to primary school student usefulness, textual reinforcement can be distracting, often reducing comprehension. Moreover, body text heavily reinforced with citations could easily bore younger inquirers who will gain most from reading this book. For this reason I imagine the author has opted for the classical educative approach over fact fortification.

Curiously, the book does not provide information on alcohol preservation or live keeping of adults. Spider collection allows many observation opportunities for budding arachnologists and this seems to be an oversight. Although some Australian spiders are very dangerous, most are not, as the book indicates. During my early childhood I kept Leaf-curling Spiders in honey-jars and in my 'Bug-catcher'® (a popular 1970s child's toy for arthropod observation), to watch their web-spinning behaviour and habits. Yet, perhaps in this age of conservation the author did not want to focus on traditional natural history practices. Nonetheless, these remain important since we know so little about the behaviour of our less common species and particularly given that so many Australian species still remain to be described.

Dr Hawkeswood's book aids rapid identification of common spiders likely to be encountered in bushland or home gardens in southern Australian cities. It is a welcome addition to the casual naturalist's library, and well suited to laypersons wishing to get to know the local species and learn of their habits as a recreational pursuit. As a registered teacher of biology, I can recommend it as a useful resource for school and public libraries in that it provides general information in a readily accessible form, being particularly useful for school projects. For school children, the glossy presentation, large plates, easy-to-read style and clear structural diagrams of spider external anatomy will be a major attraction and provide foundational knowledge prior to inquisitive hunting, garden observation and cautious collection. Having also worked professionally in both entomology and arachnology, I remain hopeful that young readers may be stimulated to learn more about the ecology of the Australian spider fauna. Nature books read during my childhood fuelled my own biogeographical interests, so I'm sure Dr Hawkeswood's handy book will similarly pique the curiosity of many young readers whose developing interests gravitate towards spiders or other arthropods such as insects. And, through such interest some may progress to professional roles in biological or species diversity research.

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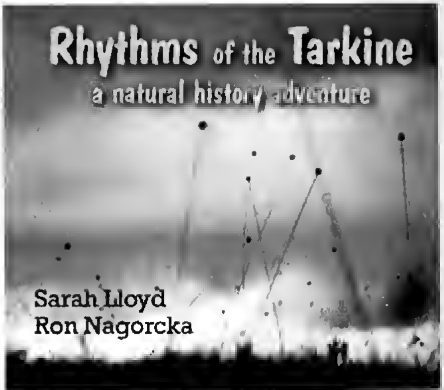
Rhythms of the Tarkine: a natural history adventure

Book by Sarah Lloyd; CD by Ron Nagorcka

Publisher: *Sarah Lloyd, Birralee, Tasmania 7303. Book and CD in slipcase. 2004. Book 98 pages, paperback; colour photographs; black and white drawings. CD duration 74 minutes. ISBN 0-646-44118-3. RRP $35.00*



Between the Arthur and Pieman Rivers in north-western Tasmania lies the largest tract of unprotected wilderness in the State. This region, covering an area of some 447 000 ha, was named the Tarkine in honour of the Tarkiner people who lived in the area until British settlement. The Tarkine comprises a variety of vegetation communities – buttongrass plains, coastal heaths, the largest cool temperate rainforest in Australia, and eucalypt forests – which are home to 56 threatened and endangered species. It also contains the greatest concentration of Aboriginal sites (240+, including remnants of villages) in Australia. In short, this area is one of the world's great treasures, but is under threat from the forestry and mining industries. The campaign to protect it has been running for over 20 years, but considerable damage has already occurred. At present 73 000 ha are protected from logging, but not from mining.

Sarah Lloyd and Ron Nagorcka have explored 11 sites in the area (shown on the map at the front of the book), and have recorded their experiences and observations in words, pictures and sounds. They communicate clearly not only their passion for the beauty and complexity of this descendant from the primeval forests of the ancient supercontinent, Gondwana, but also a strong sense of what a great loss its destruction would be. The text is beautifully written, containing a wealth of interesting and carefully researched information. With a keen eye for detail, Sarah paints a vivid picture of the scenery, vegetation and wildlife, as well as the history of settlements in the area, such as Balfour and Guildford. In just a few words she brings to life some of the early explorers – Henry Hellyer and James 'Philosopher' Smith, for example. The text is enhanced by colour images of animals, plants and fungi contributed by several photographers, including Sarah, and also by Nicholas Sheehy's monochrome drawings of birds and insects. The main text is followed by details of the 99 CD tracks, a table of fauna sightings, and an index of flora and fauna with the scientific names printed next to the common names. Tracks on the CD are numbered and highlighted throughout the text.

The CD features 89 tracks of high quality recordings of animal sounds–mainly birdsong, but also calls of insects, frogs and the Tasmanian Devil–interspersed with ten of Ron's innovative musical compositions based on these sounds. To the untrained ear the music may seem strange at first, but appreciation grows with repeated listening. Six musicians, including Ron, perform the compositions on various instruments. Wilderness areas such as the Tarkine, where, to quote Bob Brown, 'one is imbued with the awe of being part of nature's continuum', are always a source of inspiration, whether for photographers, writers, artists, musicians, botanists, zoologists or anyone who just enjoys the experience of being there. One of my favourite tracks on the CD is the recording of the exquisite ascending call of the Ground Parrot, accompanied by the distant roar of the mighty Southern Ocean. Atmospheric indeed.

This publication should appeal to anyone with an interest in natural history. Needless to say, a visit to the Tarkine is now at the top of my 'must do' list.

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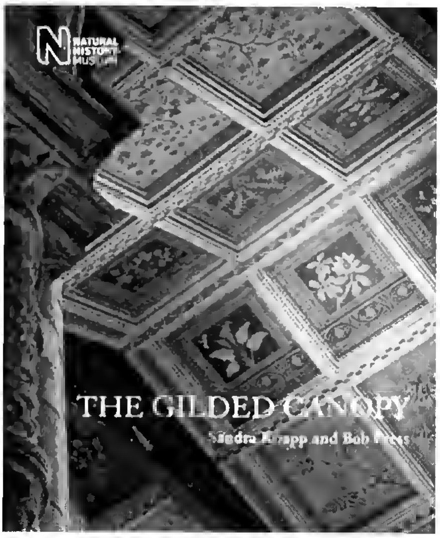
The Gilded Canopy
Botanical Ceiling Panels of the Natural History Museum

by Sandra Knapp and Bob Press

Publisher: *Natural History Museum, London, 2005. 168 pages, hardback; colour photographs. ISBN 0565091980. RRP $49.95*



This attractive little book documents the decorative botanical panels that adorn the ceilings of the Central Hall, Landing and North Hall of Natural History Museum, London.

The founding Director, Richard Owen, conceived the Museum as being a 'cathedral to nature' where learning and discovery about the natural world were paramount and where national pride in the British Empire could be celebrated. His vision is reflected in the Museum's neo-Romanesque design by architect Alfred Waterhouse.

Waterhouse envisaged a grand central hall, or 'nave', where Owen's directive for an 'Index Museum', a comprehensive introduction to the order of nature, could be realised. Smaller, more specialised galleries radiated from the hall. A grand staircase led from the hall to the smaller North Hall where the natural history of the British Isles was to be displayed. The gilded decorative ceilings featuring plants from around the world were to unify the separate halls while introducing visitors to the marvels of the plant kingdom.

Knapp and Press were unable to find any of Waterhouse's original drawings on which the ceilings decorations are based, so it is not clear how the initial selection of plants was made. As the panels are reminiscent of herbarium specimens, it is possible that the Museum's Keeper of Botany, William Carruthers, was involved. It is believed that the final selection of plants was made by the artist James Lea of the Manchester firm Best and Lea, and were probably painted in situ from scaffolding. Despite budget constraints, the gilded ceiling decorations are quite extraordinary.

There are 12 plants depicted and named in the Central Hall, each consisting of six panels combining to make one major picture. Generally they are European in origin or are introduced plants of economic benefit, for example the Tasmanian Blue Gum *Eucalyptus globulus*, which was being cultivated in Southern Spain for the production of eucalyptus oil. The Showy Banksia *Banksia speciosa* seems a surprising inclusion on these criteria but, as the authors point out, it is perhaps a tribute to Sir Joseph Banks who bequeathed to the Museum his herbarium from his various voyages of discovery.

The apex of the ceiling is decorated by simpler, more stylised depictions of plants, almost like photographic negatives. Possibly inspired by Nathaniel Wallich's *Plantae Asiaticae Rariores*, published between 1830-32, these plants are not named, and despite painstaking research the authors were not able to conclusively identify all of them. By contrast, the plants on the ceiling panels above the staircase at the southern end of the Great Hall are more accurately depicted and have their scientific names. All had some influence on human civilisation or trade and most were those upon which Britain built up trade, empire and industrial might, e.g. tobacco, cotton, coffee. Knapp and Press provide some interesting notes and stories on the introduction and exploitation of some of these species, including sugar cane and opium poppy.

The 18 plants from throughout the British Isles portrayed in the Northern Hall are also botanically accurate and shown with their scientific names. They represent a variety of habitats, and again the authors provide interesting notes on a selection of them.

The book does not provide a detailed analysis of the style of the artwork and techniques, and frustratingly there is only one passing reference to Victorian interior design. However, it does provide the first comprehensive listing of the plants so beautifully represented in the ceiling panels of the Natural History Museum, and may be of great interest to the botanically inclined visitor.

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One Hundred Years Ago

EXHIBITION OF WILD FLOWERS

Following the custom of late years the October meeting of the Field Naturalists' Club consisted chiefly of an exhibition of wild flowers. These had been sent by members and friends from many distant parts of the State, such as Casterton, Dimboola, Echuca, Benalla, Sale, Castlemaine, Bendigo, &c, and, thanks to the cool weather, arrived in very good condition, so that the display was one of the best yet held. An additional feature was a fine series of flowers of Australian plants blooming in the Melbourne Botanic Gardens, showing that, contrary to the prevailing idea, many of our indigenous flowers are capable of cultivation.

From *The Victorian Naturalist* XXIII p 132, November 8, 1906

Backyard Insects

by Paul Horne and Denis Crawford

Publisher: *The Miegunyah Press, Carlton, Victoria 2005. 2 ed, 252 pages, paperback, colour photographs. ISBN 0522852025. RRP $24.95.*

Insects and other arthropods are an integral part of urban Australia. These invertebrates that share our homes and gardens are incredibly diverse and they perform an enormous range of ecological functions. A selection of over 100 different insect species is presented in *Backyard Insects*, covering a broad range of fascinating creatures representing many of the major groups of insects. The book, which is now in an updated and revised edition, will inspire a keener interest in the insect denizens in our own backyard.

In the friendly and informative text for individual species, Paul Horne tells us fascinating details of the often bizarre life cycles, dietary habits and behaviour of our backyard insects. Although 18 insect orders are included, the majority of species covered in the book belong to only five orders, Hemiptera (true bugs), Coleoptera (beetles), Diptera (flies), Lepidoptera (moths, butterflies) and Hymenoptera (ants, bees, wasps) so a brief account of each of these more conspicuous orders is provided before individual species are presented. The text throughout the book is carefully presented to be clearly understood by even very young readers. Specialist terms are kept to a minimum but a short glossary explaining a few commonly used technical terms is provided. I'm happy to see that a large number of the insects chosen for inclusion are provided with not only a common name but also a scientific name, most often to the level of species, but occasionally to genus only. In addition, the species illustrated are classified to order and almost all to family. A further valuable inclusion is an indication, in millimetres, of the size of the insect. To round off the species accounts a small section is included with some brief, general comments on a few groups of common non-insect invertebrates including spiders, scorpions, slaters, slugs, millipedes and centipedes.

Denis Crawford's photomicrography techniques for imaging live entomological specimens produce superb results in this book. The photographs are full colour, larger-than-life and mostly full page, enabling easy identification. In my younger years I found endless entertainment in books on Australian insects such as those by John Child, Walter Froggatt, Keith McKeown or Robin Tillyard but unfortunately at that time none was accompanied by the beautiful close-up images that photography can now provide. A valuable addition to the current edition of *Backyard Insects* is the inclusion of more images of the immature stages such as eggs of the Australian plague locust, ootheca of the green mantid, nymphs of the katydid and passionvine hopper and larvae of the codling moth and hover fly. Another asset is the inclusion of some images of symptoms of the presence of insects such as leaf-blister sawfly mines or termite damage to wood.

There are two appendices, which deal respectively with collecting and photographing insects. In addition a bibliography is included, listing a good range of books on both Australian insects and on nature macrophotography.

In my opinion, *Backyard Insects* is a valuable guide for nature lovers, gardeners and especially younger people for whom the insect world of the suburban backyard can provide a captivating kaleidoscope of subject material.

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The Victorian Naturalist

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From the Editors

In reflecting on their year's work, which concludes with this issue, the Editors take both pleasure and pride in reporting on their achievements over the past twelve months. In a year of great variety of subject matter, of particular note was the special issue, in August, which focused on bryophytes. It has become customary in the on-going production of this journal that one issue each year is devoted to a specific theme or subject. It is likely that, in the long term, this year's special issue will rank alongside those on Box-Ironbark (February 1993) and Fungi (April 2001) as a particularly memorable and important one.

Elsewhere in this issue, there is a list of the many individuals who have assisted in some way with the production of this year's issues of *The Victorian Naturalist*. The Editors are pleased to acknowledge this help, happily and voluntarily given, and without which the entire process would be a great deal more demanding. We are pleased also to thank those individuals who have provided papers for publication in these pages. In the production of a quality journal, much depends on such continuing support. A regular stream of papers not only ensures that issues can be produced, but also helps the editors maintain a high quality. To complete the circle, this in itself encourages potential authors to offer papers.

The Editors would like to take this opportunity of wishing the many readers and friends of *The Victorian Naturalist* a happy and relaxed Christmas and New Year season.

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Front cover: Golden Sun Moth *Synemon plana*. Photo by Rohan Clarke. See article on p 362.
Back cover: Haiku by Christopher Palmer.

Some flowers visited by the Australian Painted Lady *Vanessa kershawi* (Nymphalidae, Lepidoptera) in northern Sydney bushland

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Abstract
Adults of the Australian Painted Lady *Vanessa kershawi* were recorded visiting the flowers of 17 species of plants for nectar, in bushland of northern Sydney, New South Wales, Australia. More than half of these were native plants, predominantly in the family Myrtaceae. Most of the plants visited were dicotyledons. The growth forms of the plants visited by *V. kershawi* ranged from herbs, through to shrubs and one species of tree. All native flowers visited by *V. kershawi* were white or cream coloured. Flowers of weed species visited were white, yellow, purple or orange. Tubular, cup-shaped and dish-shaped or open flowers were fed upon by *V. kershawi*. In the wild, ready availability of nectar may be the overriding factor in determining flower selection by *V. kershawi* adults. *V. kershawi* may play a role in the pollination of many of the 17 plant species recorded in this study. As a migratory butterfly species, *V. kershawi* may be involved in the long range dispersal of the pollen of a number of common native and exotic plant species. (*The Victorian Naturalist* **123** (6), 2006, 352-361)

Introduction

The Australian Painted Lady *Vanessa kershawi* (family Nymphalidae, subfamily Nymphalinae) is a very common, medium-sized butterfly occurring throughout south-eastern Australia and also in parts of central and western Australia (Braby 2000; Braby 2004). Adults of *V. kershawi* have been observed for much of the year in southern New South Wales (NSW) and Victoria, with peak abundance in spring, but are apparently absent from there in mid-winter (Braby 2000). The adults of *V. kershawi* are migratory and have been observed moving in large numbers, especially in spring (Smithers and Peters 1966; Smithers 1969; Common and Waterhouse 1981; Braby 2000; Braby 2004). The larvae of *V. kershawi* feed almost exclusively on various native and introduced species of plants in the daisy family (Asteraceae) (Braby 2000; Edwards *et al.* 2001).

Some information has been published about the diet of adult *V. kershawi*. For example, Hawkeswood (1981) listed seven introduced species of plants whose flowers were visited by *V. kershawi* adults in the Glenbrook area of the lower Blue Mountains, NSW, in the summertime. He listed Cobbler's Pegs *Bidens pilosa*, Coreopsis *Coreopsis lanceolata*, Tall Fleabane *Erigeron floribundus* (= ?*Conyza albida*), Stinking Roger *Tagetes minuta* and Dandelion *Taraxacum officinale* (all in the Asteraceae), Japanese Honeysuckle *Lonicera japonica* (Caprifoliaceae) and *Pavonia hastata* (Malvaceae) as adult food plants of *V. kershawi*. Nunn (2002) mentioned that the introduced daisy species Smooth Catsear *Hypochoeris glabra* and Lesser Hawkbit *Leontodon taraxacoides* were commonly visited for nectar by *V. kershawi* in the Ballarat region of Victoria. Williams and Powell (2006) observed *V. kershawi* feeding on the flowers of Capeweed *Arctotheca calendula* (Asteraceae) on Woody Island, off the coast of southern Western Australia.

A few authors have noted some native plants fed upon by *V. kershawi* adults. Keighery (1975) recorded *V. kershawi* as a visitor to the flowers of Coastal Banjine *Pimelea ferruginea*, Rose Banjine *P. rosea* and *P. sulphurea* (all in the Thymelaeaceae) in Western Australia. Stace and Fripp (1977) observed *V. kershawi* visiting white-flowered plants of Common Heath *Epacris impressa* (Epacridaceae) in spring in eastern Victoria. *Vanessa kershawi* was recorded foraging on the flowers of Plunkett Mallee *Eucalyptus curtisii* (Myrtaceae) in Queensland (Dunn 1994). Williams and Powell (2006) observed adults of *V. kershawi* feeding on the flowers of *Pimelea ferruginea* and of Variable Groundsel *Senecio lautus* (Asteraceae), on islands of the Recherche Archipelago in

Western Australia. Braby and Edwards (2006) frequently observed *V. kershawi* adults feeding from the flowers of daisies (Asteraceae) and Eucalypts (Myrtaceae) in the Griffith district of inland southern NSW.

The aim of this present study was to find out which species of plants weare visited for nectar by *V. kershawi* adults in the bushland of northern Sydney.

Observations and Discussion

Observations for this study were made in the Lane Cove River catchment area of northern Sydney, NSW, in the years 1995-1998 and 2003-2005. Much of the natural vegetation in the study area is open-forest, with smaller amounts of woodland and heathland also present (Clarke and Benson 1987; Benson and Howell 1990). The open-forests of the study area are dominated by a few species of eucalypt, most commonly Sydney Peppermint *Eucalyptus piperita*, Red Bloodwood *Corymbia gummifera* and Sydney Red Gum *Angophora costata*. The understoreys of these forests are often shrubby and floristically diverse, with the families Proteaceae, Fabaceae, Myrtaceae and Rutaceae strongly represented. These plant families also dominate woodland and heathland within the study area. Herbs, sedges, grasses and subshrubs are most evident in areas that have recently been burnt. Keith (2004, pp 146-147) provided a general description of the Sydney Coastal Dry Sclerophyll Forests, which are typical of most of the study area's surviving vegetation. In the study area, watercourses and disturbed places (such as the edges of bushland) are frequently dominated by introduced weed species, e.g. Small-leaved Privet *Ligustrum sinense* (Oleaceae) and Lantana *Lantana camara*. The observations for this study were made in sclerophyllous vegetation, mostly growing on sandstone. Harden (1990-1993) was consulted as the main authority for plant names to be used in this paper.

In the course of this fieldwork, *V. kershawi* adults were recorded feeding on the nectar of 17 species of plants (Table 1). On most occasions the butterflies were observed inserting their proboscises into the flowers and it was assumed that this indicated that they were feeding on nectar. Some instances have been included where a butterfly moved from flower to flower in a manner highly consistent with nectar feeding, but I was unable to observe whether it inserted its proboscis into the flowers. In these cases it was inferred that the butterfly was probably feeding on nectar. However, it is worth noting that butterflies may occasionally land on flowers without feeding on their nectar.

Of the 17 species visited by *V. kershawi*, ten were native species, predominantly belonging to the family Myrtaceae (Figs 1 and 2). Other native plants visited were in the families Thymelaeaceae, Colchicaceae (Liliaceae *s. lat.*) and Xanthorrhoeaceae. All of the native plants visited are common species within the study area, except for *Melaleuca styphelioides*, which is locally rare. The introduced plant species visited by *V. kershawi* were from the families

Fig. 1. *Vanessa kershawi* feeding on nectar of *Kunzea ambigua* (Myrtaceae).

Fig. 2. *Vanessa kershawi* foraging on flowers of *Angophora hispidia* (Myrtaceae).

Table 1. Some flowers visited by the Australian Painted Lady *Vanessa kershawi* for nectar, in the bushland of northern Sydney. An asterisk before the plant species name indicates an introduced plant, occurring either in bushland or in weed thickets and patches of weeds associated with bushland.

Family / Species	Growth Form	Flower Colour	Flower Shape	Month(s) of Feeding by *V. kershawi* Adults
Dicotyledons				
Asteraceae				
**Ageratina adenophora*	herb	white	(florets) tubular	October
**Coreopsis lanceolata*	herb	yellow	tubular	December
**Senecio madagascariensis*	herb	yellow	tubular	November
Rosaceae)				
**Cotoneaster glaucophyllus*	shrub	white	'cup'	November
Myrtaceae				
Angophora hispida	tall shrub	white	'dish'	December
Eucalyptus piperita	tree	white	'cup'	January
Kunzea ambigua	tall shrub	white	'cup'	Oct., Nov., Dec.
Leptospermum polygalifolium	shrub	white	'dish'	November
Leptospermum trinervium	shrub	white	'dish'	October
Melaleuca styphelioides	tall shrub	white	short tube	November
Oleaceae				
**Ligustrum sinense*	tall shrub	white	short tube	October, November
Thymelaeaceae				
Pimelea linifolia	shrub	white	tubular	Sept., Oct., Nov., Dec., Jan.
Verbenaceae				
**Lantana camara*	tall shrub	orange	tubular	October
**Verbena bonariensis* (s. lat.)	herb	purple	tubular	November
Monocotyledons				
Colchicaceae (Liliaceae s.lat.)				
Burchardia umbellata	herb	white	open	October
Xanthorrhoeaceae				
Xanthorrhoea arborea	_	white	open	January, February
Xanthorrhoea media	_	white	open	October

Asteraceae (Fig. 3), Rosaceae, Oleaceae and Verbenaceae. Most of the flowers visited were dicotyledons. Only three of the species visited were monocotyledons. This list is by no means exhaustive and could be expanded by more intensive and widespread observations. Even so, it begins to give some idea of the diet of adults of *V. kershawi* in the bushland of northern Sydney. *Vanessa kershawi* was not seen feeding on plant sap in the study area.

Flower Shape

Faegri and van der Pijl (1979) suggested that the 'typical' butterfly blossom has a narrow tube and a flat 'rim', e.g. *Lantana* and *Buddleja*. They also recognised that butterflies are able to feed on other flower types. In addition, they stated that butterflies frequently feed on the florets of daisies. Rutowski (2003) indicated that flower shape is important to butterflies in learning which flowers to visit for nectar.

The flowers visited by *V. kershawi* in northern Sydney bushland ranged from tubular in shape to 'cup'-shaped, 'dish'-shaped, or open. The only native species with tubular flowers visited by *V. kershawi* was Slender Rice Flower *Pimelea linifolia*. Armstrong (1979) listed a number of butterfly species, recorded as visiting *Pimelea* flowers. Hawkeswood (1981) noted that *P. linifolia* was visited for nectar by many adult butter-flies at Glenbrook. *Pimelea* *linifolia* is commonly visited by many different species of butterfly in the bushland of northern Sydney, including *V. kershawi* (pers. obs.). *Pimelea linifolia* often flowers abundantly in the understorey of northern Sydney's bushland in the first few years after fire, when its nectar is probably an important food for adult butterflies, including *V. kershawi*.

Most of the native flowers visited by *V. kershawi* in northern Sydney bushland were 'cup' or 'dish'-shaped and easy to access for a wide range of nectar-feeding insects, including butterflies. These native plant species were mostly in the family Myrtaceae. For example, the Dwarf Apple *Angophora hispida* has very broad, large and 'open' flowers that attract a diverse and abundant array of insects (Fig. 2), in the bushland of Sydney (Musgrave 1972; Benson and McDougall 1998; pers.obs.). Other 'open', or readily accessible, flowers visited by *V. kershawi* in northern Sydney bushland include those of the Broad-leaf Grass-tree *Xanthorrhoea arborea* and of *X. media* (Xanthorrhoeaceae). The flowers of *A. hispida* and *X. media* are usually abundantly produced only in the first year or so after fire (Benson and McDougall 1998, 2005; pers. obs.).

The flowers of the weed species visited by *V. kershawi* were predominantly tubular, though the Small-leaved Privet *Ligustrum sinense* has very short floral tubes and the daisies visited also have rather short tubular florets.

Theoretically, *V. kershawi* might be expected to experience more competition for nectar from other insects (e.g. bees, beetles and flies) at the more open flowers. However, in practice such competition often may not be an important factor. Most of the observed visits to 'open' flowers by *V. kershawi* were to plants that were flowering abundantly. Generally, there seemed to be sufficient amounts of nectar available for the relatively small number of butterflies (often only one) visiting any particular plant at a given time. However, it is possible that the introduced Honeybee *Apis mellifera* might significantly compete with native insects for nectar, when *A. mellifera* forages in large numbers on flowering plants (including some species with tubular flowers).

Kevan and Baker (1999) indicated that butterflies (with large wings) probably have a lower metabolic rate in flight than some other insects, such as hovering bumblebees and moths. The lower energy requirement of butterflies stems at least partly from their ability to regulate their temperature by basking in sunlight (Kevan and Baker 1983; Bernhardt 1999; Weiss 2001). So, *V. kershawi* may require smaller amounts of nectar (per gram of body weight) than some insects in some other orders, e.g. bees and hover flies. Kevan and Baker (1999) stated that competition between insect flower visitors has been little studied. They suggested that butterflies may be less dominant at flowers than some other insects, such as bumblebees and hover flies.

Kevan and Baker (1999) noted that the composition of nectar varies between different flower types and also between different plant families. They stated that open, bowl-shaped flowers tend to be hexose-rich and that their nectar tends to be concentrated, due to evaporation. They noted that the flowers of daisies also tend to be hexose-rich. Kevan and Baker (1983; 1999) also stated that flowers 'pollinated' by butterflies tend to be sucrose-rich. These are flowers with deep or 'concealed' nectaries (Proctor *et al.* 1996). For example, the notable 'butterfly bush' *Buddleja davidii* has nectar that is rich in sucrose (Baker and Baker 1983). There is also some indication that flowers 'pollinated' by butterflies may have higher levels of amino acids in their nectar (Kevan and Baker 1999).

Flower Configuration and Abundance

Kevan and Baker (1983) noted that the packing of flowers into dense inflorescences saves foraging insects energy. They also noted that walking generally uses far less energy than hovering flight, when insects are foraging on flowers. Faegri and van der Pijl (1979) stated that 'typical' butterfly blossoms, such as *Lantana* and *Buddleja*, have their flowers aggregated into dense masses and that this minimises 'travel costs'. May (1988) studied the flower selection and foraging energetics of two butterfly species in Florida, USA. He found that the more densely packed flowers visited by the butterflies in his study

Fig. 3. *Vanessa kershawi* feeding on nectar of *Senecio madagascariensis* (Asteraceae).

area tended to provide less energy per flower. This was because these flowers tended to be smaller and consequently produced less nectar per flower than the larger, but less densely packed flowers. He concluded that the flowers with longer corollas tended to be more profitable for the two butterfly species in his study area. Corbet (2000) found that the Painted Lady *Vanessa cardui* tended to visit flowers massed in dense inflorescences, at a study site in Britain.

The flowers visited by *V. kershawi* in the bushland of northern Sydney were often clustered closely together on plants that were flowering abundantly. This often enabled the butterfly to walk over the plant from one flower to the next, e.g. when visiting Tick Bush *Kunzea ambigua* (Fig. 1) and Small-leaved Privet flowers. Foraging in such a way would be likely to help the butterfly to conserve energy.

The individual flowers of Slender Rice Flower, Lantana and the florets of daisies are not large and each may yield a relatively small amount of nectar. However, these flowers are packed densely together in 'heads'. This enables a butterfly to perch on a 'head' of flowers and feed in rapid succession from numerous flowers, in an energy efficient manner. Also, the flowers of the Broad-leaf Grass-tree are arranged in long vertical 'spikes', enabling the butterfly to walk easily between individual flowers as it feeds. Such feeding efficiencies probably assist *V. kershawi* to live within the constraints of its energy budget.

Flower Colour

An important role of flower colour may be to attract the butterfly (and other insects) from a distance, particularly when plants are flowering abundantly. Weiss (2001) suggested that butterflies use long-distance visual cues to locate nectar sources. However, according to Rutowski (2003) it is not known whether butterflies use visual cues to locate nectar sources at distances greater than a few metres. At closer distances, flower colour is important in helping the butterfly to recognize and locate flowers (Rutowski 2003) and in guiding insects to the precise source of nectar (Kevan and Baker 1983). Faegri and van der Pijl (1979) stated that it was not known whether nectar guides 'mean anything' to butterflies. Rutowski (2003) indicated that butterflies tend to visually detect resources (such as flowers) at distances of up to one or two metres and that visual recognition of such resources mostly takes place at distances of a few centimetres.

Briscoe (2003) noted that there is considerable variation in the number of spectral classes of photoreceptors in the compound eyes of different moth and butterfly species. For example, some butterflies in the family Nymphalidae have been found to possess three or four spectral classes of photoreceptors, whereas some of the Hesperiidae have only three. The retina of the Asian Yellow Swallowtail *Papilio xuthus* (Papilionidae) has five spectral classes of photoreceptors (red, green, blue, violet and ultraviolet), placing it amongst the most complex of the butterfly retinas that have been studied (Briscoe 2003). True colour vision has been confirmed, by means of behavioural experiments, in *P. xuthus* (Kinoshita *et al.* 1999) and the Orchard Swallowtail *Papilio aegeus* (Kelber and Pfaff 1999).

The spectral responses and photoreceptors of the compound eye of a number of butterfly species in the family Nymphalidae were studied by Eguchi *et al.* (1982), Steiner *et al.* (1987) and Kinoshita *et al.* (1997). For example, Steiner *et al.* (1987) found evidence to suggest that the compound eye of the Small Tortoiseshell *Aglais urticae* was sensitive to ultraviolet, blue and green light.

Briscoe *et al.* (2003) found that the compound eye of the Painted Lady *Vanessa* *cardui* has three types of photoreceptors (green, blue and ultraviolet) and that this species apparently lacks red-absorbing visual pigments. Horridge *et al.* (1984) also could not find evidence of red-sensitive photoreceptors in the eye of the Yellow Admiral *Vanessa itea*. Briscoe and Bernard (2005) found that representatives of four other genera of nymphalid butterfly, closely related to *Vanessa*, also evidently lacked red-sensitive photoreceptors. This evidence, taken together, indicates that *V. kershawi* is probably unable to see the colour red. It also seems likely that the compound eye of *V. kershawi* is sensitive to green, blue and ultraviolet light.

Butterfly vision is significantly different from human sight. For example, it is possible that *V. kershawi* might be attracted to ultraviolet light reflecting from some flowers. Such reflections are invisible to the naked human eye. Dyer (1996) studied the reflection of near-ultraviolet (UVA) radiation from the flowers of a number of Australian native plants. He studied twenty white-flowered species, all of which did not reflect UVA radiation. For example, he found that the UVA reflection for a white-flowered *Pimelea* sp. was 'dark'. None of the other plant species studied by him corresponds with species recorded in this present study, as food plants of adult *V. kershawi*.

Weiss (2001) noted that innate colour preferences have been recorded for foraging butterflies in the families Nymphalidae, Papilionidae and Pieridae. She indicated that such colour preferences may vary between genera within a family, between species within a genus and even between the sexes of a given species. Briscoe (2003) indicated that the reason for these preferences is not well understood.

Nunn (2002) conducted an experiment, the results of which implied that *V. kershawi* might possibly have shown some preference for yellow artificial 'flowers' over white or purple artificial 'flowers'. However, the butterflies that she tested were captured from 'the wild', so it is possible that they might have already learned to favour yellow flowers. To unequivocally determine an innate colour preference (and exclude the possible influence of learning), it might be necessary to use methods similar to those employed by Kinoshita *et al.* (1999).

The Painted Lady *V. cardui* is similar to *V. kershawi* and is common and widespread in North America, Europe, Asia and Africa (Braby 2000). Janz (2005) noted that *V. cardui* is an opportunistic species, capable of annually colonizing large areas in the temperate portions of the world during spring. Bennett (1883) studied *V. cardui* at one site in Britain. He found that *V. cardui* visited Common Knapweed *Centaurea nigra* and Greater Knapweed *C. scabiosa* (Asteraceae). Both of these species have purple (or 'reddish-purple') flowers. Corbet (2000) observed adults of *V. cardui* feeding on a variety of flowers at a site in Britain. Janz (2005) indicated that selection of nectar sources by *V. cardui* may be determined largely by local abundance and availability. He noted that it may be unusual for *V. cardui* to use the same plant species for both nectar and larval food, at any given locality. In Australia, *V. cardui* has been recorded in only a few localities in Western Australia, and then only sporadically, suggesting that it is not permanently established there (Braby 2000; Braby 2004). This precludes a comparative study of the adult feeding behaviour of *V. kershawi* and *V. cardui* in the wild, in south-eastern Australia.

A study by Kay (1982) found that the Red Admiral *Vanessa atalanta* strongly preferred purple flowers of a common European herb, Devil's-bit Scabious *Succisa pratensis* (Dispacaceae), over white flowers of the same plant species. Kay suggested that such a pattern of discrimination may involve an innate or fixed colour preference in the butterfly. Scherer and Kolb (1987) observed that the feeding reaction of the Small Tortoiseshell *Aglais urticae* (Nymphalidae) was elicited by the yellow and blue regions of the spectrum (possibly also indicating an innate colour preference).

Weiss (1995) reported that the Gulf Fritillary *Agraulis vanillae* (Nymphalidae) can learn to favour one colour of flower over another, depending on the amount of nectar provided by the flower. She indicated that this capacity for associative colour learning is likely to be widespread amongst flower-foraging butterflies. Weiss (2001) noted that foraging butterflies can quickly learn to associate a sugar reward with a particular colour and that they can rapidly learn to switch their colour preferences when a previously unrewarding colour is made rewarding.

Flowers visited by *V. kershawi* in northern Sydney bushland were mostly white. All of the native plants visited had white or cream coloured flowers. It seems plausible that this does not indicate a flower colour preference by *V. kershawi*, but rather that the best available native nectar sources happened to be predominantly white coloured flowers. The weed species visited by *V. kershawi* had white, yellow, purple or orange flowers.

No discernable preference for one particular flower colour was noticed in the foraging behaviour of adult *V. kershawi* in the study area. However, this study was not designed to detect such a preference. Flower colour preference may not be an overriding factor in the selection of nectar sources by *V. kershawi*, in the bushland of northern Sydney. It seems plausible that an abundant source of readily accessible nectar would be sought by this butterfly, almost regardless of the flower colour. There are obvious survival advantages for such a widespread, migratory species in not being rigidly selective about the colour of flowers from which it feeds. It seems likely that such a common and widespread species would tend to be somewhat opportunistic and flexible in its selection of nectar sources. Such flexibility may well involve learning abilities similar to those discussed by Weiss (1995; 2001).

Whether *V. kershawi* would readily feed from red flowers remains to be determined. Red is probably somewhat less abundant than white, as a flower colour in the bushland of northern Sydney, where red-coloured flowers tend to be fed upon primarily by birds. For example, Pyke (1983) found that the flowers of Mountain Devil *Lambertia formosa* and Red Spider Flower *Grevillea speciosa* are visited by honeyeaters (Meliphagidae). As mentioned above, it seems unlikely that *V. kershawi* can see the colour red.

Flower Scent

Apparently, it is not known whether scent plays any role in attracting *V. kershawi* to feed on flowers. Kevan and Baker (1999) stated that 'butterfly-pollinated flowers' are mostly weakly scented, but that butterflies can orient strongly to olfactory cues. Proctor *et al.* (1996) indicated that some butterfly species are evidently capable of using scent to search for food. Barth (1985) stated that some butterflies in the family Nymphalidae use olfaction to find their food. Raguso and Willis (2003) indicated that floral scent has been found to attract some species of Nymphalidae from a distance and can also prompt some butterflies in this family to land on and probe flowers. Pellmyr (1986) found that three species of Fritillary (Nymphalidae) were strongly attracted to the scented morph of the Japanese herb *Cimicifuga simplex* (Ranunculaceae), but the butterflies were not very responsive to scentless plants of the same species.

Proctor *et al.* (1996) suggested that scent may attract some butterflies from a distance, alerting them to start searching for a food source, and that it also may act as a recognition signal for food sources that previously have been used by some butterfly species. Proctor *et al.* (1996) noted that some butterfly species first react to scent at a distance of 20 centimetres, whereas others can apparently react to scent at a distance of 30 metres (extending to 60 metres with a favourable wind). They also stated that the Red Admiral *Vanessa atalanta* has been found to use both visual and olfactory cues to seek food (consisting of flowers, dung and sap). However, some other butterfly species apparently do not respond to scent when seeking food.

Musgrave (1972) reported that Tick Bush flowers have a very strong scent and he suggested that this 'almost sickly-sweet aroma' may act as an attractant to insects. *Kunzea ambigua* flowers are quite often visited by *V. kershawi* (Fig. 1) and also by other species of butterfly in the bushland of northern Sydney (pers. obs.). However, it is not clear whether these butterflies are attracted to the scent of *K. ambigua* flowers.

Pollination

Bernhardt (1999) noted that relatively few plants are pollinated exclusively by butterflies. Quantitative data on the performance of butterflies as pollinators are somewhat scarce (Weiss 2001). An individual butterfly species may effectively pollinate some, but not all, of the plant species visited by the butterfly for nectar (Murphy 1984; Jennersten 1984).

Wiklund *et al.* (1979) studied the Wood White *Leptidea sinapis* (Pieridae) in Sweden and concluded that this butterfly was probably not an effective pollinator of the flowers that it visited for nectar. They suggested that this butterfly species may have been acting as a 'nectar thief'. Murphy (1984) suggested that this may have been because the flowers that were visited by *L. sinapis* happened to be structurally unsuited to pollination by butterflies. A study conducted by Courtney *et al.* (1982) in England indicated that some butterfly species, including the Small Tortoiseshell *Aglais urticae* (Nymphalidae), may be important in transporting pollen over distances of many kilometres. Murphy (1984) reported that the Checkerspot Butterfly *Euphydryas editha* (Nymphalidae), in California, USA, can carry large amounts of some pollen types on its body and wings. He also considered that this butterfly was a likely pollinator of a number of plant species. Jennersten (1984) found that butterflies in Swedish meadows were probably only minor pollinators of the majority of plant species visited and were probably stealing nectar from the flowers of 'legumes' (Fabaceae, subfamily Faboideae). Schmitt (1980) suggested that even a small amount of pollination by butterflies can increase the dispersal of genes within a plant population. She studied three species of *Senecio* (Asteraceae) in the Rocky Mountains, Colorado, USA, and found that butterflies can carry and transfer pollen between *Senecio* plants.

There apparently has been little information published about the specific effectiveness of butterflies as pollinators of plants in Australia. Keighery (1975) suggested that some butterfly species, including *V. kershawi*, were probably effective pollen vectors for a number of species of *Pimelea* in Western Australia. Hopper (1980) found some evidence to suggest that butterflies may be minor pollinators of *Syzygium tierneyanum* (Myrta-ceae) in northern Queensland. Also, the observations made by Ireland and Griffin (1984) suggested that butterflies may be relatively minor pollen vectors for the Yellow Stringybark *Eucalyptus muelleriana* in Victoria. Hawkeswood (1985) concluded that butterflies were probably not important pollinators of Corkwood Wattle *Acacia bidwillii* (Mimosaceae) at Townsville, Queensland. House (1997) noted that butterflies have been recorded transporting eucalypt pollen.

Vanessa kershawi may play a role in the pollination of many of the plants listed in Table 1, including the weed species. Given that *V. kershawi* is a migratory species, its greatest significance as a pollinator may be in the long range dispersal of pollen between isolated stands of a given plant species. In NSW, large numbers of *V. kershawi* can fly considerable distances over periods of up to 7-8 weeks, especially in the springtime (Braby 2000). Such migratory flights are probably fuelled largely by nectar and the migrating butterflies may pause quite often to feed on flowers. While making prolonged migratory flights, many Lepidoptera feed along the way (Johnson 1969). The main migration of *V. kershawi* in NSW can start any time between mid August and late November and there is some evidence of a smaller return movement between February and April (Smithers and Peters 1966; Smithers 1969; Braby 2000).

Many of the species of plants visited by *V. kershawi* in this study (Table 1) flower at times of the year when *V. kershawi* could be migrating. Many of these plant species are common, widespread and produce abundant flowers. For example, Tick Bush *Kunzea ambigua* occurs commonly in many of the sandstone bushland areas of northern Sydney. When in flower, *K. ambigua* produces abundant nectar and is quite often visited by *V. kershawi* (Fig. 1), as well as numerous other nectar-dependent insect species, including other species of butterfly (Musgrave 1972; Benson and McDougall 1998; pers. obs.). Whilst native bees and the introduced Honeybee *Apis mellifera* may be amongst the most effective pollinators of *K. ambigua* over short to medium distances, it is possible that migratory butterflies (and perhaps also migrating moths) may play a role in the pollination of *K. ambigua* and other plant species over longer distances.

Conclusions

The majority of plants visited by adults of *Vanessa kershawi* for nectar in the study area were native species, predominantly in the family Myrtaceae. Most of the plants visited were dicotyledons. The growth forms of the plants visited by *V. kershawi* for nectar ranged from herbs, through to shrubs and one species of tree. Most of the flowers visited were white or cream coloured. Other flower colours visited were yellow, purple and orange. No discernible preference for one particular flower colour was noticed in the foraging behaviour of adult *V. kershawi* in the study area. However, this study was not designed to detect such a preference. It may be that an abundant source of readily accessible nectar would be sought by *V. kershawi*, almost regardless of the flower colour. (However, *V. kershawi* may not be able to see the colour red). It seems plausible that such a common and widespread species would tend to be flexible and somewhat opportunistic in its selection of nectar sources.

A variety of flower shapes were fed upon by *V. kershawi* in the study area, ranging from tubular to very open or broadly dish-shaped flowers. Open flowers appeared to be visited as often as, if not more frequently than, tubular flowers. *V. kershawi* was not observed feeding on plant sap in the study area.

As a migratory butterfly species, *V. kershawi* may be involved in the long-range pollination of a number of common native and exotic plant species. However, the effectiveness of *V. kershawi* as a pollinator requires further research.

Not much is known about the extent to which the diet of adults of *V. kershawi* varies across Australia. Nectar from native plants in the family Myrtaceae may provide a major portion of the diet of adult *V. kershawi* in the forests and woodlands of northern Sydney. Whether this also may apply in other forested areas of coastal Australia could be worth investigating. Another possible line of enquiry is whether scent plays a role in attracting this species of butterfly to flowers.

In conclusion, much remains to be learnt about the foraging behaviour and ecology of adults of *V. kershawi* and also of other Australian butterflies.

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Golden Sun Moth *Synemon plana*: discovery of new populations around Melbourne

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Abstract
The Golden Sun Moth *Synemon plana* is a small diurnal moth that is critically endangered in Australia. The species had been known from just six areas in Victoria until 2003, when new populations were discovered at the Craigieburn and Cooper Street Grasslands north of Melbourne. In response to these discoveries, Biosis Research Pty Ltd has undertaken a number of targeted surveys for Golden Sun Moth as part of ecological investigations of land proposed for development around Melbourne. This report provides a general outline of the species' habitat requirements and biology, and briefly describes the discovery of additional populations and implications of these survey results.
(*The Victorian Naturalist* **123** (6), 2006, 362-365)

Introduction

Golden Sun Moth *Synemon plana* (see cover) is a small diurnal moth from the family Castniidae that is listed as critically endangered in Australia under the Environment Protection and Biodiversity Conservation Act 1999. The species was once widespread in the temperate grasslands and grassy woodlands of Victoria, the Australian Capital Territory and southern New South Wales but is now restricted to small disjunct populations throughout its former range. Surveys undertaken in 2000 reported Golden Sun Moths from 43 sites in New South Wales and 12 in the Australian Capital Territory (Clarke 2001). Prior to 2003, the species had been reported from just six areas in Victoria – Broadford, Tallarook, Flowerdale, Dunkeld, Hamilton and near Nhill-Salisbury (C O'Dwyer pers. comm.).

In December 2003 a substantial population of 'hundreds' of sun moths was found at the Craigieburn Grasslands by members of the Merri Creek Management Committee and Friends of the Craigieburn Grasslands (van Praagh 2004). They also sighted four males in the Cooper Street Grasslands in Campbellfield. Subsequently another population was discovered in Craigieburn, approximately 7 km north of the Craigieburn Grasslands, with 30-50 individual males observed (L Macmillan, Merri Creek Manage-ment Committee, pers. comm.).

In response to these recent discoveries, Biosis Research Pty Ltd undertook a targeted survey as part of ongoing ecological investigations of land proposed for residential subdivision in Epping, Victoria. During December 2004 and January 2005, four populations were located that were not previously known to exist, and were occupying habitat not previously considered typical for the species, as the vegetation was generally dominated by Kangaroo-grass *Themeda triandra* rather than wallaby-grasses *Austrodanthonia* spp.

This increased knowledge led to surveys being conducted on several other properties in the Craigieburn/Epping area that were known to support potential habitat for the species. Surveys were also extended to include the Deer Park area as the Golden Sun Moth historically occurred through western Melbourne, as indicated by Museum Victoria records collection from Altona, Broadmeadows, Keilor and Glenroy (Fig. 1). These surveys revealed several additional populations of Golden Sun Moth.

Habitat requirements

Generally, it has been thought that Golden Sun Moths are restricted to native grassland and grassy woodland areas dominated by wallaby grasses *Austrodanthonia* spp., which are important as larval food plants. Floristic and soil surveys from Golden Sun Moth sites undertaken by

O'Dwyer (1999) and O'Dwyer and Attiwill (1999) found the species occupied native grasslands and grassy woodlands with greater than 40% cover of *Austrodanthonia* spp. Habitat structure is likely to be an important element for species such as the Golden Sun Moth in which females display from a sedentary position to attract a patrolling partner. It is therefore expected that grasslands characterised by an open tussock structure and the presence of *Austrodanthonia* spp. provide the most suitable habitat.

Biology

The biology of the Golden Sun Moth is summarised below, based on information from ACT (1998), Clarke and O'Dwyer (2000), O'Dwyer *et al.* (2000) and van Praagh (2004).

Females are poor fliers and tend to bask, flashing their bright orange hindwings to attract patrolling males. Individual female territories are small and they are thought to walk between tussocks to lay their eggs. Based on comparisons with *Synemon magnifica* from Canberra, it is assumed that females lay their eggs (oviposit) between the tillers of *Austrodanthonia* grasses, the larval food plant. Early instar caterpillars feed internally on the plant tissues while later instars feed on the underground parts of the grass for up to two (or even three) years before pupating and emerging through a previously prepared tunnel to the surface.

The main adult flight season near Melbourne extends from late November to January, depending on temperature and site aspect. Adults lack functional mouthparts so their life span is only a few days, but adult emergence occurs continually throughout the flight season.

Golden Sun Moths are diurnal (day flying), with males most readily observed as they patrol for females. Male flight is low (~1 m), fast, and can be prolonged, but they are rarely found more than 100 m from suitable breeding habitat (Clarke and O'Dwyer 2000).

New populations around Melbourne

Craigieburn/Epping area

Six new populations have been found during Biosis Research Pty Ltd surveys in the Craigieburn/Epping area. Initially four new populations ranging from seven to over 60 individual males were recorded during surveys in the Epping area during the 2004/5 flight season. They were observed in association with stony rises with a lower density of *Austrodanthonia* spp. than previously considered suitable habitat. Additional populations were subsequently found at two other localities in the Craigieburn area during surveys in the 2004/5 and 2005/6 seasons, with three males observed flying at one site and 13 males at the other.

Interestingly, a number of the male Golden Sun Moths were observed in flight over paddocks, as far as 400 m from the nearest patch of suitable wallaby grass breeding habitat. This finding is substantially different from the 100 m previously considered in the scientific literature to be the maximum flight distance from breeding habitat.

Observations of the colonies in the Craigieburn/Epping area over two consecutive flight seasons (2004/5 and 2005/6) suggest that there are two populations that fly in alternate years; one may be substantially more numerous than the other. This means that populations not seen in one year could be found in the next, or large populations seen in one year could be much diminished in the second year. This is consistent with the biology of the species, in which the larval stage is thought to last for two or more years.

Deer Park area

Observations of a number of males demonstrated the existence of an additional population in the Deer Park area during the 2005/6 flight season. While there are no previous records of the species from that area, it is within the distributional range of the species as indicated by Museum Victoria specimens from Altona and Keilor (Fig. 1).

Some of the newly found sites are on private properties that are currently subject to assessment for potential development approval. At present it is not possible to publish details of floristics and habitat structure, land tenure and management activities at these new sites. This information will be important to gain further understanding of the species' requirements and will be made available in due course.

Fig. 1. Distribution of Golden Sun Moth records around Melbourne.

Since survey intensity has varied between sites, and surveys at some locations have been aimed simply at determining whether the species is present, the numbers of individuals documented at various sites does not necessarily reflect the relative size or importance of those populations.

Implications

The finding of these new populations around Melbourne suggests the Golden Sun Moth is more widespread and may have less specific habitat requirements than previously thought. Extensive surveys are now underway to improve our understanding of the distribution and habitat requirements of the species in the Melbourne area. It is hoped that this will assist with determining the relative size and importance of populations and therefore establishing priorities for conservation and management. Information gathered will also contribute to knowledge of what constitutes optimal habitat for the Golden Sun Moth.

In the meantime, the potential presence of the species should be considered for any area within the range of the species where native grassland or grassy woodland habitat is present.

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One Hundred Years Ago

EXCURSION TO WILSON'S PROMONTORY

Insects, generally speaking, were not plentiful, nor were any rarities secured. Those seen were such as are found at Beaumaris, Frankston, and along the Mornington Peninsula. The most favourable localities visited were the grass-tree flats on the south-east corner of the inlet and the valleys between Oberon and Waterloo Bays. Lepidoptera, chiefly micros, were most noticeable at the former locality, but although several of the well-known forms were fairly plentiful, the number of species was very limited. Among the butterflies, the Common Brown, *Heteronympha merope*, was very numerous on one of the ridges behind our landing-place, but, strange to say, we saw very few during the remainder of the trip. The Mountain Brown, *Tisiphone abeona*, as well as the Painted Lady, *Pyrameis kershawi*, and the Australian Admiral, *P. itea*, were met with every day. Amongst the "blues", *Neolucia agricola*, our Williamstown friend, was fairly common on Tongue Point, and still more so at Waterloo Bay. This species, which is also found in Tasmania and South Australia, seems to delight in situations exposed to strong sea winds. Five species of "skippers" (Hesperidæ) were taken, the rarest being *Hesperilla dispar* and *Mesodina halyzia*.

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Some taxonomic and ecological observations on the genus *Banksiamyces*

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Abstract
The stalked cup-fungus *Banksiamyces* is reported from 13 wild and one cultivated *Banksia* species. The geographic range of *Banksiamyces* is expanded to include Western Australia, South Australia, Victoria, Tasmania and NSW. Forty-five collections of *Banksiamyces* were examined in detail for a range of macro- and micro-morphological characters. Amongst the collections were all four of the previously described *Banksiamyces* species (*B. katerinae*, *B. maccannii*, *B. macrocarpus* and *B. toomansis*). Some collections that did not accord with these taxa were assigned to *Banksiamyces* aff. *macrocarpus* and *B.* aff. *toomansis*. The two species *B. katerinae* and *B. toomansis* appeared closer than initially proposed. The strict host-specific relationship suggested by some earlier studies was not confirmed. Evidence is provided for production of the fruit-body in early spring, and production of multiple crops of the same species on the one cone over successive fruiting seasons. Apothecia of these crops are of different macroscopic appearance, with lighter apothecia being mostly immature, and darker apothecia producing spores. This phenomenon may explain previous observations of seemingly different species on the same cone. (*The Victorian Naturalist* **123** (6) 2006, 366-375)

Introduction

The fungal genus *Banksiamyces* is found growing only on cones of *Banksia*. The small, grey, cup-like fruit bodies are relatively dull and inconspicuous, and perhaps this explains the small amount of attention the fungal genus has received in comparison to the copious literature on its host (Taylor and Hopper 1991; George 1996). The genus *Banksiamyces* was erected by Beaton and Weste (1982) for *B. toomansis* and the newly described *B. katerinae* and *B. macrocarpus*; a fourth species, *B. maccannii*, was described by Beaton and Weste (1984). *Banksiamyces toomansis* was first described by Berkeley and Broome (1887), in the genus *Tympanis*, from a *Banksia* collected 'on the banks of the River Tooma' [the Tooma River rises in the Snowy Mountains of southern N.S.W. and flows into the Murray near Tintaldra]. The only other collections reported prior to the studies of Beaton and Weste (1982, 1984) were two of *Banksiamyces toomansis* (as *Encoelia toomansis*) examined by Dennis (1958a, 1958b), one on *Banksia marginata* from Victoria and one from an un-named *Banksia* from South Australia.

The fruit-body of *Banksiamyces* is an apothecium, consisting of a fertile upper surface (the hymenium), which is slightly concave or cup-like (especially when dry), with a basal stipe. The four species of *Banksiamyces* recognized by Beaton and Weste (1982, 1984) were separated on the basis of micro- and macro-morphological features of the apothecium, and each was described from a single *Banksia* host.

- *Banksiamyces macrocarpus* (on *Banksia spinulosa*) occurs on the central surfaces of follicle valves and has relatively large apothecia, dark grey in colour, and microscopically there are pigmented granular hyphae extending down the length of the stipe.
- *Banksiamyces katerinae* (on *Banksia ornata*) has tight clusters of small, dark grey apothecia on the lips of *Banksia* follicle valves, lacks pigmented granular hyphae in the stipe, and has spores which are uniformly ellipsoid.
- *Banksiamyces toomansis* (on *Banksia marginata*) has a more solitary habit, with apothecia on the central surfaces of the follicle valves, the apothecia are lighter grey, and pigmented hyphae extend only partially to the base of the stipe.
- *Banksiamyces maccannii* (on *Banksia saxicola*) has comparatively large spores and asci, and the light brown apothecia are located both at the base of the follicle valve and on the intra-follicle tissue.

Seven species of *Banksia* are recognised from Victoria: *Banksia canei*, *B. integrifolia*, *B. marginata*, *B. ornata*, *B. saxicola* (formerly included in *B. integrifolia*), *B. serrata* and *B. spinulosa* (Walsh and Entwisle 1996). Beaton and Weste (1984) noted that *Banksia canei*, *B. integrifolia* and *B. serrata* also hosted *Banksiamyces*, but the collections were sterile, and not able to be identified. Fuhrer and May (1993) mention a cone of *Banksia marginata* from South Australia on which occurred both *Banksiamyces katerinae* and *B. toomansis*, and also that an unidentified *Banksiamyces* occurs on the Queensland *Banksia conferta*, cultivated in Victoria.

Fuhrer and May (1993) considered that not only could some species of *Banksiamyces* grow on more than one *Banksia* host species, but also that more than one species of *Banksiamyces* could grow on the same *Banksia* cone. They state that most dried collections examined were sterile, but considered that 'In the absence of spores there are sufficient other distinguishing characters … for satisfactory identification'.

Additional collections of *Banksiamyces* have accumulated at the National Herbarium of Victoria, particularly from South Australia and Western Australia, allowing further observations on the host range, species delineation, geographic range and phenology of the genus *Banksiamyces*.

Materials and Methods

Specimens held at the National Herbarium of Victoria (MEL) and the Herbarium, School of Botany, University of Melbourne (MELU) were examined. Among these collections, those that did not include sufficient data about location, the *Banksia* host, or the exact date of collection were excluded. Holotypes for *B. katerinae*, *B. macrocarpus* and *B. maccannii* also were examined, as were two of the three authentic specimens used by Beaton and Weste (1982) in their redescription of *B. toomansis*, and a paratype of *B. macrocarpus* (MEL 2022388). In total 45 collections were studied (Appendix A).

Before determining the specificity of the fungus-host relationship, fungi were identified and grouped using the morphological characters employed by Beaton and Weste (1982; 1984) in their treatment of the genus. These characters were: (1) apothecium diameter, (2) apothecium position, (3) apothecium external colour, (4) stipe length, (5) position of pigmented hyphae, (6) paraphysis shape, (7) paraphysis septate or not, (8) spores in asci uni or biseriate, (9) staining of ascus apical plugs with Melzer's Reagent (blue or not), (10) spore length, (11) spore width, (12) Q value (individual spore length divided by spore width), and (13) position of apothecia on follicle valve/ intrafollicular tissue.

For each collection, macroscopic characters (1-3) were determined from dried material using a dissecting microscope before cross-sections of at least two apothecia (from at least two *Banksia* cones, where present) were placed in a weak (<5%) KOH solution and heated. These sections were examined under × 100 magnification and stipe length measured. Sections were crushed by pressure on the cover slip and surveyed at × 1000 magnification where observations were made on spores and paraphyses. Slides were then flushed with water before the addition of Melzer's Reagent to determine any staining of apical plugs. At MELU there were some existing slides of apothecia from holotypes which were already mounted in a lactophenol-cotton blue solution. Fresh mounts of apothecia from these collections were made in a weak KOH solution.

When measuring spore size a minimum of 10 spores were randomly selected. Where possible these spores were divided equally between those found within asci and those found ejected from the asci (free). A one tailed t-test assuming unequal variance was conducted to determine if spores found within asci were smaller than those found free.

Maps of the distribution of the different species were produced and compared to maps of the host range. Where possible, the identity of the *Banksia* host was checked and confirmed. Where insufficient host material existed, the host identity assigned by the collector was compared to the known range of the host species. If the two correlated then the identity assigned by the collector was accepted.

Results

Banksiamyces occurred on 14 species of *Banksia*, from southern New South Wales, Victoria, South Australia and south-western Western Australia (Appendix A). All of the *Banksia* cones appeared to be wild-collected, with the exception of one cultivated *Banksia baxteri* from Cranbourne, Victoria.

Sixteen of the 45 collections of *Banksiamyces* examined were found to be immature (without spores, or occasionally with only a few spores in asci and none free). The one collection from *Banksia menziesii* and the two collections from *B. serrata* were all immature, as were nine of the 14 collections on *B. marginata* and four of the seven from *B. spinulosa*. All collections on the remaining ten host species (*B. baxteri, B. canei, B. integrifolia, B. nutans, B. occidentalis, B. ornata, B. pulchella, B. saxicola, B. speciosa* and *B. sphaerocarpa*) were mature.

Distribution maps of *Banksiamyces* species (Fig. 1) are based on fertile specimens; among the sterile collections examined, two were from Tasmania.

Some apothecia were pale grey and some were much darker, to charcoal grey or blackish-brown. Of particular note was the relationship between the external colour of *Banksiamyces* apothecia and their maturity. Apothecia in 20 collections were light grey in colour. Of these collections, 16 had no spores present and two had spores present only in asci. By contrast, collections with charcoal grey to blackish-brown apothecia always had spores present within the asci and some spores free. There were three collections which had at least one cone on which both a cluster of light grey and a cluster of dark grey apothecia were present (MEL 2019585, MEL 2063135 and MEL 2022284) (Fig. 2). These clusters were analysed separately as far as spore characters. Once again, in comparison to darker apothecia on the same cone, light apothecia had either no spores at all, or had more spores in the asci than were free.

Spores located within asci were found to be markedly smaller than those observed floating free in the mounting medium. Across all collections, spores located within

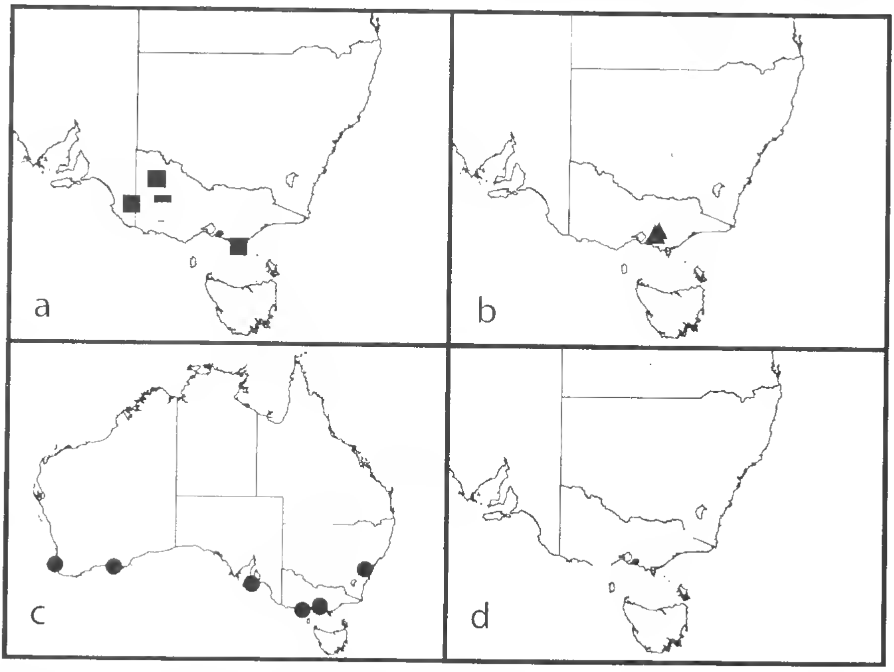

Fig. 1. Distribution of *Banksiamyces* species, based on fertile material only. **a.** *B. katerinae* (filled square) and *B. maccannii* (open square); **b.** *B. macrocarpus* (filled triangle) and *B.* aff. *macrocarpus* (open triangle); **c.** *B. toomansis*; **d.** *B.* aff. *toomansis*.

Fig. 2. Light (upper) and dark (lower) apothecia of *Banksiamyces toomansis* on the one cone of *Banksia marginata* (MEL 2019585).

asci had a mean length of 5.5 µm which were significantly shorter than free spores which had a mean length of 6.7 µm (t= -7.496, df= 401, P= 0.000). Spores within asci also had a significantly smaller width than those found free (t= -5.817, df= 401, P= 0.000). Spores found within asci had a mean width of 2.6 µm compared with free spores which had a mean width of 3.2 µm. It appears that either the spores located within asci had yet to mature to their full and final size, or the mounting medium causes swelling of the spores. For consistency, our analyses used only measurements taken from free spores.

Collections of *Banksiamyces* were made in all months, but most commonly in spring to late summer (Fig. 3). Herbarium collections do not accumulate from systematic surveys and therefore the number of collections per month is merely an indicator of collector activity. However, it is apparent that immature collections were nearly all found in late winter and spring.

Using six characters showing significant variation, collections were grouped into six taxa (Table 1), four of which corresponded to the species described by Beaton and Weste (1982; 1984), with two un-named taxa, each with affinities to one of the named taxa. Immature collections could not be identified with certainty, and the following refers only to mature collections.

All collections found on *Banksia spinulosa* were distinguished by their large apothecia diameter, long stipe and pigmented hyphae extending from the base of the hymenium to the base of the stipe. Spores were often smaller with a cylindrical shape (reflected in the higher Q value). These features, as well as the host species, accord well with the description of *Banksiamyces macrocarpus* (Beaton and Weste 1982).

Most collections found on *Banksia saxicola* had the characteristic large spores of *Banksiamyces maccannii* as described by Beaton and Weste (1984). Mean spore dimensions are quite separate from those of the other taxa (Fig. 4). These specimens were also distinguished by a lack of pigmented hyphae in the stipe.

One collection, also growing on *Banksia saxicola* (Table 1, MEL 2022131, *Banksiamyces* aff. *macrocarpus*), had far smaller spores than *Banksiamyces maccannii*, an extremely large apothecium diameter, pigmented hyphae extending to the base of the stipe and a large stipe reminiscent of *B. macrocarpus*. This collection is considered to be closest to *B. macrocar-pus*, differing in the spores which are slightly broader, and hence with a lower Q value than recorded for *B. macrocarpus*. The small number of collections of *Banksiamyces macrocarpus* from *Banksia spinulosa* available for study means that with more collections, the range of variation of spore size and shape may well extend to encompass the dimensions of spores from the *B. saxicola* collection.

Eleven collections on eight different *Banksia* hosts were assigned to *Banksiamyces toomansis*, on the basis of relatively small spore size (particularly smaller spore width), and pigmented hyphae which extended only part of the way towards the stipe base. Among the collections was one examined by Beaton and Weste (1982), from 'Chapple Vale'.

All five collections on *Banksia ornata* were consistent with *Banksiamyces katerinae* as described by Beaton and Weste (1982). Differences between *B. katerinae* and *B. toomansis* were far subtler than the differences between *B. maccannii* and *B. macrocarpus*. *Banksiamyces katerinae* has slightly larger spores than *B. toomansis* (Table 1 and Fig. 4). However, it should be noted that the spore dimensions which we recorded for the holotype of *B. katerinae* (6.30 × 3.10 µm) also fall within the range of variation of *B. toomansis* (see Table 1). In the same way, the apothecium size of *B. katerinae* is slightly smaller than *B. toomansis*, but the two species show overlap for this character. In fact, both these species overlap for all other characters. They are both unique in being the only species to show pigmented hyphae extending only part way down the stipe and having apothecia sometimes growing on the lips of the follicle valves. On the basis of its spore width (3.60 µm), which was wider than in any of the collections of *B. toomansis*, one collection growing on *Banksia integrifolia* (MEL 2022166) was also assigned to *Banksiamyces katerinae*.

Four collections found on the cones of *Banksia marginata* and *B. canei* were assigned to *Banksiamyces* aff. *toomansis* (Appendix A, Table 1). While the spores of this group fell well within the limits of *B. toomansis*, the stipe was longer in three of the collections (3.7 to 4.5 mm, in contrast to the maximum of 2.2 mm for *B. toomansis*), and, unlike *B. toomansis*, pigmented hyphae stretched to the base of the stipe. Also in contrast to *B. toomansis*, no apothecia were observed on the lips of the seed follicle.

In identifying collections, some of the characters that were recorded appeared to vary randomly across or within collections, or showed little variation within the genus. These included paraphysis shape, whether or not paraphyses were septate, the position of the spores in the asci, and the blue staining or otherwise of apical plugs with Melzer's reagent.

The geographic range of the genus *Banksiamyces* shows a decided southern Australian bias (Fig. 1). Within the genus, *B. toomansis* appears to have the widest distribution. By contrast, *B. maccannii*, (being limited to the host *Banksia saxicola*) is restricted to the Grampians, one of the two sites in Victoria where its host *Banksia* grows (the other is Wilsons Promontory).

Discussion

Taxonomy

Six *Banksiamyces* taxa were distinguished, four of which match the species already described by Beaton and Weste (1982; 1984).

Banksiamyces maccannii and *B. macrocarpus* are well characterised by the large spores of the former and the larger apothecia of the latter, with pigmented hyphae

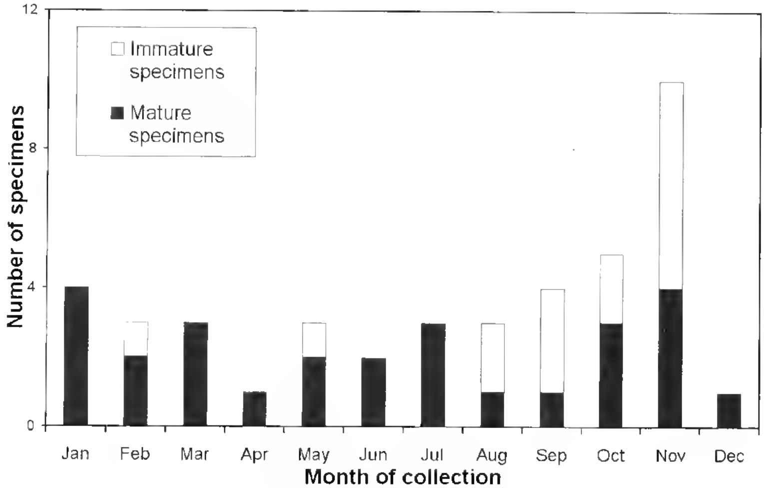

Fig. 3. Frequency distribution for month of collection of *Banksiamyces*.

Table 1. Characters separating *Banksiamyces* taxa. For measurements, the range of means across different collections is provided, followed in parentheses by the grand mean across all collections. Pigmented hyphae position: 0 = no pigmented hyphae (hyaline hyphae in gelatinous matrix), 1 = extending part way from base of hymenium towards stipe base, 2 = extending from base of hymenium to base of stipe. Apothecia position: a = on follicle valve lips, b = on base of follicle valve, c = on intra-follicle tissue.

Banksiamyces taxon	No. collections	*Banksia* host	Mean spore length × width (µm)	Mean Q (µm)	Mean apothecia diameter (mm)	Maximum stipe length (mm)	Pigmented hyphae position	Apothecia position
B. katerinae	6	*B. integrifolia* *B. ornata*	6.3-7.6 × 3.1-4.2 (6.97 × 3.73)	1.67-2.25 (1.90)	1.4-2.6 (2.04)	1.3-2.4 (1.60)	1	a, b, c
B. maccannii	4	*B. saxicola*	9.3-9.9 × 3.1-4.6 (9.54 × 4.09)	2.09-2.59 (2.39)	1.6-2.4 (2.10)	1.3-2.6 (1.75)	0	b, c
B. macrocarpus	3	*B. spinulosa*	5.0-6.3 × 1.8-2.2 (5.60 × 1.89)	2.93-3.08 (3.00)	4.3-5.1 (4.70)	5.4-12.0 (8.70)	2	b, e
B. aff. *macrocarpus*	1	*B. saxicola*	5.4 × 2.4	2.28	8.1	8.1	2	c
B. toomansis	11	*B. baxteri* *B. integrifolia* *B. marginata* *B. nutans* *B. occidentalis* *B. pulchella* *B. speciosa* *B. sphaerocarpa*	4.3-7.0 × 2.0-3.3 (5.83 × 2.78)	1.76-2.85 (2.18)	2.1-3.2 (2.56)	1.2-2.2 (1.99)	1	a, b, c
B. aff. *toomansis*	4	*B. canei* *B. marginata*	5.8-6.3 × 2.2-2.8 (6.07 × 2.50)	2.16-2.82 (2.49)	2.1-2.7 (2.38)	1.3-4.5 (3.39)	2	b, c

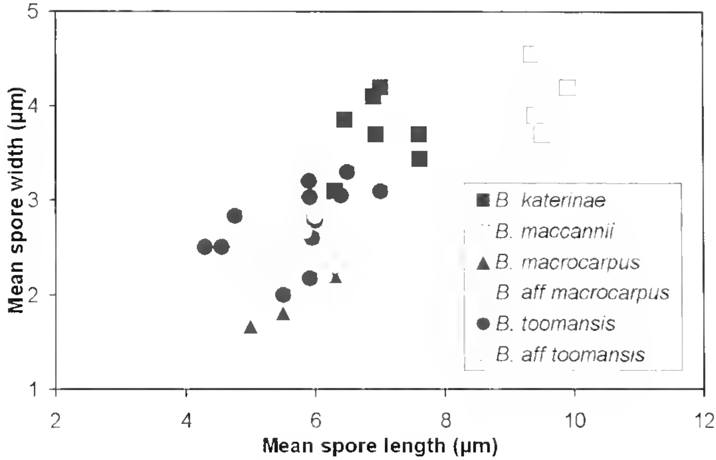

Fig. 4. Spore dimensions of *Banksiamyces* species. Each point is the mean for an individual collection, based on measurements of free spores.

extending to the base of the stipe. Each of these species is known only from one host *Banksia*. In contrast, *B. toomansis* and *B. katerinae* clearly require further analysis. The overlap between *B. toomansis* and *B. katerinae* for characters such as spore size, apothecia diameter, stipe length and pigmented hyphae position, would suggest that these two species are closer than was originally thought. While collections of *B. katerinae* generally had broader spores (as suggested by Beaton and Weste 1982), spores measured from the *B. katerinae* holotype fell well within the limits of *B. toomansis*. The separation of these two species is made even more problematic when it is considered that the spore measurements used by Beaton and Weste (1982) in their description of *B. toomansis* were taken only from spores located within the asci. Indeed when the *B. toomansis* authentic specimen was examined, no free spores could be found. We found that spores within *Banksiamyces* asci were significantly smaller than those found free. Spore measurements taken from the *B. toomansis* authentic specimen are most likely smaller than would be so for mature spores of the same specimen. Consequently, a larger spore size for the *B. toomansis* authentic specimen can be hypothesized, and this would move the species closer still towards the description of *B. katerinae*. Both *B. katerinae* and *B. toomansis* require further examination to determine their status in relation to one another. We consider that any swelling in the mounting medium would be uniform, and thus not affect the comparability of measurements from within our study. We acknowledge that further studies on the effect of maturity and mounting medium on spore size would be instructive.

Two taxa of *Banksiamyces* encountered in this investigation did not fit within the four species already described by Beaton and Weste (1982; 1984). While these taxa appear distinct, further work is required to determine if these groups warrant separation at the species level, or can be accommodated within the known species if the limits of variation of characters are expanded. For example, if collections assigned to *Banksiamyces* aff. *toomansis* were accepted as *B. toomansis*, then that species would have stipes varying from short to long and pigmented hyphae varying from extending partially to fully to the stipe base. At present, within each of the four described species, all collections have the same pattern for the extent of the pigmented hyphae in the stipe.

Several of the characters used by Beaton and Weste (1982; 1984) in their description of the four *Banksiamyces* species did not appear to differentiate any of the species. In particular, the position of the apothecia on the *Banksia* cone may be more influenced by the structure of the cone than by some feature of the *Banksiamyces* species itself. This contention is partially supported by the observation that *Banksiamyces* are generally more common on parts of the *Banksia* follicle valves where the tomentum has eroded rather than on the hard glabrous surfaces of the cone.

Further studies on the taxonomy of the genus are required. Given the few characters which show significant variation, and the difficulty of identifying many collections due to sterility, delimitation of species would benefit from analysis of biochemical and molecular characters. If species can be grown in pure culture, cultural characters also may be of assistance.

Ecology

Banksiamyces remains known only from *Banksia*. The number of *Banksia* host species from which the fungus is known has been increased to 14. The existence of more than one species on the same host has been confirmed with the presence of *B. maccannii* and the much smaller-spored *B.* aff. *macrocarpus* on different collections of *Banksia saxicola*. The occurrence of one *Banksiamyces* species on multiple *Banksia* hosts (up to eight hosts for *Banksiamyces toomansis*), and the occurrence of more than one *Banksiamyces* species on the same *Banksia* host, demonstrates that a strict host specific relationship between *Banksia* and *Banksiamyces* does not exist at the species level. While certain groups show preference for particular hosts, *B. macrocarpus* appears to be the only species found exclusively on one *Banksia* species, and it does not share this *Banksia* host with any other *Banksiamyces* species. Even for this *Banksiamyces*, the collection assigned to *B.* aff. *macrocarpus* eventually may prove to be *B. macrocarpus*, which would then extend the host range to *Banksia saxicola*.

Amongst collections examined in this study, there were no instances of two distinct *Banksiamyces* taxa growing on the same *Banksia* cone. Nevertheless, it has been suggested that more than one species of *Banksiamyces* can grow on the one *Banksia* cone at the same time (Fuhrer and May 1993) – *B. katerinae* and *B. toomansis* on the one cone of *Banksia ornata*, and *B. toomansis* and *B. maccannii* on the one cone of *Banksia saxicola*. Fuhrer and May (1993) did not utilise spore measurements for identification of *Banksiamyces* species. Therefore, an alternative explanation is that the occurrence of two types of apothecia on the same cone reflects two different crops of the same species each from a different fruiting season (perhaps annual crops). This explanation is supported by our observations that, in general, lighter apothecia lacked spores while darker apothecia were all fertile and, in particular by observations that where a *Banksia* cone had two different types of apothecia growing on it, the lighter grey apothecia were usually immature (the new crop), whereas the spatially separate darker grey apothecia growing on the same cone were mature (possibly the previous year's crop). Dennis (1958b) noted that a collection of *Banksiamyces toomansis* from September was immature, while one from June had abundant free spores and mostly empty asci, but did not relate this to apothecium colour. Our observations suggest that apothecia colour (as far as the contrast between light grey and charcoal grey to blackish-brown) is a function of the maturity of the fruiting body rather than a basis on which to separate different species within the genus.

It is not known how long *Banksiamyces* fruit bodies persist on the *Banksia* cone. Thus the time of collection does not necessarily reflect the time of first appearance of the fruit bodies. Nevertheless, the presence of immature fruit bodies predominantly in the period from late winter to spring (August to November) does suggest that this may be the time of fruit body initiation. Longitudinal studies of *Banksiamyces* life history are required to confirm this, and would also assist greatly in determining how clusters of apothecia of different colour originate.

The collections examined expand the geographic range of *Banksiamyces* within Victoria as well as further into southern New South Wales, South Australia, Western Australia and Tasmania. On current knowledge, *Banksiamyces* is restricted to southern Australia, although *Banksia* occurs in far north Western Australia, far north Northern Territory, and along the entire eastern seaboard to far north Queensland (Taylor and Hopper 1991; George 1996). It is interesting to note that although the distribution of known *Banksia* hosts extends substantially further north, *Banksiamyces* has yet to be found in these regions. For example, *Banksia integrifolia* extends to southern Queensland and there are populations of *B. spinulosa* as far north as the Mossman district of Queensland. Further surveys throughout the range of known hosts and of the numerous *Banksia* species on which *Banksiamyces* is yet to be found will be of interest.

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Appendix. Collections of *Banksiamyces* examined.

Herbarium no.	*Banksia* host	State	Locality	Date of Collection
Banksiamyces katerinae				
Holotype*	*ornata*	VIC	Grampians, Mt Zero	24.x.1964
MEL 2070194	*ornata*	SA	Naracoorte	29.v.1999
MEL 1054521	*ornata*	VIC	Wyperfeld, Black Flat	16.ix.1968
MEL 2022166	*integrifolia*	VIC	Wilsons Prom., Mt Oberon	9.xi.1989
MEL 2022168	*ornata*	VIC	Wyperfeld	16.vi.1961
MEL 2022184	*ornata*	VIC	Grampians, Mt Zero	24.x.1964
Banksiamyces maccannii				
Holotype*	*saxicola*	VIC	Grampians, Mt William	5.i.1984
MEL 2068724	*saxicola*	VIC	Grampians, Mt William	18.v.1975
MEL 2090368	*saxicola*	VIC	Grampians, Victoria Range	13.i.2000
MEL 2090369	*saxicola*	VIC	Grampians, Mt William	12.i.2000
Banksiamyces macrocarpus				
Holotype*	*spinulosa*	VIC	Tonimbuk	26.iv.1981
MEL 2090366	*spinulosa*	VIC	Warburton East	13.ii.2000
MEL 2022388	*spinulosa*	VIC	Beenak	9.vii.1981
Banksiamyces* aff *macrocarpus				
MEL 2022131	*saxicola*	VIC	Grampians, Victoria Range	11.xii.1966
Banksiamyces toomansis				
Authentic *B. toomansis* I*	*marginata*	VIC	Otways, Chapple Vale area	16.vi.1963
MEL 2090367	*integrifolia*	NSW	Blue Mountains	no date
MEL 2019585	*marginata*	SA	Kangaroo Island	18.x.1985
MEL 2022174	*marginata*	VIC	Langwarrin Flora Reserve	28.xi.1983

Appendix cont'd.

Herbarium no.	*Banksia* host	State	Locality	Date of Collection
MEL 2051421	*sphaerocarpa*	WA	12km SE Busselton	1.viii.1998
MEL 2057573	*nutans*	WA	Mt Merivale, 20km E. Esperance	8.iii.1997
MEL 2057574	*pulchella*	WA	Mt Merivale, 20km E. Esperance	15.ii.1997
MEL 2057575	*pulchella*	WA	Mt Merivale, 20km E. Esperance	30.iii.1997
MEL 2057576	*speciosa*	WA	Mt Merivale, 20km E. Esperance	31.i.1997
MEL 2063135	*baxteri*	VIC	Cranbourne Royal Botanic Gardens	16.vii.1995
MEL 259001	*occidentalis*	WA	Mt Merivale, 20km E. Esperance	9.iii.1997
Banksiamyces aff. ***toomansis***				
MEL 2070196	*canei*	VIC	Omeo Hwy	no date
MEL 2090370	*marginata*	VIC	Blackwood	2.vi.1991
MEL 2017890	*canei*	VIC	E. Highlands, Nunniong Plateau	13.xi.1964
MEL 2022165	*marginata*	VIC	Otway Plain, Kennedy's Creek	26.xi.1961
Banksiamyces sterile or immature collections				
Authentic *B. toomansis* 2*	*marginata*	VIC	Wonga Park near Gellibrand	17.v.1965
MEL 2091608	*marginata*	VIC	Between Penola and Casterton	21.ix.2000
MEL 2101859	*spinulosa*	VIC	Wilsons Prom.	21.ii.2002
MEL 2017887	*serrata*	VIC	East Gippsland, Howe Hill	2.xi.1969
MEL 2017889	*spinulosa*	VIC	Wilsons Prom., Lilly Pilly Gully	30.ix.1973
MEL 2019581	*marginata*	VIC	Grampians, Serra Range	4.xi.1992
MEL 2022121	*marginata*	VIC	Between Bullengarook and Blackwood	8.xi.1964
MEL 2022162	*menziesii*	WA	Bullsbrook East	25.x.1977
MEL 2022164	*spinulosa*	VIC	East Gippsland, Howe Ranges	10.xi.1969
MEL 2022172	*spinulosa*	VIC	Wilsons Prom., Lilly Pilly Gully	4.xi.1980
MEL 2022173	*marginata*	VIC	Wilson's Prom., Lilly Pilly Gully	30.ix.1973
MEL 2022176	*marginata*	VIC	Wilson's Prom., Sealers Cove	30.x.1964
MEL 2022179	*marginata*	TAS	Lake St Clair, Cynthia Bay	Possibly i.1977
MEL 2022180	*marginata*	VIC	Grampians, Victoria Range	11.xi.1974
MEL 2032795	*serrata*	VIC	Dutson Downs, near Sale	22.viii.1971
MEL 227981	*marginata*	TAS	Flinders Is., Whitemark	31.viii.1991

* All types and authentic material cited are held at MELU. Collection details are as follows:
Holotype *B. macrocarpus* – Coll. *B. Fuhrer* (G. Beaton 418, EO 0620).
Holotype *B. maccannii* – Coll. *I. McCann* (G. Beaton 420, EO 0622).
Holotype *B. katerinae* – Coll. *K. Beaton* (G. Beaton 268, EO 0433).
Authentic specimen *B. toomansis* 1, cited by Beaton and Weste (1982) – Coll. *G. Beaton 40* (EO 0411).
Authentic specimen *B. toomansis* 2, cited by Beaton and Weste (1982) – Coll. *G. Beaton*, no number. Located in packet with *G. Beaton 40* (EO 0411).

One Hundred Years Ago

EXCURSION TO WILSON'S PROMONTORY

Reptiles were poorly represented. The only snakes seen were Copper-heads, *Denisonia superba*, a speies also found in New South Wales and Tasmania. On opening one of those killed we found in the stomach a small lizard, *Liolepisma guichenoti*, a small frog, and two earthworms. Although I have often examined the contents of the stomach of our larger snakes this is the first instance in which I have found earthworms. All specimens were in good preservation, and had evidently been but recently swallowed.

From *The Victorian Naturalist* **XXII** p 202, March 8, 1906

Annotated records of the Greater Glider *Petauroides volans* from *The Victorian Naturalist* 1884-2005

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Abstract
A survey of *The Victorian Naturalist* was undertaken for records of the Greater Glider *Petauroides volans*. This report compiles around 52 distribution records, and summarises naturalists' observations of the animal's behaviour and feeding. Those concerned with the ecology and conservation of arboreal marsupials generally, and the Greater Glider in particular, should find this work useful as it compiles many interesting and important records of this the largest and most conspicuous of the gliding possums. (*The Victorian Naturalist*, **123** (6), 2006, 376-382)

Introduction

The Greater Glider *Petauroides volans* (family Pseudocheiridae) is the largest (900 – 1700 g) of the gliding marsupials (Strahan 1995). It is strictly folivorous, feeding on the buds, shoots and leaves of mainly eucalypt species, and it is hollow and forest dependent (Strahan 1995; Menkhorst and Knight 2001; Lindenmayer 2002; Goldingay and Jackson 2004). The current distribution of *P. volans* is from Victoria (Vic) in the south to the tropic of Capricorn in Queensland (Qld) in the north. It is found mainly among the tall wet forests within this range. The variable coat colouration of the Greater Glider extends from black with a white underbelly through mixtures of grey and cream, although pure white individuals are also reportedly common (Strahan 1995; Menkhorst and Knight 2001; Lindenmayer 2002). The conservation status of this species is stated as 'common' or 'secure' for the three states it inhabits (Menkhorst and Knight 2001; Goldingay and Jackson 2004). The historical and more recent records of this species in *The Victorian Naturalist* are at present scattered in many articles and naturalists' notes, and this adds to the inaccessibility and under-appreciation of these records. We have aimed to bring these records together in a single summary to augment other readily accessible information on the natural history of this species (Strahan 1995; Menkhorst and Knight 2001; Lindenmayer 2002). Such compilations may ultimately assist with conservation appraisal. This paper presents an annotated chronology of Greater Glider records from a desktop survey of all volumes of *The Victorian Naturalist*.

Greater Glider records from *The Victorian Naturalist*

Forbes-Leith and Lucas (1884) provided a checklist of the mammals of Victoria, and indicated that the 'Great Flying Phalanger' *Petaurus taguanoides* (=*P. volans*) was a resident species. Following this, a group of (presumably dead) 'Great Flying Phalangers' were exhibited by Mr A Coles of Melbourne at a 'conversazione' of the Club held on 14-15 June 1894 (Anon 1894). On 14 August 1905, Mr AE Kitson presented a 'skeleton, with skin attached, of a flying squirrel, *Petauroides volans*, found on a barbed-wire fence at Allambee East, South Gippsland. This animal had been caught by the foot on a barb, and had slowly and miserably perished' (Anon 1905). Batey (1907) wrote that the 'Great Brush Squirrel, *Petaurus taguanoides*', was:

> never very plentiful; some 12 years ago [1885] I found one drowned in a large dam at Newham. They were more common in the Macedon region, further north, than with us [at Sunbury district]. Mr W. Thom told me of two albinos he had seen at Bullengarook.

At a meeting of the club held on 12 February 1923, Mr HB Williamson exhibited a 'Flying Phalanger, picked up dead at Dandenong' (Anon 1923). However, no specific name for the specimen was provided, and it may or may not have been the Greater Glider. Fleay (1928) commented that Greater Gliders are among the 'favourite game' of the Powerful Owl *Ninox strenua*. The ability of the Powerful Owl to take the Greater Glider also has been noted more recently (i.e. Galbraith 1974).

In November 1931 near Mitta Mitta, CW Brazenor of the National Museum, Melbourne discovered a Greater Glider in a big Blue Gum. 'It was, however, impossible to take it alive, the tree being too big to fell' (Brazenor 1931).

David Fleay (1933a) provided a then authoritative article on the biology, habitat and distribution of the Greater Glider, including notes on its captivity, feeding, nesting and breeding habits, and vocalisations. Captive animals favoured Long-leaved Box *Eucalyptus goniocalyx* or *E. nortonii* and Common Peppermint *E. radiata* (Fleay 1933a). A photograph of Manna Gum *E. viminalis* habitat used by Greater Glider 'in a gully at Upper Beaconsfield (Vic.)' was included with Fleay's (1933a) paper on the species. Other distributional records included a capture at Delegate, New South Wales (NSW), a pair at Traralgon, a pair at Daylesford which were captured and taken into captivity (see also Fleay 1935), one or more at Beaconsfield, and observations of several animals at Mitta Mitta in January 1933 including a female taken from Callaghan's Creek when a Blue Gum *E. globulus* was felled. At Bendoc, Fleay stated that 'it was not uncommon to find suspended bodies' in barbed wire used to fence off farms. 'These animals had caught their volplaning membranes on the sharp barbs when swooping low, and so had died a miserable and lingering death'. Other reports of dead Greater Gliders were the result of animals crossing open spaces on the ground and falling prey to the fox *Vulpes vulpes*. In relation to its distribution and habitat, Fleay (1933a) stated:

> Favouring the tallest timber areas, and generally inhabiting dead trees in the gullies of mountainous country, the range of *Petauroides volans* extends down the highlands of Eastern Australia from Southern Queensland to Victoria. Further north in Queensland a smaller sub-species represents the only other member of this very interesting genus. In Victoria I have never observed the species further west than the Ballan-Daylesford forest, though more western records may have been established ...Apparently the species never reached the suitable environment of the Otway region...

In November 1942, a photograph of a 'Greater Flying Phalanger' appeared in an article by Carthew (1942). However, in the December issue of *The Victorian Naturalist* it was clarified that this was erroneous, and the caption for the photograph should have stated 'Yellow-bellied Possum-Glider, Or Flying Phalanger, *Petaurus australis*' (Anon 1942).

Norman Wakefield recorded the 'Dusky Glider *Schoinobates volans*' (= *P. volans*) as a sub-fossil from a number of cave deposits in Victoria including M-27 and M-28 (Wakefield 1960a) and Pyramids Cave (Wakefield 1960b; 1967). The presence of the species in the deposits was attributed to the predatory action of Quolls *Dasyurus* spp. which caught Gliders when they occasionally descended to the ground. Smaller marsupials were thought to have been deposited by owls. The cave deposits are of Holocene-Late Pleistocene age (see also Harris and Goldingay 2005).

In 1960, Mr Frank Buckland of 'Sunny Corner', Mallacoota, contributed some notes on gliders which mainly pertained to their acrobatics. He stated that in the bushlands of East Gippsland, the Greater Gliders could be heard especially when Red Ironbark *E. sideroxylon* is in flower (Buckland 1960). However, according to Wakefield (1970), Buckland's records are actually of Yellow-bellied Glider and not Greater Glider. Wakefield (1970) stated that the voice and gliding accomplishments of the Yellow-bellied Gliders had been credited erroneously to the Greater Gliders, 'which is, in fact, a sedentary, slow-moving, silent animal of minor gliding ability'.

Wakefield (1960a) suggested Greater Gliders were 'quite plentiful in heavy forest' to the north of Buchan. In early December 1960, a Greater Glider was seen while spotlighting near Mount Tara at Buchan (Anon 1961a). In June 1961, on a mountain road between Walhalla and Woods Point (towards Matlock), Mrs Ellen Lyndon found remains of a Greater Glider which had been taken by a Wedge-tailed Eagle *Aquila audax* (Lyndon 1961).

> We stopped and backed the car to look at it [the Wedgetailed Eagle], curious to know what it had been feeding upon. Hunting around in the undergrowth, I came on the still warm carcase of what appeared to be a large black possum, with thick soft fur and a long ringed tail. It proved to be the rear half of a Dusky Glider (*Schinobates volans*) [= *P. volans*], the largest of the glider-possums and the first of its species that we had seen. Unfortunately, the front quarters and the body contents had been completely eaten by the eagle. Lying flat, with membranes extended, black above and white below, the shape was oddly kite like. From toe to toe across the rump the measurement was twenty inches. The small pink soles of the hind feet bore knobby clawless "thumbs" and two of the toes were joined in the one enclosing skin to form the double combing nail, or, more properly speaking, the syndactylous toe.

Anon (1961b) noted that the popular name 'Dusky Glider' is used in David Fleay's (1947) *Gliders of the Gum Trees*. Subsequently, Garnet (1962) highlighted that the wide range of common names for the species often led to confusion, even for experienced naturalists. Wakefield (1963) supported Fleay's suggestion that 'Dusky Glider' should be universally adopted, despite the occasional white specimen. Wakefield (1963) also reported that the species 'is quite abundant in the mountain forests of the eastern half of Victoria, but it does not occur anywhere west of Port Phillip Bay'. Some recent observations made by Mr J Hyett of Croydon also were detailed:

> On the night of January 19, 1963, ten Greater Gliders were seen at Myers Creek, several miles north of Healesville, on trees along the main road. Most were very high in the eucalypts, but one was seen at twenty feet on a mass of Twining Silkpod (*Parsonsia straminea*). Its body was well spread as it climbed over the plant, so that the gliding membranes could be seen easily, joining the forelimbs at the elbows. It was observed to eat several leaves of the silkpod.
>
> At Yellingbo, a Powerful Owl was perched in a Black Wattle (*Acacia mearnsii*) overhanging the stream. Gripped in its talons was a Greater Glider whose head had been eaten. The owl regurgitated a pellet as we were watching it. This was recovered and found to contain glider fur, small fragments of skull bones, and the wing covers of two species of longicorn beetles.

On 6 July 1963, two Greater Gliders were found whilst spotlighting near Powelltown, and it was reported that one of these animals was 'rather low in a large messmate' (King 1963). In 1965, the Fauna Survey Group observed six Greater Gliders (Anon 1965; 1966a). These were for 18 May in Blue Gum *E. globulus* subsp. *bicostata* at a locality 10 miles north-west of Buchan (by NA Wakefield), 19 and 20 May in Messmate *E. obliqua* and Manna Gum *E. viminalis* along Tulloch Ard Road near Buchan (by NA Wakefield and J McCallum); 29 May on Britannia Creek Road and at Yellingbo (by W King); and on 6 November a Yellow-bellied Glider was seen (also by W King) in a *Eucalyptus ovata* tree at Woori Yallock (Anon 1966a).

On 9 May 1966, Ms V Parry addressed a general meeting of the Club on her Masters of Science research at Monash University on Kookaburras. She stated that during the study, Greater Gliders were 'predatory on the eggs of Kookaburras, and that these invaders were driven away fiercely from the region of the nest' (Anon 1966b). A record of the 'Greater Glider' was also provided for Powelltown/Labertouche State Forest (Anon 1967).

In June 1966 and June 1967, the Mammal Survey Group studied a small area of secondary regrowth forest south of the Darlimurla township, South Gippsland (Seebeck *et al.* 1968). Greater glider was recorded as:

> Not common in the area. Four specimens were seen, all feeding high up in the trees. On two occasions the food tree was identified as Mountain Grey Gum, *Eucalyptus cypellocarpa*. Animals were seen feeding between 7.40 pm and midnight.

Seebeck *et al.* (1968) also stated that the 'Squirrel' of South Gippsland of the 1880s (citing *The Land of the Lyre Bird*, second edition by South Gippsland Development League 1966) referred 'probably' to both *Petaurus* and *Schoinobates* (= *P. volans*).

Towards the end of 1967, some spotlighting was undertaken by a party of field naturalists in the Upper Thompson Valley (Anon 1968). At 11 pm, a Greater Glider was seen and reported as

Jet black; fine big chap; slow movement, pretending to hide. Some noise from us and up he goes a bit, across on to a branch to take up the stance of the textbooks (expecting a fee perhaps?). But how poor the textbooks are, and what would the soap advertisements give for this brilliant black and white?

At 12.25 am, another Greater Glider was seen, and reported as 60 feet up (Anon 1968).

Fryer and Temby (1969) conducted a mammal survey at Stockman's Reward, north-east of Marysville, during May 1967 and May-June 1968. Twenty-seven Greater Gliders were counted during spotlighting in 1967 but only 10 were found in 1968. The difference between counts of Greater Gliders on each trip was thought to be related to the drought at that time.

Even the habitually wet area dried out excessively during the drought and many of the eucalypts on the hills died. In the valleys undergrowth was killed and the young gums, the main supply of food for the Greater Gliders, dried out considerably. As the Greater Glider population in 1967 was quite concentrated, some had to leave to find new areas of food trees and this could explain the fewer sightings of Greater Gliders in 1968.

Fryer and Temby (1969) also noted that several animals were seen whilst gliding 'often between trees about ninety yards apart.'

O'Donnell (1970) reported on a 'quite plentiful' Greater Glider population in the Porepunkah district, north-eastern Victoria. At least seven animals were seen in this area in 1967-1968. Some of these animals were observed feeding on *E. globulus* subsp. *bicostata*, *E. radiata*, *E. viminalis*, Red Stringybark *E. macrorhyncha*, Broad-leaved Peppermint *E. dives*, Long-leaved box *E. goniocalyx*, Wonga-vine *Pandorea pandorana*, Blackwood *Acacia melanoxylon* and Hazel Pomaderris *Pomaderris aspera*. An albino Greater Glider seen at Mount Buffalo also was mentioned, as well as several other arguably doubtful Porepunkah records from animals that were only heard and not seen. A caption provided by the Editor stated that the Greater Glider is regarded as silent, and some of these records from vocalisations may have in fact been *Petaurus australis*. For additional comments on the supposed vocalisations of Greater Glider and the confusion with *P. australis* see Rodda (1929), Fleay (1932, 1933a, b, 1947, 1954) and especially Wakefield (1970).

In February 1970, two Greater Gliders were spotlit near Tram Creek in the Upper Lerderderg Valley; one in *E. radiata*, the other in Mountain Grey Gum *E. cypellocarpa* (Deerson *et al.* 1975). At that time, these were the most westerly sightings of the species in the Mammal Survey Group's records. Other Greater Glider records from this area included one seen on Campaspe Road in August 1969 in a dead Messmate *E. obliqua*; and another 11 km north-east of this locality in 1967 (Deerson *et al.* 1975). Hampton and Seebeck (1970) conducted a mammal survey in the Mount Macedon region, and although no Greater Gliders were found, they mentioned that the species was known to occur at that time just outside the area of their survey. Also mentioned were the earlier records provided by Batey (1907). Wakefield (1970) recorded Greater Gliders in the Yellingbo area, central Victoria in 1965 and 1966.

Anon (1974) reported that on 16 and 17 February 1974 the Greater Glider was observed during spotlighting, in the vicinity of Mt Baw Baw. Some were also spotlighted at the Easter Camp around Mt Cobbler and Mt Speculation. 'An unusual incident was the observation at close quarters of a Greater Glider sitting in the middle of the road. It had apparently landed there between two parties setting out in cars to spotlighting areas' (Anon 1974). Zirkler (1974) stated that Greater Gliders are known to occur at Tidbinbilla Nature Reserve, NSW.

Gilmore (1977) spotlighted 11 Greater Gliders in a survey of the Stradbroke area of South Gippsland, and noted that the species was widespread in the taller stringybark and gum forest but was not recorded in *E. nitida* or *E. consideniana*. Anon (1979) reported Greater Gliders seen on a trip to Mt Cobbler and Mt Speculation. Dixon (1979) lists the Greater Glider as present in the Alpine Area of Victoria and NSW. Ambrose (1979) records Greater Glider as 'uncommon' in the Wallaby Creek Catchment, and as an obligate tree hollow user.

Van Dyck and Gibbons (1980) noted Greater Gliders as 'usually major components' of regurgitated pellets of Powerful Owls. They also cited Seebeck (1976) and Fleay (1968) in stating that 'Powerful Owls from Victoria to Queensland show a definite preference for large, slow moving prey items such as Ringtails and Greater Gliders'. Brunner *et al.* (1981) stated that Greater Gliders are recorded as prey of the feral cat *Felis catus* in Victoria (also see Coman and Brunner 1972).

Callanan (1981) undertook 42.4 hours' spotlighting at Wallaby Creek (September 1974 – November 1978). Three Greater Gliders were seen in mature Mountain Ash forests and another two were spotted in mixed eucalypt forests. Seebeck *et al.* (1983) employed stag-watching in November 1980 and July 1981 and seven Greater Glider observations were made along the Snobs Creek Road (south of Eildon) and a further 11 were made at Upper Thomson River (north of Toorongo).

Nicholls and Meredith (1984) made 98 Greater Glider observations in the Mt Timbertop region between 1971 and 1976. Densities were quite high – they made 42 sightings in 4 km of spotlighting in riparian and *E. radiata* forests along Eight Mile Creek, and five individuals were known to inhabit two trees adjacent to the Timbertop School. Only dark-phase individuals were recorded in the region; in the Strathbogie Ranges (50 km west) light-phase individuals were reportedly common. Greater Gliders were reportedly more numerous in *E. radiata* open forests, which were typically in gullies and on the wetter foothill ridges, as well as in riparian vegetation associated with the valleys of the major streams. However, they were apparently less numerous in the *E. dives* open forests on the dry foothill ridges.

Loyn *et al.* (1986) recorded the Greater Glider in pellets of the Sooty Owl *Tyto tenebricosa* from Thurra River, East Gippsland. Read (1987) recorded Greater Gliders at Bodalla State Forest (NSW). The Mammal Survey Group spotlighted Greater Gliders on Errinundra Plateau in December 1986 (Anon 1987). Regan *et al.* (1988) conducted a mammal survey in East Gippsland in a Callistemon thicket and adjacent sclerophyll woodland dominated by *E. obliqua* and *E. dives*. Seven sightings of Greater Glider were made in the woodland and traces of the species were also detected in fox and/or dog scats in that area.

Dixon and Huxley (1989) reviewed notes, photographs and mammal collections of Donald F Thomson, which are now held in Museum Victoria. This review included details of a juvenile Greater Glider specimen which was photographed (reproduced in Dixon and Huxley 1989) and collected at Mooroolbark, Vic. in December 1932 (DTC 13; skull); and a male specimen (DTC 12 1229; skin and skull) collected at Toorloo Arm, Gippsland Lakes on 31 March 1934. Dixon and Huxley (1989) also commented that the Greater Glider

> is an inhabitant of eucalypt-dominated habitats; from low open coastal forests to the tall forests of the ranges, and low woodland west of the Dividing Range. As a result of urban development it is now unlikely to be a common inhabitant in the Mooroolbark area.

Lindenmayer (1992) recorded Greater Glider in the Mountain Ash forests in the Central Highlands of Victoria, and also commented that in this area it is 'more commonly observed emerging from tall, large diameter trees with hollows (see also Lindenmayer *et al.* 1991). Wallis *et al.* (1996) recorded Greater Glider in scats of the Fox but not those of the Cat, from a collection from Dandenong Ranges National Park (NP).

Garth and Garth (1996) regularly recorded Greater Gliders whilst spotlighting at Badger Weir Park, Healesville (now within Yarra Ranges NP). They stated that:

> Most evenings around fifteen minutes around dusk, a pair of Greater Gliders leave their hollow in the Manna Gum and make a spectacular glide over our heads to commence their foraging in the mixed species forest upstream. On one notable occasion in October 1995, the female did not glide, and was observed to be carrying a juvenile on her back. This youngster has been seen leaving the nest tree with its parents up until August 1996.

Taylor (1996) also spotlighted a Greater Glider with pouch young near Healesville. This rare sighting was made on 27 September 1995 at 21.35 hours in wet sclerophyll forest.

Reid (1997) reviewed records of the Greater Glider feeding on Mistletoes and proposed that they may reduce local populations of Mistletoe species. These feeding observations were on *Muellerina eucalyptoides* in Boola Boola State Forest (Henry 1985); *Amyema pendula* in Coolangubra State Forest, NSW (Kavanagh and Lambert 1990); and *A. pendula* near Armidale, NSW (Porter 1990).

In reference to mammal introductions on Wilsons Promontory NP, Seebeck and Mansergh (1998) stated that one Greater Glider 'of unknown origin, was liberated in the Vereker Range in February 1929 and another, at a site not identified, in March 1934' (see also Wescott 1998). The species 'is widespread in the South Gippsland Highlands and foothills to the north of Corner Inlet' (Norris *et al.* 1979). Seebeck and Mansergh (1998) also commented that the natural absence of Greater Glider from Wilsons Promontory reflects the 'island' nature of this NP.

Calder and Calder (1998) noted that the Greater Glider occurs 'down from the Plateau' at Mount Buffalo NP. van der Ree (1999) collated observations of wildlife becoming entangled with barbed-wire fencing from various sources including naturalist groups, professional societies and databases of government departments and wildlife carers. He found two records of the Greater Glider entangled in barbed wire in Victoria, six records for NSW and four records for Queensland.

Conclusion

In summary, 96 reports were identified with information on Greater Gliders. These produced around 52 distribution records, excluding those from the same locality and fossil records. The records span the period from pre 1905 to 1998. The records include observations of the species utilising 10 eucalypt species: *E. cypellocarpa*, *E. dives*, *E. globulus*, *E. goniocalyx*, *E. macrorhyncha*, *E. nortonii*, *E. obliqua*, *E. ovata*, *E. radiata* and *E. viminalis*. Feeding was observed on six non-eucalypt species: *Acacia melanoxylon*, *Amyema pendula*, *Muellerina eucalyptoides*, *Pandorea pandorana*, *Parsonsia straminea* and *Pomaderris aspera*. There are also records of the Greater Glider as prey of seven predators: Cat, Dog, Fox, Wedge-tailed Eagle, Quoll, Powerful Owl and Sooty Owl. Greater Glider is also recorded as predator i.e. on Kookaburra eggs. Hence, *The Victorian Naturalist* is a particularly rich source of records on the Greater Glider. These records are a useful supplement to other information available from museum holdings and wildlife Atlas records.

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Practices, experiences and opinions of snake catchers and their clients in southern Australia

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Abstract

The occurrence of snakes on private properties concerns many residents. Translocation of snakes by licensed snake catchers from private properties to public land is a common management practice in many urbanised areas in Australia. However, little is known about the practices of the snake catchers and the effectiveness of this management in terms of solving human-snake conflict. Mail questionnaires were used to survey licensed snake catchers from South Australia, and South Australian and Victorian residents who have used snake catchers. Catchers received calls from spring to autumn. The most frequently relocated snakes in South Australia were Brown Snakes *Pseudonaja* spp. Catchers chose release sites based on permit stipulations, perceived suitability of habitat, and likelihood of repeat encounters with humans. Residents detailed various beliefs for the occurrence of snakes on their property, including prey and shelter availability, and proximity to 'snake habitat', and, after first having a snake removed from their property, most found snakes subsequently. These repeat encounters suggest that education regarding snake encounters and discouraging snakes from entering/staying on their properties should be provided to residents, and that alternative management strategies for snakes in urban areas should be investigated. (*The Victorian Naturalist* **123** (6), 2006, 383-389)

Introduction

Human-snake conflict is common wherever both are abundant (Sealy 1997, Nowak 1998, Whitaker and Shine 1999, Fearn *et al.* 2001, Shine and Koenig 2001, Clemann *et al.* 2004). This conflict is heightened where highly venomous snakes occur. A recent survey of residents in urban areas of New South Wales showed that, of all animals likely to be encountered in suburbia, snakes were the least desired around people's homes (Davies *et al.* 2004). The most abundant and frequently-encountered snakes in south-eastern Australia are large, highly venomous members of the family Elapidae. Several of these are common in both urban and rural areas, and frequently come into contact with humans (Clemann *et al.* 2004). Although direct persecution of snakes remains common (Whitaker and Shine 2000), relocation of 'nuisance' snakes is often the government-sanctioned approach to managing this issue (Clemann *et al.* 2004).

Human-snake conflict involves two key issues – human dimensions and biological/ecological factors. The human dimensions issue involves the opinions, biases, motivations, knowledge and behaviours of people and organisations involved in this conflict. The biological/ecological factors involved in snake translocation include the effects of capture and relocation on individual snakes, and impacts on conspecifics and other taxa at both the 'donor' and release sites. Both issues have been largely neglected. Most studies of snakes relocated to solve human-snake conflict have involved viperid taxa in North America (e.g. Sealy 1997, Nowack 1998). Only recently has there been any investigation into the effects of translocation on Australian elapid snakes (Butler *et al.* 2005a, b).

An initial investigation of the human dimensions of human-snake conflict examined the practices of licensed snake catchers and 'first-contact organisations' who channel calls from the public to snake catchers in urbanised areas in Victoria (Clemann *et al.* 2004). That study showed that many elapid snakes were relocated every year, and that snake catchers, whilst usually following permit stipulations, apply a suite of subjective criteria when choosing release sites. In the present study, I expand on previous results (Clemann *et al.* 2004), adding data from questionnaire surveys of licensed snake catchers and residents who have used the services of these catchers in South Australia, and also present some details from Victorian residents who have used snake catchers.

Permit stipulations

Within Victoria, snake catchers operate under permits issued by the Department of Sustainability and Environment (DSE), allowing them to capture and translocate snakes. These catchers are predominantly private citizens, although a minority are keepers at zoological parks or are employed by local governments, either as full-time animal officers, or on an as-needed basis. Permit stipulations require catchers to release snakes on public land with suitable habitat no more than five kilometres from the point of capture. This distance was perceived by policy-makers to be sufficient to solve human-snake conflict, whilst not moving the snake beyond the probable natural distribution of the species (S Watharow, pers. comm.).

In South Australia a 'Snake Catcher's Permit' is required to capture and translocate snakes. This permit allows catchers to capture and translocate any reptile that is causing anxiety or danger to a member of the public. It directs catchers to translocate any indigenous snakes removed from properties, although captured Eastern Brown Snakes *Pseudonaja textilis* may be kept or traded (Department for Environment and Heritage (DEH) 2004). Translocation distance is a maximum of two kilometres, but snakes are not to be released close to dwellings. Alternatively, snakes may be retained for onward transmission to the South Australian Museum or to the holder of a permit to take protected animals.

Methods

Licensed snake catchers in South Australia and residents who have used the services of snake catchers in South Australia and Victoria were surveyed by mail-out questionnaires, which included postage-paid reply envelopes. Questionnaires were not sent directly to residents. Rather, each snake catcher receiving a questionnaire was asked to forward a specific 'resident' questionnaire to five people who had used their services. Each of the state governments has a register of licensed snake catchers. In Victoria, the 45 licensed snake catchers surveyed by Clemann *et al.* (2004) were asked to forward residents' questionnaires to former clients (i.e. potentially 225 residents if each catcher forwarded questionnaires to five residents). The South Australian DEH was unwilling to release contact details for licensed snake catchers. Consequently, a DEH staff member forwarded questionnaires to licensed snake catchers, and, as for Victoria, these snake catchers were asked to forward questionnaires to five residents who had used their services. Questionnaires were mailed to 28 licensed snake catchers in South Australia, and therefore potentially to 140 residents.

The snake catcher's questionnaire sought details of: 1. the number of calls received to remove snakes each year; 2. the proportion of call-outs that resulted in the capture of a snake; 3. the seasonal timing of calls; 4. the relative contribution of different species to the total captures; 5. the immediate future of captured snakes (translocation, euthanasia, kept captive by self or others, sold to others or commercial pet trade); 6. the distance that snakes were translocated; 7. the selection and number of release sites; 8. whether catchers offered residents information regarding snakes and snake management; 9. whether catchers advertised their services; and 10. whether the catchers charged a fee for the service.

The resident's questionnaire sought details of: 1. the first organisation called to arrange for a snake removal; 2. the resident's beliefs about the reason for the presence of the snake on their property; 3. whether they expected to find snakes on their property following the initial removal; 4. whether they had found subsequent snakes; 5. whether they were charged a fee; 6. whether they thought the fee was reasonable; and 7. whether they were satisfied with the service provided.

Results

Tables 1 and 2 summarise the questionnaire results from snake catchers and residents respectively. Questionnaires were returned by nine (32%) catchers from South Australia (Table 1). One return was not included in Table 1 because that person had only recently received a licence, had not attended any call-outs, and did not provide answers to any questions. Questionnaires were returned by four

Table 1. Responses of licensed snake catchers from South Australia to questions regarding snake capture and translocation practices.

Usual number of call-outs per year	Percentage of call-outs that result in a capture	Months of highest number of call-outs	Species involved in captures?[a]	Fate of captured snakes	Distance snakes moved (km)?	Always use same release site?	Do you offer information	Do you advertise?	Do you charge a fee ($AUD)?
Company receives hundreds	'majority'	spring, summer	BS 94% RBB 5% CH 1%	Translocation	Within 2 km	No	Yes verbal and printed	Parent co. advertises in phone book & with bumper sticker	$50-100
80 (~50% resolved over phone)	65-70%	October November February March, April	EBS 90%, RBB 5% MS 5%	Translocation captivity	Within 2 km	No	Yes verbal and printed	No	No
10 last year (new service in the area)	~50%	December January	EBS	Translocation	< 2 km (usually > 1km)	No	Yes verbal and printed	Yes flyers distributed around town	< $50
15-20, plus 15 false alarms 'lizards or imagination'	50%	Late spring early autumn	YFWS 80%, WBS 20% 2 CS 1 WP and 1 CP (escapees) 1 rubber toy snake	Translocation	2 km	No	Yes verbal and give talks to groups	No, but RSPCA^ and local businesses refer people to this catcher	No
Only one callout (only recently) licensed	1/1	One in October	BS	Euthanasia	< 3 km	No	Yes verbal	No	No
50-100 (respond to ~50% of these)	<50%	Not answered	EBS ~50% RBB ~50%	Not answered	Within 10 km	Not answered	Yes, verbal	Not answered	Not answered

Table 1. cont'd

Usual number of call-outs per year	Percentage of call-outs that result in a capture	Months of highest number of call-outs	Species involved in captures?[a]	Fate of captured snakes	Distance snakes moved (km)?	Always use same release site?	Do you offer information	Do you advertise?	Do you charge a fee ($AUD)?
0	Not answered	Spring early summer	BS	Translocation	~3 km	Yes	Yes, verbal	No	Not applicable
20	50%	Summer	MS, YFWS WBS, EBS	Translocation	15 km	No	Yes, verbal	No	No

[a]BS = Brown Snake *Pseudonaja* spp., RBB = Red-bellied Black Snake *Pseudechis porphyriacus*, CH = Dwarf Copperhead *Austrelaps labialis*, EBS = Eastern Brown Snake *Pseudonaja textilis*, MS = Mulga Snake *Pseudechis australis*, YFWS = Yellow-faced Whip Snake *Demansia psammophis*, CS = Curl Snake *Suta suta*, WP = Water Python *Liasis fuscus*, CP = Carpet Python *Morelia spilota*, WBS = Western Brown Snake *Pseudonaja nuchalis*
^Royal Society for the Prevention of Cruelty to Animals

South Australian and seven Victorian residents (Table 2). It is not known how many catchers cooperated with forwarding questionnaires to residents.

South Australian snake catchers

Five respondent catchers operated in rural cities and towns, whereas two operated in suburban Adelaide; one did not indicate his or her area of operation. One catcher simply removed snakes from his or her own property, and therefore had not received any call-outs (but was present for the removal of one snake from a school and one from a horse-show). Most considered that approximately 50% or more of attended calls resulted in the capture of the snake. Several noted that they did not attend all calls, resolving up to 50% of inquiries over the telephone, or that a considerable proportion of calls were false alarms – 'lizards' or 'imagination'.

South Australian and Victorian residents

Two of the four South Australian respondents lived in rural cities, one lived within a couple of kilometres of the centre of Adelaide, and one did not indicate where they lived. Two South Australian residents were charged a fee by the catcher, and both believed the fees to be reasonable (one noting that 'our family safety is worth more'). One respondent offered to pay the snake catcher, but this payment was refused, and another noted that they were not charged since they had caught the snake, and simply wanted the catcher to relocate it so that no one would kill it.

All responding Victorian residents lived in Melbourne suburbs. Three mentioned weather as a factor contributing to snake activity ('…we always get a snake after a really hot, dry day'), and local disturbance, such as adjacent housing developments, was also mentioned as a reason for the presence of snakes.

All respondents expected to encounter other snakes on their property subsequent to the initial removal; indeed seven had done so. The issue of repeat encounters with snakes elicited both positive and negative responses from residents; 'removing the snake has nothing to do with getting more', and 'I'm hoping that once the houses are built behind us, the snakes won't be

Table 2. Responses of residents from South Australia and Victoria to questions regarding snake management on their property.

State	'First contact' organisation that you called	Why was snake attracted to your property	Do you believe that you will encounter more	Have you observed any since first relocation	Were you charged a fee?	Was it reasonable?	Were you satisfied with service?
South Australia	'Snake Away Services', Lameroo	Bird life, mice, eggs	Yes	Yes	Yes ($10)	Yes	Yes
South Australia	Personal friend, a licensed snake catcher	Pet cat brought it into house	Yes	Yes	No	n/a	Yes
South Australia	Whyalla Fauna and Reptile park	Property close to bushland, with lots of garden beds to provide shelter for snakes	Yes	No	No	n/a	Yes
South Australia	'Snake Away Services', Campbelltown	Bird aviary, pile of old sleepers and tin	Yes	No	Yes ($65)	Yes	Yes
Victoria	Altona Council	Resident was told it was because of mice	Yes	Yes	No	n/a	Yes
Victoria	Wyndham Council	Possibly looking for water (dry summer), also lots of mice in area	Yes	Yes	No	n/a	Yes
Victoria	Wyndham Council	Property very close to Skeleton Creek	Yes	Yes	No	n/a	Yes
Victoria	'The council'	May have been seeking cool shelter because of very hot weather	Yes	No	No	n/a	Satisfactory - not pleased about being asked to 'keep an eye' on the snake
Victoria	Hobson Bay Council	Neighbouring development forcing snakes to move, rockery pond and/or watering the garden on a hot day might have attracted them	Yes	Yes	No	n/a	Yes
Victoria	Wyndham Council	Swimming pool, house shade, garden rock heap	Yes	Yes	No	n/a	Yes
Victoria	Hume City	Property backs onto creek and has long grass	Yes	No	Yes	Yes, because we have young children'	

so prevalent', versus 'they have every right to be here' and 'I hope the housing development doesn't deprive them of habitat ... (I have found dead snakes that were) probably killed by feral cats which are a far worse problem from an ecological standpoint – at least the snakes are native!'.

Discussion

The response rate of the South Australian snake catchers (32%) is similar to that reported by Clemann *et al.* (2004) for the same questionnaire sent to Victorian catchers (31%), and is typical for mail surveys, which usually generate a response rate of 10-50% (Neuman 2000). However, some snake catchers are wary of interaction with licensing agencies (pers. obs.), and may have been reluctant to respond to the questionnaire, even though it was administered from a research (rather than regulatory) government institute. Similarly, some non-respondents may have been unwilling to detail practices that infringed their permit conditions, although others did report such activities.

The response rate of residents is unknown, since it is not known how many snake catchers forwarded questionnaires. Some catchers may have been selective as to whom they forwarded questionnaires, possibly including only those residents whom they felt would provide a positive appraisal of their services. Since only a third of catchers returned questionnaires, it is likely that many were similarly casual in forwarding questionnaires to residents. A similar response rate from residents who did receive a questionnaire may have contributed to the very poor response rate, and it is likely that the responses from residents represent experiences with only a couple of catchers in each state.

South Australian snake catchers

The main differences between the practices of Victorian snake catchers reported by Clemann *et al.* (2004) and the present study relate to differences in species' abundance and distribution, and differences in permit stipulations. For example, whilst Tiger Snakes *Notechis scutatus* were the most frequently relocated snake in most parts of greater Melbourne (Clemann *et al.* 2004), Brown Snakes *Pseudonaja* spp. were most frequently relocated in South Australia. Similarly, most Victorian catchers reported moving snakes no further than five kilometres from the point of capture (as per permit stipulations, Clemann *et al.* 2004), whereas most catchers in South Australia move snakes no more than two kilometres, as per their permit requirements.

In other respects the reported practices of South Australian catchers mirrored those of their Victorian counterparts. Snake catchers from both states may be involved in many relocations annually (usually tens per catcher, but sometimes far more). The months and seasons reported as having the highest number of call-outs were spring to autumn (October to April). This is the period of peak activity for reptiles in temperate south-eastern Australia, where most ectothermic vertebrates undergo a period of considerably reduced activity in the colder months. Most catchers in both states use multiple release sites, and chose sites that they believed reduced the chance of further human-snake conflict, as well as suiting the perceived ecological needs of the snake (Clemann *et al.* 2004). Finally, most snake catchers in both states offer information to residents on snake biology and management.

South Australian and Victorian residents

Although sample sizes were very small, there was an apparent difference between South Australian and Victorian residents in terms of first contact organisations. Those in South Australia called specific snake removal companies, a friend who was a licensed snake catcher, or a fauna park, whereas the Victorians contacted their local council, perhaps reflecting differences in available services or differential understanding amongst residents about the availability of these services. In areas where snakes commonly occur on private properties, such as where housing estates adjoin creeks or bushland, contact between residents and catcher is often prompted by 'word-of-mouth' recommendation between neighbours. In this way particular catchers, businesses or local governments become known as an effective point of first contact (S Watharow pers. comm.).

Residents reported three broad beliefs as to why snakes occurred on or were attracted to their property – proximity to bushland or other snake habitat (especially when this habitat was being disturbed), availability of potential prey, or availability of shelter. Although some of these reasons may be intuitive, in some cases these opinions are also likely to reflect the advice or observations of the attending catchers (Clemann *et al.* 2004), most of whom offer information on snake habits.

All respondents believed that they would encounter more snakes after the initial removal. Mostly this was due to or reinforced by the fact that they had encountered at least one more snake. Although improved property management might minimise the number of snakes subsequently occurring on some of these properties, the removal of a snake clearly does not provide a lasting solution to unwanted contact between humans and snakes. Relocated snakes are part of a larger local population, and, consequently, it will be necessary for some residents to accept that snakes occur on or near their property, and moving individual snakes several kilometres does not prevent repeat encounters.

Residents from both states were very positive in their appraisal of the service provided by catchers, and some specifically mentioned the value of the information provided by the catchers regarding snake biology and property management. Clearly, snake catchers provide a valuable community service that is highly regarded by residents. However, translocating snakes may be problematic for the snakes, and does not provide a lasting solution to human-snake conflict. Moving snakes over large distances can lead to aberrant behaviour (Butler *et al.* 2005a, b) and elevated mortality rates (e.g. Reinert and Rupert 1999). Additionally, relocated snakes may travel from release sites into neighbouring private properties (Butler *et al.* 2005a). There is a need for greater public education regarding the management of snakes, as well as the evaluation of alternative management practices.

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Sexing Little Penguins *Eudyptula minor* using bill measurements

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Abstract
In Little Penguins *Eudyptula minor* there are no reliable plumage or body size differences that can be used visually to distinguish the sex of individuals. However, sexual dimorphism of morphometric measures has been noted, with males always being a little larger than females. In this study, differences between *E. minor* sexes at eight colonies in south-eastern Australia were determined statistically via discriminant function analysis (DFA) and through the utilization of DNA-based techniques developed for non-ratite birds. The DFA correctly determined gender in 91.1% of cases and molecular methods were 100% accurate. Our DFA success rate of classification is similar to that previously published for Little Penguins in Victoria. In this study statistically significant differences in mean bill depths and lengths were found between Little Penguin colonies at St Kilda, Phillip Island and Gabo Island, compared to colonies at Kangaroo Island, Granite Island, Middle Island and London Bridge. As birds in eastern populations (St Kilda, Phillip Island, Gabo Island) exhibit statistically significantly smaller beaks (bill depth and bill length), separate discriminant functions were investigated for each phenotypically distinct geo-spatial cohort. Interestingly, cluster analysis for bill length identified three groups: western (Kangaroo Island and Granite Island), eastern (St Kilda, Phillip Island and Middle Island) and the London Bridge Little Penguin colony, which constituted a separate group. We conclude that while there is a slight increase in DF power for colonies west of Cape Otway and for some specific colonies, colony-specific DFA is not required to identify the sex of Little Penguins in south-eastern Australia. (*The Victorian Naturalist* **123** (6) 2006, 390-395).

Introduction

The Little Penguin *Eudyptula minor* is the smallest penguin species and is endemic to temperate seas in Australia and New Zealand. Australia has one sub-species (*E. minor novaehollandiae*), found from Fremantle (WA) in the west to northern NSW and Tasmania in the southeast. There are five sub-species in New Zealand (Kinksy and Falla 1976). However, Banks *et al.* (2002) recently demonstrated that molecular results subdivide *E. minor* into only two clades: 1) the majority of New Zealand colonies and 2) Australia (sample from Phillip Island) and Otago *E. minor*.

In order to manage Little Penguin populations effectively, demographic analyses require the accurate determination of gender of the animals in the field (Caughley and Gunn 1996). However, Little Penguins show no differences in plumage between genders, and body size is also similar for males and females (Agnew and Kerry 1995).

Bill depth has been a useful sexually distinguishing morphological feature in Little Penguins from Tasmania (Gales 1988), New Zealand (Renner and Davis 1999, Hocken and Russell 2002) and also from Phillip Island and Gibson Steps in Victoria (Arnould *et al.* 2004). Gales (1988) was the first to use a discriminant function (DF) that uses bill depth and length. The New Zealand work also developed DFs that demonstrated each sub-species required different functions. Arnould *et al.* (2004) found the DFs derived by workers for New Zealand populations of *E. minor* were poor predictors of gender for Little Penguins at Phillip Island and Gibson Steps. Gales' (1988) DF derived from a Tasmanian population yielded a reliability of 89.3% and 92.2% for birds at the two Victorian sites (Arnould *et al.* 2004) compared to 94% in Tasmania.

Preliminary results from our studies at seven colonies of Little Penguins in south-eastern Australia suggested bill dimensions of adults varied among colonies. Arnould *et al.* (2004) found similar differences in bill depth in their studies that prompted them to propose colony-specific DFs might be needed in order to determine the gender of birds accurately, rather than just using the one DF for the Australian sub-species.

The aim of this paper is to see whether it is possible to derive a single DF that can be used to determine accurately the gender of Little Penguins at eight sites in south-eastern Australia.

Methods

Bill depth (vertical thickness at the nostrils) and length (length at exposed culmen to tip of bill) were measured (± 0.1mm) on 50 adult *E. minor* at seven of the sites shown in Fig. 1. To minimize inter-operator variation the same person took all measurements. Data provided in Arnould *et al.* (2004) for known-gender birds at Gibson Steps were used to test both Gales' (1988) and our overall discriminant function.

Blood samples were collected from the birds using standard techniques (Ellegren 1996) and gender determined genetically using the methods of Fridolfsson and Ellegren (1999) that rely on intron length variation in the sex chromosome-specific CHD (chromo-helicase–DNA binding protein) gene locus. This allowed us to know the gender of the birds that had previously had their bill measurements taken.

The molecular method of gender determination was verified by application to 40 Little Penguin carcasses from Middle Island, Warrnambool, that had been killed by foxes and subjected to gender determination by dissection.

Geographic variation in sexual dimorphism was tested using Kruscal-Wallis non parametric ANOVA. The Mann-Whitney test was used to assess for *post hoc* differences and a P-value of <0.05 was considered statistically significant. Discriminant function analysis was used to identify the gender of individual penguins. We used both bill depth (BD, mm) and bill length (BL, mm) in our DF. Assumptions associated with discriminant function analysis were not violated. The DF we derived was tested on 350 birds. Wilk's Lambda test was used to determine whether both variables (BD and BL) contributed significantly to the model. Canonical discriminant function coefficients were derived in order to establish the linear function (Gales 1988). Cluster analysis was undertaken with respect to location to determine if there were any distinct homogeneous sub sets.

Results

Examination of the seven sites for statistically significant differences (Table 1) in bill length as a function of location (Fig. 1) revealed that *E. minor* from the Kangaroo Island, Granite Island, Middle Island and London Bridge colonies have significantly longer bills when compared to birds from the more eastern colonies (Fig. 2a). Analysis of the seven sites for statistically significant differences in bill depth derived a similar result, with *E. minor* from Kangaroo Island, Granite Island and London Bridge having significantly deeper bills compared to *E. minor* from the more eastern colonies (Fig. 2b).

Cluster analysis was also performed on the variables Bill Length and Bill Depth as a function of location. Bill Length proved the more interesting variable with three groups identified: western (Kangaroo and Granite Island), eastern (St Kilda, Phillip Island and Middle Island) and the London Bridge Little Penguin colony, which is a separate group (Fig. 3). Gales' (1988) had DF = -83.10 + (10.06 ln BL) + (17.99 ln BD), where DS is the discriminant score and ln the natural logarithm. When we applied this DF, we found it produced differences in the success rate of classification for predicting the gender of Little Penguins (Table 1). The DF that Gales (1988) derived was most reliable for birds in the east of Victoria.

Arnould *et al.* (2004) derived the following DF for Little Penguins at Phillip Island and Gibson Steps: DS = 1.242 BD – 16.774 The DF model derived by Arnould *et al.* (2004) from Phillip Island and Gibson Steps *E. minor* colonies successfully determined sex for 88.3% of the *E. minor* observations from south-eastern Australia.

Testing each of the seven *E. minor* colonies separately for the DF model derived by Gales (1988) and Arnould *et al.* (2004) resulted in varying success. The accuracy of both DF models decreased at the Kangaroo Island, Granite Island, Middle Island and London Bridge colonies, while it increased at the St Kilda, Phillip Island and Gabo Island *E. minor* colonies (Table 2).

The DF we derived from all samples from all locations is: DS = -18.710 + (1.292 BD) + (0.015 BL).

Table 1. Mann-Whitney *post hoc* one-tailed differences for bill length of *Eudyptula minor* from seven colonies tabulated (n = 50 individuals /colony, * statistically significant at the 0.05 level). Z = z-scores, P = p-value.

		Kangaroo Island	Granite Island	Middle Island	London Bridge	St Kilda	Phillip Island
Granite Island	Z P	0.574 0.566		1.110 0.267	0.707 0.480	-3.149 0.001*	3.623 0.000*
Middle Island	Z P	-0.622 0.534	1.110 0.267		0.565 0.572	-1.968 0.025*	2.385 0.009*
London Bridge	Z P	-0.299 0.765	0.707 0.480	0.565 0.572		-2.907 0.002*	3.167 0.001*
St Kilda	Z P	-3.051 0.002* K>StK	-3.149 0.002* GrI>StK	-1.968 0.049* MI>StK	-2.907 0.004* LB>StK		0.128 0.898
Phillip Island	Z P	3.414 0.001* K>PI	3.623 0.000* GrI>PI	2.385 0.017* MI>PI	3.167 0.002* LB>PI	0.128 0.898	
Gabo Island	Z P	-3.112 0.002* K>GI	3.240 0.001* GrI>GI	2.197 0.028* MI>GI	2.914 0.004* LB>GI	-0.073 0.941	0.130 0.897

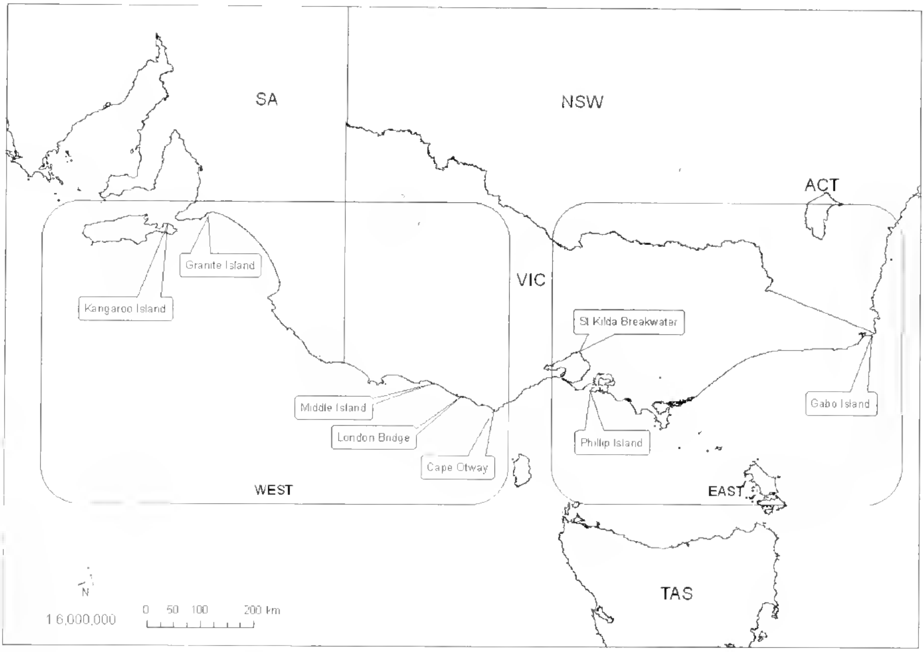

Fig. 1. The location of the eight colonies of Little Penguins used in this study.

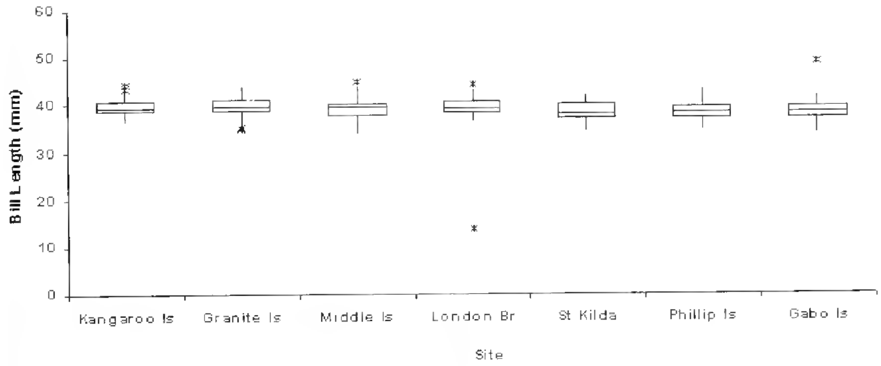

Fig. 2a. Box plot of bill length for the seven *Eudyptula minor* colonies in south-eastern Australia (the median is identified within the box, the data spread is identified as the distance between the ends of the box, and the lines extend to extreme values. X represents outliers).

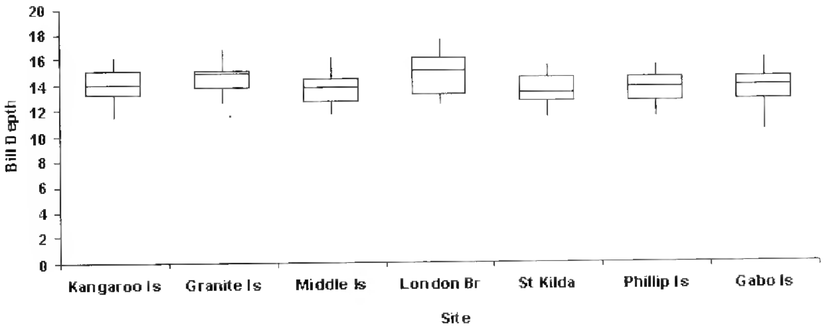

Fig. 2b. Box plot of bill depth for the seven *Eudyptula minor* colonies in south-eastern Australia (the median is identified within the box, the data spread is identified as the distance between the ends of the box, and the lines extend to extreme values).

Rescaled Distance Cluster Combine

```
  C A S E       0         5          10         15         20         25
Label   Num     +---------+----------+----------+----------+----------+

KI      1       òûòòòòòø
GI      2       ó÷          ùòòòòòø
SK      5       òòòûòø ó    ó
PI      6       òòò÷ ùò÷        ùòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòø
MI      3       òòòòò÷              ó                                ó
GA      7       òòòòòòòòòòòòò÷                                       ó
LB      4       òòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòòò÷
```

Fig. 3. Cluster Analysis of *Eudyptula minor* bill length for seven colonies in south-eastern Australia. (KI: Kangaroo Island, GI: Granite Island, SK: St Kilda Breakwater, PI: Phillip Island, MI: Middle Island, GA: Gabo Island, LB: London Bridge).

Table 2. Geographically grouped and colony-specific DFs for the *Eudyptula minor* breeding in south-eastern Australia.

Location	Discriminant Function	Success rate of classification This Study	Gales (1988) Tasmania DF	Arnould *et al.* (2004)
East of Cape Otway	= (BD X 1.425) + (BL X 0.048) - 21.312	91.3%		
West of Cape Otway	= (BD X 1.328) + (BL X 0.011) - 19.692	90.5%		
Kangaroo Island	= (BD X 1.443) + (BL X 0.042) -22.148	88.2%	73.0%	74.0%
Granite Island	= (BD X 1.362) + (BL X 0.107) -24.115	88.0%	80.0%	80.0%
Middle Island	= (BD X 1.452) + (BL X 0.049) -21.889	96.0%	76.0%	76.0%
London Bridge	= (BD X 1.37) + (BL X -0.038) -18.702	94.0%	76.0%	76.0%
St Kilda	= (BD X 1.236) + (BL X 0.139) -22.053	88.9%	88.9%	88.0%
Phillip Island	= (BD X 1.687) + (BL X 0.169) -29.578	94.3%	94.3%	93.0%
Gabo Island	= (BD X 1.341) + (BL X -0.039) -16.939	94.1%	84.3%	84.0%

Using all samples the DF correctly predicted gender in 91.1% of birds tested, with DS values >0 as male and those <0 females. This DF was almost as reliable as the one we derived for determining gender of birds in the eastern colonies (91.3%) compared with those in the west (90.5%). A discriminant function was developed for each of the seven sites, for sites clustered both east and west of Cape Otway, and overall, for all sites (Table 1).

Discussion

We found mean adult Little Penguin bill depth and length varied between the eight sites sampled in this study. This supports the observations reported by Arnould *et al.* (2004) who also found differences in bill depth in birds from different colonies; these differences prompted them to suggest there might be a need for a different DF for each colony in Australia. Fig. 2 indicates that birds from our sites clustered into two groups – one east of Cape Otway and one to the west. In all sites, the males had statistically significantly larger bills than the females.

When the DF derived by Gales (1988) in Tasmania was applied for the eight sites (the seven sites used in this study and Gibson Steps), gender was successfully determined in 81.7% of cases. When Gales' DF was applied separately to the data from the seven colonies studied, the reliability was lowest for the western colonies and higher for the colonies at St Kilda, Phillip Island and Gabo Island.

Our DF correctly determined gender in birds from the eight colonies in 91.1% of cases. Further, its reliability in determining gender of birds in the eastern colonies (91.3%) compared with those in the west (90.5%) was also high. The colony-specific DF success rates varied, with a high success of 96% for the Middle Island colony and a low of 88% for the Granite Island birds.

The DF we have derived is thus more reliable at predicting the gender of penguins in south-east Australia in comparison with other DFs that have been published for the same species elsewhere.

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Is there always a bias towards young males in road kill samples? The case in Victorian Koalas *Phascolarctos cinereus*

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Abstract

Mortality due to road trauma can have large negative impacts on some populations and often is biased towards age/sex classes that have higher rates of movement: individuals during the breeding season and juveniles while they are dispersing. A bias towards young males has been found in two previous studies of road kill Koalas in southeast Queensland. Such a bias was not found in the present study of Koala skulls from populations across Victoria. This may be due to the different Koala population structures and densities or road types and characteristics. (*The Victorian Naturalist* **123** (6) 2006, 395-399).

Introduction

Individuals of many species are killed on the roads (Trombulak and Frissell 2000; Taylor and Goldingay 2004) and this can have large negative effects on populations of wild animals (Dufty 1994; Jones 2000; Hebblewhite *et al.* 2003; Lopez *et al.* 2003). Road trauma is known to impact some Koala populations (Backhouse and Crouch 1990; Lunney *et al.* 1996; Thompson 1996). The Phillip Island Koala population in Victoria decreased substantially between 1973 and 1988, mostly due to high mortality from road trauma (Every 1986; Backhouse and Crouch 1990).

Mortality rates due to road trauma have been found to differ between temporal seasons (Taylor and Goldingay 2004) and may be greater in age/sex classes that have high dispersal rates or increased activity levels (Bonnet *et al.* 1999, Inbar and Mayer 1999). For example, Coulson (1989) found that 48% of road killed Eastern Grey Kangaroos *Macropus giganteus* were 1 to 2 years of age, the age when they were dispersing. A significant bias towards road kills of two-year-old macropods was also found by Lee *et al.* (2004). Additionally, males were more likely to be hit than females in five species of macropods, possibly because of their greater ranging behaviour (Coulson 1997). A high proportion of ungulate road traumas are also related to dispersal and breeding behaviour (Groot Bruinderink and Hazebroek 1996). Similar patterns of male-biased mortality caused by road trauma have been found in

Koalas (Weigler *et al.* 1987; Dique *et al.* 2003b).

Methods

Koala skulls were opportunistically collected from Victorian Koala populations and measured at several Victorian State and University Museums (Table 1). Fresh Koala carcasses also were collected opportunistically from roadsides during travel throughout Victoria (1999-2002). The populations ranged from high density with little vehicular traffic or dogs (e.g. Snake Island) to low density, probably declining populations with high traffic volumes and domestic dogs (e.g. Phillip Island).

Skulls collected from Snake Island, Framlingham and Mt Eccles were assumed to have resulted from natural mortality, as road traffic and predation by domestic dogs *Canis familiaris* are considered negligible at these sites. Skulls from other populations were allocated a cause of death including natural mortality, death resulting from road trauma or unknown cause of death. Koalas were presumed to have died from road trauma if the carcass was found within 50 m of a road (most were detected on the roadside verge). Koalas were allocated to the 'unknown cause of death' category if there was no information regarding the collection details. Skulls were pooled across all locations according to the cause of death.

All skulls were cleaned and the age of the Koala at death was estimated using a nine-point tooth wear class (TWC) scoring system (see McLean 2003). The length and width of each skull were measured and used in combination with TWC to determine the sex of the Koala (see McLean 2003).

The frequency distribution of skulls across all TWCs was assessed with Kolmogorov-Smirnov Z, 2 independent samples tests to compare age and sex-specific mortality patterns. The overall sex ratio of Koalas presumed to be killed by road trauma was compared with Chi-square tests.

Results

Mortality due to road trauma was spread over all TWCs greater than TWC I in females and TWC II in males (Fig. 1). Of the Koalas that were presumed killed by road trauma, 39% of females and 17% of males were in the older TWCs (V – VII combined); only 2.5% of the road trauma group were in TWC II. The overall sex ratio of 1:1.35 (17 males: 23 females) for Koalas presumed killed by road trauma was not significantly different from parity ($\chi^2 = 0.9$, d.f. = 1, $P > 0.05$).

There was little evidence of a difference in the pattern of age-specific mortality of male Koalas that died of natural causes compared with unknown causes, or natural causes compared with road trauma, or unknown causes compared with road trauma (Table 2). Similarly, there was little evidence of a difference in these same comparisons for females (Table 2).

Discussion

In the present study, a similar proportion of male and female skulls were collected beside roads and these were spread relatively evenly over all TWCs. Additionally, Koalas presumed killed on the road had a similar age distribution to those that died of natural causes in both males and females. The absence of young Koalas (TWC I) in the road kill sample is probably due to the fact that the skull sutures of young Koalas are not well formed, and the skulls break up more quickly than the skulls of older Koalas, rather than any suggestion that this age class is not subject to road trauma. The contribution of the older animals (TWC VI and VII) to the sample is interesting given that very few individuals of that age have been found in live Koala populations studied in Victoria (McLean 2003).

The pattern of age- and sex-specific road trauma in the present study differs from studies of Koala mortality in 'near urban' and 'heavily urbanised' environments in southeast Queensland (Weigler *et al.* 1987; Dique *et al.* 2003b) where it was found that mortality due to road trauma was male-biased. Dique *et al.* (2003b) found that 61% of the Koalas that died from road trauma were males, a significantly higher proportion than in the local population (41%, $n = 58$). Additionally, young males (2 – 4 years of age) were disproportionately represented in the road trauma group compared with the population while no

Table 1. Number of Koala skulls collected from each Victorian locality. * Sites where a proportion of the skulls measured were from koalas presumed to be killed by road trauma.

Site	# skulls	Site	# skulls	Site	# skulls
Snake Island	210	Lake Tarli Karn	2	Keilor	1
Unknown*	180	Langwarren	2	Kerang	1
Phillip Island*	101	Rosedale	2	Lang Lang	1
Boho*	65	Sandy Point	2	Launching Place	1
Brisbane Ranges	60	Somerville	2	Lima South	1
French Island	40	St Margaret's Is.	2	Macks Creek	1
Mt Eccles	32	Stony Rises	2	Mallacoota*	1
Zoo	23	Swan Hill	2	Maroondah Weir	1
Walkerville	22	Tyabb	2	Meeniyan	1
Healesville	18	Warneet	2	Mildura	1
Ararat	14	Wartook	2	Molesworth*	1
Mt Macedon*	9	Werribee Gorge	2	Monomeik	1
Wilsons Prom	9	Willung	2	Mooroduc	1
Creswick	8	Yarck*	2	Mornington	1
Woodend*	7	You Yangs	2	Mt Charlie	1
Framlingham	6	Alexandra	1	Mt Dryden	1
Grey River Reserve	5	Altona	1	Mt Robertson	1
Kennett River	5	Axedale Forest	1	North Mangalore	1
Macedon	5	Bairnsdale	1	New Gisborne	1
Bacchus Marsh	4	Bass	1	Nyora*	1
Frankston	4	Beaufort	1	Pearcedale	1
Gisborne	4	Bochara	1	Pental Island	1
Leongatha	4	Boolara	1	Port Franklin	1
Morwell	4	Broadford*	1	Rawson	1
Portland*	4	Broken River	1	Raymond Island*	1
Traralgon	4	Bullengarook	1	Romsey	1
Violet Town	4	Bunyip State Park	1	Rosebud	1
Warrandyte	4	Calder Hwy	1	Sale	1
Yarram	4	Chiltern	1	Sassafrass	1
Cranbourne	3	Cobow	1	Sprinvale South	1
Ferntree Gully	3	Corranderk	1	Strezlecki	1
Grampians	3	Dandenong	1	Tarwin Lower*	1
Kyneton	3	Darrimon	1	Toora	1
Monash	3	Deer Park	1	Tooradin	1
Mt Eliza	3	Devon North	1	Torquay	1
Mt Martha	3	Digby	1	Trentham	1
Ralph Illidge	3	Doncaster*	1	Twin Lakes	1
Riddells Creek	3	Ellenbank	1	Upper Beaconsfield	1
Yea*	3	Emerald	1	Warby Ranges	1
Buffalo	2	Fish Creek	1	Welshpool	1
Castlemaine	2	Geelong	1	Winniclad Creek	1
Chinaman Island	2	Hume Hwy	1	Woodside	1
Euroa*	2	Jerralong	1	Woori Yallock	1
Inverloch	2	Kalorama	1	Yarra River	1

such pattern was evident in females (Dique *et al.* 2003b). Also, reports and veterinary examinations of Koala road trauma in southeast Queensland were male-biased (Weigler *et al.* 1987, Nattrass and Fiedler 1996). The results of the present study also contrast with Canfield (1991) who found that young to middle-aged male Koalas were highly represented in road trauma incidents on the central northern coast of New South Wales, especially during the breeding season.

The differences between Queensland and Victoria in the road kill age and sex biases are unlikely to be due to differences between the two areas in a) dispersal patterns or b) sex-biased movements during the breeding season. Similar patterns of male-biased dispersal have been found in Queensland using radio-tracking (Gordon *et al.* 1990, Dique *et al.* 2003a) and genetic techniques (Fowler *et al.* 2000. Ellis *et al.* 2002) to those found in Victoria (Mitchell 1990b; Mitchell and Martin 1990). Male

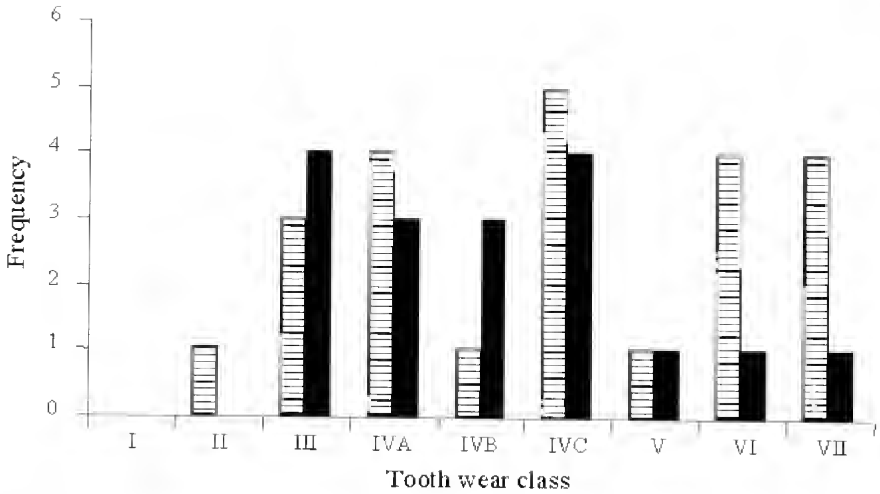

Fig. 1. Frequency of female (hatched bars) and male (filled bars) Koalas that were presumed killed as a result of road trauma in each tooth wear class, total = 40.

Table 2. Comparison of the age distributions of male and female Koala skulls between causes of death using Kolmogorov-Smirnov Z, 2 independent samples tests. Z is the Kolmogorov-Smirnov score, n is the sample size and P is the probability.

Comparisons	Males Z	Males n	Males P	Females Z	Females n	Females P
Natural causes and unknown causes	0.52	89, 231	0.95	0.69	81, 225	0.72
Natural causes and road trauma	0.61	89, 17	0.86	0.48	81, 23	0.98
Unknown causes and road trauma	0.76	231, 17	0.61	0.28	225, 23	1.00

Koalas also increased their overnight movement distances (Melzer and Houston 2001) and ranging behaviour (Mitchell 1990a) during the breeding season in both Queensland and Victoria.

Potential causal factors for differences in road kill frequencies and sex- and age-biases are traffic volume and speed, structure of the roadside verge and the surrounding population density (Dique *et al.* 2003b, Lee *et al.* 2004). Unfortunately, little is known about the demography or population density of the Victorian Koala populations from which the road trauma skulls were found. The reasons remain unclear as to why the road kill sample was consistently biased towards young male Koalas in other states, yet such a bias was not detected in Victoria.

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One Hundred Years Ago

EXCURSION TO WILSON'S PROMONTORY

The wood-boring larvæ of *Hepialus lignivora* were plentiful and in all stages of growth, but only one was found to have changed into the chrysalis stage. This emerged on the 12th January following. The larvæ of the well-known moth *Mamestra ewingi* were extremely plentiful, particularly on the beach at Oberon Bay, where they were seen in dozens crawling down from the grass tussocks over the sand, only to be caught by the incoming tide or eaten by the sea-birds. About 80 species of Coleoptera were taken, among which were 7 species of Buprestidæ , none of which require special mention. Among the other orders, 6 species of Cicadas were bottled, including several of the brilliant little *Cicada aurata*, which was numerous on the grass flats on the Derby River, and kept up their continuous shrill song from daylight till dark.

From *The Victorian Naturalist* **XXII** p 203, March 8, 1906

Australian Natural History Medallion 2006

Ian Fraser

In 1980, a few years after completing an honours degree in ecology at Adelaide University, Ian Fraser moved to the Australian Capital Territory. He travelled extensively in the region, becoming familiar with the complexities of its natural areas, its flora and fauna and its biodiversity and ecology. This familiarity always had its basis in scientific understanding but was never isolated from his sense of wonder, the appreciation of beauty and the sense of awe and excitement that underpins his mission to share 'the bush' with others. His essential philosophy is that understanding will lead to appreciation, and thus foster a conservation ethos. Through his publications, talks and lectures, radio programs, nature-based tours and service on conservation committees, Ian has made a strong contribution to increasing the knowledge of Australian natural history.

His service has been recognised with the honour of the ACT Landcare Media Award 1995, for his *Nature Table* contribution to Elaine Harris' radio programs, and the ASGAP Australian Plants Award 2001, for services to conservation and education. This presentation was accompanied by a seminar paper, *Maintaining Links between Landscape, Plant and Animal Communities*, which discussed timescales in Australian evolution and obligate plant-animal relationships.

Together with Margaret McJannett, artist Helen Fitzgerald and photographer colleagues, Ian Fraser has written a number of books portraying the local natural history: *Above the Cotter: a drivers' & walkers' guide to the North Brindabellas* (1991); *Wild about Canberra: a field guide to the plants and animals of the ACT* (1993); *Wildflowers of the Bush Capital: a field guide to Canberra Nature Park* (1993); *Over the hills and Tharwa Way: Eastern Namadgi National Park* (1994); *Neighbours in trouble: endangered plants and animals in the ACT* (1996); and *Wildflowers of the Snow Country: a field guide to the Australian Alps* (1998).

Ian's monthly column in *Gang-Gang*, the newsletter of the Canberra Ornithologists Group, is characteristically called *Avian Whimsy* and it encourages readers to think about many aspects of birds.

There is a long, diverse list of associations that have benefited by Ian's talks and presentations. It includes: Field Naturalists of Canberra; Canberra Ornithologists Group; Australian Native Plants Society; National Parks Association (ACT); Friends of the Australian National Botanic Gardens; ACT 4WD Club; Namadgi National Park; Women's International ACT; Wamboin and Murrumbateman Landcare Groups; Birds Australia; and Cumberland Bird Observers Club.

He presents a series of courses with evocative titles for the Australian National University Centre for Continuing Education: 'Understanding Birds', 'Understanding Plants', 'Understanding Orchids', 'From Gondwana to Australia' and 'But what does it mean?' which demystifies the complexity of floral and faunal names.

Since 1992 Ian has been the guest of a fortnightly local radio natural history show, one of ABC Canberra's longest-running, regular guest spots. He answers listeners' queries, comments enthusiastically on their observations and returns off-line with confirmation if he's unsure of an initial answer. Through shared and appreciated observations and deceptive informality, Ian extends interest in natural history and conservation into the general community. He has also prepared 160 or so 5-minute natural history segments for local radio which are repeated seasonally. In each of these snippets he presents information about a species, a phenomenon, an historical aspect of Australian natural history or seasonal insights. These segments have been made into the four CD set, *Four Seasons of the Bush Capital*, issued in 2004.

Ian was employed by the Australian National Botanic Gardens to ereate the baekground material for the widely viewed 2005 exhibition *Phoenix - Fire and Australian Plants*. The exhibition would have increased understanding of Australian flora for those many national and international visitors to the eountry's national botanic gardens. He has also been eontracted by the National Capital Authority to run educational bird walks in summer and write guide sheets for natural history walks.

Beeause of his breadth of knowledge about speeies and eeosystem functions in the region and his ability to impart this knowledge to the lay person, the NSW National Parks and Wildlife Service commissioned Ian to research and write some 250 threatened species' profiles for the South-East Direetorate web-site (120 animal species and 130 plants). He also wrote and designed a series of broehures on *The Impact of Bushfires on the Environment* for the same organisation.

Ian Fraser administered the Canberra Environment Centre for several years, linking its environmental resource centre and edueative roles to the wider eommunity. His nature-based tourism operation, Environment Tours, continues to operate in assoeiation with the Centre.

Ian was eo-founder and first Direetor of the Conservation Couneil of the South East Region and Canberra (CCSERAC) in the early 1980s. The Council is the peak eonservation organisation in the Region, using its resourees to monitor and comment on ehanges to the environment on behalf of many member groups. CCSERAC promotes proteetion of the environment from urban eneroachment and human impaet, using input from Ian and other aeknowledged experts.

He also has eontributed to the proteetion of Australia's native flora and fauna through his involvement in two advisory eommittees to the ACT Government, viz.

- the ACT Flora and Fauna Committee, whieh makes reeommendations on plant and animal speeies and ecological eommunities that warrant listing as vulnerable or endangered under the ACT's *Nature Conservation Act 1980*, and
- the ACT Natural Resouree Management Committee, whieh advises the ACT Government on general eonservation and environmental management matters in the ACT.

The ACT Flora and Fauna Committee has responsibilities for assessing the eonservation status of the ACT's flora and fauna and the eeologieal signifieance of potentially threatening proeesses. Assessments are made on nature eonservation grounds and serve to advise the ACT Government. The Committee develops Action plans describing the threats to habitats or speeies, eonservation issues relating to and proteetive strategies appropriate for speeies declared to be in serious deeline in the ACT. Ian Fraser has served on the Committee since its inception in 1995.

He has been a member of the ACT Government's advisory committee dealing with nature conservation and natural resource management continuously sinee 1984. He now ehairs the ACT Natural Resouree Management Advisory Committee which is responsible for the development and implementation of the ACT Natural Resourees Management Plan, as well as broader adviee on land and wildlife management matters.

In all of these roles Ian has eontributed, by serving on committees of management, to the proteetion and understanding of Australian native flora and fauna within the ACT and importantly in a regional eontext.

The January 2003 bushfires that devastated Vietorian and NSW alpine areas also altered the region's Brindabella Ranges and Namadgi National Park almost beyond recognition. Ian's reaetion to the virtual loss of his 'workplaee' was to make a series of personal and then offieial journeys to assess the impact and to interpret it in the long-term eontext of the ecology of fire in the Australian landscape. He was invited by Environment ACT to aeeompany them into the burnt areas, which would be elosed to the public for many months, to report on them to the Canberra community via ABC radio and throughout the world via reports posted on the internet.

His reviews and explanations of plant regrowth, germination, exeeptional flowering patterns and speeies' variations stimulated great interest among local amateur naturalists and the community. Ian helped many Canberra residents to eome to terms with biodiversity losses by explaining the cycles of fire-related damage. He ran a specific public course on the effects of fire – its origins in the Australian landscape, the ecology of fire in different habitats, and responses of Australian biota to fire. In this sense the fires were a catalyst for an extension of interest in natural history and conservation within the general community, which Ian nurtured with great skill.

Working with botanist Geoff Butler, Ian has professionally carried out many surveys under New South Wales' Environment Planning and Threatened Species Act. This has involved assessing the likely presence of populations of threatened species and surveying the condition of habitats so that local government authorities can develop appropriate restrictions or controls before development or rural subdivision proceeds. Local councils were able to promote environmentally friendly landscape changes in their jurisdictions. Nearly 70 such surveys have now been conducted in NSW, illustrating the esteem in which Ian's and Geoff's skills and integrity are held by local councils, the NSW NPWS and private developers.

In association with The Environment Centre (and formerly the Conservation Council), Environment Tours have been operating since 1981, 'to introduce people to new areas and to increase appreciation of our region with an emphasis on information and fun'. Ian Fraser and Margaret McJannett co-hosted these tours until 2001 and since then Ian has been running them alone. By mid 2006 he had led 365 tours comprising day trips, overnight trips, 3-4 nights away and 2-3 week major tours. The tours have explored the natural history of the ACT and hinterland, all non-urban regions of New South Wales, and included outstanding areas of Victoria, Tasmania, South Australia, the Northern Territory's 'Red Centre', Queensland and Western Australia. Ian incorporates experiences from prior private visits, meticulous research, knowledge of botany, zoology, geology, Aboriginal heritage, land-use changes and local expertise in presenting these popular trips. He is leader, guide, mentor, teacher as he extends participants' interest in natural history and conservation and nurtures their own skills as naturalists and observers.

The nomination for the Australian Natural History Medallion was made by the Field Naturalists Association of Canberra and letters of support were received from Canberra Ornithologists Group, Australian Native Plants Association (Canberra region), 666 ABC Radio Canberra, Office of the Commissioner for the Environment ACT, Executive Director Arts Heritage and Environment, and the Department of Environment and Conservation NSW.

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One Hundred Years Ago

EXCURSION TO WILSON'S PROMONTORY

The only objectionable animals in the Park are wild dogs and snakes. Rabbits, we were glad to find, had not reached the Promontory. The dogs are not true Dingoes, but have escaped from fishermen, hunting parties, and selectors, and have interbred with the Dingo to such an extent as to have amost effaced the latter.

From *The Victorian Naturalist* **XXII** p 195, March 8, 1906

Brian Smith

24 June 1939 – 19 July 2006

His car's number plate, "SNAIL7", said it all – here was someone with a quirky sense of humour and whose passion was terrestrial molluscs. The number plate belonged to Brian Smith, who died recently in Launceston, Tasmania.

Born and educated in Stockport, near Manchester, he studied for his undergraduate degree and his doctorate at Bangor University in Wales. In 1964 he decided that Australia would be a much better place than Britain for a zoologist, so migrated with his first wife to Melbourne. Brian lectured at Monash University for a time before joining the then National Museum of Victoria as Curator of Invertebrates in July 1967.

Brian met Helen, who was to become his second wife, at the Museum of Victoria in the early 1970s. At the time she was Assistant Curator of Entomology. In 1985, Brian left the museum and, having married Helen, moved with her to Mildura then Wangaratta, where he worked on melanoma research in the pathology department of Wangaratta hospital. During several subsequent moves Brian continued his work on native Australian snails, particularly with the development of a massive database to catalogue the entire fauna. In 1987, Brian and Helen moved to the UK to obtain qualifications in tropical medicine, with the aim of going to Tanzania in 1990. After eight months in Tanzania Brian became ill and returned to Australia where he lived for a time with his old friends Ron and Win Kershaw in Launceston, while working at the Queen Victoria Museum and Art Gallery. In due course Brian and Helen moved to Scottsdale, Tasmania, and he was able to continue with his work in Launceston for the next eight years before they moved back to Victoria, living in Bendigo for about three years. However, the call of the Queen Victoria Museum was strong and, in 2003, they returned to Launceston.

As stated above, Brian's great passion was snails and he made a major contribution to the knowledge of the land snail fauna of Australia. His many publications included two excellent handbooks on the non-marine mollusca of South-Eastern Australia and Tasmania, to say nothing of numerous articles in *The Victorian Naturalist*. He also was a major contributor to the mollusc volumes of the *Fauna of Australia Series*. He had a huge impact on natural history societies, in particular the FNCV, which he joined in October, 1966. He was a member of the council from 1973 to 1978 and also 1981 to 1982, President from 1978 to 1981 and again in 1985; he was convenor of the editorial committee of *The Victorian Naturalist* from April 1976 to January 1977 and Acting Editor from January 1979 to March 1980.

Brian was heavily involved with the Malacological Society of Australia and also the Marine Study Group of Victoria (later the Marine Research Group). With this group, he helped set up a census of Victorian intertidal species from 1977 to 1984, which culminated in the publication of an excellent handbook *Coastal Invertebrates of Victoria*. He instigated Saturday work-days at the museum in Melbourne in July 1967, at which interested amateurs could spend a day each month working on their particular interest within the collections. These work-days have continued right up to the present.

Following Brian's resignation from the Museum of Victoria in 1986, he was appointed as an Honorary Associate in recognition of his outstanding work there. In March 1988, he was elevated to the status of Curator Emeritus. In early April this year, Brian was diagnosed with a malignant brain tumour and, following surgery, he slowly returned to work as Curator of Zoology at the Queen Victoria Museum. He had virtually completed another major project, a new census of the marine molluscan fauna of Tasmania, and continued with this until his final few weeks.

The snail world, and also field naturalists everywhere, have lost a great mentor, but his memory will live on through his large output of publications and the many friends he made during his time among us.

Alan Monger
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Thank you from the Editors

The Victorian Naturalist would not be successful without the enormous amount of time and effort given voluntarily by a large number of people who work behind the scenes.

One of the most important editorial tasks is to have papers refereed. The Editors would like to say thank you to the following people who refereed manuscripts published during 2006:

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Cbantal Carrigan
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Chris Tyshing
Yolanda van Heezik
Rob Wallis
Eric Woehler
Jeff Yugovic

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Bernadette Sinclair
Simon Townsend
Christine Tyshing
Lyndsey Vivian
Rob Wallis
Alan Yen

The Mountain Katydid *Acripeza reticulata* (Orthoptera): a tourist to Wilsons Promontory, Victoria?

Introduction

The Mountain Katydid (sometimes, but less properly, known as the Mountain Grasshopper) *Acripeza reticulata* Guerin (Tettigoniidae, Phaneropterinae) is one of the more distinctive endemic Orthoptera in Australia, and can not be confused easily with any other species. Males are fully winged, and females flightless with shortened tegmina and no hind wings. Both sexes are dark grey to black, with the abdomen ringed with dorsal bands of bright blue and red (or orange) that are exposed by raising the wings if the insect is disturbed. *Acripeza* is thus highly aposematic, and is characteristically alpine or subalpine, and widespread in the southern alps (Rentz 1996), where it can be locally common in summer, usually conspicuous on the ground or low vegetation. However, Rentz noted that lowland populations of *Acripeza* are known from near Nyngan (New South Wales) and Moonie (southern Queensland). Green and Osborne (1994) noted that, although *Acripeza* occurs above the treeline in Tasmania, it is common only in the lower subalpine zones on the mainland mountains, and extends as far as 'the plains towards Broken Hill'.

In this note, the finding of a living female of *A. reticulata* in Wilsons Promontory National Park, southern Victoria, is reported, representing a considerable outlier from the previously recorded range of the species.

Victorian distribution

Acripeza is distributed widely in Victoria's alpine and subalpine zones. The Museum Victoria Orthoptera collection includes specimens of *Acripeza* from the following localities: Mt Bogong, Mt Hotham, Corryong, Whisky Flat, Mt Buller, Mt Skene, Mt McKay. However, and more intriguingly, there are also individual specimens from three more southerly localities (presumed approximate coordinates not on data labels have been inserted by me), as follows: Lerderderg Gorge (37° 33'S, 144° 24'E), Warrnambool (38° 23'S, 142° 30'E), and Mt Sabene (sic) (presumed Mt Sabine, 38° 38'S, 143° 44'E).

New record

Victoria, Wilsons Promontory National Park, 38° 54'S, 146° 15'E, sandy heathland, on ground,1?, 21 February 2006, L. Murray.

The capture site, some 150 m west of the main north-south road to Tidal River, was in an open sandy dune-swale system with sporadic *Leptospermum laevigatum* cover, open understorey and much near-bare ground. The insect was photographed alive and, with permission of Parks Victoria staff, retained as a voucher to be deposited in Museum Victoria.

Discussion

The origin of this specimen is unclear. It seems highly improbable that such a conspicuous insect would have escaped earlier notice on Wilsons Promontory if a resident population occurs there. The alternative option is that it was transported there in a vehicle, with one of the vehicles from La Trobe University present at the time of discovery the most likely candidate. This vehicle had been used for fieldwork in the Victorian alps from 13-17 February, including visits to Mt Hotham (1600 m, 15 February) and Mt Sarah (1550 m, 16-17 February). It had then been returned to Melbourne, the interior emptied and vacuumed and the outside washed, before it was driven to Tidal River on 19 February, and to various sites on the Promontory over the following days. The clear implication is that the *Acripeza* could have entered the car during the previous week and escaped detection during cleaning, repacking and again emptying the vehicle and eventually left the car at the site of discovery. The insect was discovered about 60 m from the nearest vehicle, about 45 minutes after arrival at the site.

Further searches will be made to determine whether a resident population exists. However, even if introduced as above, the female was alive, active and apparently healthy when found and the possibility cannot be dismissed that it could have been a successful colonist. For the present, this intriguing record is best treated as an isolated stowaway individual, but it demonstrates the ease with which such inadvertent introductions may be made and the care needed to prevent them. In this case, the projected scenario entails the insect being in the vehicle, eluding deliberate sanitation and repeated use, for a period of (probably) some six days, and transport over some 600 km (Hotham-Melbourne, Melbourne-Tidal River, subsequent trips).

Nevertheless, the incidence of the other southern Victoria specimens listed above leaves the possibility of a more natural occurrence of the species on Wilsons Promontory, and the precise locality is thus not advertised here. The purpose of this note is to alert entomological visitors to this possibility, in the hope that further specimens of this striking orthopteran may indeed be found.

Acknowledgements

I am grateful to Lewis Murray for alerting me to this exciting find, to Elaine Thomas (Parks Victoria), Ken Walker (Museum Victoria) and Pete Green (Botany, La Trobe University), for advice and help.

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Rentz D (1996) Grasshopper country. (University of New South Wales Press: Greenwich, NSW)

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Donations were gratefully received during 2006 from the following:

	$
Andrew Isles	1000
Albury Wodonga Field Naturalists Club Inc	20
Helen Aston	50
Field Naturalist Club of Ballarat	25
Burnie Field Naturalists Club Inc	30
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Julia Davis	10
Clarrie Handrek	20
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Brendan Murphy	50
Geoffrey Paterson	20
Alan Reid	10
The Royal Society of Victoria Inc.	100
Upper Goulburn Field Naturalists Club	50

If you would like to contribute to the fund, which supports the Australian Natural History Medallion, donations should be sent to: The Treasurer, Field Naturalists Club of Victoria, Locked Bag 3, Blackburn, Vic. 3130. Cheques should be made payable to 'Australian Natural History Medallion Trust Fund'.

The medallion is awarded annually to a person who is considered to have made the most signifieant contribution to the understaning of Australian natural history in the past ten years.

Successfully Growing Australian Native Plants

and ...

Colour Your Garden with Australian Natives

by Geoff and Bev Rigby

Publisher: *Bloomings Books, 2005 compendium edition. 224 pages, hardback; colour photographs. ISBN 0646451057. RRP $39.95*

This compendium edition consists of two books bound together, *Successfully Growing Australian Plants* by Geoff Rigby and *Colour Your Garden with Australian Natives* by Geoff and Bev Rigby. In these well presented books the authors have shared with the reader their many years of expertise and passion for our Australian natives. *Successfully Growing Australian Plants* is 'a practical guide to simple do's and don'ts when planning, establishing and developing a home garden and growing and propagating your own plants.' *Colour Your Garden with Australian Natives* is a coloured guide to native plants for the home garden.

Successfully Growing Australian Plants has chapters on: Planning Your Garden, Establishing and Maintaining Your Garden, Garden Development and Propagating Your Own Plants. The book also includes information on flower arrangements, pressed flowers and photography. Each chapter is colour coded and concludes with a summary of do's and don'ts with page references back to the text. There are just over 30 tables with plant lists for a wide variety of locations and conditions, for example: native plants that will flower reasonably well in shaded conditions, plants for cold frosty conditions, plants with perfumed flowers, plants with perfumed foliage, plants suitable for pots, plants suitable for Bonsai culture, shrubs suitable for screens or hedges, vines and creepers for fences and trellises and many more. I thought these tables were particularly useful. This book has many beautiful photographs of gardens throughout, including photos of botanic gardens, bushland, street plantings and private gardens.

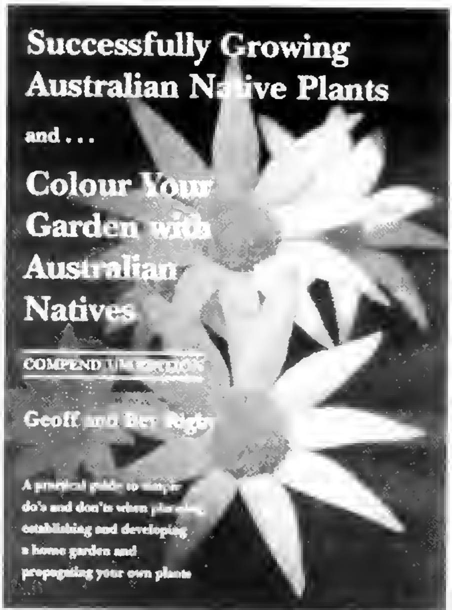
The second book, *Colour Your Garden with Australian Natives* by Geoff and Bev Rigby, has chapters on different coloured flowers, e.g. 'reds and pinks', 'yellows and green' and 'blues, purples and mauves'. For each species in each of these chapters there is a very clear photograph, a short description on plant form, and useful notes on plant cultivation. Following the flower colour chapters is an interesting chapter on 'Colour without flowers', which includes fruits, nuts and colour in foliage, tree trunks and bark. Again, all species described are beautifully illustrated with photographs. The book concludes with a summary of plants and flowering times for all flowers described, and for 'Colour without flowers' there is a summary of plants and their features.

Another dimension to *Successfully Growing Australian Plants* is the addition of two traditional stories: *The Flannel Flower Story* from the D'harawal People and *The Waratah Story – How the Waratah became Red* - from the Awabakal People. Similarly, in *Colour Your Garden with Australian Natives* each chapter begins with a gorgeous short poem or part poem: for example 'Colour Without Flowers' begins with -

> Flowers that smell like sweetest honey
> Flowers like puffs of snow
> Fruits like little wooden goblets
> Buds a dark-red glow -
> Darling of the summertime,
> Wherever it may grow.
> Nuri Mass. *Australian Wildflower Magic* (the Writers Press, 1967)

This adds a nice touch to both books and illustrates the authors' love of our native flora.

The last chapter in *Colour Your Garden with Australian Natives* is a guide to native gardens around our big beautiful country. Descriptions are provided for 37 gardens. Each of these gardens is described with interesting notes on its history and devel-



opment. I was pleased to see this updated with a table in *Successfully Growing Australian Plants,* with the addition of another 6 gardens around Australia. Only one native garden is listed in the vast and diverse Northern Territory: the Darwin Botanic Garden. Given the size and diversity of vegetation in this state, the Olive Pink Botanic Garden in Alice Springs and the Alice Springs Desert Park are notable omissions from this list.

A main disappointment with both books is that no mention is made of the potential threat of some native species as environmental weeds. A few examples of known environmental weeds include: *Acacia saligna* (Golden Wreath Wattle), *Pittosporum undulatum* (Sweet Pittosporum) and *Sollya heterophylla* (Bluebell Creeper). In my opinion the authors should have either excluded known environmental weeds or highlighted their potential threat to surrounding remnant bushland.

If you are looking to establish a native garden, or add some native plants to your garden, this compendium edition is well worth a look. Bev and Geoff Rigby's books have a lot of practical information to offer. The strength of these two books is the high quality colour photographs throughout, which beautifully illustrate the text.

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Thankyou from the Editors

Sincere thanks to our book reviewers for 2006 who provided interesting and insightful comments on a wide range of books and other materials:

Eve Almond	Raelene Cooke	Virgil Hubregtse
Peter Beech	Kelvyn Dunn	Bernie Joyce
Maria Belvedere	Ian Endersby	Roger Pierson
Sarah Bouma	David Geering	Gary Presland
Rohan Clarke	Maria Gibson	John Wainer
Nick Clemann	Merilyn Grey	

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Wedge-tailed Eagle

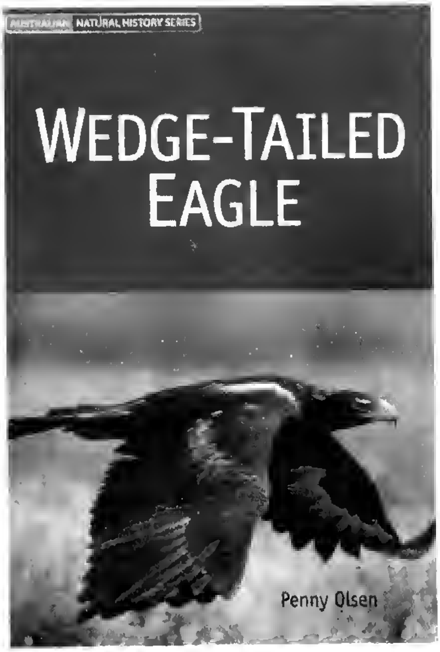
by Penny Olsen; illustrations by Humphrey Price-Jones;
colour photographs by Peter Merritt

Publisher: *CSIRO Publishing, 2005. 111 pages, 22 colour photographs, 21 pencil drawings. Paperback, ISBN 0643091653. RRP $39.95*

Many years ago, I went for a picnic in the country with seven friends who were not particularly interested in birds. We were playing a game with bats and tennis balls when someone noticed that a pair of Wedge-tailed Eagles had come into view. We all paused to gaze admiringly at those magnificent birds as they passed gracefully overhead, and our day was richer for the experience.

It is always exciting to see a Wedge-tailed Eagle, whether soaring, gliding, perched, or taking off laboriously from a kangaroo carcass at the side of a road. If you are curious about how this bird lives, when it breeds, how fast it can fly, why it can see so well, how many types of animal it eats, and so on, you will find the answers in this book. Author Penny Olsen, an expert on birds of prey, provides a comprehensive, very readable overview of what is currently known about this impressive bird, from its appearance in Aboriginal rock paintings 5000 years ago to details revealed by modern research; from relentless persecution as a killer of lambs, to protection, conservation and now, regrettably, suffering habitat destruction. Surprisingly for such an iconic species, there are still several gaps in our knowledge, and more research needs to be done: as the author states, 'Where the facts are unknown but there is strong basis for assumption, I have taken a few liberties, but I have generally stuck to the known.' (p. 3).

There are 11 chapters: Musings, Eagles and Aborigines, Early records and names, Eagles and their relatives, The eagle's country, Eagle specifics, Flight and sight, Reproduction, From egg to adult, Hunting and prey, and Threats. These are followed by a list of scientific names of animals and plants mentioned in the text, a 14 page bibliography, and an index. The text is liberally sprinkled with quotes from many authors, and is illustrated by 22 clear colour photographs by Peter Merritt, and 21 pencil drawings by Humphrey Price-Jones.



Unfortunately, in addition to a number of typographical errors, there are a few inaccurate statements. For example, the Wedge-tailed Eagle's tail is not 85-105 cm, as stated on p. 30, but 35-48 cm. In the caption at the bottom of p. 59, 'reduce' should presumably be 'increase'; and, worst of all, in the sentence at the bottom of p. 85, '... the number of lambs taken recently justifies the removal of eagles', 'recently' should be 'rarely'.

Nevertheless the book contains a great deal of interesting – and often entertaining – information. It is a very good summary of current knowledge about this eagle, and will appeal to ornithologists, nature lovers, conservationists and, of course, all eagle enthusiasts.

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Guidelines for Authors – *The Victorian Naturalist*

Submission of all Manuscripts

Submission of a manuscript will be taken to mean that the material has not been published, nor is being considered for publication, elsewhere, and that all authors agree to its submission.

Authors may submit material in the form of research reports, contributions, naturalist notes, letters to the editor and book reviews. A ***Research Report*** is a succinct and original scientific paper written in the traditional format including abstract, introduction, methods, results and discussion. A ***Contribution*** may consist of reports, comments, observations, survey results, bibliographies or other material relating to natural history. The scope of a contribution is broad and little defined to encourage material on a wide range of topics and in a range of styles. This allows inclusion of material that makes a contribution to our knowledge of natural history but for which the traditional format of scientific papers is not appropriate. Research reports and contributions will be refereed by external referees. ***Naturalist Notes*** are generally short, personal accounts of observations made in the field by anyone with an interest in natural history. These may also include reports on excursions and talks, where appropriate, or comment on matters relating to natural history. ***Letters to the Editor*** must be no longer than 500 words. ***Book Reviews*** are usually commissioned, but the editors also welcome enquiries from potential reviewers.

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Research reports and contributions must be accompanied by an abstract of not more than 200 words. The ***abstract*** should state the scope of the work, give the principal findings and be complete enough for use by abstracting services.

Three copies of the manuscript should be provided, each including all tables and copies of figures. Original artwork and photos can be withheld by the author until acceptance of the manuscript. Manuscripts should be typed, double spaced with wide margins and pages numbered. Please indicate the telephone number (and email address if available) of the author who is to receive correspondence. Submission of manuscripts should be accompanied by a covering letter.

An electronic version and one hard copy of the manuscript are required upon resubmission after referees' comments have been incorporated. Documents should be in Microsoft Word or RTF format.

Taxonomic Names

Cite references used for taxonomic names. References used by *The Victorian Naturalist* are listed at the end of these guidelines.

Abbreviations

The following abbreviations should be used in the manuscript (with italics where indicated): *et al.*; pers. obs.; unpubl. data; and pers. comm. which are cited in the text as (RG Brown 1994 pers. comm. 3 May). Use 'subsp.' for subspecies.

Units

The International System of Units (SI units) should be used for exact measurement of physical quantities.

Figures and Tables

All illustrations (including photographs) are considered as figures and will be designed to fit within a page (115 mm) or a column (55 mm) width. **It is important that the legend is clearly visible at these sizes.** For preference, photographs should be of high quality/high contrast which will reproduce clearly in black-and-white. They may be colour slides or colour or black-and-white prints. Line drawings, maps and graphs may be computer generated or in black Indian Ink on stout white or tracing paper. The figure number and the paper's title should be written on the back of each figure in pencil. If a hand-drawn figure is scanned it must be done at a minimum of 600 dpi.

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Tables must fit into 55 mm or 115 mm. If using a table editor, such as that in MS Word, do not use carriage returns within cells. Use tabs and not spaces when setting up columns without a table editor.

All figures and tables should be referred to in the text and numbered consecutively. Their captions must be numbered consecutively (Fig. 1, Fig. 2, etc.) and put on a separate page at the end of the manuscript. Tables should be numbered consecutively (Table 1, Table 2, etc.) and have an explanatory caption at the top.

Please consult the editors if additional details are required regarding document formats and image specifications. Authors who are not computer literate should contact the editors to make special arrangements.

Sequence Data

All nucleotide sequence data and alignments should be submitted to an appropriate public database, such as Genbank or EMBL. The accession numbers for all sequences must be cited in the article.

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Authors are advised to note the layout of headings, tables and illustrations as given in recent issues of the Journal. **Single spaces** are used after full stops, and **single quotation marks** are used throughout.

In all papers, first reference to a species should use both the common name and binomial. This journal uses capitalised common names for species, followed by the binomial in italics without brackets, e.g. Kangaroo Grass *Themeda triandra*. However, where many species are mentioned, a list (an appendix at the end), with both common and binomial names, may be preferred. Lists must be in taxonomic order using the order in which they appear in the references recommended below.

References

References **in the text** should cite author and year, e.g. Brown (1990), (Brown 1990), (Brown 1990, 1991), (Brown 1995 unpubl.), (Brown and Green 1990), (Brown and Green 1990; Blue 1990; Red 1990). If there are more than two authors for a paper use (Brown *et al.* 1990). These should be included under **References**, in alphabetical order, at the end of the text (see below). The use of unpublished data is accepted only if the data is available on request for viewing. Pers. obs. and pers. comm. should not be included in the list of references. **Journal titles should be quoted in full.**

Leigh J, Boden R and Briggs J (1984) *Extinct and Endangered Plants of Australia.* (Macmillan: South Melbourne)

Lunney D (1995) Bush Rat. In *The Mammals of Australia*, pp 651-653. Ed R Strahan. (Australian Museum/Reed New Holland: Sydney)

Phillips A and Watson R (1991) *Xanthorrhoea*: consequences of 'horticultural fashion'. *The Victorian Naturalist* **108**, 130-133.

Smith AB (1995) Flowering plants in northeastern Victoria. (Unpublished PhD thesis, University of Melbourne)

Wolf L and Chippendale GM (1981) The natural distribution of *Eucalyptus* in Australia. Australian National Parks and Wildlife Service, Special Publications No 6, Canberra.

Other methods of referencing may be acceptable in manuscripts other than research reports, and the editors should be consulted. **The bibliographic software 'EndNote' should NOT be used.** A style guide for *The Victorian Naturalist* is available on our website. For further information on style, write to the editors, or consult the latest issue of *The Victorian Naturalist* or edition of *Style Manual for Authors, Editors and Printers* (John Wiley & Sons: Milton, Qld).

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Checking species names is the responsibility of authors. The books we use as references for articles in *The Victorian Naturalist* are listed below. **Authors should refer to the source used for species names in their manuscripts.** In every case, the latest edition of the book should be used.

Mammals – Menkhorst PW (ed) (1995) *Mammals of Victoria: Distribution, Ecology and Conservation.* (Oxford University Press: South Melbourne)

Reptiles and Amphibians – Cogger H (2000) *Reptiles and Amphibians of Australia*, 6 ed. (Reed Books: Chatswood, NSW)

Insects – CSIRO (1991) *The Insects of Australia: a textbook for students and research workers.* Vol I and II. (MUP: Melbourne)

Birds – Christidis L and Boles W (1994) *The Taxonomy and Species of Birds of Australia and its Territories.* Royal Australian Ornithologists Union Monograph 2. (RAOU: Melbourne)

Plants – Ross JH (ed) (2000) *A Census of the Vascular Plants of Victoria*, 6 ed. (Royal Botanic Gardens of Victoria: Melbourne)

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the ant zigzags
under the weight of its payload

the ant threatens me
as I approach–
one against one

the ant
buries the dead
tiny undertaker

underworld
of silent clones
the ant nest

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