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From the Country: an Anthology

by TR Garnett. Edited by George Seddon. Original illustrations by JS Turner

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In this book we become acquainted with three men who, with their active interest in gardening and conservation of the environment, as well as in the arts and social issues, helped change Australian attitudes towards a range of environmental problems, especially those created by the application of a European approach to the Australian landscape.

TR (Tommy) Garnett came from England to be Headmaster of Geelong Grammar School. Among his many activities, he played a part in the foundation of the Australian Garden History Society, the Open Garden Scheme (his garden at St Erth in Blackwood was among the first to participate), and the resurrection of Victoria's country botanic gardens. Over a period of 15 years (1980-1994) he contributed articles, under the heading 'From the Country', to the gardening section of *The Age*. Sixty-nine of these articles appear in the book.

JS (John) Turner, also from England, was Professor of Botany at the University of Melbourne for 35 years, and was involved in many conservation battles, including the 'Save the Dandenongs' campaign. He was also an artist, and 22 of his powerful scraper-board images of plants, gardens and country scenes illustrate the book.

George Seddon, editor and writer of almost one third of the text, was Director of the Centre for Environmental Studies at the University of Melbourne. In the first 27 pages, he introduces Garnett and Turner, and, through his writing, himself. Following this, he presents his selection of Garnett's articles in 8 sections (Tommy, Teacher, Designer, Interrogator, Bird Man, Historian, Traveller, Essayist), with the aim of revealing facets of the author's character. Each section is accompanied by its own introduction in which Seddon gives his interpretation of what follows. After the final article, an amusing postscript by Sir John Medley (a former Vice-Chancellor of the University of Melbourne) precedes the bibliography and index.

Garnett's lively, entertaining, informative articles cover a wide range of subjects, from chooks to botanical names to a musical performed in Alice Springs. There is keen observation ('It is always worth documenting the exceptional'); incisive comment ('The trouble is that most decision-makers do not live in sparsely populated arid zones'); practical suggestions ('Pantyhose are enormously valuable in a garden because of their elasticity'); thought-provoking comments ('Were hamburgers invented by, or on behalf of, far-seeing insecticide manufacturers?'); interesting facts ('You can grow Myrtle Beech (*Nothofagus cunninghami*) from cuttings'); and social comment ('Social viruses ... spread across the world and there are no quarantine officers to test them').

Seddon's commentaries contain much additional information, but sometimes border on self-indulgence: surely it was unnecessary to include that quatrain by 17th century satirist Thomas Brown (p. 89) in the middle of a discussion about Australian plants? The lines jangle around in the mind, serving only to reveal something of Seddon's knowledge of literature.

The Index is quite comprehensive, but more entries (e.g. 'sawmillers' p. 143 and 'viruses' p. 200) would have been welcome. Also, 15 of the illustrations, and the photo of St Erth on p. 56, have been omitted.

I did not see Tommy Garnett's articles when they were first published, but have enjoyed this opportunity to catch up with at least a few of them.

Virgil Hubregtse
6 Saniky Street
Notting Hill, Victoria 3168

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Cover: Ian Endersby, the 2002 Australian Natural History Medallion recipient, with Lady Southey, Lieutenant Governor of Victoria. Photo by Anne Morton.

Web address: http://www.vicnet.net.au/~fncv/
Email fncv@vicnet.net.au

Small-scale Patterns of Occurrence of Snow Pratia *Pratia gelida* at Hospice Plain, Mount Buffalo National Park

John Morgan[1], Susanna Venn[1], Lynise Wearne[1], Max Bartley[1]
and Sharne McMillan[1,2]

Abstract

The broad habitat and small-scale microsite requirements of the rare perennial subalpine herb Snow Pratia *Pratia gelida* (Lobeliaceae) were investigated at Hospice Plain, Mount Buffalo National Park. Permanent transects were established in two populations occurring in a *Poa costiniana* wet tussock grassland community and a *Carex gaudichaudiana* fen and the local patch type, soil depth, soil pH and topography determined at small spatial scales. The occurrence of *P. gelida* at both sites was strongly and positively associated with the presence of bare ground on organic soils maintained by (a) frost heave or (b) creek-bed scouring. Whenever intense competition from adjacent herbs, grasses or shrubs occurred, *P. gelida* declined in abundance, suggesting that it is a poor competitor for space and/or resources such as light. Hence, the maintenance of bare ground patches by natural processes appears critical to the on-going persistence of the species. Additionally, *P. gelida* distribution was strongly favoured by local-scale topographic depressions, suggesting that water availability is also important. Invasion of bare ground patches by non-native species such as Brown-top Bent Grass *Agrostis capillaris* and Yarrow *Achillea millefolium* was observed and hence, potentially constitutes a threatening process. *Pratia gelida* is amongst the rarest of subalpine plants given its (a) restricted distribution, (b) restricted habitat and (c) small-population size and it warrants on-going monitoring to ensure that the dynamic population processes we predict are maintained. (*The Victorian Naturalist* **120** (1), 2003, 4-9)

Introduction

The Victorian alps form a more or less continuous chain of peaks and plateaus from the Baw Baws to Mount Bogong where they abut the Snowy Mountains of New South Wales. Mount Buffalo is the most isolated mountain in this system. Its vegetation consists of several widespread subalpine plant communities including tussock grasslands, wetlands and dry heathlands, and has affinities with the flora of the Baw Baw Plateau rather than the vegetation of the nearest peaks at Mount Feathertop and Mount Cobbler (Walsh *et al.* 1984; Walsh 1998). The isolation of the mountain (in both space and over recent geological time) has prompted some authors (e.g. Walsh 1998) to speculate on whether the present-day flora of Mount Buffalo represents a botanical bridge (i.e. is a remnant of formerly more extensive cool-climate flora) or, rather, represents a botanical island (i.e. local speciation of the subalpine flora that has occurred since isolation from other Victorian mountains). The concentration of highly localised species at Mount Buffalo suggests that a degree of evolution in isolation from other subalpine areas has indeed occurred (Walsh 1998). Four true endemic subalpine species are known from Mount Buffalo. This level of local endemism is greater than that found at other Victorian mountains (Walsh 1998). Many other plant species also have very restricted occurrences outside of Mount Buffalo (e.g. Buffalo Mintbush *Prostanthera monticola*, Buffalo Small-flowered Grevillea *Grevillea alpivaga*) while several species may warrant taxonomic investigation to clarify their status (Walsh 1998). Hence, Mount Buffalo makes an important contribution to the total diversity of subalpine flora in Victoria.

The conservation of any ecosystem and its component species requires an understanding of the environmental and biological factors that interact in complex ways to produce and maintain those ecosystems. In Victoria, subalpine areas have been generally well studied at Lake Mountain (Ashton and Hargreaves 1983), on the Bogong High Plains (Carr and Turner 1959; Williams and Ashton 1987; Wahren *et al.* 1994, 1999) and at the Bennison High Plains (Farrell and Ashton 1973). These (often long-term) studies provide a powerful insight into the ecology of subalpine systems, as well as their response to

[1] Department of Botany, La Trobe University, Bundoora, Victoria 3086
[2] Ecology Australia, Station Street, Fairfield, Victoria 3078

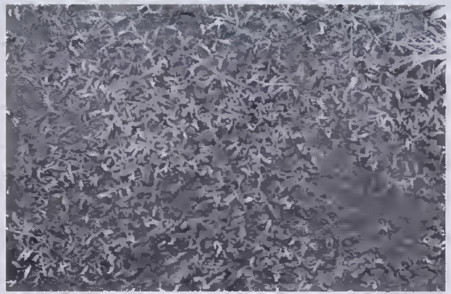

Fig. 1. *Pratia gelida* rhizomes growing in a bare ground patch at Hospice Plain, November 2001. Photo by Michele Kohout.

Fig. 2. The Hospice Plain subalpine grassland showing habitat of *Pratia gelida* in foreground. Note the bare ground patches surrounded by closed vegetation. Photo by Michele Kohout.

disturbance. At Mount Buffalo, however, almost no research has been conducted that examines plant community dynamics and ecosystem function, despite the area's national park status since 1898. However, there has been recent work on the effects of fire in subalpine communities (Wahren and Walsh 2000) and the factors governing the distribution and disturbance response of endemic plant species such as Buffalo Sallee *Eucalyptus mitchelliana* (Lawler *et al.* 1997, 1998) and Buffalo Sallow Wattle *Acacia phlebophylla* (Heinze *et al.* 1998). Calder and Calder (1998) highlight the need to continue scientific study of the mountain's biota to ensure effective conservation and understanding in relation to human- and climate-induced change.

Pratia gelida Snow Pratia (Lobeliaceae) is a shortly rhizomatous perennial (Fig. 1) that is listed as rare in Australia and vulnerable in Victoria (Briggs and Leigh 1996). It has a restricted distribution in Victoria, being primarily confined to frost hollow wet grasslands and *Carex*-dominated fens on the Mount Buffalo plateau, with an additional recent record near Mount Wellington (Neville Walsh pers. comm.). In total, three discrete localities are known (of undetermined population size) at Mount Buffalo; these are found at Hospice Plain, Blackfellows Plain and Wirbill Plain (Allison Marion pers. comm.). Almost nothing is known about the ecology of this species and the factors likely to influence its long-term survival. Given the restricted distribution and limited total population size of this species, it is imperative to understand the factors that affect population turnover and persistence. The present study aimed to start this process by identifying the broad habitat of the species at Hospice Plain and to examine the microsite requirements that enable this species to exist at local scales.

Methods

Study site

Pratia gelida was studied at Hospice Plain (146°48' E, 36°43' S), the largest of the 'high-valley plains' (Rowe 1970) at Mount Buffalo. Mean annual precipitation at the Mount Buffalo Chalet, 1.5 km east of the study site, is approximately 1900 mm and much of this falls as snow during July-September (Bureau of Meteorology unpubl. data). Mean maximum temperatures (19°C) occur in February while mean minimum temperatures (-4°C) occur in July. The average frost-free period is 44 days at the Mount Buffalo Chalet (Rowe 1970), but the valley plains of the study site would almost certainly experience more frost due to cold-air drainage. The geology is Devonian granite (Rowe 1970). Shallow alpine humus soils are typical across the plain with peat and humified peat more common in areas with a permanently high water table (Rowe 1970).

Hospice Plain is a gently sloping, treeless valley at 1320 m dominated by *Poa costiniana* tussock grasslands (Fig. 2). Several entrenched drainage lines and Crystal Brook dissect the relatively flat plain, while fen communities, dominated by *Carex gaudichaudiana* and herbs such as *Pratia surrepens*, are also locally common. Walsh *et al.* (1984) have described the major plant communities of the area. The area is listed as a Special Protection Zone

Table 1. Description of sites used to study small-scale habitat requirements of the vulnerable *Pratia gelida* at Hospice Plain, Mount Buffalo National Park. * denotes introduced species.

Site	Community	Description	Associated species
1	Herbfield within *Poa costiniana*	Gently sloping area with large bare ground patches maintained by frost-heave, interspersed by hummocky grass or shrub patches	*Pratia surrepens*, *Hydrocotyle sibthorpioides*, *Gonocarpus montanus*, **Agrostis capillaris*
2	*Carex gaudichaudiana*-dominated fen	Large depression (approx. 30 cm deep) in wet grassland with seasonal creeks emptying into the system and depositing silt and coarser material onto the vegetation. Probably was once a Sphagnum bog	*Pratia surrepens*, *Sphagnum cristatum*, **Agrostis capillaris*

(Natural Resources and Environment 1996).

Field sampling

Hospice Plain was surveyed in May and November 2001 to determine the location of all *P. gelida* populations at this site and their preferred habitat. The populations were noted using a GPS, the area occupied by the population was estimated, and the dominant landscape setting was recorded as (a) grassland (dominated by *Poa costiniana*, but including the intertussock herbfield community), (b) fen (dominated by *Carex gaudichaudiana*), (c) streambank, (d) disturbed bare ground or (e) other.

To determine the small-scale patterns of abundance of *P. gelida*, its microsite requirements and its association with microtopography and soil, two discrete populations at Hospice Plain were selected for study in May 2001 (Table 1). At each population, a transect permanently marked with wooden stakes was established that ran from outside the *P. gelida* population, directly through it, and out the other side. The length of the transect was 23.1 m at Site 1 and 15 m at Site 2.

Contiguous 100 cm^2 quadrats were sampled along each transect (n = 231 at Site 1 and n = 150 at Site 2) and the presence/absence of *P. gelida* noted. Dominant (≥50% cover) patch type of each quadrat was classed according to groundcover condition: grass (dominated by *Poa costiniana*), sedge (dominated by *Carex gaudichaudiana*), herb (dominated by *Pratia surrepens* or *Gonocarpus montanus*), heath (dominated by *Grevillea australis*) or bare ground. Where patches were co-dominated by groundcover types, this was noted. At 20 cm intervals, soil depth was determined by pushing a metal probe into the ground to a maximum of 30 cm depth, or until bedrock was reached, and soil pH was estimated using a CSIRO Inoculo pH kit. Microtopography was surveyed at 50 cm intervals using a dumpy level.

Data analysis

The association between *P. gelida* occurrence versus patch type and soil depth was explored using contingency tables (Zar 1984).

Results

Pratia gelida occurred in at least 21 separate locations at Hospice Plain and occupied areas ranging from 0.25 m^2 to >100 m^2 (Table 2). These populations ranged from habitats that were seasonally submerged (i.e. five fen populations and two streambank/streambed populations) to areas more likely to rarely be inundated (i.e. depressions in herbfield or tussock grassland areas). Two large populations were observed growing in bare ground disturbances created by previous pipe works in the area (Table 2).

At small spatial scales, *P. gelida* occurred significantly more frequently (Site 1: $\chi^2 = 136$, df = 3, $p < 0.001$; Site 2: $\chi^2 = 44$, df = 3, $p < 0.001$) at each site in bare ground patches created by frost heave (at Site 1) and stream scouring or silt deposition (at Site 2); 82-88% of bare patch-types were occupied at both sites (Table 3). The exotic grass Brown-top Bent Grass *Agrostis capillaris* was observed colonising this patch-type at both sites whilst the exotic forb *Achillea millefolium* was established in bare-ground areas near Site 1. *Pratia gelida* plants were rarely observed in heath and grass-dominated patches, but were often

Table 2. Summary of *Pratia gelida* populations located at Hospice Plains, Mount Buffalo National Park during May and November 2001.

Parameter		No. of populations
Population Location	Grassland	12
	Fen	5
	Streambank	2
	Disturbed	2
Population Area (m^2)	<1	10
	1-5	3
	5-20	4
	>20	4

Table 3. Number of quadrats with (+) or without (-) *Pratia gelida* in relation to dominant ground cover type when sampled at two populations at Hospice Plain, Mount Buffalo National Park during May 2001.

	Site 1 – Grassland		Site 2 – Fen	
	+	-	+	-
Heath	3	17	0	0
Grass	14	130	8	26
Sedge	0	0	16	16
Herb	14	38	8	40
Bare ground	61	8	32	7

Table 4. Association between presence (+) and absence (-) of *Pratia gelida* at the fen community (Site 2), Hospice Plain, and soil depth.

Soil depth (cm)	Pratia occurrence	
	+	-
<10	12	16
10-30	11	2
>30	2	7

associated with the low-statured, herb-dominated patches (27% of these patches at Site 1 were occupied by *P. gelida*) or sedge-dominated patches (50% of these patches at Site 2 were occupied by *P. gelida*).

At Site 1 in the tussock grassland, there was no association between soil depth and *P. gelida* occurrence; all soils were alpine humus soils >30 cm deep and had pH 5.5-6.0. At Site 2 in the fen community, however, *P. gelida* occurred on peaty soils of all depths (i.e. 1 to >30 cm), but was significantly ($\chi^2 = 9.58$, df = 2, $p < 0.05$) associated with soils of intermediate depth (i.e. 10 – 30 cm; Table 4) with a pH 5.5.

At both sites, *P. gelida* was associated with small-scale topographic depressions (Fig. 3).

Discussion

Providing a scientific basis for conserving rare species requires an understanding of the factors that affect species abundance, the persistence of their populations and their vulnerability to change. Naturally-occurring rarity occurs because all plant species differ in three fundamental aspects of their distribution:

(i) geographic range – whether a species occurs over a broad area or whether it is endemic to a small area.

(ii) habitat specificity – whether the species occurs in a variety of habitats or is restricted to one or a few specialised sites.

(iii) local population size – whether a species is found in large populations somewhere within its range or has small populations wherever it is found.

The restricted distribution of *Pratia gelida* combined with its small population size (or more correctly, small area occupied given the clonal nature of the species) and its narrow habitat breadth (i.e. confined to largely bare ground patches in wet communities) suggests that this species should be classified amongst the rarer of plant species in the Australian alps. Alpine species likely to be similarly 'rare' are habitat specialists confined to plant communities with restricted occurrence, e.g. feldmark species in Kosciuszko National Park (Costin *et al.* 2000). Such species are likely to require high conservation protection because of the potential for rapid population change and hence, regional extinction.

The occurrence of *P. gelida* at Hospice Plain was strongly and positively associated with the presence of bare ground on (usually deep) organic soils maintained by frost heave or creek-bed scouring. Populations repeatedly occurred in association with local-scale topographic depressions, suggesting that water availability is also an important determinant of their distribution when bare ground is available for colonisation. The co-occurrence of these conditions at Hospice Plain was restricted to areas usually less than 20 m^2 in fens and the intertussock spaces of wet tussock grasslands, indicating that the species has

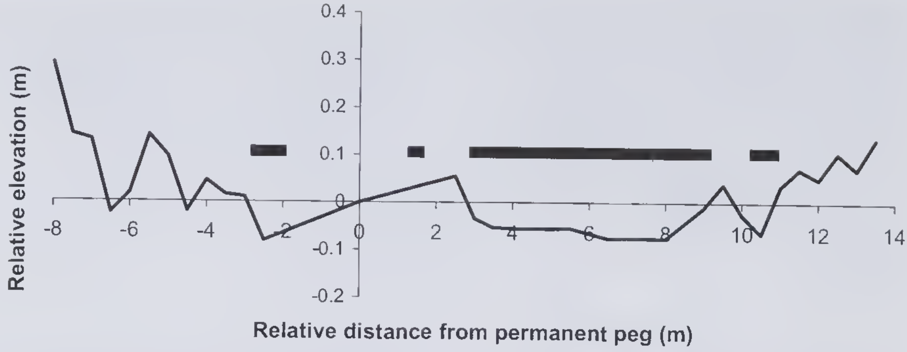

Fig. 3. An example of the relationship between microtopography (relative elevation in metres) and the small-scale distribution of *Pratia gelida* (horizontal black bar) across a wet herbfield community at Hospice Plain, Mt Buffalo.

extremely specific habitat requirements. Whenever intense competition from adjacent herbs, grasses or shrubs occurred in these wet communities, *P. gelida* declined in abundance, often to be replaced by *Pratia surrepens*, suggesting that it is a poor competitor for space and/or resources such as light. Alternatively, the deep rhizomes of the species (i.e. greater than 10 cm; authors pers. obs.) may allow the species to persist through frost-heave events that cannot be survived by shallow rooted herbs and grasses.

This distinction remains to be determined but it is of ecological significance to the future dynamic of the species. If bare ground patches occupied by *P. gelida* are indeed being colonised by co-occurring herbs such as *Pratia surrepens* and *Gonocarpus micranthus*, then local population extinction may be possible due to competitive interactions, particularly in the many populations occupying areas less than 1 m^2. If, on the otherhand, *P. gelida* is the only species capable of persisting in frost-heaved wet soil, the dynamic of the system is likely to remain more static and small patches may even expand due to the action of frost heave. Regardless, the maintenance of some bare ground patches by natural processes would appear critical to the on-going persistence of the species, as has been increasingly recognised for some other alpine species (Williams 1992). Invasion of bare ground patches in wetland areas by non-native species such as *Agrostis capillaris* and *Achillea millefolium* was observed in the vicinity of the studied populations and hence, may constitute a threatening process to the continued survival of *P. gelida*. Whilst *A. capillaris* has previously been identified as a serious weed of subalpine grasslands and wetlands (McDougall 1982; McDougall and Appleby 2000), *A. millefolium* has only recently been identified as a potentially serious invader of subalpine vegetation (Johnston and Pickering 2001). Its presence in relatively intact vegetation (greater than 100 m from roadsides) at Hospice Plain is therefore cause for concern. If these non-native species establish on bare ground occupied (or potentially colonisible) by *P. gelida*, it is likely that the rare species will be unable to compete successfully with the more vigorous and productive invaders, leading to local declines in population size and/or extent. It would appear that a concerted eradication effort is appropriate at Hospice Plain to ensure that the bare ground habitat patches of *P. gelida* are not compromised in future by these exotic species.

Conclusion

Pratia gelida is restricted to moist, bare ground gaps in the frost hollow grassland at Hospice Plain and the abundance of the species is constrained by competition from native and (potentially) exotic species. The species appears to have small populations (or more correctly, covers a small areal extent) and hence, is perhaps vulnerable to rapid change. The maintenance of small-scale, bare ground patches by natural processes appears necessary for persistence of this rhizomatous species and hence, monitoring of populations on Hospice Plain is desirable at 2-3 year intervals to ensure that the small-scale population turnover predicted for this species does indeed occur. Exotic species that may compromise these processes need to be monitored and removed where necessary. Future studies should focus on the rate of bare ground creation and population turnover necessary to maintain the species, as well as the role of seedling recruitment in colonising new bare patches.

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The Editor
The Victorian Naturalist
FNCV
Locked Bag 3
P.O. Blackburn
Victoria 3130

Reproductive Characteristics of Road-verge and Reserve-interior Populations of *Exocarpos cupressiformis* Labill. (Santalaceae)

Brad R Murray[1]

Abstract

Fragmentation of native vegetation by roads exposes species to the conditions of a different surrounding ecosystem where the road verges onto the original habitat. An important issue for conservation biology is how native species respond to these human-made ecosystems. In this study I compared reproductive characteristics, including seed output, seed mass, predispersal seed predation and dispersal appendage mass, between road-verge populations of the woody perennial, *Exocarpos cupressiformis* Labill., and nearby populations within undisturbed vegetation, in the Black Mountain Reserve in Canberra (Australian Capital Territory). Road-verge populations produced significantly more seeds per area of canopy cover and tended to have larger dispersal appendages than non-verge populations in the reserve interior. There were no significant differences in seed mass or levels of predispersal seed predation between road-verge and reserve-interior populations. However, seed mass and predispersal seed predation varied significantly among populations within the two locations. These findings demonstrate that populations of *E. cupressiformis* in disturbed habitats on road verges had an increased capacity for colonisation and a higher potential rate of increase through greater seed output and a tendency for larger investment in dispersal. (*The Victorian Naturalist* **120** (1), 2003, 10-14)

Introduction

The construction of roads through native vegetation results in loss of habitat and fragmentation of remaining ecosystems (Spellerberg 1998). Fragmentation exposes species that remain within fragments to the conditions of a different surrounding ecosystem where the original habitat approaches the road (Murcia 1995). Several factors, including light intensity, temperature, litter moisture and hydrological patterns, differ substantially between road verges and the interior of fragments (Andrews 1990; Matlack 1993). An important issue for conservation biology is how native species respond to the creation of these different, human-made ecosystems (Murcia 1995). In the present study, I examined the influence of road verges on the reproductive characteristics of a native Australian plant species, *Exocarpos cupressiformis* Labill. (Ross 2000).

Differences in reproductive characteristics between road-verge and non-verge populations have been documented for several plant species in the family Proteaceae. Road-verge plants of *Banksia hookeriana* (Lamont *et al.* 1994a), *B. menziesii* (Lamont *et al.* 1994b) and *Grevillea barklayana* (Hogbin *et al.* 1998) were found to produce more seeds than nearby non-verge populations. In contrast, Lamont *et al.* (1993) found that road-verge populations of *B. goodii* had lower seed output. These contrasting patterns demonstrate that assessment of the reproductive characteristics of species occurring in road-verge habitats should be carried out on a case-by-case basis (Hogbin *et al.* 1998; see also Cunningham 2000). Here, in addition to comparing seed output between road-verge and non-verge populations of *E. cupressiformis*, I also examined whether other reproductive traits linked to seed output, including seed mass, predispersal seed predation and dispersal appendage mass, differed between populations at the two locations.

Methods

Native Cherry *Exocarpos cupressiformis* occurs in forest and woodland in the Australian Capital Territory, New South Wales, Victoria, Queensland, South Australia and Tasmania (Fairley and Moore 1995). In the ACT, plants are found growing within the Black Mountain Reserve and along its road verges. The Black Mountain Reserve, approximately 9 km^2 in area, is part of the Canberra Nature Park, situated in the centre of Canberra. The annual mean rainfall for the area is approximately 600-700 mm (Bureau of Meteorology, Canberra, Australia).

[1] Institute for Water and Environmental Resource Management, University of Technology, Sydney, Gore Hill, NSW 2065
Email Brad.Murray@uts.edu.au

Exocarpos cupressiformis is a tall shrub or small tree with numerous thin pendulous branchlets (Fairley and Moore 1995). Small flowers (in short cylindrical spikes, 3-6 mm long) are produced in spring through to autumn across the natural range of the species (Carolin and Tindale 1994), and primarily in spring in the Black Mountain Reserve. The fruit, which is hard and green, is a globular nut (5-6 mm diameter) that rests on a succulent red receptacle approximately 10 mm long (Cronin 1989; Robinson 1991). Several bird species including Crimson Rosella *Platycercus elegans* and Pied Currawong *Strepera graculina* have been observed eating the receptacle with the nut and, in addition, receptacles of fruit which have fallen to the ground have been observed with small bite marks consistent with small mammal foraging (pers. obs.). The single-seeded nut, wrapped in a very thin pericarp, is hereafter referred to as the seed, while the receptacle is referred to as the dispersal appendage.

A total of eight *E. cupressiformis* populations was selected for this study on Black Mountain. Four replicate populations were situated on road verges and another four located well within the reserve in undisturbed natural vegetation. All populations were separated by at least 100 m and each population was in low abundance (approximately 10-20 individuals/ha). Plants in road-verge populations all occurred within 5 m of the road, consistent with estimates of the width of road verges in other studies in Australia (Lamont *et al.* 1994a, b). Reserve-interior populations were situated at a distance of more than 50 m from the road or from any form of detectable disturbance such as walking tracks or clearings. This distance of 50 m from the road is also consistent with previous work (Lamont *et al.* 1994a, b), and was based on the finding that some edge effects can be present up to 50 m into vegetation (Matlack 1993). Within each population, 10 adult plants were selected that appeared healthy and unblemished, with at least 5 m separating each plant within locations. In an attempt to ensure that there was no plant size bias between road-verge and reserve-interior populations, plants of similar height (between 2-5 m) were selected for analysis.

An estimate was made of the canopy cover of each plant by first finding the longest linear dimension (in a horizontal plane) from one end of the plant to the other and then the length of the perpendicular bisector, again from one tip to the other. Using these as the two dimensions (a and b) of an ellipse, the formula ($\pi ab/4$) was used to estimate canopy area. The total number of seeds produced by each plant was counted in the field approximately two weeks prior to the occurrence of natural fruit-fall (December 2000). All measurements of seed output per plant were expressed as number of seeds per area of canopy cover.

Fruits were collected from individual plants to determine seed mass, dispersal appendage mass and predispersal seed predation. In some cases this was the complete fruit set (when this was less than 20) and when greater ranged from 21 to 80 fruits. To estimate seed mass and dispersal appendage mass, ten seeds (fewer if the complete fruit set was less than 10) from each plant in each population were separated from their dispersal appendages, and both seed and dispersal appendage were dried in an 80° oven for 48 hr. Dry weights of seeds and dispersal appendages were then determined by weighing on a Cahn 29 Automatic Electrobalance, and mean values obtained for each population.

Evidence of predispersal seed predation was obtained by noting the presence or absence of a small (≤1 mm diameter) hole on the surface of seeds. Preliminary inspection of seeds with holes indicated that seed material within the exocarp had been destroyed. A sample of 100 seeds with holes, in addition to a second sample of 100 seeds that appeared untouched by predators, was collected from the complete fruit collection across all populations. These 200 seeds were cut open to determine whether there was any evidence that seeds with holes were still intact (i.e. not destroyed) or whether apparently untouched seeds had been destroyed. In all cases, seeds with holes were empty of contents while seeds with no holes were all intact. Attempts to rear pre-dispersal seed predators from intact seeds in the laboratory were unsuccessful. For each plant in this study, estimates of predispersal seed predation were assumed to be the proportion of collected fruits with external holes.

Analysis of variance was used in all statistical analyses, nesting the factor 'population' within 'location' (road-verge or reserve-interior). The variance ratio (F-statistic) for the effect of 'location' was calculated as the 'location' mean square divided by the 'populations within location' mean square. Where significant differences in any of the response variables were detected within road-verge or reserve-interior locations, the Bonferroni test was used to conduct post-hoc comparisons (Norman and Streiner 2000). Data for seed output per area of canopy cover, seed mass as well as dispersal appendage mass were all log transformed prior to analysis, while data for the proportion of seeds destroyed by predispersal predators were arcsine-square root transformed to improve linearity.

Results

Seed output per area of canopy cover was significantly higher in road-verge than in reserve-interior populations ($F_{1,6} = 24.55$, $p = 0.003$; Fig. 1a), and also varied significantly among plant populations within the reserve-interior ($F_{6,72} = 2.93$, $p = 0.01$). Plants in population RI1 produced significantly fewer seeds per area of canopy cover than plants in population RI3 ($p < 0.05$; Fig. 1a). Seed output per area of canopy cover did not differ significantly among populations found on road-verges.

There was no significant difference in seed mass between road-verge and reserve-interior populations ($F_{1,6} = 0.92$, $p = 0.38$; Fig. 1b), but there were significant differences in seed mass among plant populations both within the reserve-interior and on road verges ($F_{6,72} = 3.25$, $p = 0.007$). Among road-verge sites, seed mass was significantly lower in population RV2 than in population RV4 (all $p < 0.05$; Fig. 1b). Among reserve-interior sites, seed mass in populations RI1 and RI3 was significantly lower than in population RI4 ($p < 0.01$ for RI1 vs RI4, and $p < 0.05$ for RI3 vs RI4; Fig. 1b).

Although there was a trend for dispersal appendage mass to be higher in road-verge populations compared with reserve-interior populations (Fig. 2a), this was marginally non-significant ($F_{1,6} = 4.49$, $p = 0.08$). Dispersal appendage mass did not vary significantly among populations within either of the two locations ($F_{6,72} = 2.06$, $p = 0.07$).

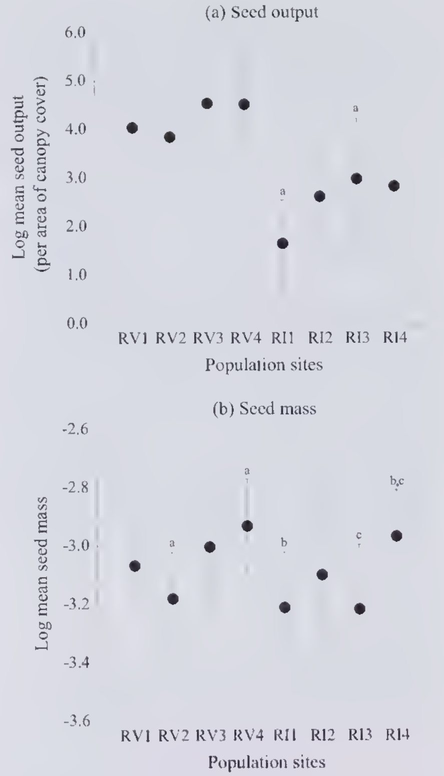

Fig. 1. (a) Log mean seed output per area of canopy cover for the four road-verge populations (RV1-RV4) and the four reserve-interior populations (RI1-RI4), and (b) log mean seed mass for the four road-verge populations (RV1- RV4) and the four reserve-interior populations (RI1-RI4), ± SD. Letters above population site means indicate that those two sites differ significantly from one another according to post-hoc tests.

The proportion of seeds destroyed by predispersal seed predators did not differ significantly between road-verge and reserve-interior locations ($F_{1,6} = 0.31$, $p = 0.60$), but did vary significantly among plant populations ($F_{6,72} = 7.00$, $p = 0.001$; Fig. 2b). Among road-verge sites, predispersal seed predation was significantly higher for populations RV1 and RV2 than for populations RV3 and RV4 (all $p < 0.01$; Fig. 2b). Among reserve-interior sites, predispersal seed predation in population RI2 was significantly higher than in population RI4 ($p < 0.01$; Fig. 2b).

The patterns observed in the present study did not appear to be a consequence

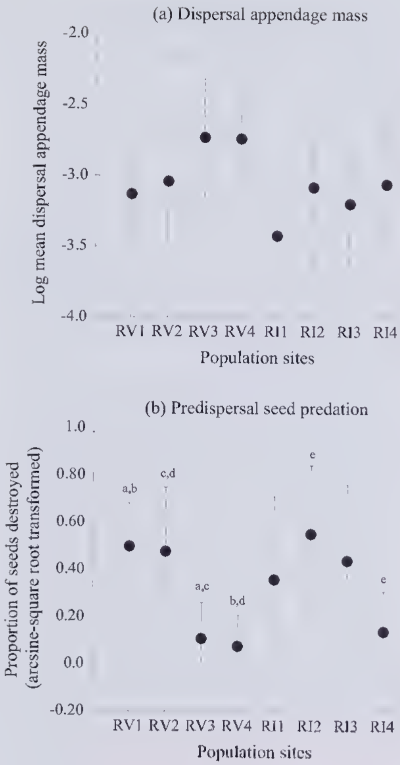

Fig. 2. (a) Log mean dispersal appendage mass for the four road-verge populations (RV1-RV4) and the four reserve-interior populations (RI1-RI4), and (b) the proportion of seeds destroyed by predispersal predators for the four road-verge populations (RV1-RV4) and the four reserve-interior populations (RI1-RI4), ± SD. Letters above population site means indicate that those two sites differ significantly from one another according to post-hoc tests.

of plant size bias, as there was no significant difference in plant height between reserve-interior and road-verge populations ($F_{1,6} = 1.02$, $p = 0.35$).

Discussion

Higher seed output (per area of canopy cover) was observed in road-verge populations of *E. cupressiformis* compared with reserve-interior populations. This finding concurs with several studies which have reported increased reproductive output in roadside plants of other species (Lamont *et al.* 1994a, b; Hogbin *et al.* 1998; but see Lamont *et al.* 1993). Seed output per area of canopy cover is a central quantity determining the potential colonisation ability of a species (Henery and Westoby 2001) and its potential rate of increase (e.g. Murray and Westoby 2000). There was also a tendency for road-verge populations of *E. cupressiformis* to produce seeds with larger dispersal appendages. While this latter pattern must be interpreted cautiously, the increased incentive for removal by vertebrate herbivores could contribute further to the increased colonisation capacity of road-verge plants. It is noteworthy that the response of road-verge plants did not include the production of larger seeds, which are competitively superior during early seedling establishment (Leishman *et al.* 2000). The relatively greater success of populations on road verges suggests that *E. cupressiformis* is an *r*-selected species, as it possesses important life-history traits correlated with superior colonisation ability and success in disturbed or early successional habitats (Begon *et al.* 1996). Further support for this suggestion comes from the fact that, although all populations in the present study were in low abundance, preliminary survey work has found that abundant populations only occur in disturbed areas (usually <10 years since fire; B Murray, unpubl. data), at least in the ACT.

Roadside vegetation experiences substantially different abiotic conditions compared to vegetation located further from the road. These differences, which include higher light levels, increased water and mineral nutrient availability induced by run-off from the road, and reduced competition for resources because the road apron is free of large plants, may have contributed to higher seed output in road-verge plants (Lamont *et al.* 1994a, b; Hogbin *et al.* 1998). For example, in the present study, plants in road-verge populations appeared to be exposed to direct sunlight for most of the day, while plants in reserve-interior populations were shaded by the canopy overstorey and received only minimal and temporary direct sunlight. However, mechanisms generating an increased potential for population increase in road-verge populations have yet to be determined specifically for *E. cupressiformis*.

No significant difference was observed between road-verge and reserve-interior populations with respect to the proportion of seeds destroyed by predispersal seed predators. However, predispersal seed predation did vary among populations within sites. It is possible that not all predation by predispersal granivores was taken into account. However, the random sample of 100 seeds without visible holes inspected from across all populations indicated that visibly intact seeds were indeed whole. Investigation of the sample of 100 seeds with holes revealed that all of these seeds were empty of contents. It was thus assumed that most predispersal seed predation would be assessed by using counts of seeds with holes as a proportion of the total seed count for each plant. This finding for *E. cupressiformis* demonstrates that predispersal seed predation is highly variable from one location to the next, irrespective of whether the population is located on either road-verges or within the reserve.

Interpretation of the results of the present study rests on the assumption that its short-term nature provides a realistic picture of continuing patterns of reproduction within road-verge populations (see also Hogbin *et al.* 1998). Long-term studies of the population dynamics of *E. cupressiformis*, as well as other species found on road verges, are crucial for a comprehensive evaluation of the response of native species to the creation of road-verge habitats. Such studies are especially important considering that the Black Mountain Reserve contains a diverse flora and fauna, including significant stands of remnant Snow Gums in the lower areas, and around forty species of orchids representing two thirds of the total orchid diversity recorded for the ACT (Burbidge and Gray 1970).

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The Potential Impact of Climate Change on Plant Communities in the Kosciuszko Alpine Zone

Catherine Marina Pickering[1] and Tristan Armstrong[2]

Abstract

The potential impacts of increased temperatures, decreased precipitation and decreased duration of snow cover over the next seventy years are evaluated for twelve plant communities in the Kosciuszko alpine region of Australia. The approach taken is speculative and provides a series of hypotheses about potential patterns of change. The short alpine herbfield and snowbank feldmark communities are likely to be negatively affected by the predicted declining snow cover, as snowbanks become fewer and smaller. Windswept feldmark, however, may become more widespread if snow cover declines, exposing new areas to freezing temperatures, high winds and resultant loss of soil cover. Climate change initially may have a beneficial or neutral effect on the tall alpine herbfield. If snow cover continues to decline below 3-4 months per year, as is predicted, then the tall alpine herbfield could eventually decline in area. Bogs, fens, raised bog and valley bog communities are likely to vary in area as changes in precipitation, runoff and evaporation alter the competitive ability of plant species belonging to these communities. Heath communities are likely to increase in area as increasing temperature and declining snow cover favour shrub species over grasses and herbs. Increasing diversity and abundance of alien plant species within the alpine zone are likely to continue and may be amplified by climate change. (*The Victorian Naturalist* **120** (1), 2003, 15-24)

Introduction

Human induced climate change has been predicted to occur within the next hundred years (Houghton *et al.* 1996; Whetton 1998). The impact of this change on plant biodiversity and ecosystems, including alpine ecosystems, is currently being examined using predictive and experimental methods (Vegetation/Ecosystem Modelling and Analysis Project 1995; Green 1998; Guisan *et al.* 1998; Hansell *et al.* 1998; Kienast *et al.* 1998; Saetersdal *et al.* 1998; Körner 1999).

The largest alpine area in Australia around Mt Kosciuszko may be severely affected by climate change. Dramatic changes in temperature, precipitation and snow cover have been predicted to occur within the next seventy years (Hennessy *et al.* 1998; Whetton 1998; Table 1). The lack of high altitude refuges or a permanent nival zone is likely to restrict altitudinal succession in this area in the event of a significant increase in temperature and decrease in snow cover. The total alpine area (250 km^2 or 0.015% of mainland Australia) is not large, and the altitudinal range is only 400 m (Costin *et al.* 2000).

The predicted climate changes are likely to affect the species richness and abundance of plants in the Kosciuszko alpine flora (Good 1998; Pickering 1998). It could result in a longer, warmer growing season, changes (overall decreases) in soil moisture, changes in relative competitive ability of plants, increased herbivory and changes to the reproductive ecology of some species (Good 1998; Pickering 1998).

A detailed knowledge of the ecology of individual alpine plant species and their distributions in Australia is in most cases minimal, so it is only feasible to postulate about the impacts of climate change on the main plant communities for which more information, such as factors affecting distribution is available (Costin 1954, 1957, 1958, 1989; Costin *et al.* 1959, 1969, 2000; Carr and Turner 1959; Bryant 1971a, 1971b; Edwards 1977; Keane *et al.* 1979; Mallen 1986; Mallen-Cooper 1990; Good 1992; Green and Osborne 1994; Kirkpatrick and Bridle 1998, 1999). In this paper we hypothesise about potential changes in the pattern of distribution and association of the eleven natural communities recognised by Costin (1954, 1957; Costin *et al.* 2000), as well as alien plant species (Mallen-Cooper 1990; Johnston and Pickering 2001), in the main Australian alpine region.

The approach taken in this paper involves a series of 'what if' ecological scenarios, rather than more detailed ecological and

[1] School of Environmental and Applied Sciences, Griffith University, PMB 50 Gold Coast Mail Centre, Queensland 9726 Australia.
Email c.pickering@griffith.edu.au
[2] Ecological Genetics Laboratory, Landcare Research PB 92170, Auckland, New Zealand

Table 1. Predictions for climate change for snow covered regions of the Australian Alps including the Kosciuszko alpine area, based on climatic models produced by the CSIRO (Whetton 1998).

	Best-case 2030	Worst-case 2030	Best-case 2070	Worst-case 2070
Temperature	+ 0.3°C	+1.3°C	+ 0.6°C	+3.4°C
Precipitation	0%	-8%	0%	-20%
Predicted area covered by snow[1]				
Remaining area	4540 km^2	1870 km^2	3770 km^2	195 km^2
Percentage reduction in area	18%	66%	39%	96%

[1] Area covered by snow for >30 days; currently there are 5540 km^2 that have >30 days of snow on the ground.

Table 2. Plant communities of the alpine region of Kosciuszko National Park (after Costin 1954; Mallen 1986; Good 1992; Costin *et al.* 2000).

Plant Community-Alliance	Biodiversity of vascular species	Area[1]
Short alpine herbfield *Plantago-Neopaxia*	23 species and varieties, nearly all mat forming	0.85
Windswept feldmark *Epacris-Chionohebe*	18 species and varieties with many mat forming, or dwarf species	0.30
Snowbank feldmark *Coprosma-Colobanthus*	Floristically simple and specialized with 6 species, all herbs	1.62
Tall alpine herbfield *Celmisia-Poa*	Floristically diverse with up to 131 species recorded; mixture of grasses and herbs; many Asteraceae	61.63+
Tall alpine herbfield *Brachyscome-Austrodanthonia*	Floristically simple and specialized with 14 species recorded, including several species of ferns	+
Sod tussock grassland *Poa-Rytidosperma*	93 species and varieties; large numbers of monocots, particularly grasses and *Carex* species	+
Fen *Carex gaudichaudiana*	71 species, with many grasses *Carex* and *Juncus* species; some herbs	5.80++
Valley bog *Carex-Sphagnum*	31 species, with several grasses, and many *Carex* and *Juncus* species; some herbs	++
Raised bog *Epacris-Sphagnum*	77 species and varieties with several grasses, and many *Carex* and *Juncus* species; some herbs and small shrubs	++
Heath *Epacris glacialis*	35 species and varieties, many shrubs	++
Heath *Oxylobium-Podocarpus*	57 species and varieties, many shrubs	22.61
Alien plants	48 species and increasing, mainly from families Poaceae and Asteraceae	~0.14

[1] Percentage of area mapped in *Kosciuszko Alpine Flora* (Costin *et al.* 2000). Values for some plant communities combined. + Small areas of *Brachyscome-Austrodanthonia* tall alpine herbfield and *Poa-Rytidosperma* sod tussock grassland included in *Celmisa-Poa* tall alpine herbfield estimate. ++ Value includes fen, bog and *Epacris glacialis* heath.

climatic modelling of current and future distributions. The results are therefore broad and the arguments are necessarily speculative. They provide a series of hypotheses that can be tested against detailed climatic and distribution models once more information about the ecology and distribution of Australian alpine plants and communities becomes available.

Existing plant communities

Plants in the Kosciuszko alpine area of Kosciuszko National Park, New South Wales occur in clearly distinct communities arranged in a complex spatial mosaic reflecting microclimate, nutrient availability and topography (Costin 1954, 1989; Kirkpatrick and Bridle 1999; Costin *et al.* 2000). The most widespread and abundant of these communities is the tall alpine herbfield. It occupies 55% of the Kosciuszko alpine zone, largely in well-drained locations at mid-altitudes (Costin 1954; Costin *et al.* 2000; Table 2). Similar communities of tall herbfield are found in other alpine areas in Australia (Kirkpatrick and Bridle 1998, 1999) and in New Zealand (Mark and Dickinson 1997). The next most widely distributed communities, covering around 25% of the Kosciuszko alpine zone are the heaths (Costin 1954; Costin *et al.* 2000). These occupy damp sites associated with bogs (*Oxylobium-Podocarpus* alliance) as well as rocky, well-drained sites in the case of the heath alliance dominated by *Epacris glacialis* (Costin 1954, 1957; Costin *et al.* 2000). One of the more specialised, less common communities is the short alpine herbfield that occurs on wet sites below snowbanks, and on wet semi-bare surfaces (0.85% of the alpine zone). Other specialised communities with highly restricted distributions include natural feldmark communities that occupy very wind-exposed sites (windswept feldmark) and snow-patch feldmark that occurs in association with snow patches (Costin 1954; Costin *et al.* 2000; Table 2). The sod tussock grassland, fen, valley bog and raised bog communities occur in temporarily or permanently wet sites (Costin 1954, 1957; Clarke and Martin 1999; Costin *et al.* 2000; Table 2). Grazing and burning has adversely affected many plant communities, including windswept feldmark. These practices ceased in the Kosciuszko alpine zone in the 1950s (Costin 1954; Good 1992), although grazing still occurs in some alpine areas in Victoria (Good 1992).

Evaluation of impacts on plant communities

Climate change may affect the distribution of the plant communities directly through changes in temperature, precipitation and snow cover. It may also have indirect effects through longer growing seasons, changes in soil moisture and changes in vegetative competition (Pickering 1998). The effects of general climate change on abiotic factors thought to determine the distribution of alpine plant communities will be examined in this paper. For example, predicted climate change would alter the duration of snow cover, freezing temperatures and soil moisture: variables that have been associated with the distribution of several alpine plant communities (Costin 1954, 1957; Carr and Turner 1959; Ashton and Williams 1989; Kirkpatrick and Bridle 1998, 1999; Costin *et al.* 2000). Changes in these factors due to human disturbance in the past (grazing, trampling) have led to changes in the distribution of many of these communities, supporting the link between the factors and community distributions (Costin 1954; Wimbush and Costin 1979; Ashton and Williams 1989; Clarke and Martin 1999; Costin *et al.* 2000; Johnston and Pickering 2001). The specific predictions discussed in this paper represent the authors' estimates of how each community may respond, and therefore are indicative, not demonstrative.

Predicted impacts of climate change

Short alpine herbfields and snow bank feldmark communities

The duration of snow cover is predicted to reduce by between 39% and 96% by 2070 (Table 1) resulting in fewer/smaller late snow banks. This is likely to affect the distribution and composition of short alpine herbfield and snowbank feldmark communities that occur under late snow banks. In the lower sections of snow banks in the Kosciuszko alpine zone, where the soils are often deep and nutrient rich (Costin 1954), the short alpine herbfield may become vulnerable to invasion by the herbs and grasses from adjacent tall alpine herbfields. Low temperatures and a short growing season are thought to limit taller species from growing in areas currently occupied by short alpine herbfields (Costin 1954; Table 3).

In the upper regions of snowbanks where snowbank feldmark occurs, windswept feldmark species may start to establish. Decreasing snow cover is likely to result in these areas no longer being sheltered from high winds in autumn and spring, potentially leading to soil erosion, frost heave and formation of stony erosion pavements; all conditions that favour windswept feldmark species (Costin 1954).

Windswept feldmark

The potential expansion of windswept feldmark is not just limited to areas above late snowbanks. A reduction in the snow cover is likely to result in more areas along ridges and other areas experiencing high winds and freezing conditions in autumn and spring (Good 1992). Decreasing snow cover is likely to lead to these areas losing topsoil, resulting in an increase in the area of stony erosion pavements that favour windswept feldmark species. This type of succession from tall alpine herbfield species to windswept feldmark species that are specifically adapted to these extreme conditions has previously occurred when soils were eroded by grazing or trampling (Costin *et al.* 1959; Bryant 1971a; Edwards 1977; Keane 1977; Wimbush and Costin 1979; Costin *et al.* 2000).

It is not clear if further reduction in snow cover and increase in temperature would result in the windswept feldmark expanding, stabilising, or eventually declining. If temperatures, particularly minimum temperatures continued to increase, then grasses and herbs from tall alpine herbfields could in turn replace windswept feldmark species. However, this would depend on the rate of soil recovery and the potential for tall alpine herbfield species and others such as alien plants to establish and survive in the extreme conditions. Soil recovery can be very slow, with areas of secondary feldmark produced by grazing in the Kosciuszko alpine area still present after fifty years (Good 1992; Johnston and Ryan 2000).

Brachyscome–Austrodanthonia *tall alpine herbfield*

The *Brachyscome–Austrodanthonia* tall alpine herbfield is a specialised plant community restricted to areas around rocks, overhangs and ledges in alpine regions: areas that are subject to rapid natural erosion (Costin 1954; Costin *et al.* 2000; Table 3). While snow cover remains adequate, this community appears unlikely to be greatly affected by climate change, as there is limited potential for other species to invade the already unstable habitat (Costin 1954). However, if snow cover is reduced to less than three months a year in these areas, then the *Brachyscome–Austrodanthonia* tall alpine herbfield community may be lost, as it appears to depend on three or more months of snow cover a year (Costin 1954; Table 3).

Celmisia-Poa *tall alpine herbfield*

Climate change is likely to be beneficial or neutral for species in the tall alpine herbfield community as long as there is adequate (3-4 months) snow cover. Increased vegetative growth of the grasses and tall herbs as a result of longer, warmer growing seasons is likely to enhance the competitive advantage of these plants relative to mat and cushion species of short alpine herbfield (Good 1998; Pickering 1998). Tall alpine herbfield species may invade areas currently occupied by mesic communities (bog, fen, raised bog, and valley bog communities) if the water table drops as a result of decreases in overall precipitation and increases in temperature, particularly during the summer (Table 3).

Increasing temperatures may lead to increased abundance and activity of many insect and mammal herbivores that are currently restricted by low temperatures (Green and Osborne 1994; Green 1998). Increased herbivory would alter the relative abundance of plant species depending on their palatability, with species such as *Poa* spp. and some Asteraceae potentially decreasing, and other less palatable species increasing. Grazing by local animals has been found to depress diversity in alpine grasslands through preferential feeding on forbs (Wilson 1994). Whether increased herbivory will be offset by increased growth of plants in warmer conditions is not clear.

Table 3. Climatic and other conditions associated with plant communities in the alpine region of the Snowy Mountains (Costin 1954, 1957; Mallen-Cooper 1990; Good 1992; Costin *et al.* 2000).

Plant community	Climatic range Alpine	Subalpine	Montane	Precipitation	Snow cover	Other factors thought to affect distribution
Short alpine herbfield	+				>8-9 months	During summer, plants are exposed to constant ice-cold water as a result of snow melt
Windswept feldmark	+				Snowcover removed in spring and autumn by high winds	During spring and autumn there is a diurnal cycle of freezing and thawing of soil with frost heave and soil erosion due to absence of snow cover. This type of feldmark can form as a result of disturbance (secondary feldmark due to grazing)
Snowbank feldmark	+				>8-9 months	Occurs in areas of significant temperature fluctuations diurnally when snow melts in summer
Brachyscome-Austrodanthonia tall alpine herbfield	+			1950-2340 mm	4-9 months	Occurs in areas that experience wide diurnal temperature variation in snow-free period
Celmisia-Poa tall alpine herbfield	+			1950-2340 mm	4-9 months	Mainly determined by climate with the duration of snow cover in winter and temperature range in summer the most important features
Sod tussock grassland	+	+		780-2340 mm	1-6 months	Occurs in areas with impaired soil aeration due to uniform and gentle relief, and/or subnormal minimum temperatures with wide diurnal temperature fluctuations due to cold air drainage
Fen	+	+	+		Not a requirement	Occurs in wet, level or gently sloping conditions along permanent watercourses in valleys or on flats with a high water table
Valley bog	+	+		1300-2340 mm	1-6 months	Conditions intermediate between those of fen and raised bog. Occurs in areas with high soil moisture and atmospheric humidity. Hotter and drier conditions result in the loss of *Sphagnum*
Raised bog	+	+	+	1300-2340 mm	Not a requirement	Occurs on slopes with acid and base-deficient soils that are permanently wet. Raised hummocks of moss form
Epacris glacialis heath	+	+	+	650-2340 mm	Not a requirement	Occurs on even flat to gently sloping areas where water-logged or poorly aerated soil prevails. Soils are strongly to moderately acid, with imperfect aeration
Oxylobium-Podocarpus heath		+	+		1040-2340 mm	Mainly in exposed and windswept conditions in subalpine zone, but in protected areas in alpine zone.
Alien plants	+	+	+		Potentially limited by snow cover	Able to tolerate highly variable conditions but apparently not snow cover for many months

Some areas currently occupied by tall alpine herbfield may be colonised by shrubs from adjacent heath communities. Shrubs are currently considered to be restricted from establishing in areas occupied by tall alpine herbfield by strong winds in summer and by snow cover in winter (Costin 1954; Table 3). Continued loss of winter snow cover may result in the tall alpine herbfield being completely replaced by heath communities.

Sod tussock grassland

Warmer nights, drier soils and greater soil aeration due to predicted climate change could result in increased growth of herbs and shrubs in sod tussock grasslands, eventually resulting in a heath community (Table 3). In subalpine regions these changes might occur within a relatively short time (<70 years). Over a longer time, trees may also become established in these areas as minimum temperatures increase (Slatyer 1989; Good 1998).

Fens

Decreased precipitation and increased temperature may result in a decrease in run-off into fens leading to a drop in the water table. These types of changes could alter the competitive advantage of fen species, resulting in the replacement of the *Carex* community by sod tussock grassland species in drier sites. A reduction in snow cover may also result in the alpine *Carex* community being invaded by subalpine wet tussock grassland species. In sloping aerated sites, tall alpine herbfield species and *Epacris* heath species may eventually colonise *Carex* fens.

Valley bogs

The floristically simple valley bog *Carex-Sphagnum* community occurs in areas that are intermediate between those occupied by fen and raised bog (Costin 1954; Good 1992). Valley bogs respond poorly to desiccation, with sod tussock grassland and *Epacris* heath establishing when moisture drops and soil aeration increases (Costin *et al.* 1959; Bryant 1971a; Good 1992). Therefore a reduction in soil moisture associated with climate change is likely to promote the replacement of valley bogs by sod tussock grassland species. A reduction in snow cover, to levels currently experienced in the subalpine zone, could result in valley bog communities being colonised by species found in subalpine tussock grassland and heath communities.

Raised bogs

The raised bog *Epacris-Sphagnum* community occurs in cooler acidic and permanently wet areas (Costin 1954, 1957; Good 1992; Costin *et al.* 2000; Table 3). It is susceptible to accelerated drying and erosion of underlying peat as a result of even minor levels of disturbance (Costin 1954; Costin *et al.* 1959; Edwards 1977; Good 1992; Clarke and Martin 1999). These types of changes have in the past resulted in invasion by grasses and shrubs (Costin 1954; Costin *et al.* 1959; Clarke and Martin 1999). Warmer, drier conditions are likely to lead to the colonisation of areas currently occupied by the raised bog community by *Poa* spp. and other tall alpine herbfield species. If snow cover declines further then colonisation by valley bog species in wetter areas and by heaths in drier areas is also possible.

Oxylobium-Podocarpus *heath*

The *Oxylobium-Podocarpus* heath is floristically diverse and is widespread in alpine and subalpine areas (Table 3). In alpine regions it occurs in sheltered areas on rock outcrops, glacial moraines and along the banks of watercourses (Costin 1954, 1957; Good 1992; Costin *et al.* 2000).

If predicted climate changes occur, many of these shrub species may invade communities from which they were previously restricted by snow cover, such as the tall alpine herbfields and sod tussock communities. The *Oxylobium-Podocarpus* heath may itself be colonised by woodland species that are currently restricted by cold nights. Therefore, the *Oxylobium-Podocarpus* heath community may colonise new habitats at higher altitudes, but is unlikely to increase in total area, as it may be replaced by woodland species in the subalpine zone.

Epacris-Kunzea *heath*

Epacris-Kunzea heath occupies flat to gently sloping areas with poorly aerated soils (Costin 1954, 1957; Good 1992; Costin *et al.* 2000; Table 3). This heath alliance replaced wetter communities such as sod tussock grasslands and bogs when soil structure was damaged and soil moisture declined due to intensive grazing (Costin *et al.* 1959). Shrubs and other members of *Epacris-Kunzea* heath may, therefore, replace fen and bog species if conditions become warmer and drier.

Alien plants

Alien plants are already well established in the Australian alpine and subalpine zones (Bryant 1971b; Costin 1970; Mallen 1986; Mallen-Cooper 1990; Kirkpatrick and Bridle 1998; Costin *et al.* 2000; Table 3). They are common along tracks and roads, in gravel pits and some areas of revegetation (Bryant 1971b; Costin 1970; Mallen-Cooper 1990). Natural communities have been invaded by alien plants, particularly if they have experienced some degree of soil disturbance (Bryant 1971b; Edwards 1977; Mallen 1986; Mallen-Cooper 1990). There is a strong negative correlation between altitude and the diversity and abundance of alien plants. There are at least 118 alien species in the subalpine zone but only around seven species are regularly found in the alpine zone (Mallen 1986; Mallen-Cooper 1990).

The species richness and abundance of alien plants has been shown to be related to climatic conditions and they are likely to become more abundant and widespread with predicted climate change. Germination and establishment experiments for alien seed sown into natural plant communities in the Kosciuszko alpine zone found that some species of alien plants currently limited to the subalpine zone were able to germinate and grow at higher altitude, particularly following disturbance (Mallen-Cooper 1990). However, they were unable to reproduce due to desiccation, frost heave and low temperatures (Mallen-Cooper 1990). Therefore, warmer conditions along with increasing levels of disturbance are likely to enhance the establishment and spread of alien species.

Alien plants pose a particular threat to alpine ecosystems as they may interrupt successional cycles by quickly invading and colonising bare ground. A continuous cover of vegetation, particularly snow grass (*Poa* spp.) appears to restrict the establishment of alien plants in the Kosciuszko alpine zone (Mallen-Cooper 1990). However, on bare ground formed by previous human disturbance (grazing, fire, trampling), and natural processes (such as late snow cover, herbivory) alien plants have become established (Edwards 1977; Wimbush and Costin 1979; Mallen-Cooper 1990; Johnston and Pickering 2001). In tall alpine herbfield, episodes of late snow cover or herbivory kill grasses, allowing herbs to become established (Wimbush and Costin 1979; Good 1992, 1998). After a few years grasses displace the herbs, completing a well-documented successional cycle (Wimbush and Costin 1979; Good 1992, 1998). Alien plants may interrupt this cycle by becoming established in the bare areas and excluding other species. Already, Cats-paw *Hypochoeris radicata* and Red Sorrel *Acetosella vulgaris* can be found in areas of tall alpine herbfield with broken cover (Wimbush and Costin 1979; Mallen-Cooper 1990).

Discussion

Changes to plant communities in the largest alpine region of Australia are likely as a result of climate change. The overarching pattern of change is likely to involve alterations in the distribution and species composition of the existing communities, primarily due to fundamental changes in the climatic factors that define their present distributions.

Some native species are likely to benefit from climate change by colonising new areas. Shrub species are particularly likely to expand in range, along with some herbs and grasses of the tall alpine herbfield. Even some species from the restricted plant communities that are expected to decline may benefit, at least in the short to medium term. For example White Purslane *Neopaxia australasica* and Silver Ewartia *Ewartia nubigena* that are found in the short alpine herbfield and feldmark respectively can colonise bare areas and so may increase in abundance with climate change. These species have increased in cover following previous disturbances, and often colonise areas associated with human disturbance (Edwards 1977; Keane 1977; Wimbush and Costin 1979; Good 1992).

Predicted impact of climate change on other alpine and subalpine areas in Australia

Plant communities similar or identical to those occupying the main alpine region of Kosciuszko National Park as well as other plant communities, occur in the alpine and subalpine regions of Tasmania and Victoria (Costin 1954; McDougall 1982; Kirkpatrick 1989; Kirkpatrick and Bridle 1998, 1999; Costin *et al.* 2000). Climatic conditions appear to be the primary factors associated with the distribution of the different vegetation types in all of these regions (Kirkpatrick and Bridle 1998). Therefore, it is possible that climate change could alter the pattern and distribution of plant communities in all alpine areas in Australia. Plant communities in any of these alpine regions that have limiting climatic requirements would be affected in similar ways to those in the Kosciuszko alpine region. This may involve reductions in long lasting snow banks and other factors determining the distribution of some specialised plant communities (Ashton and Williams 1989; Kirkpatrick and Bridle 1998, 1999). However, alpine regions in Australia vary in total area, altitudinal range, current patterns of snow cover, composition of communities and existing intensities and types of human impacts (McDougall 1982; Ashton and Williams 1989; Costin 1989; Kirkpatrick 1989, 1997; Good 1992; Kirkpatrick and Bridle 1998, 1999; Costin *et al.* 2000), so the overall patterns may be very different in each region. However, it is clear that reductions in the duration of snow cover are likely to affect all of the alpine regions in Australia.

Limitations imposed by current understanding of the Kosciuszko alpine environment

This study has intentionally examined the more direct responses of communities to primary climatic factors for two reasons. Firstly, it appears that climate is a crucial factor determining the distribution of the communities, with edaphic, topographic and biotic factors also important, but often broadly correlated with climatic variables (Costin 1954; Kirkpatrick and Bridle 1998; Körner 1999). Summer temperatures, rainfall, duration of snow cover and low temperatures in winter have all been proposed as defining factors for alpine communities in Kosciuszko National Park and other alpine areas (Costin 1954; Carr and Turner 1959; Wimbush and Costin 1979; Ashton and Williams 1989; Good 1992; Kirkpatrick and Bridle, 1998; Clarke and Martin 1999). Therefore, changes in these variables are likely to alter the ecology of the Kosciuszko alpine ecosystem.

The second reason for the focus on physical and specifically climatic factors, rather than biotic factors, is that information about biotic interactions at the community level is limited for the Australian Alps. For example, the composition and location of different soil biota has been proposed to be an important factor affecting changes in vegetation in alpine communities in response to climate change. Due to the limited information available about their role in the ecosystem, it is difficult to speculate about the possible effects of climatically induced changes on the soil biota.

Although a little more is known about the role of insects and other animals in the alpine zone, particularly with respect to herbivory and pollination (Carr and Turner 1959; Inouye and Pyke 1988; Ashton and Williams 1989; Wilson 1994; Green and Osborne 1994; Pickering 1997; Stock 1999) the extent of the information is still inadequate for more detailed predictions. Therefore, it is clear that a better understanding of the potential impacts of climate change on this important and fragile ecosystem requires active research into the current ecology of this system, and that this research must be given a high priority.

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Investigating Interconnectivity in a South-eastern Australian Forest Ecosystem

Charles McCubbin[1]

Introduction

Australia is home to more plant and animal species than most other countries on earth. Separated from other landmasses of the world for about 50 million years, the unique flora and fauna have evolved into life forms and ecosystems found nowhere else.

Left to themselves for so long, each organism of an ecosystem has formed relationships that rely on others for their food resources, habitat needs and reproduction strategies. No single living entity exists by itself; instead, it is connected to and dependent on many other organisms and abiotic factors present in the same system. That is, it depends on its environment.

Relationships between organisms are very complex and reliance on preferred food items varies over the seasons as availability changes. If one link is broken and one species removed from the chain the organism that relies on it may also disappear. Climate or any other factors that limit the distribution of one organism may also limit the distribution of other interdependent organisms.

In our time, the remaining natural systems of our country are under relentless pressure from the burgeoning human population and much of the landscape has become degraded and fragmented. Lack of knowledge and understanding of the importance of the relationships at work in the ecosystems may result in the irretrievable loss of keystone species. It is not just trees, mammals and birds that are lost when land is cleared. The framework of the ecosystem is also lost; the microscopic fungi and bacteria, and invertebrates on which the larger organisms depend. The interdependence of all life is poorly understood and as our understanding of what is lost is incomplete, the loss may also be irreversible.

This essay discusses methods of exploring a functioning ecosystem based on this concept. The first part of this essay outlines some of the many variables involved in a forest ecosystem and highlights aspects that may not be immediately obvious to observers of natural history. This should illustrate the importance of many underrated organisms (e.g. invertebrates, fungi) to the proper functioning of an ecosystem.

The second part provides examples of interconnectivity in the environment and demonstrates how the presence of one component in multiple interactions links many species together.

The final section looks at an approach to explore these interactions that would allow the participation of school children and field naturalists. By documenting many links of interconnectivity, important 'link species' can be identified and the likely consequences of losing a link species can be speculated upon.

This knowledge of ecosystem functions will provide evidence for this and future generations of the interdependence of all its

[1] PO Box 248, Sale, Victoria 3850
Email cmccubbin@hotkey.com.au

components and the importance of each organism within, and the complexity of, the ecosystem. It should also convince specialist and generalist naturalists that all groups of organisms are important in the environment.

Ecosystem processes

An ecosystem such as an Australian forest is not just an assembly of plants and animals, some of which have commercial value, while the majority do not. Most of the components have evolved together and are mutually interdependent: all forests are in a continuous state of change, either through the aging process, climate change, extreme weather events, fire or even the annual seasonal cycle of rising and falling productivity and fertility. A forest can be likened to a single living entity.

Below, some important ecological processes are outlined, to give an idea of some of the types of interactions that occur in forest ecosystems. This is not intended to be a comprehensive survey of all processes that occur, but to give a taste of some of the important ones.

Forest systems

Many Australian forests grow on poor soils where the standing biomass represents nearly all the available nutrients. The stability of the system is dependent on the extent to which biological waste products and the total mass of any organisms at the end of their life span are converted by decomposers into forms available for reabsorption by plants. Losses from the system of key elements and trace elements by leaching, erosion, logging or other land clearing must not exceed the rate at which bacteria, protozoa and fungi can convert insoluble forms into compounds that plants can absorb. Recruitment of key elements by fungal or bacterial action is slow and incompatible with large-scale harvesting of timber or other organic natural resources.

Trophic levels

Ecosystems can be visualised in terms of one or more food webs, which illustrate connections between organisms. The relative position of each organism is known as its trophic level. Green plants, the harvesters of the sun's energy and producers for the entire community, occupy the first trophic level. The second level is the plant eaters or herbivores. The third trophic level is occupied by the carnivores that eat the herbivores. In addition, there are side chains that include the parasites that attack organisms at all trophic levels and the decomposers that convert dead organic matter into forms that plants can reuse. Some omnivores and predators have places in more than one trophic level.

Within a functioning forest ecosystem the relationship between prey and consumers (herbivores, carnivores or omnivores) is varied. In the simplest scenario, prey organisms become more numerous, allowing their predator numbers to increase. This reduces prey abundance causing predator numbers to decline. The cycle then begins again. More often than not the position of a species in an ecosystem is the result of millennia of co-evolution.

Prey species develop a range of defence strategies. For example, plant species have developed a variety of toxins (1080 in *Gastrolobium* sp.), thorns (Blackberry) or hairs (nettles) as protection against predation; cane toads have toxins and skunks an offensive smell. The gradual development of defence strategies by prey exerts a selective pressure on their predators, favouring those that become tolerant to toxins or develop techniques to overcome these defences. A predator that is too successful will destroy its own food supply while the prey that is free of the selective pressure of a predator may do likewise and may also lose fitness when weak or inferior strains are no longer culled. It is a continuous process and an advantage to both predator and prey to maintain some sort of balance. However, it is an extremely complex process and the dynamics are not fully understood even in these seemingly simple situations.

Biochemical processes

A functioning forest ecosystem involves, and is dependent on, a multitude of chemical processes. These include the development of toxins for both defence and attack; the production of surfactants that wash off foliage to improve soil penetration by rain; and the production of hormones and pheromones that regulate almost every facet of life. There is even the production of growth and germination inhibitors by plants, or indirectly by symbionts, directed against competitors or even against offspring that may otherwise compete for the available nutrients in the root-zone of the parent.

Symbiotic relationships

It is not uncommon for a degree of accommodation to develop between one organism and another that would use it for food. An adult insect may be an important pollinator of its larval host, but its larvae may only consume the less toxic new or juvenile foliage or attack only old or sickly plants with reduced defences. Frequently this accommodation develops into symbiotic relationships: non-lethal parasitism, commensualism or mutualism.

Symbiosis occurs when different species live together to the benefit of at least one of those species. Mutualism occurs when both symbionts benefit from the relationship. Symbiotic or mutualistic relationships between unrelated organisms are very common and many have evolved to the point where one or both partners can no longer survive outside the relationship. Some of the more complex relationships involve more than two organisms, e.g. the tripartite relationship between fungi, potoroos and eucalypts.

Soil organisms

Bacteria and fungi are likely to be one of the largest components of forest ecosystems. In the decomposing litter on the surface and the root-zone beneath each square metre of forest soil, there are countless billions of bacteria and kilometres of fungal filaments, together with millions of protozoa, nematodes, mites and springtails plus countless thousands of other invertebrates, most of them still undescribed.

It is easy to think of forests in terms of their above-ground visible components and to ignore the considerable proportion of the biomass that is beneath the soil surface. The roots of plants are obviously a large component. As plant roots grow through the soil they release sugars, amino acids, gummy polysaccharides and other compounds making the root-soil interface a zone of intense activity where bacteria and fungi proliferate. Such an active population of microorganisms can influence plant health in many ways: it can aid in the release of nutrients from soil and stimulate the production of plant growth hormones. Root exudates also attract pathogens. Fungi and bacteria produce defensive chemicals to protect themselves against each other; these are the source of many of our antibiotics.

The soil can be thought of as almost a living entity in its own right, in which the primary action taking place is the breakdown of organic matter and the release of plant nutrients.

Succession

A climax dry sclerophyll forest is a fully developed community, the final and most stable stage of a long process called succession. This is the process in which an empty space is first colonized by a simple community of pioneer species that are gradually replaced by increasingly complex assemblages culminating in a forest community that characterises a particular region. At each stage in the process species appear, become more numerous, then decline as successional stages become less favourable to them. No successional stage supports all the organisms which can be found in a region.

Destruction of a part of an existing ecosystem by recurrent events such as fire, flood, storm or landslide ensures that no forest remains a climax community forever and that species specialised for particular successional stages always have habitat available. As forest areas are fragmented by human activities, individual segments may no longer be large enough to ensure all successional stages exist, resulting in species loss.

Diversity is always desirable, because an assortment of organisms can exploit the resources of an environment more fully than a single species. The greater the diversity of a functioning ecosystem the better it will withstand adverse conditions.

Coping with adverse conditions

Many organisms in the forests have evolved strategies for coping with adverse seasons or conditions through: the production of resistant seeds or spores; the ability to fast for extended periods; reduction in activity through dormancy, hibernation, aestivation or diapause; local movement between microclimates or seasonal shifts to different elevations.

Even in the same general locality there can be considerable differences in the species mix and the total biomass of the forest, depending on the aspect, e.g. in hilly country. Differences in geology or soil type can have a profound effect on what grows where, as can variations in available moisture, with stream sides and seepage lines often clearly indicated by the greater vigour and diversity of the communities they support.

Migration and dispersal

Substantial numbers of animals migrate, particularly flying vertebrates and insects, resulting in movement both in and out of particular locations. Australia has its share of long distance seasonal bird migrants, as well as birds, bats and insects that make shorter seasonal journeys. There are also non-seasonal or nomadic movements in response to irregular rainfall, periodic drought, food availability or population movements. Migrating animals always have the potential to transport seeds, spores, viruses, bacteria and parasites along their migration routes, with potential consequences for receiving environments.

Many organisms disperse in an entirely random fashion, taking advantage of air and water currents or hitching rides on passing animals. However, there is no certainty that their ultimate destination will be suited to their requirements. These organisms normally have very high rates of reproduction that can withstand wastage, and they are always ready to exploit any favourable niche that becomes available. Spiderlings using gossamer parachutes utilise air currents as do viruses, the spores or cysts of bacteria, fungi, moulds, liverworts, mosses, ferns, and the minute eggs and specialised cyst or spore stages of some invertebrates; animals become unwitting hosts and transporters of burrs, ticks and other parasites.

Innumerable plants and fungi produce fruiting bodies that have evolved with and are often eaten by animals. The animals disperse the enclosed or attached spores or seeds, either dropping the seed once the softer fruit tissue is consumed or by voiding the spores or seeds ingested with the fruit in their droppings. In some cases the co-evolution is so specialised that spores or seeds will only germinate after passing through the gut of a particular evolutionary partner or partners, e.g. mistletoe and the Mistletoebird.

Many small insects and seeds have evolved for dispersal on the wind or by water. Larger organisms may be carried out of their regular range by extreme weather events such as storms.

Human activity is now responsible, both intentionally and accidentally, for the introduction of a huge variety of organisms to new locations; sometimes with damaging consequences for their receiving environments. Very few places on earth have not been affected. These new patterns of dispersal by humans create collections of organisms that have not evolved together and consequently often do not function as a natural ecosystem.

Interconnectivity in a south-eastern Australian forest ecosystem

To illustrate this point of extensive interconnectivity in the Australian landscape, interactions between several members of a forest ecosystem are described below. The systems are divided in significant interactions with wattles (System 1), those with eucalypts (System 2) and those that include both wattles and eucalypts or other members of the first two systems (System 3). These interactions could easily be grouped or classified many other ways; the main purpose, however, is to show the strong connections, and in some cases dependence, between species.

System 1

Sugar Glider *Petaurus breviceps* (Fig. 1) – feeds on nectar, invertebrates, invertebrate exudates, sap from eucalypts and *Acacia* (Fig. 2) gum. The *Acacia* gum is produced by the plant as a wound sealant in response to boring beneath the bark by Goat Moth *Xyleutes* sp. (Fig. 3) and longicorn beetle grubs (family Cerambycidae). The favoured trees of Sugar Gliders are Late Black Wattle *Acacia mearnsii* and Silver Wattle *A. dealbata*. During winter only *Acacia* gum and sap from eucalypts is available for Sugar Gliders.

Christmas Beetles *Anoplognathus* sp. (Fig. 4) are included in the Sugar Glider's

Fig. 1. Sugar Glider *Petaurus breviceps*.

Fig. 2. Wattle tree *Acacia* sp.

Fig. 3. The Wattle Goat Moth *Xyleutes* sp.

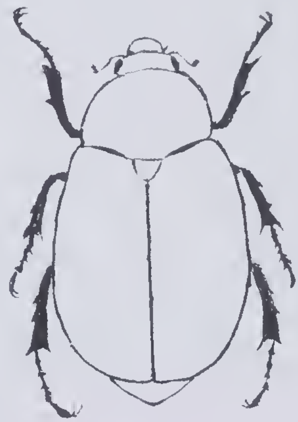

Fig. 4. Christmas Beetle *Anoplognathus* sp.

diet. Where Sugar Gliders are no longer present, Christmas Beetles proliferate and defoliate the trees.

Yellow-tailed Black-cockatoo *Calyptorhynchus funereus* – feeds on Goat Moth and longicorn beetle larvae obtained from wattles.

Wattles produce seeds with elaiosomes (nutritional structures) attached. These have evolved to encourage ants and birds to disperse the seeds of the parent plants. Ants and birds receive a nutritional treat, and wattles have their seeds dispersed more widely which improves their chances of germination.

Nitrogen is an important nutrient for all plants but it is not easily accessible to them, except through the decay of organic matter or the agency of nitrogen-fixing bacteria and blue-green algae that convert atmospheric nitrogen into forms that plants can use. Some soil bacteria infect compatible plants to form root nodules where nitrogen fixing takes place. The best known of these belong to the genus *Rhizobium* that form symbiotic relationships with wattles, Cassias and pea flowers.

System 2

Long-nosed Potoroo *Potorus tridactylus* and the Long-footed Potoroo *P. longipes* are highly dependent on fruiting bodies from mycorrhizal fungi in their diet.

Eucalypts are an important source of nectar for mammals, birds and invertebrates.

Mammals, birds and invertebrates are pollinators of eucalypt flowers.

Eucalypts are an important source of nesting hollows for mammals and birds.

Christmas Beetles feed on the leaves of eucalypts. Where beetle numbers proliferate, eucalypts may be defoliated by feeding pressure.

The ichneuman wasp *Lissopimpla excelsa* is an important pollinator of the Tongue-orchid *Cryptostylis erecta*. The orchid flower mimics the pheromones emitted by the female wasp and attracts male wasps that try to mate with it. The frustrated wasps fly from flower to flower taking pollen and depositing it as they go. The orchids are dependent on the wasp for pollination.

Orchids are dependent on fungi in nutrient deficient soils where the fungi enable the seeds of the orchid to germinate.

Mycorrhizal fungi form a symbiotic relationship with many plant species. The fungi take nutrients from the soil and make them available to plants particularly on soils that would otherwise be unable to support them. In return, the plant supplies the fungi with carbohydrates and vitamins.

Mycorrhizal fungi have evolved a range of strategies for spore dispersal. Hypogeous fungi fruit underground and produce pheromones to attract animals which dig them up and eat them. Spores may be dispersed during feeding by the animal; attaching to the fur of the animal during eating and later being brushed off; or by being deposited in droppings.

System 3

Mistletoes are semi-parasitic, relying on their host for nutrients and water. Many different plant species, including *Acacia* (System 1) and *Eucalyptus* (System 2), are host to mistletoe. Some mistletoes infest many species of trees and shrubs while others are specialised (host specific).

Mistletoebird *Dicaeum hirundinaceum* prefers the fruits of mistletoes and is an important dispersal agent for the mistletoe. Their method of voiding the seeds and attaching these to the plant is a reliable dispersal medium.

Flower wasps (subfamily Thynninae) parasitise the larvae of Scarab Beetles by burrowing down to lay their eggs on the underground grubs. Some of the larger species parasitise Christmas Beetle grubs. The next season when the new flower wasps emerge from the soil, the wingless females position themselves on plant stems and use pheromones to attract the much larger winged males. The males mate with the females and, carrying the coupled females curled under their abdomens (Fig. 5), take them to feed at the flowers of various shrubs and trees, of which they are often pollinators. They also feed on exudates of some scale insects. After feeding, the females drop to the ground and seek out the underground grubs on which they lay their eggs. Grazing animals or human activity that eliminates the flowering understorey can disadvantage the flower wasps allowing Christmas Beetle numbers to increase.

Fig. 5. Male flower wasps carry the wingless females to feed at flowers.

Sugar Gliders (System 1) rely on eucalypts (System 2) for nectar and sap during winter when invertebrates are scarce. Mature eucalypts are a source of nesting hollows. Sugar Gliders and Yellow-tailed Black-cockatoos (System 1) are amongst the mammals and birds that use hollows in mature eucalypts.

Lichens are a symbiotic partnership between a fungi (the mycobiont) (System 2) and an alga or cyanobacteria (the photobiont) (System 1). Lichens are found in almost every environment. They are very slow growing, and some species colonise bare rock where they initiate soil production. Epiphytic species adorn the trunks and branches of larger plants while others grow on bare soil. Their main requirement is water and any mineral traces contained in it, but lichens can remain dormant for long periods when it is dry. Many are sensitive to air pollution.

Investigating a functioning forest or woodland ecosystem

In order to improve our understanding of the complexity of the environment, I propose a project that involves documenting interconnectivity of ecological processes from single bits of information, gathered by observers with varying levels of experience and expertise. The individual pieces of information gathered can be quite simple, but when collated into a data bank will reveal some of the complex relationships in ecosystems. Another benefit of this project is to allow people to discover this complexity themselves through hands-on investigation.

Topics for investigation include:

1. What date does each plant come into flower? How long does it flower? When do its seeds ripen? When do they fall? Do these times vary from year to year?
2. What insects and birds are seen feeding at the flowers? A voucher specimen or photograph may be needed to identify most insects.
3. Does the plant have extra-floral nectaries? When do they produce nectar? What insects are seen feeding from them?
4. What insects are feeding on the foliage? Are there any lerps, scale insects, gall insects or leaf miners?
5. Are ants or wasps or other insects feeding on the plant exudates? Is anything preying on the scales themselves?
6. Have you seen birds feeding on the galls? What species of birds?
7. Have you tried to observe the galls to see what insects come out of them?
8. Are there any insects preying on other insects?
9. Are there any spiders on the plant? What kind?
10. Are there ants on the foliage? What are they doing?
11. Where are the ants' nests? What sort of nest?
12. What time of day is each ant species active? Are they active all year? When do they swarm?
13. What food items are they dragging back to their nests? What do the workers eat for their own energy needs?
14. Which birds seem to be eating invertebrates, including spiders?
15. What fungi can you find? What time of year? Fungi include moulds and rusts. Can you find fungal threads in the leaf litter?
16. Can you find invertebrates that are associated with fungi? Can you raise some maggots and grubs that decompose some mushrooms?
17. How many different kinds of mosses, liverworts or lichens can you find? Where are they growing?
18. Are there any tiny organisms crawling around in the leaf litter, when it is dry, when it is damp? Can you identify them?
19. If you find grubs and caterpillars on plants can you raise them to find out what they turn into, photographing and dating all stages?
20. What insects come to the bodies of dead animals? How long do they take to arrive? How many different sorts? In what order do they come? Over what passage of time? A fresh road-killed Rabbit will teach you a lot.

The list of questions that can be asked is endless, and each piece of information can be collated by children and their teacher and then kept in a data bank. Different animals will be found on plants at different times of the year. Some insects will only be common at intervals of several years. Is this due to weather conditions that happened to suit them or do they have life cycles of more than one year?

The task of investigating the complexity of ecosystems is immense, but faced with the consequences of accelerating biodiversity loss, can we afford not to attempt it? By collecting the data we increase our knowledge of the interconnectivity of species.

Some aspects of this undertaking would require the level of skill and equipment only found in universities or research institutes, but simple natural history observations of readily observed taxa by school students and non-specialists will greatly advance our knowledge of ecosystem function. Any number of contributors, especially school children, can become involved, and the participation of members of the Field Naturalists Club of Victoria and other field naturalists clubs around the state can provide expertise and enthusiam to the investigations.

Adopting a single patch of bushland for long-term repeat observations may be the best option, particularly for schools, because the amount of information that can be gained in one place will amaze most participants and be an education in itself. Each student could be allocated only one or two plants in a given study area to monitor through the year, recording the data on standardised pre-printed sheets with map references and columns for information.

Comprehensive databases for Victorian biota already exist, such as Atlas of Australian Birds, Atlas of Victorian Wildlife, Flora Maps, Fungimap etc. The information collected by students at the schools that adopt a patch of bushland could provide valuable additions to these databases.

Distribution maps of each species can be placed over a geological map of Victoria and reveal correlation between a particular plant and a particular soil type. Likewise contoured maps of Victoria or maps showing the isohyets would indicate if either of these factors were critical to a particular plant's distribution. Organisms with particularly strong connections to a plant would include pollinators, seed dispersal vectors, bacterial or fungal symbionts. If any of these species are threatened or endangered then this will threaten the continuance of the organism that depends on them. The survival of herbivores able to consume many different plant species is more secure than those that feed on only one species. The discovery of connections will give forewarnings of the consequences of any species loss. Key species have a place in many different connections and the relative importance of any organism can be ascertained by how often it features in other species' ecology.

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Australian Natural History Medallion 2002

Ian Endersby

Lady Southey, Lieutenant Governor of Victoria, presented Ian Endersby with the 2002 Australian Natural History Medallion on 11 November 2002. Ian's interest in natural history has been life-long and his most important contribution has been sharing his knowledge with others.

One of Ian's major achievements was the organisation and management of the RAOU (now Birds Australia) Victorian Wetland Bird Survey. Between 1987 and 1992, over 200 amateur observers counted birds on more than 400 wetlands throughout the State, four times a year. He did most of the planning for the project, recruited observers, obtained funding, managed all of the correspondence, count sheets and printout correction, and wrote quarterly newsletters. In a similar fashion, he was involved in the planning of an invertebrate survey for the FNCV at Glynn's Reserve, Warrandyte in 1996. He organised permits, prepared identification manuals for ants and beetles, and assisted with the training of participants, as well as participating in the collection and sorting of material. Ian has also contributed to the Edithvale Wetland Bird Survey, the Organ Pipes National Park Insect Survey, the RAOU Bird Atlas, the Galah and Lorikeet Surveys conducted by the Victorian Ornithological Research Group, and the Fungimap Project.

The following accounts show how Ian's expertise in natural history led to important discoveries and conservation actions. In 1969, Ian visited the only population of the Cabbage Tree Palm *Livistona australis* in Victoria. He wrote to the then Forests Commission drawing their attention to the Palms and the need for preservation. As a direct result of his lobbying, a reserve of 620 acres was set aside for the preservation of the Palms. Ian was also instrumental in the discovery of *Hemiphlebia mirabilis* on Flinders Island. The species had previously been known from Victoria and Tasmania and Ian played an important role in filling in the gap in the species distribution. The details of this new locality record were published in *Notulae Odonatologicae*. During a year-long study of the Eltham Copper Butterfly *Paralucia pyrodiscus lucida*, Ian established new information about the life history of the species that was of conservation significance, and this study was published in the *Proceedings of the Royal Society of Victoria*.

For a year, in 1997, Ian was 'Naturalist in Residence' for *The Victorian Naturalist* when he wrote on topics ranging from insects and spiders to fungi and the mechanism of tides. He also initiated the series on 'How to be a field naturalist' in *The Victorian Naturalist* which provided an introduction on how to go about the study of each facet of this broad topic. Ian has also had many articles and book reviews published in refereed journals such as *The Victorian Naturalist, Australian Entomologist, Victorian Entomologist and Proceedings of The Royal Society of Victoria,* and other nature and club publications. His most popular subjects have been in the fields of entomology and ornithology but he can also extend his wide knowledge to cover other ecological and conservation issues. In 1992 Ian began contributing to Recent Ornithological Literature, the international abstracting service sponsored by the American Ornithological Union, the British Ornithological Union and the Royal Australasian Ornithological Union and so far he has supplied over 600 annotated citations. He has also researched and assembled a bibliography of over 500 citations on the natural history of Norfolk Island. This he has provided to the Norfolk Island Flora and Fauna Society, the Conservator of Public Reserves and Environment Australia as well as researchers on the island. There are sections on birds, botany, geology, invertebrates, marine life and pests.

Ian is a much sought after speaker both to professional societies and amateur groups. He regularly makes presentations to field naturalist groups, bird societies, garden societies and 'friends' groups such as Geelong Bird Observers Club, Friends of the Royal Botanic Gardens, Glen Waverley Garden Club, Victorian Wetlands Trust and the Melbourne Junior Field Naturalists Club, to name but a few. Talks about insects or bird behaviour are favourites, but he can speak on topics as diverse as cosmology, petroleum geology and strategic planning for conservation organisations. The talks are generally illustrated with Ian's own high quality slides and examples of his nature photography can also be seen on Museum Victoria's website. Ian has membership in over 20 natural history, entomology, ornithological and conservation societies and is an active participant in the Royal Society of Victoria, the Entomological Society of Victoria, the Field Naturalists Club of Victoria and Birds Australia.

In recent years Ian has acted as a nature tour guide, re-enacting one of Ferdinand von Mueller's journeys in the centenary year of his death, and taking international tourists through eastern and central Australia, and the Kimberley and Arnhem Land for the New York-based Lindblad organisation. Ian has led bird watching and insect excursions for many amateur natural history and conservation groups. He spent time at the Mount Buffalo Chalet as resident naturalist, giving talks and leading field trips to examine the birds, plants, geology and alpine ecology of the area. He was also the leader of the invertebrate section of a field week to commemorate the centenary of Mount Buffalo National Park in 1998.

Through the Royal Society of Victoria, Ian has arranged seminars on molecular taxonomy, insect conservation and alpine ecology. He developed and presented an introductory course on insects for the Barren Grounds Bird Observatory, prepared a manual to aid the identification of most Victorian aquatic invertebrates to family level, and published a current checklist to the State's dragonfly fauna, logging changes in nomenclature and new records.

Ian Endersby has maintained the tradition of the amateur naturalist who, in his spare time, has built a solid knowledge of a broad range of topics and sought to relate the various elements to each other. The wide-ranging interests and public education activities of Crosbie Morrison and Norman Wakefield were his early role models. He is erudite, inquisitive and, most of all, happy to pass on his own hard-gotten information and to encourage others to accept the challenge of taking their natural history studies to a higher level. He is comfortable talking with practising scientists and with those just starting in the field. Watching the growth of those for whom he has acted as mentor could be considered his greatest natural history achievement. Congratulations Ian.

The Entomological Society of Victoria Inc nominated Ian Endersby as a recipient of the Australian Natural History Medallion.

(Prepared by Merilyn Grey from the citation accompanying the nomination.)

Natalie Joanne Smith

1974 – 2002

Naturalist

Natalie Smith joined the Field Naturalists Club of Victoria in 1996. In October 1999 she became an FNCV Council member and Conservation Coordinator for the Club, a position she held until ill health forced her retirement in December 2000. During this period she was also the FNCV representative for Environment Victoria.

Natalie grew up in the Melbourne suburb of Viewbank, attending Viewbank Primary School and Ivanhoe Girls Grammar. She subsequently studied Biological Sciences at La Trobe University, Bundoora Campus, Melbourne, where she majored in Zoology and was awarded a BSc (Hons).

In common with many young Australians, Natalie's childhood was characterised by a love of sport and the outdoors. A keen sportswoman, she was also an active participant in the Viewbank Girl Guides. But the dominant theme in Natalie's life was her love of natural history and the bush. From her school years onwards, she had a particular interest in and love of Australian wildlife.

On completion of her degree, Natalie worked with the Australian Trust for Conservation Volunteers on bushland restoration projects. She obtained a term Ranger position with Parks Victoria at Sugarloaf Reservoir Park in 1997. In 1998 she secured a permanent Ranger's position at Yarra Bend Park in Melbourne, a position she held until her death in July 2002.

Natalie was an active FNCV member, with a particular interest in the activities of the Fauna Survey Group. In the short time she held the position of Conservation Coordinator, the issues she addressed included the following:

- Big Hill Goldmine Development, Stawell;
- Epson Wetland Housing Development (on a significant remnant of Plains Grassy Wetland, West Gippsland);
- Marine National Parks – joint submission with Marine Research Group;
- Regional Forests Agreements – submission on Western Victoria and East Gippsland Consultation Papers;
- Victoria's Biodiversity Strategy 1997 – FNCV talks and field trips to investigate issues and invitation to members to form a working group;
- Box Ironbark Forests and Woodland investigation;
- Support for the creation of a Rushworth-Mt Black National Park;
- Statement of FNCV policy on State Forest Management, Vegetation Thinning, Apiculture and Eucalyptus Oil Production;
- Greens Bush, Mornington Peninsula National Park – submission to Mornington Peninsula Shire Council objecting to increased use of equestrian ground;
- Goolengook Forest Blocks – letter to the Premier supporting addition to Errinundra National Park.

Natalie was an active contributor on the FNCV Council. At the time ill health forced her resignation, she was organising a diverse program of speakers and excursions around the theme of Biodiversity.

Natalie exhibited a love of life and a deep love of the environment. She liked nothing better than being out in the bush and she relished the opportunities the Club provided for close encounters with our cryptic wildlife. She recognised the threats to Victoria's natural heritage and, in both her work and her recreation time, she strove to protect that heritage.

Although reserved by nature, Natalie left a lasting impression on everyone she met. Without ever pushing herself forward, she was a solid contributor within the Club and a good-humoured companion on field trips. Her quiet passion for the environment was well known to her friends and colleagues, as was her commitment to work for its protection. In many ways Natalie represented the spirit of the FNCV. Her tragic and untimely death, after a lengthy battle with cancer, is a great loss to the Club, her family and to all who knew her.

(This tribute has been compiled from information kindly provided by Peter Lynch, Ann Williamson, Sheila Houghton and Fiona Casey.)

The Long Dry: Bush Colours of Summer and Autumn in South-western Australia

by Alex George

Publisher: *Four Gables Press, 2002. RRP $20*

This book of 92 pages is mainly a pictorial essay on the vegetation of south-western Australia during the driest months. The author has observed over a long and distinguished botanical career certain subtle changes that occur in a variety of species as they begin to dry out. As the available water decreases and the plants show signs of stress, the colour of their leaves begins to change with the result that hillsides or heathlands can display very autumn tonings.

It is well known that a number of our plants have developed the ability to lose a dramatic amount of their moisture content and then fully recover once rains arrive. These are known as 'resurrection plants' and include genera such as *Borya*, *Chielanthes* etc.

This publication for the first time, I think, actually verbalises and illustrates this phenomenon, and it is interesting to note the return of plants to their normal condition once the moisture and lower temperatures arrive. The summer that highlighted this occurrence was as recent as 2000/1. Some of the photographs date back to the 1970s, which reinforces the concept that this phenomenon is not new but is part of the evolutionary development of species.

Not in all cases were the affected plants able to recover; some species appeared more susceptible and turned up their toes. It is interesting to see that the dates are included in the captions so that an understanding of the time frame can be achieved. It is as part of this captioning that a little more explanation of the images is given.

We say that a picture is worth a thousand words, and this is relied upon by the author as there are fewer than five pages of text. However it is in that text that the questions are raised which could encourage future research that may shed some light on the plant physiology and ecology of this phenomenon.

The book certainly draws our attention to isolated instances that the viewer may have observed around the country after drought conditions.

Two smaller sections highlight alternative ways stressed vegetation attempts to survive. The first is using other 'close down' techniques such as shedding or shrivelling of foliage to cover and protect shoots or rootstocks. The sacrifice of branches to enable overall plant survival, or the complete defoliation of an individual to ensure the stems remain alive, provides the chance of rejuvenation once conditions improve.

Secondly, attention is drawn to the summer/autumn flowering of plants as a survival strategy.

A number of observation sites have been selected and regularly visited, and it is from recordings made that this book has arisen. It is applicable specifically to the 'wildflower corner' of WA but has a general application to the way we see the bush under dry conditions.

It is indexed and supplies a comprehensive further reading list.

Trevor Blake
22 Vista Avenue
East Ringwood, Victoria 3135

Fires and the High Country

The Independent Scientific Committee Interim Report on Kosciuszko National Park is now available for comment. Those with an interest in fire as a natural process or a management tool will be very interested in the section on fire values, written before the recent bushfires in NSW and Victoria occurred. There are also chapters on earth sciences values, karst values, fauna values and pressures on these values, among many others. The report is available on the web at www.npws.nsw.gov.au under Independent Scientific Committee Interim Report. A free copy of the report on CD is also available from NSW National Parks by telephoning 1800 200 208. Printed copies are limited. Thank you to Dr Catherine Pickering of Griffith University for bringing this important report to our attention.

The Field Naturalists Club of Victoria Inc.

Reg No A0033611X

Established 1880

In which is incorporated the Microscopical Society of Victoria

OBJECTIVES: ***To stimulate interest in natural history and to preserve and protect Australian flora and fauna.***

Membership is open to any person interested in natural history and includes beginners as well as experienced naturalists.

Registered Office: FNCV, 1 Gardenia Street, Blackburn, Victoria 3130, Australia.
Postal Address: FNCV, Locked Bag 3, PO Blackburn, Victoria 3130, Australia.
Phone/Fax (03) 9877 9860; International Phone/Fax 61 3 9877 9860.

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Newsletter Editors: Mrs Joan Broadberry, 2 Shaun Court, Templestowe 3106. 9846 1218
and Dr Noel Schleiger, as above.
Conservation Coordinator: Mr Jim Walker, 167 Balaclava Road, Caulfield 3162. 9527 5601

Group Secretaries

Botany: Mr Keith Marshall, 8/423 Tooronga Road, Hawthorn East 3123. 9882 3044
Geology: Mr Rob Hamson, 5 Foster Street, McKinnon 3204. 9557 5215
Fauna Survey: Ms Sophie Small, 4 Alvira Court, Frankston 3199. AH 9783 6108
Marine Research: Mr Michael Lyons, 18 High Street, Nunawading 3131. AH 9877 3987
Microscopical: Mr Ray Power, 36 Schotters Road, Mernda 3754. 9717 3511
Terrestrial Invertebrate: Dr Alan Yen, as above.

MEMBERSHIP

Members receive *The Victorian Naturalist* and the monthly *Field Nat News* free. The Club organises several monthly meetings (free to all) and excursions (transport costs may be charged). Field work, including botany, mammal and invertebrate surveys, is being done at a number of locations in Victoria, and all members are encouraged to participate.

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Discovering Mount Buffalo

by Philip Ingamells

Publisher: *Victorian National Parks Association, 2001. 80 pages, soft cover. ISBN 1875100148. RRP $14.95(inc GST)*

As a distinctive and spectacular landscape feature, the Mount Buffalo granitic plateau always seems to invite exploration, whether viewed from near or afar.

Explorers Hume and Hovell passed by it in 1824 and gave it the present name, and Thomas Mitchell sighted it in 1835, but it was the 27-year-old botanist Dr Ferdinand Mueller and Gardens Superintendent John Dallachy who, in 1853, made the first *recorded* exploration of the plateau. By this time, the surviving original inhabitants of the area, the Taungurung people, had mostly been relocated to mission stations elsewhere.

Much has been written about the Mount and its history since Mueller's exploration—in the National Park's centenary year we had 'The Mount Buffalo Story, 1898–1998' by Webb and Adams, and the special issue of *The Victorian Naturalist* (October 1998). However this new little book, 'Discovering Mount Buffalo', will fill a special niche. The word 'discovering' in the title is the key to its intended purpose — it is designed to help anyone experience the satisfaction and excitement which comes from making one's own discoveries, rather than merely being provided with information. And as the book's opening line states encouragingly, 'Of all Victoria's national parks, Mount Buffalo is perhaps the most generous in revealing its treasures.'

This is an attractive, information-rich yet compact field guide which recognises that people will make discoveries in many different ways and on many levels.

After some background on the Mount's geological origins, and a brief summary of the area's Aboriginal and post-1850s human history, the greater part of the book is devoted to clear guide notes to twenty-eight walks. These range from short and easy walks (including some tracks suitable for people with disabilities) through to longer and more challenging ventures (in winter as well as warmer weather). The particular features and emphases of each walk are clearly identified as an aid to planning. History, natural features, safety precautions and other appropriate visitor practices are skillfully interwoven throughout the descriptions; references to Aboriginal culture and names are incorporated where known. Seven suitably-scaled maps by Guy Holt support the walk descriptions.

Field naturalists will still need to carry their specialised references for flora and fauna however—the book's small size limits the selection of photos and drawings of living things to 34 plants (out of some 550 recorded for the Park), thirteen birds, three snakes, two insects and one mammal. A comprehensive bird list is included.

It is evident that a great deal of care and thought has gone into the writing and design of this booklet. Author Philip Ingamells, editor Barbara Vaughan and designer Lauren Statham have given us a production which is abundantly illustrated, well laid out, easy to use and, to my eye, particularly accurate in content and presentation (just a few very minor typographical slips in captions).

Although I have been to Mount Buffalo many times, I'm looking forward to future visits with this book as a guide. Reading it has reminded me that there is always so much more to discover.

Highly recommended!

Leon Costermans
1/6 St Johns Avenue
Frankston, Victoria 3199

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Cover: A Brush-tailed Phascogale *Phascogale tapoatafa* with a group of Sugar Gliders *Petaurus breviceps* that are feeding on honey. (See Contribution, p 40.) Photo from FNCV Collection.

Web address: http://www.vicnet.net.au/~fncv/
Email fncv@vicnet.net.au

Fauna Survey Group (FSG) Contribution No. 23

The Use of Artificial Nestboxes by Brush-tailed Phascogales *Phascogale tapoatafa* in Rushworth Forest

Stuart Dashper[1] and Susan Myers[1]

Abstract

The Brush-tailed Phascogale *Phascogale tapoatafa* is a medium-sized carnivorous dasyurid that is now considered to be rare in Victoria. In order to gain more information about the Phascogale population of Rushworth Forest the Fauna Survey Group of the Field Naturalist Club of Victoria has been studying the distribution and abundance of this species over the last six years, using a combination of nestboxes, trapping, stagwatching and spotlighting. Rushworth Forest is a Box-Ironbark forest that, as a result of forestry practices, is composed mainly of homogenous stands of small diameter trees, as revealed by a floristic survey conducted as part of this study. During a six-year study period with 15 inspections, a total of 57 individual Phascogales was found in 92 nestboxes. Phascogales were found to mainly use nestboxes in the absence of suitable natural tree hollows. Phascogales appear to be patchily distributed through the forest and in very low density due to the lack of suitable tree hollows. In these areas with few mature hollow-bearing trees, nestboxes can be used to increase Phascogale numbers in the short term. The best siting of nestboxes to achieve maximum usage by Phascogales can be predicted by using a simple floristic survey of the sites prior to nestbox location, allowing a more targetted approach to nestbox siting. The protection of older larger diameter trees, especially hollow-bearing trees, is needed in Rushworth forest to increase Phascogale numbers. (*The Victorian Naturalist* **120** (1), 2003, 40-48)

Introduction

The Brush-tailed Phascogale or Tuan *Phascogale tapoatafa* is a medium-sized carnivorous dasyurid that lives on a diet of large arthropods, moths and other insects as well as small reptiles, mammals and birds (Cuttle 1983). It has recently been proposed that the Phascogale is also an important pollinator of eucalypt tree species (Goldingay 2000). The Phascogale is monoestrous with all males of the species dying before they reach the end of their first year, females sometimes live for over two years but a single breeding season is the norm. Previous studies in forested habitat have shown that female Phascogales forage over home ranges of 30-60 ha that do not overlap, while males forage over areas greater than 100 ha. Male home ranges overlap extensively with both females and other males (Traill and Coates 1993; Soderquist 1995a). Even in good quality forested habitat such as The Whipstick (immediately north of Bendigo, central Victoria), the female home range has been estimated at up to 60 ha (Soderquist 1995a). It has also been reported that there is a tendency in this species for groups of females (each with an individual home range) to be surrounded by extensive vacant habitat, further reducing the density of the animal and breeding possibilities (Soderquist 1995a). Interestingly, a recent study of Phascogales in remnant roadside vegetation on fertile soil with a high density of large trees revealed a small home range of 5 ha (van der Ree *et al.* 2001). Detailed information on the biology of the species can be found in Cuttle (1983), Halley (1992) and Soderquist (1993a, b, 1995a, b).

The Brush-tailed Phascogale is considered to be rare in Victoria and is listed under the Flora and Fauna Guarantee Act, 1988 (Menkhorst 1995; Humphries and Seebeck 1997). In recent times the range of this species in Victoria has decreased markedly, such that it is now considered locally extinct in large areas of its former range, including Gippsland. The stronghold of the Phascogale is now the Box-Ironbark forests, and possibly remnant roadside vegetation, of central Victoria (Menkhorst 1995; van der Ree *et al.* 2001). Its short life span and the inherently low density of this animal, especially in disturbed habitat, make it vulnerable to local extinction. The fragmentation of the Box-Ironbark forest habitat exacerbates this sit-

[1] 13 Ryan Street, East Brunswick, Victoria 3057

uation. It is therefore likely that large intact areas of suitable forested habitat are necessary for the conservation of the Phascogale in Victoria.

The detection of the Phascogale has been problematic due to its low density, nocturnal habits and generally cryptic behaviour. The Phascogale was only confirmed to occur in Rushworth Forest in the early 1990s (Soderquist *et al.* 1996).

Rushworth Forest, located between the township of Rushworth in the north and Graytown in the south, is the largest remaining contiguous tract of Box-Ironbark forest in Victoria at approximately 25,000 to 32,000 ha in size (depending upon definition of forest boundaries). Rushworth Forest occurs on nutrient-poor soils on the foothills on the north of the Great Dividing Range and is abutted by Redcastle State Forest to the west and Puckapunyal Army Reserve to the south. The forest is dominated by Red Ironbark *Eucalyptus tricarpa* and Grey Box *Eucalyptus microcarpa*. In the southern part of the forest is Mt Black Flora Reserve, which boasts a more mature forest featuring Red Stringybark *Eucalyptus macrorhyncha*. A more detailed description of the location, extent and vegetation of Rushworth State Forest can be found in recent reports (ECC 2000; Myers and Dashper 1999; Wilson and Bennett 1999). The forest is used mainly for the extraction of hardwood for firewood and fence posts (ECC 2000) and management practices have resulted in a high density of small diameter trees and a paucity of mature, large-diameter hollow-bearing trees within the forest.

In order to gain more information about the Phascogale population of Rushworth Forest the Fauna Survey Group (FSG) of the Field Naturalists Club of Victoria (FNCV) has been studying the distribution and abundance of this species over the last six years, using a combination of nestboxes, trapping, stagwatching and spotlighting.

Methods

The FSG of the FNCV conducted regular surveys of the Rushworth Forest from June 1994 to March 2001 on a four to six monthly basis using a combination of trapping, spotlighting and nestbox inspection. The initial surveys conducted by the FSG from June 1994 to early 1996 used only trapping and spotlighting to detect the species.

ATCV nestboxes

In late 1995 the FSG began monitoring a series of 92 nestboxes that had been erected in 1992 by Australian Trust for Conservation Volunteers (ATCV) with the aim of determining the presence of the Phascogale in Rushworth Forest (Soderquist *et al.* 1996). All of the nestboxes have similar dimensions (22 cm high, 22 cm deep and 40 cm wide) with an entrance hole diameter of ~35 mm, which was designed to allow the entry of Phascogales but prevent larger animals using the nestboxes. The entrance hole diameter also allows other small animals such as the Sugar Glider *Petaurus breviceps*, Yellow-footed Antechinus *Antechinus flavipes* and Feathertail Glider *Acrobates pygmaeus* to use these boxes.

The nestboxes are located at 23 sites, with each site consisting of four nestboxes along a transect with the nestboxes spaced at 50-70 m intervals giving a total length to each transect of 150-210 m. Most lines of nestboxes are located in gullies or along creek lines scattered through the southern, central and eastern sections of Rushworth forest. The nestboxes are located on the eastern side of the tree approximately 3-4 m above ground. The quality of manufacture of these nestboxes was very variable and as a consequence repair of a reasonable proportion of these nestboxes has been carried out on a regular basis. Some of these nestboxes have now been replaced with nestboxes of differing designs.

From November 1999 the FSG ceased monitoring nine of the ATVC nestbox sites (36 nestboxes) located in the centre and south of the forest as in nine surveys over four years there had never been any signs of Phascogale use (i.e. scats or nesting material). These nestboxes also did not house Sugar Gliders or other species.

Large FSG nestboxes

In December 1995 the FSG erected 50 nestboxes at five sites in the northern and central areas of the forest. These are large, deep boxes (37 cm high, 28 cm deep and 24 cm wide) with a 34 mm diameter entrance hole and were mounted on the eastern side of the tree approximately 5 m above the ground. These nestboxes were erected in lines of ten, and were paired with 50 m between two boxes then ~300 m to the next pair of nestboxes. These nestboxes were inspected on average twice a year, or a total of nine times since they were erected.

Small FSG nestboxes

Three new nestbox sites were established by the FSG in November 1999 in the central region of the forest. These were located between 1-2 km west of the two ATCV nestbox sites that had the highest Phascogale occupancy rates. A floristic survey was carried out prior to erecting the small FSG nestboxes (see below). The sites were chosen based on the absence of large diameter trees and stags at the site. Each site had four nestboxes along a transect with the nestboxes spaced at 50-70 m intervals and were mounted on the eastern side of the tree approximately 3 m above the ground. These boxes were obtained from Keelbundora (La Trobe University Wildlife Reserves). They have an entrance hole of 35 mm diameter located in the lower corner of the box that leads into a small chamber that the animal has to climb up to reach the main chamber. The boxes are 24 cm high, 18 cm deep and 18 cm wide, therefore having a small internal volume.

Nestbox observations

Nestbox occupancy and contents were recorded by visual inspection. On an irregular basis the contents of unoccupied nestboxes (i.e. nesting material) was removed. The aim of this was two-fold: 1) to determine if the box was being used even if empty at the time of inspection, and 2) to enhance the life of the nestbox as nesting material, especially the green leaf nests of the Sugar Glider, accumulates, becoming heavy and causing the bottom of the nestbox to fail.

Floristic survey around ATCV nestboxes

A floristic study was conducted at each of the 23 ATCV nestbox sites between June 1997 and February 1998. An area of 20 × 150-210 m was marked out around the nestboxes by measuring 10 m from either side of each of the four nestboxes along the transect. This created a rectangular area around the four nestboxes in the transect that due to the variability in distance between nestboxes at each site had an area that ranged from 3000 to 4200 m^2. The number and species of all trees within the marked area were determined at each site. The diameter at breast height (dbh) of each tree was determined using a marked rope that divided the trees into three categories, small (<20 cm), medium (20-45 cm) and large (>45 cm). The number of 'stags' and hollow-bearing trees were determined by observation at each site. These data were standardized by expressing them per ha. The major plant species of the mid-storey and ground-layers were recorded as were the number of coppiced trees. The canopy and mid-storey cover, the amount of ground cover and fallen timber were also estimated.

Trapping

Trapping was conducted throughout the southern, central and northern areas of the forest using a mix of Elliott and small cage traps baited with a mixture of honey, rolled oats and peanut butter, sometimes mixed with vanilla essence, as described in Myers and Dashper (1999). A mix of Elliott and cage traps were placed on the ground in transects with at least 20 m between each trap.

Spotlighting and stagwatching

Spotlighting was conducted on an irregular basis usually beginning 1 to 3 hr after sunset and continuing for 1 to 2 hr. On average groups of 4 to 6 people with two spotlights walked slowly along roads or tracks within the forest. Stagwatches were conducted occasionally during the study period and usually involved a group of 8 to 15 people watching marked trees in an area of 1 to 2 ha for a period of one hour around sunset. Chance sightings of Phascogales while walking or driving around the forest at night were also recorded. No Phascogales were seen during daylight hours.

Results

Trapping

On average a low catch rate of 0.003 animals/trap night was obtained with a total of 2316 trap nights (Table 1). All seven Phascogales were trapped at sites less than 2.2 km from Melville's Lookout, which represents a convenient, prominent feature close to the centre of the Mt Black Flora

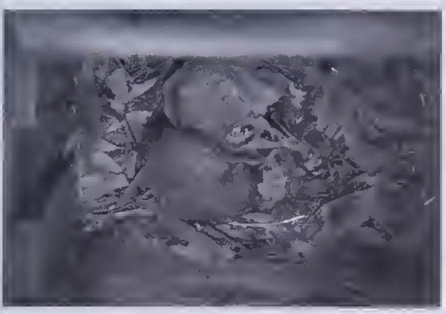

Fig. 1. Brush-tailed Phascogale and Sugar Glider found sharing a nestbox. The nestbox contains a Sugar Glider *Eucalyptus*-leaf nest.

Reserve. Interestingly, all Phascogales trapped were female and these animals were trapped in the months of December, January and April.

ATCV nestboxes

A total of 57 Brush-tailed Phascogales was recorded in the 92 ATCV nestboxes between December 1995 and March 2001. During this time thirteen surveys of these nestboxes were conducted. Of the total of 23 ATCV nestbox sites, Phascogales were never found at 13 sites. Six nestbox sites recorded two or fewer individuals over the whole study period; therefore, the majority of Phascogale records was confined to four nestbox sites.

Of the 57 individual Phascogales recorded in the ATCV nestboxes, 29 sightings were of individual animals. Eleven of the animals sighted were females and their dependent young (one female and seven young and one female with two young, both sightings in November). Three well-developed juveniles (presumably siblings) were found in a single nestbox in January. Five pairs of adult animals, that were presumed to be mating, were observed during May. In May 1999 four adult Phascogales of indeterminate sex were found sharing a nestbox. In another nestbox located only 105 m away a pair of Phascogales were found.

A follow up survey of these nestboxes three weeks later revealed a single Phascogale in each of these two nestboxes. Interestingly, on the second nestbox inspection, an adult Sugar Glider was sharing its nest with a Phascogale (Fig. 1). Both animals appeared to be in good health and were asleep when the box was opened. We have documented the use of Phascogale nests by

Table 1. Number and sex of Phascogales trapped in Rushworth Forest between June 1994 and March 2001. Grid references given refer to the maps Nagambie (7924) and Heathcote (7824). Traps were placed on the ground with intervals of ~20 m between traps.

Date	Trap nights	No of Phascogales caught	Trap site
			MAP 7824CV
June 1994	240	0	166 277
Dec 1994	726	2♀	170 276
April 1995	285	3♀	194 285
Dec 1995	210	0	194 323
Jan 1997	40	0	196 310
Jan 1997	40	0	185 315
Jan 1997	60	0	184 353
June 1997	300	0	198 294
Jan 1998	80	0	196 414
May 1998	26	0	200 267
Jan 1999	166	2♀	200 252
			MAP 7924
Feb 2000	40	0	235 420
Feb 2000	40	0	241 431
May 2000	43	0	298 418
			MAP 7824CV
Mar 2001	20	0	148 318
Total	2316	7♀	

Sugar Gliders (Myers and Dashper 1997) but as far as we are aware, this is the first report of these species sharing nests. Further to this, in May 2000 a Phascogale was found sharing a nestbox with five Sugar Gliders. In the adjacent nestbox were a further two Phascogales.

Floristic survey of ATCV nestbox sites

The surveyed areas around the 23 ATCV nestbox site areas had an average of 220 trees ha^{-1}, with a range of 60-406 trees ha^{-1}. There was an average of 17.6 large trees (>45 cm dbh) per ha. However, this data was skewed by the presence of three sites with high numbers of large trees (40.0, 53.3 and 60.7 trees ha^{-1}), excluding these sites the average was 11.8 trees ha^{-1} with a dbh of >45 cm. There was an average of 152 small trees (<20 cm dbh; range 13-346 ha^{-1}) and an average of 58 medium trees (20-45 cm dbh; range 18-144 ha^{-1}). The actual diameter of the large trees was determined at 12 of the 23 sites, with three of these sites having no trees with a dbh of >60 cm and six sites having less than five trees with a dbh of >60 cm. Twelve of the 23 nestbox sites had less than five stags

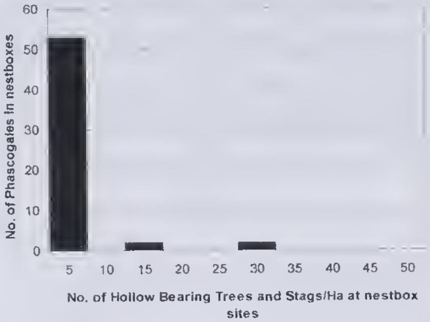

Fig. 2. The relationship between nestbox occupancy by Phascogales and the number of stags and hollow-bearing trees per hectare around nestbox sites.

Fig. 3. Phascogale in an unadorned nestbox. This was a rare occurence as most Phascogales were sighted in nestboxes containing a Phascogale nest or less commonly a Sugar Glider nest. This indicates that this nestbox was not used on a regular basis by the animal.

and/or hollow-bearing trees per hectare with only five sites having more than 20.

Twenty-one ATCV nestbox sites had Red Ironbark *Eucalyptus tricarpa* present, 22 sites had Grey Box *E. microcarpa*, seven sites had Red Box *E. polyanthemos*, whilst only three sites had Red Stringybark *E. macrorhyncha*. This is a reasonable representation of the forest that is dominated by Grey Box and Red Ironbark with Red Stringybarks being confined to rockier, higher ground, especially hill tops. There was an obvious negative relationship between the number of hollow-bearing trees (HBTs) and stags per hectare around the nestbox site and the number of Phascogales using the nestboxes (Fig. 2). Nearly all records of Phascogales in nestboxes (53/57) were at sites where there were fewer than five stags and potential hollow-bearing trees per ha. Four observations of Phascogales were in nestbox sites that had relatively large numbers of HBTs and stags per ha. All of these observations were of single animals and two of these sightings were of an individual in an unadorned nestbox (i.e. no nesting material was present; Fig. 3).

There was no apparent relationship between the species or number of trees per ha, canopy or mid-storey cover or mid-storey and ground layer plant species around a nestbox site and use of that nestbox site by Phascogales. The level of fallen timber was low at all but two nestbox sites. These sites had a relatively high number of stags and HBTs and the nestboxes at these sites had never been used by Phascogales.

Large FSG nestboxes

The 50 nestboxes erected by the FSG in December 1995 are located in five lines, each over a kilometre in length so floristic surveys were not considered feasible. However, a general description of the sites is as follows: Site 1 – good habitat with a relatively high number of hollow-bearing trees and good understorey; Site 2 – variable habitat with some large diameter trees, good understorey in places; Site 3 – a large number of small diameter trees with few large trees; Site 4 – variable habitat with some large diameter trees; Site 5 – hilly, poor soil with little understorey and very few large trees, dominance of Ironbark.

These nestboxes were surveyed nine times between March 1996 and March 2001. No Phascogales have been sighted in these boxes; however, Phascogale scats have been found in two boxes at Site 4. A Phascogale nest was found in a nestbox at Site 5 in March 2001. This nestbox was over half-filled by a Sugar Glider leaf nest and the Phascogale nest was constructed on top of the Sugar Glider nest. Of the five FSG large nestbox sites, 1 and 2 have shown no signs of usage by any species whereas the remaining three nestbox lines have been used extensively by Sugar Gliders with a maximum of 75 individuals found in these 30 nestboxes in August 1998 (Dashper unpubl. data).

Table 2. Phascogale usage of small FSG nestboxes between February 2000 and November 2001. Each site has four nestboxes along a transect with approximately 50 m between boxes. Only one nestbox at each site was occupied at any given time. The nestboxes were erected in November 1999. [a] Phascogales scats found in nestbox. [b] Phascogale scats and nesting material found in nestbox.

Site	Feb 2000	May 2000	Aug. 2000	March 2001	June 2001	Nov 2001
24	0	0	0[a]	0[b]	1	4
25	0	0[a]	0[b]	1	1	3
26	0	2	1	1	1	3

Small FSG nestboxes

These nestboxes have been inspected four times; the initial survey three months after the boxes were erected showed no signs of Phascogale activity (Table 2). The second survey in May 2000 found two Phascogales in a single nestbox (possibly mating) at one site and signs of Phascogale usage at another site. The number of individuals recorded at the three sites increased such that each site was occupied by at least one individual by June 2001 and in November each site had one adult female with young (Table 2).

A floristic study at these three sites detected fewer than five stags or hollow-bearing trees per ha were found in these areas. Two of these sites were dominated by a high density of small diameter Red Ironbark, a situation common within Rushworth Forest. The third site contained more Red Stringybark, a species that does not form hollows suitable for Phascogale usage, even though the bark of this tree is used extensively by Phascogales for nest building (Traill and Coates 1993).

Stagwatching

Two stagwatches were conducted at an ATCV nestbox site that was located in good habitat. Five years of surveys revealed no signs of nestbox use by either Phascogales or Sugar Gliders at this site. Over two nights, seventeen observers were positioned under potential hollow-bearing trees in the area surrounding the nestbox site at dusk. No Phascogales were observed; however, a total of ten Sugar Gliders in three groups was observed emerging from three hollow-bearing trees shortly after dusk. All of these den trees were within 150 m of the unused nestboxes.

A stagwatch conducted around Three Jim's Dam in January 1997 detected a single Phascogale emerging from a large hollow-bearing tree at dusk. The animal descended to the ground, jumped over an Elliott trap and dispersed. Over five years there has been no evidence of Phascogales using an ATCV nestbox site that is within 60 m of the dam.

Spotlighting

Phascogales were rarely sighted during spotlighting. One individual was spotlit approximately 2 km west of Melville's lookout and another animal was found approximately 2 km south of Melville's lookout. One animal was seen in the Whroo area.

Discussion

One of the recommendations of the Flora and Fauna Guarantee Action Statement for the conservation of the Brush-tailed Phascogale was to establish long-term monitoring of important populations (Humphries and Seebeck 1997). The FSG undertook trapping, spotlighting and the erection and monitoring of nestboxes at Rushworth Forest to help meet this recommendation. Detection of Phascogales by trapping and spotlighting was largely unrewarding. Over a seven year period with a total of 2316 trap nights only seven female Phascogales were trapped. All of the animals trapped by the FSG were in areas where mature trees were relatively abundant, mainly in and around the Mt Black Flora Reserve in the south of the forest. We did not trap Phascogales in areas where there were only few large trees and no artificial nestboxes. Only three Phascogales were detected by spotlighting in the forest during the same seven year period and two of these were within the Mt Black Flora Reserve. Although the Phascogale is regarded as a highly cryptic animal this low level of detection indicates a low density, and possibly a patchy distribution within the forest.

Monitoring of the 92 ATCV nestboxes detected Phascogales in fewer than three nestboxes per inspection (3% usage) and most of this occupancy was at two nestbox sites, which accounted for 42 of a total of 57 (74%) recorded individuals. No Phascogales have been sighted in the 50 large FSG nestboxes over the five year study period and only a small number of scats and nesting material detected. The low general usage of fairly randomly sited nestboxes is further indication of a low Phascogale population density. The continued high usage of two specific ATCV nestboxes sites by Phascogales led us to investigate this phenomenon.

It has been anecdotally reported that Phascogales will not use nestboxes if mature trees with natural hollows are present (Soderquist *et al.* 1996; Traill and Coates 1993). Soderquist (1999) found that trees in Box-Ironbark forests with a diameter of <20 cm lack hollows and that trees with a diameter of 20-40 cm have very few hollows. Of trees 40-60 cm diameter, 3-38% had hollows, depending on species. Canopy hollows occur most commonly in trees of >60 em in diameter.

Few trees of greater than 60 cm dbh were detected in this study. Only the number of stags and hollow-bearing trees showed any relationship with nestbox usage by Phascogales. The two ATCV nestbox sites that had high Phascogale usage had no stags in the immediate area and one of these nestbox sites had no potential hollow-bearing trees whilst the other had only 3.1 potential hollow-bearing trees per ha. Ten other ATCV nestbox sites had fewer than five stags and hollow-bearing trees per ha and these ten sites together with the previous two sites accounted for 53 of the total 57 (93%) recorded individuals. This clearly demonstrates that in areas where there are relatively large numbers of hollow-bearing trees, Phascogales rarely use nestboxes. This was confirmed during stagwatches where a Phascogale (and Sugar Gliders) were seen emerging from hollow-bearing trees in close vicinity to nestboxes that had not been used by either species over a five year period.

Interestingly, there were four ATCV nestbox sites that had fewer than five hollow-bearing trees per ha that were not used by Phascogales. Trapping and spotlighting were conducted around these nestbox sites, but no Phascogales were detected. These results could indicate that there were either a number of undetected hollows that were being used by Phascogales in the area or that there are tracts of forest where the animal only occurs at very low density or not at all.

This may be due in part to the life strategy and dispersal of Phascogales. In Box-Ironbark forests female Phascogales have large, mutually exclusive home ranges. Males have even larger home ranges that may overlap the ranges of more than one female as well as other males in adjoining areas (Soderquist 1995a). Phascogales are born in June/July and are reported to remain with their mother until early summer, after which they disperse to establish their own territories (Soderquist and Lill 1995). The female young tend to disperse only a short distant or may usurp the maternal home range. The male young tend to disperse widely and are reported to travel at least 3 km from the natal area (Soderquist and Ealey 1994). The limited dispersal of juvenile females may therefore limit the colonisation of potentially useable habitat that is surrounded by unsuitable habitat and this may constrain the density of this animal in state forests where management practices have produced large areas of mainly small diameter trees.

To help determine if this hypothesis had any credence, the small FSG nestbox sites were established in areas of low stag numbers so that dispersing juvenile females from litters raised in the ATCV nestboxes should be able to disperse to these nestbox sites. The rapid colonisation and usage of these nestboxes are consistent with our belief that large areas of Rushworth Forest support very few Phascogales, for if these areas already supported Phascogales, the nestboxes would be unlikely to have been used, especially by females raising young. These three new nestbox sites, along with the two ATCV nestbox sites, should now form a breeding nucleus for Phascogales within the forest. These results also show that targeting nestbox placement based on a visual floristic survey of the area and proximity to habitat with a good number of stags and potential hollow-bearing trees or recently used nestboxes will greatly increase nestbox usage by Phascogales.

The high usage of these small FSG nestboxes by Phascogales (25% occupancy) is in stark contrast to the lack of usage of the large FSG nestboxes where only two sets of scats and a single nest have been found in five years. The large interior size of the

FSG nestboxes may deter Phascogale use as the only recorded Phascogale nest was in a box that was over half full with a Sugar Gliders' nest. However, Phascogales have been reported to use similar sized nestboxes in the Christmas Hills (Ray Gibson pers. comm.). It is also likely that the low usage of up to three of these nestbox sites could be due to extensive areas of unsuitable habitat surrounding these sites.

Our studies also indicate that in Rushworth Forest, individual Phascogales may use a single nestbox for extended periods of time. This is in contrast to the natural situation where Phascogales have been reported to rarely utilise the same den site on consecutive nights and may use as many as 30 different sites each year (Humphries and Seebeck 1997; Traill and Coates 1993; van der Ree *et al.* 2001). This constant use of a single den site may expose the animal to a higher rate of predation. It has also been noted that in areas with few mature trees, Phascogales will resort to using unsuitable hollows (i.e. too shallow or exposed) that leads to an increase in predation rates (Soderquist *et al.* 1996).

The record of six Phascogales in the ATCV nestboxes in such a small area is a most unusual occurrence at that time of year. Soderquist and Ealey (1994) have reported three male Phascogales in a nest on one occasion and postulated they may have been siblings. The FSG has recorded pairs of Phascogales in nestboxes at Rushworth Forest in the breeding season (May) but never more than two animals. This is the first time to our knowledge that four adult Phascogales have been found in the same nest.

The large nestboxes erected by the FSG have posed some problems for regular monitoring. The nestboxes are very heavy which made attaching them to trees difficult. The height of the nestboxes (~5 m above ground) means that a long extension ladder is necessary to check the boxes. The large distance between nestboxes means that a great deal of time and effort is needed to inspect the boxes. In retrospect the size of the boxes was too large, they were located too high on the tree and having ten nestboxes along a single long transect created inspection problems.

In conclusion, the Brush-tailed Phascogale appears to be patchily distributed through the Rushworth Forest. As a result of management practices in State Forests such as Rushworth there appear to be large areas of the forest that do not have enough large, hollow-bearing trees to act as den sites for Phascogales. The limited dispersal of female Phascogales may also limit colonization of suitable habitat that is surrounded by unsuitable habitat. As such these animals occur at a much lower density in this habitat than could be expected. Therefore, the permanent retention of all large trees (>45 cm dbh) in these forests should be encouraged.

Acknowledgements

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Behaviour and Ecology of the Bottlenose Dolphin *Tursiops truncatus* in Port Phillip Bay, Victoria, Australia: an Annual Cycle

Carol Scarpaci[1,2], Peter J Corkeron[3] and Dayanthi Nugegoda[1]

Abstract
Port Phillip Bay, Victoria is home to a population of Bottlenose Dolphins *Tursiops truncatus*. There is no published information on the seasonality of the ecology and behaviour of this population. This paper reports on this population in the southern end of Port Phillip Bay by land-based observations. Dolphins were continuously observed after first sighting using an instantaneous sampling technique to document focal group activity. Results indicate that Bottlenose Dolphins are present in the study area year round, while the probability of sighting dolphins is influenced by season. The most common group size observed was 2-5 dolphins. The most common behaviour observed was travel (59.9%) followed by feeding (32.1%). Social behaviour (8%) was only documented in summer. The presence of adult-calf groups in the study area throughout the year suggests that the southern end of Port Phillip Bay may serve as a nursery area for the Bottlenose Dolphins. (*The Victorian Naturalist* **120** (2), 2003, 48-54)

Introduction

Port Phillip Bay is located on the south-eastern coast of Victoria, Australia and is home to the only recorded resident population of Bottlenose Dolphins *Tursiops truncatus* in this region. Even though it is the most extensively studied cetacean (reviewed by Shane *et al.* 1986; Würsig 1989), limited publications (Scarpaci *et al.* 2000a, b; Scarpaci *et al.* in press) are available on the community of Bottlenose Dolphins in Port Phillip Bay. Warneke (1995) mentioned the presence of Bottlenose Dolphins along the Victorian Coastline and Bass Strait and referred to a small and apparently resident population of these dolphins in Port Phillip Bay. Scarpaci *et al.* (2000a) monitored the behavioural patterns of Bottlenose Dolphins in the southern end of Port Phillip Bay during spring and summer and suggested that the southern end may be an important calving site for Bottlenose Dolphins in Port Phillip Bay. The study, however, was unable to determine if the southern end of the Bay was used as a habitat by the dolphins throughout the year. Goldsworthy and Dunn (2001) esti-

[1] Department of Applied Biology and Biotechnology, Bundoora Campus, RMIT University, GPO Box 2476V, Victoria
[2] Current address: Science and Food Technology, Victoria University of Technology, PO Box 14428 (W107), MCMC 8001
[3] Norwegian Institute of Fisheries and Aquaculture, N-9291 Tromso, Norway

mate that the population of dolphins in Port Phillip Bay is less than 100 dolphins.

The dolphins of Port Phillip Bay are important to cetacean-based eco-tourism and are subject to five commercial dolphin-swim tour-operators and three dolphin-watching operators. The impact of the growing eco-tourism industry on cetacean populations is still not clearly understood (Constantine and Baker 1996). This study is important to establish baseline behavioural information (hitherto unavailable) to ensure long-term survival and conservation of this population despite the impacts of eco-tourism.

An extensive study in The Bay of Islands, New Zealand by Constantine and Baker (1996) found that Bottlenose Dolphins changed their behaviour on 32% of approaches made by tour-operators. Scarpaci *et al.* (2000b) documented an increase in whistle production by dolphins in the presence of commercial dolphin swim operations in Port Phillip Bay. Other workers have also found that tour-operators impinged on dolphin behaviour because tour-boats followed and stayed with the dolphins (Acevedo 1991; Janik and Thompson 1996).

The southern end of Port Phillip Bay was chosen as a study area for three main reasons: i) all commercial 'swim with the dolphin' programs are congregated in this area; ii) this area has been proposed as a possible marine park by the Victorian Government for the protection of the marine eco-system; and iii) results from a pilot study by the authors indicates that this is the most favoured region by the dolphins (Scarpaci 1997).

Reports of geographically distinct populations of Bottlenose Dolphins have indicated that differences in intraspecific behavioural characteristics exist resulting from specific adaptations needed to survive local ecological conditions (Würsig and Würsig 1979; Shane 1990; Defran *et al.* 1999). No habitat is a replica of another, so if behaviour of Bottlenose Dolphins is influenced by habitat (Defran *et al.* 1999), behavioural characteristics will be unique for each population.

The present study investigated the seasonality of the ecology and behaviour of the Bottlenose Dolphins *T. truncatus* in the southern end of Port Phillip Bay, Victoria over a one-year period in order to understand the requirements of this population. The results presented in this paper are the first records of the behaviour of this population of *T. truncatus* over an annual cycle.

Methods

Study area

Tursiops truncatus were observed in the southern end of Port Phillip Bay, Victoria which extends from Port Phillip Heads (Point Nepean National Park) to the Quarantine Army Station situated in Portsea. The length of the study area is approximately 6 km. Observations were made both with the unaided eye and binoculars (12 × 50).

Research effort

All data presented in this paper are from land-based observations in the study area. Data collection was begun in March 1997 and concluded in March 1998. Field time was a total of 384 hr, of which 45.8 hr was spent in direct observation of dolphins (11.9% contact rate). Once located, the observer on land tracked the sighted dolphins by walking parallel to their movement and observing them for periods of 15 min to 3.7 hr. Land observations were used to ensure that dolphin behaviour was not affected by the presence of a research vessel (Würsig and Würsig 1979) and to estimate the time spent by the dolphins in this area. During all observation sessions only one observer was responsible for recording behavioural categories. This negated bias as a result of differences in individual interpretation.

The height of the observation point was 3 m above sea level. This observation point allowed the observer mobility within the study site. The same observation point was used throughout the study.

Habitat

The following variables were recorded at every sighting: date, time, location, tidal state, group composition (adults or calves), group size and distance from shore. Distance from shore was estimated by referring to buoys in the water whose distance from shore was known. Positions of dolphins in the study area were determined with reference to landmarks. Seasons were defined as follows: summer: December to

February; autumn: March to May; winter: June to August and spring: September to November. Hours of observation were consistent throughout the study during the daylight hours of 0900 to 1700 hr. Field observations were restricted to Beaufort sea states of 2 or less.

Behavioural sampling

Focal group sampling was used to document behaviour by the observer (CS) using both a 5 minute scan sample and continuous sampling for behaviour. This required the observer to record the behaviour of the group by determining what activity all or the majority of the group were engaged in (Mann 2000). Focal groups were used because it was not possible to identify individual dolphins accurately. Focal group activity was documented immediately on to prepared data sheets.

The behavioural activities of the dolphins were grouped into three categories: travel, social and feeding, as defined by Shane (1990). Travel behaviour was a steady movement of dolphins in one direction with no indication of feeding behaviour. Typical feeding behaviour observed consisted of erratic swimming, with dolphins often chasing fish at the surface of the water (prey species observed included Garfish *Hyporhamphus australis* and squid *Sepioteuthis australis*), multi-directional diving and feeding circles. Social behaviour consisted of aerial leaps, mating, rubbing, biting, touching and splashing. Group size was a visual estimate of the number of individuals within a group.

The numbers of dolphins observed were grouped into seven categories: 1 dolphin; 2-5 dolphins in a group; 6-10; 11-15; 16-20; 21-25; >25 dolphins. Categories were used rather than exact individual numbers due to difficulties encountered when trying to determine exact numbers especially with groups exceeding 10 dolphins.

'Calves' refers to foetal fold calves in this study, defined as an individual that was closely associated with a fully-grown dolphin and was either one-third the size of its accompanying adult, or had visible foetal folds. This is to ensure that calves were not confused with juveniles or calves from previous seasons.

Data analysis

To determine if the probability of sighting dolphins was influenced by season in the study area a Z test was applied (Albright *et al.* 1999). Data collected on the habitat and behaviour of the dolphins were analysed using the non-parametric Kruskal-Wallis test to determine if the means in any category were significantly different. The Mann-Whitney U test was then applied to the data for multiple pairwise comparisons of groups. Data on the length of time dolphins stayed in the study area and the time spent engaging in different behaviours were tested for homogeneity of variances by applying the Bartlett's test. Since the data were heterogeneous ($p = 0.001$), log-transformed data tested for homogeneity of variance was analyzed using a one-way analysis of variance. The statistical programs used were SPSS (8.0) and Mini-Tab (11.2) on an IBM computer. The null hypothesis was rejected if $p < 0.05$.

Results

The probability of sighting dolphins in the study area were significantly influenced by season (Fig. 1). The probability of sighting dolphins on a field visit was significantly greater in summer than in autumn ($Z = 2.34$, $p < 0.01$), winter ($Z = 4.18$, $p < 0.01$) and spring ($Z = 2.46$, $p < 0.01$) in the study area.

The mean length of time dolphins stayed in the study area per visit in each season was significantly different ($F = 3.12$; $df = 3, 71$; $p = 0.031$), being greatest during autumn (56 ± 35.9 (SD) minutes) followed by summer (39.4 ± 34.6), spring (28.2 ± 17) and winter (28 ± 17.0).

The most common group size observed was 2-5 dolphins and 33.6% of the groups were in this category. Results indicate that time spent by different group sizes of Bottlenose Dolphins in the study region was not significantly different from each other ($\chi^2 = 10.9$; $df = 6, 140$; $p = 0.09$). However, the time spent by dolphins in group sizes 2-5 ($U = 286.5$, $p = 0.027$) and 6-10 ($U = 144.5$, $p = 0.003$) was significantly greater than the time spent by solitary dolphins (i.e. group size = 1) in the study area.

Dolphins were observed to spend most of their time throughout the year travelling

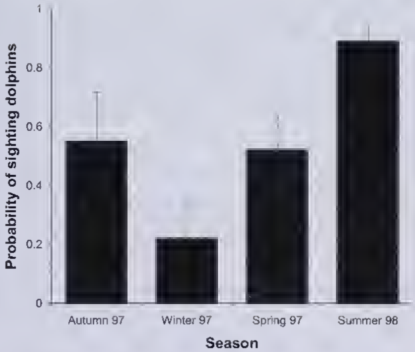

Fig. 1. Probability of sighting Bottlenose Dolphins in the study area during four seasons.

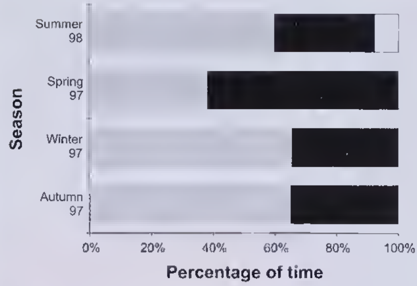

Fig. 2. The proportion of time Bottlenose Dolphins were engaged in different behaviours according to season. Grey bars, travelling; black, feeding; white, social behaviour.

(59.9%) in the study area followed by feeding (32.1%) and the least time in social behaviour (8%). However, the mean length of time dolphins engaged in each type of behaviour on any observed occasion was not significantly different from each other ($F = 0.86$; $df = 2, 109$; $p = 0.427$).

Seabirds and seals were often present when dolphins were feeding. Australian Gannets *Sula serrator* and Australian Fur Seal *Arctocephalus pusillus* were the most common species observed when dolphins were feeding.

A preliminary regression of proportions indicates that no significant difference ($p = 0.715$) was found in the time the dolphins were engaged in different behaviours according to season (Fig. 2). Travel behaviour was the most common activity observed in every season with the exception of spring. Social behaviour was only documented during summer (Fig. 2).

Calves were observed in every season. The majority of adult-calf groups were observed in autumn and the fewest in spring (Table 1). No significant difference ($p > 0.05$) was found in the number of adult-calf groups observed during different seasons.

Discussion

Seasonal factors

The results shown in Fig. 1 demonstrate that *T. truncatus* are present throughout the year in the study area; however, the probability of sighting dolphins in this study area is influenced by season. Lear and Bryden (1980) observed Bottlenose Dolphins throughout the year in Moreton Bay, Queensland; however, the number of animals observed was greater in winter than summer. Shane (1980) found that dolphin abundance declined from summer to fall, increased in winter and declined in spring near Port Aransas, Texas. In the present study, it is possible that the dolphins' movements are influenced by the increasing water temperatures in Port Phillip Bay during the summer months. This, however, may not be the case in the two studies mentioned earlier (Lear and Bryden 1980; Shane 1980) as temperatures in the tropics (e.g. Queensland) are less variable than in temperate Victoria.

It is possible that the home range of the dolphins of Port Phillip Bay changes according to season as suggested by the low probability of sighting dolphins in the study area during the colder months of the year and the short duration of stay in the study area during spring and winter. Caldwell (1955) provided the first evidence for *T. truncatus* having a home range. Connor and Smolker (1985) reported that Bottlenose Dolphins in Western Australia frequented the same coastal region for over 20 years. Several authors (Irvine and Wells 1972; Wells *et al.* 1980; Irvine *et al.* 1981) have documented home ranges of Bottlenose Dolphins in the west coast of Florida and determined that dolphins used certain parts of their home range more often during particular seasons. The study area in our report was used in all seasons by the dolphins suggesting that this is part of their home range. However, the intensity

Table 1. Percentage sightings of adults and calves in the study area.

Season	Adults	Adults and Calves
Autumn 97	60	40
Winter 97	75	25
Spring 97	87.5	12.5
Summer 98	71.4	28.6

of use differed according to season.

The increase in the sightings of dolphins during summer could also suggest the presence of transient dolphins migrating temporarily into the Bay for feeding and breeding. No photo-identification of dorsal fins is available in the peer-reviewed scientific literature for these dolphins and we are unable to distinguish transient from resident dolphins. Transient Common Dolphins *Delphinus delphis* were documented by Scarpaci *et al.* (1999) while other cetaceans such as Southern Right Whales *Eubalaena australis* have been sighted by locals in the Bay.

The length of time dolphins stayed in the study area was also influenced by season. Even though dolphins were sighted more readily in the study area during summer, the period of time they remained in the study area per visit was less than in the autumn. Based on ticket sales for car-trailer parking in the marina located near the study area it may be construed that boating activity increased greatly during the summer months (Michael Doyle, Mornington Peninsula Council, pers. comm.). Recreational use of Port Phillip Bay is at its maximum during the summer due to the long school holidays, warmer weather and the presence of commercial 'swim with dolphin' charters.

In Sarasota, Florida, Bottlenose Dolphins share their environment with boats (Wells and Scott 1997) as do the dolphins in Port Phillip Bay. Results of injuries to dolphins believed to be caused by boats in Sarasota were documented from 1983 to 1996 (Wells and Scott 1997). Results indicated that these collisions were tightly correlated with periods of higher than normal boat activity. It has been suggested that boat traffic can affect the distribution, behaviour and energy requirements of Bottlenose Dolphins and other toothed whales (Richardson 1995; Wells and Scott 1997). It is possible, therefore, that dolphins enter the study area in Port Phillip Bay more readily during summer; however, conditions are not favourable due to the presence of heavy boat traffic and they depart quickly.

Group size

Group size is highly variable for Bottlenose Dolphins ranging from one individual to more than 100. However, *T. truncatus* are generally found in small groups of 2-15 individuals (Shane *et al.* 1986; Corkeron 1990; Bearzi *et al.* 1997). The group size most commonly observed in our study area was 2-5.

Behaviour

The results presented in this paper indicate that travel behaviour was the most common activity observed within 6 km of Port Phillip Heads (opening of the Bay) followed by feeding behaviour in all seasons except in spring 1997. Ballance (1992) reported that Bottlenose Dolphins in the Gulf of California, Mexico spent 61% of their time feeding in areas within 5.5 km of an estuary mouth and 22% of their time travelling. However, in areas farther than 5.5 km from an estuary mouth 61% of their time was spent travelling followed by feeding. A study conducted in southern Texas cited in a review by Shane *et al.* (1986) found that travel behaviour was significantly greater than all observed behaviours in winter until middle spring and the first month of summer. Spring accounted for a peak both in social activity and the presence of calves (10.6%) in southern Texas. Feeding occupied approximately twice as much time during the end of summer until the first month of winter and the last month of spring (Shane *et al.* 1986).

In this study, dolphins were observed to increase their feeding time in spring and social activity was only documented during the summer months. In a study conducted on Bottlenose Dolphins in the Newport River Estuary, North California, dolphins were observed during summer to spend most of their time socializing followed by travelling and then feeding (Jacobs *et al.* 1993). However, during fall the reverse pattern occurred with social behaviour being the least observed and feeding the most commonly observed behaviour (Jacobs *et al.* 1993). The results in the present study indicate social behaviour during the summer months only. However, unlike the findings of Jacobs *et al.* (1993), it was the least commonly observed behaviour in summer. The Bottlenose Dolphins in San Diego County, California similarly spent most of their time travelling followed by feeding, socializing, playing and resting (Hanson and Defran 1993).

The dolphins of Port Phillip Bay selected to engage in social behaviour during summer when boat traffic was at its highest. Shane (1990) compared behavioural activities of Bottlenose Dolphins at two different sites and found that social behaviour was highest in the area of the heaviest boat traffic in spite of boat noise and the potential threat of being hit by a boat. Shane (1990) suggested that the aerial leaps during social activity may not simply be social activity but may serve another function, e.g. allow the dolphins to see approaching vessels which may be a hazard. In contrast, Janik and Thompson (1996) reported that the number of surfacings decreased significantly after a dolphin-watching boat approached a group of Bottlenose Dolphins.

These previous studies and the results of our own indicate the diversity of seasonal behavioural patterns evident in different populations of dolphins and thus the importance of studying individual populations before they are exposed to commercial pressures such as commercial tour-operators. It is probable that no other population will provide a suitable model for the management of a given localized population.

Calves

Calves were observed throughout the year in the study site. A study conducted by Barco *et al.* (1999) on Bottlenose Dolphins in Virginia Beach suggested that dolphin distribution was influenced by calf rearing requirements. Scott *et al.* (1990) found that females with neonates spent more time in certain geographic areas. These nursery areas have been described by Scott *et al.* (1990) and Wang *et al.* (1994) to be protected, shallow and high in prey availability. The study site in Port Phillip Bay is reputed to be a fertile fishing spot. For example, Southern Squid *Sepioteuthis australis*, a common prey species of Bottlenose Dolphins (Cockcroft and Sauer 1990), concentrates in the study area to spawn (Hall and MacDonald 1996). Also, the Bay is sheltered during the prominent south-easterly winds, possibly providing shelter for inexperienced calves. It is possible that this study site is a nursery area for the Bottlenose Dolphins in Port Phillip Bay.

Conclusion

The Bottlenose Dolphin community of Port Phillip Bay, Victoria has been exposed to the eco-tourism industry before a comprehensive evaluation of the ecological and behavioural requirements of these dolphins was made. Our study indicates that while the population of dolphins in Port Phillip Bay exhibits some similarities to populations of dolphins in other areas, the seasonality of their behaviour is different. It is hoped that these results, which provide the first record of their ecology and behaviour over an annual cycle, will aid in the management and conservation of this population.

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Distribution of Logs in a Dry Sclerophyll Forest, Brisbane Ranges, Victoria

Lindy M Banks[1] and Andrew F Bennett[1]

Abstract

Fallen timber is an important habitat resource for small vertebrate and invertebrate animals in forests. This exploratory study investigated the pattern of distribution of fallen timber (here termed 'logs') in a dry sclerophyll forest in the Brisbane Ranges, Victoria, by sampling transects located in gully, mid-slope and ridge positions, at each of 10 sites. Gullies supported a significantly higher density and volume of logs than ridges. The lowest abundance of logs was on ridges. The mean volume of logs was 98.6 m^3/ha for gullies, 38.5 m^3/ha at mid-slope positions and 13.1 m^3/ha for ridges. The volume of logs at transects was significantly positively correlated with the density of larger trees (diameter >40 cm). A number of animal species in the Brisbane Ranges potentially use logs as a resource for shelter, foraging or perching, and hence the retention of woody debris will aid in habitat management. The uneven distribution of logs in relation to forest topography and the size structure of trees suggests that gullies, and forest stands with many large trees, are likely to be important habitats for species that use fallen timber. (*The Victorian Naturalist* **120** (2), 2003, 55-60)

Introduction

Woody debris is an important component of temperate forests throughout the world (Harmon *et al.* 1986; Lee *et al.* 1997; Kirby *et al.* 1998; Stewart and Allen 1998; Lindenmayer *et al.* 1999). Three main categories of woody debris can be recognized: fallen dead wood, standing dead trees or dead wood on living trees, and stumps (Kirby *et al.* 1998). In this study we are concerned with the distribution of fallen wood, including branches and trunks, which are here termed 'logs'.

Logs add to the structural diversity of a forest and have an important role in the functioning of the forest ecosystem. They influence nutrient cycling processes by their rate of decomposition, they provide fuel for fires, and they modify the movement of water and soil on slopes (Kirby *et al.* 1998; Stewart and Allen 1998). Logs also provide resources for many species of plants and animals in forests. They are used for shelter and refuge, as breeding sites, as a complex foraging substrate, or as a pathway for movement, by a wide range of small vertebrate and invertebrate animals (Harmon *et al.* 1986; Lee *et al.* 1997; Kirby *et al.* 1998). They also host a variety of moss, lichen and fungal species, and provide shelter for seedlings of vascular plants (Harmon *et al.* 1986; Lee *et al.* 1997; Kirby *et al.* 1998).

Many factors affect the development of dead timber and the distribution of logs within a forest. Wind, disease, lightning, water logging and drought can all influence the process of tree or limb death (Kirby *et al.* 1998), while factors such as vegetation type, slope position, aspect, fire regime and forest management may affect the distribution and abundance of logs (Harmon *et al.* 1986; Kirby *et al.* 1998). There are few published accounts of the distribution and abundance of logs in temperate forests in Australia. These include reports on logs in tall wet Mountain Ash *Eucalyptus regnans* forests (Lindenmayer *et al.* 1999), dry box-ironbark forests (Laven and Mac Nally 1998) and riverine forests of River Red Gum *E. camaldulensis* (Mac Nally *et al.* 2001).

This paper reports an exploratory investigation of the spatial pattern and abundance of logs in a dry sclerophyll forest in the Brisbane Ranges National Park, Victoria. In a major review in North America, Harmon *et al.* (1986) reported that logs are not evenly distributed across forest landscapes, but vary in relation to vegetation type and topography. Therefore, the objective of the current study was to test the hypothesis that the density and volume of logs, a habitat resource for wildlife, varies in relation to slope position in the forest landscape.

Study Area

The Brisbane Ranges National Park (hereafter termed the Brisbane Ranges) is

[1] School of Ecology and Environment, Deakin University, 221 Burwood Highway, Burwood, Victoria 3251

located 80 km west of Melbourne. The Brisbane Ranges are situated on the edge of a plateau of Ordovician rocks (sandstone, siltstone, slate and shale) with hills rising sharply in places to a maximum elevation of 440 m (Hampton 1971; Parks Victoria 1997). The soils overlaying the parent material are mostly infertile and moderately erodible (Parks Victoria 1997). It is a relatively dry area, lying in a rain shadow of the Otway Ranges (Land Conservation Council [LCC] 1973), with average annual rainfall varying from 500 mm at low elevations to 700 mm at high elevations.

This study was centered on Aeroplane Road in the north-east of the Brisbane Ranges (37°45' S, 144°18' E). The vegetation has been described as grassy woodland to open forest, co-dominated by Red Stringybark *E. macrorhyncha* and Long-leaved Box *E. goniocalyx* (Hampton 1971), and was mapped by the Land Conservation Council (LCC 1973) as open forest 1 – woodland 1. The main species in this classification are Red Stringybark, Long-leaved Box, and Red Box *E. polyanthemos*. Red Ironbark *E. tricarpa* also occurs widely in this area.

Methods

Ten sites were selected, commencing from the junction of Aeroplane Road and Reids Road. Sites were regularly positioned 500 m apart along Aeroplane Road, with one site each along Mistletoe Track and Red Ironbark Track. This general area was chosen to minimise environmental variation and to sample the same vegetation type. At each site, a transect was located in the gully, at the mid slope and on the ridge, a total of 30 transects in all. From the starting point, each transect was measured for 50 m in a south-easterly direction following the slope contour. A 50 × 10 m transect (500 m^2 = 0.05 ha) was used for measuring logs, with a broader transect of 50 × 20 m (0.1 ha) used to record the tree species composition and size-class structure of trees.

The diameter and length of every log (>10 cm diameter) along each transect was measured. Logs vary in diameter along their length, and so measurement was made at an approximate mid-log length point. Logs were included only if at least 50% of the log was within the transect boundary. Tree species (>10 cm diameter at breast height (dbh)) were also recorded, with each tree allocated to a diameter size-class, namely 10-20 cm, 20-40 cm, 40-60 cm and 60-80 cm. Multiple stems below breast height on a tree were measured separately. Dead trees were also noted. Tree diameter was initially measured, but with experience diameters could be confidently assigned to size classes by visual estimate. Trees that were difficult to estimate were measured. Cut tree stumps within each transect were also counted as an indicator of logging history.

Log densities and volumes were converted to a per ha basis for analysis and comparison with other studies. Data was tested for normality and transformed using a logarithmic transformation. Two-way analysis of variance was used to test the effect of site and slope position on the density and volume of logs. *Post hoc* analysis (Student-Newman-Keul test) was run to determine where any differences lay. Correlation was used to test the relationship between log volume, log density and the density of larger trees (>40 cm dbh) at each transect.

Results

The dominant tree species at the 10 study sites were Red Ironbark, Red Stringybark, Red Box and Long-leaved Box. Red Ironbark was the most widespread species at ridge transects, present at all 10 sites. At mid-slope transects, Red Ironbark (n = 6 sites), Red Stringybark (n = 4) and Long-leaved Box (n = 3) were most frequent. A greater range of species occurred in gully transects, with Red Stringybark, Red Box, and Messmate *E. obliqua* each occurring at three sites. Swamp Gum *E. ovata*, Yellow Box *E. melliodora* and Black Wattle *Acacia mearnsii* occurred only in gullies. The average height of trees varied between slope positions, with a trend for a decrease in height as elevation increased from gullies (mean 12.6 m, range 9-20 m) to mid-slope (mean 10.4 m, range 8-14 m) to ridges (mean 7.7 m, range 6-9 m).

There was no evidence of recent logging or fire at the sites studied. At half of the transects, no cut stumps were recorded. For the remainder, there were from 1-3 stumps per 0.1 ha transect, except for one gully transect at which 9 cut stumps were recorded.

Log characteristics

A total of 471 logs were measured over the ten sites. Logs ranged in length from 0.3 to 19.7 m, and diameters ranged from a minimum of 0.1 to 0.65 m. The density and volume of logs varied considerably between transects. Log density ranged from 100 to 780 logs/ha, while log volume ranged from 2.2-327.8 m^3/ha. However, few transects (5 of 30, 17%) had a log volume of >100 m^3/ha.

Comparison between topographic positions

There was no significant difference in the density of logs between sites ($F = 1.74$, $p = 0.153$), but there was a significant difference between topographic positions ($F = 5.18$, $p = 0.017$). *Post hoc* comparison showed that the density of logs on ridges differed significantly from that in gullies. Mid-slope positions did not differ significantly from either gullies or ridges. The lowest density of logs was on the ridges.

Similar results were found for the volume of logs. There was no significant difference in the volume of logs between sites ($F = 1.69$, $p = 0.163$), but there was a significant difference between positions on the slope ($F = 9.74$, $p = 0.001$). Gullies and mid-slopes differed significantly from ridges with the lowest volume of logs on the ridges (Fig. 1). Mean log volumes for slope position were 98.6 m^3/ha in gullies, 38.5 m^3/ha at mid-slopes and 13.1 m^3/ha on ridges.

Relationship with tree characteristics

Most trees (67.5%) recorded at transects were small in diameter (10-20 cm), and only 5.3% of trees had a diameter >40 cm. There were only 0.8% of trees with diameter of >60 cm. Large trees were mainly found in gully areas (i.e. 56% of all trees >40 cm dbh) with fewer at midslopes (31%) and ridges (13%). Many of the smaller trees (<40 cm) at the study sites are from coppice regrowth.

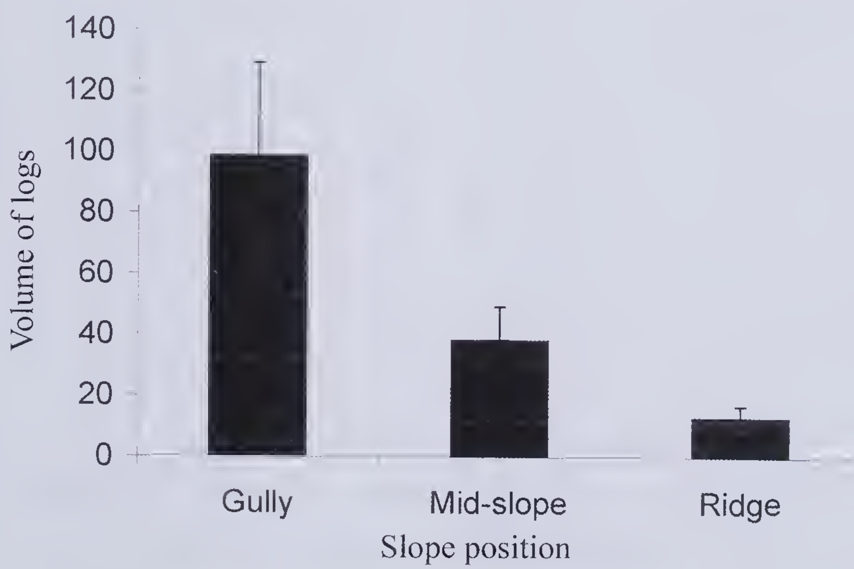

Fig. 1. Volume of logs (m^3/ha) at different positions on the slope at sites in the Brisbane Ranges. Values are means $\pm$ 1 SE.

The density and volume of logs at transects were both significantly negatively correlated with the overall density of trees ($r = -0.399$, $p = 0.029$; $r = -0.481$, $p = 0.007$ respectively), such that logs were more abundant where there was a lower tree density. Conversely, log volume was positively correlated with the density of larger trees (diameter >40 cm) ($r = 0.637$, $p < 0.001$). As the number of large trees increased, so too did the volume of logs (Fig. 2). There was a similar relationship for the density of logs ($r = 0.584$, $p = 0.001$).

Discussion

Patterns of distribution of logs

No differences were found in the density and volume of logs between study sites, indicating that the 10 sites were relatively uniform in forest structure. However, position on the slope was an important influence on both the density and volume of logs (>10 cm diameter) (Fig. 1).

Gullies contained the highest density and volume of logs. This may be, in part, due to the steepness of the slopes, because on steep slopes redistribution of logs can occur (Harmon *et al.* 1986). Lower slopes are likely to have a higher accumulation of logs because they retain fallen logs and also receive them from upslope (Harmon *et al.* 1986). Gullies also tend to have larger and taller trees than on slopes, which can be attributed to gullies providing moister environments with richer soils that leads to greater plant growth (Soderquist and Mac Nally 2000). Logs on the forest floor result from the shedding of limbs, or from entire trees falling (Lindenmayer *et al.* 1999; Lee *et al.* 1997), and consequently it is not surprising that there is a greater abundance of logs in gullies. Trees on ridges were generally shorter and smaller in diameter than those at lower positions, a consequence of dryer, harsher conditions, resulting in a lower production of logs.

The role of large trees in the production of logs was indicated by the positive correlation between the density of larger trees

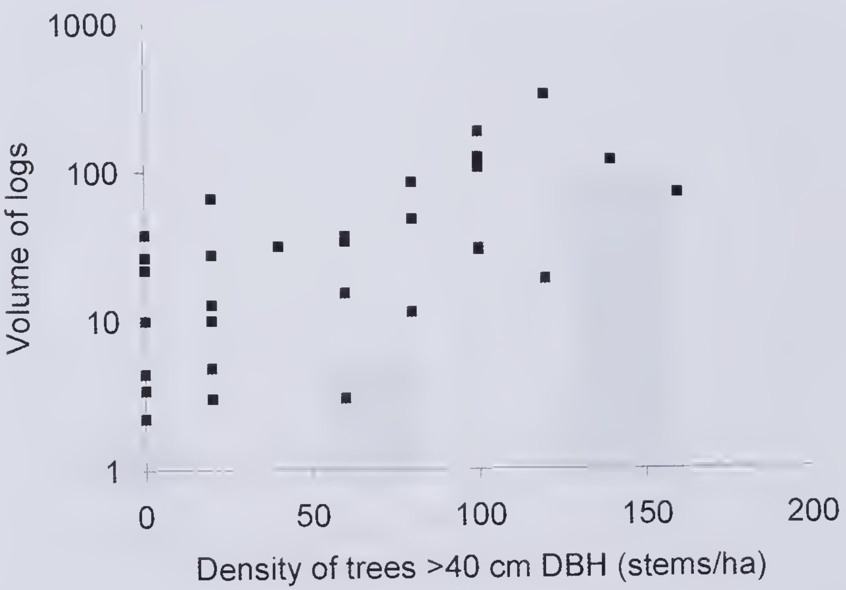

Fig. 2. Relationship between log volume (m^3/ha) and the density of trees >40 cm diameter at the Brisbane Ranges. Note that log volume is plotted on a logarithmic scale.

(diameter >40 cm) and the number and volume of logs (Fig. 2). The greater the number of large trees, the higher the volume of logs. The relatively few large trees found in this study (only 5% of trees were >40 cm dbh) were mainly located in gully areas.

Comparison of log volume with other forest types

Although there has been no logging in this part of the national park for at least 50 years, it is a relatively young forest with many trees being coppice regrowth. The volumes of logs differed between positions on the slope, with an average of 98.6 m^3/ha in gullies, 38.5 m^3/ha at mid-slopes and 13.1 m^3/ha on ridges. These results are comparable with forests in several other studies. For example, Aspen-dominated boreal forests in Canada were estimated to have 61 m^3/ha for young stands (20-30 years) (Lee *et al.* 1997) and log volume in Douglas Fir forest (<80 years) in Oregon/Washington was estimated to be 248 m^3/ha (Spies *et al.* 1998). Mountain Ash forests (20-30 years) in the Central Highlands of Victoria and Messmate forests in Tasmania had higher average log volumes of 342 m^3/ha and 174-455 m^3/ha, respectively (Lindenmayer *et al.* 1999).

However, the volume of logs in this study was high in comparison with dry forests in the box-ironbark region in central Victoria where estimates of <10 m^3/ha (Laven and Mac Nally 1998), and from 0-45 m^3/ha for different forest types (Bennett unpublished), have been recorded. The abundance of logs in a forest reflects not only the forest productivity, but also past events in forest history and management. Lindenmayer *et al.* (1999) noted that log volumes in Mountain Ash forests may be strongly influenced by the legacy of past events, such as fire or wind storms, with logs remaining on the forest floor long after the event. Similarly, in box-ironbark forests the present scarcity of logs can be attributed to the history of logging and the demand for firewood.

Use of logs by animals

Logs provide a habitat resource for a wide variety of animals, including amphibians, reptiles, birds and mammals (Harmon *et al.* 1986). Many factors affect whether individuals will use logs, including the size of the log, the state of decay, the species and the overall abundance of logs (Harmon *et al.* 1986). As a log decays, small animals (such as invertebrates and reptiles) use internal microhabitats in the log including the space underneath loose bark. In later stages of log decay, invertebrates and fungal fruiting bodies provide increased food for vertebrates that use the logs (Harmon *et al.* 1986).

Surveys of mammals in the Brisbane Ranges (Hampton 1971; Conole and Baverstock 1988) have identified several species that may be affected by structural attributes of the forest-floor environment. Two species in particular, the Short-beaked Echidna *Tachyglossus aculeatus* and Agile Antechinus *Antechinus agilis*, are likely to use logs for foraging and shelter.

Echidnas cannot cool themselves by sweating, panting or licking, and shelter may be important to regulate heat (in both hot and cold months) (Smith *et al.* 1989; Wilkinson *et al.* 1998). Such shelter includes hollows in logs and depressions under logs. Smith *et al.* (1989) reported foraging by Echidnas at the base of logs and noted that such activity did not change seasonally. The Agile Antechinus is a small insectivorous marsupial that in dry forests is often associated with high densities of logs (Menkhorst 1995). In floodplain forests of northern Victoria, a similar species, the Yellow-footed Antechinus *Antechinus flavipes*, occurred in greater numbers at sites with a high density of logs (Mac Nally *et al.* 2000).

A large number of bird species have been recorded from the Brisbane Ranges (170 species). Fallen trees and large woody debris that break down naturally provide shelter and foraging for ground-feeding birds (Barrett *et al.* 1994; Laven and Mac Nally 1998). Logs can be an important feeding substrate for insectivorous birds. Studies from dry box-ironbark forests (Laven and Mac Nally 1998) and riverine floodplain forests (Mac Nally *et al.* 2001) both reported a significantly greater occurrence and diversity of birds that are ground feeders or foragers on woody debris at local accumulations of logs, compared with areas with few or no logs.

Frogs and reptiles require some form of shelter (Cogger 1996), in many cases fallen timber, and many reptiles use logs as a basking site for regulating body temperature. Lizards use a range of log sizes, depending on the species, with the majority of logs used being partially decayed with cracks and hollows large enough to allow entry (Webb 1985).

Landscape pattern, logs and fauna

The higher abundance of logs in gullies than on ridges suggests that these parts of the forest landscape have a greater structural complexity at the ground layer and offer a greater diversity of resources for ground-dwelling animals. In box-ironbark forests of central Victoria, censuses of birds and mammals in gullies and adjacent ridge habitats found that for both groups the gullies were particularly rich habitats (Mac Nally *et al.* 2000; Soderquist and Mac Nally 2000). It would be valuable to carry out similar surveys in the Brisbane Ranges, to further understand the relationship between landscape pattern, habitat resources such as logs and large trees, and the distribution of the fauna.

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North-West Victorian Range Extension and Unusual Habitat Use of the Powerful Owl *Ninox strenua*

CL Tzaros[1], MA Weston[2] and DG Quin[3]

Abstract

In Victoria, Powerful Owls are generally wet-forest birds that only occasionally occur in drier woodlands. Their range inland of the Great Divide may be influenced by the presence of riparian vegetation along major rivers. We report an observation of an adult Powerful Owl on the Wimmera River near the edge of the Little Desert National Park, outside its usual range and habitat. This is the second published report of this species well inland of the Great Divide in western Victoria, although we uncovered an additional unpublished report. These reports suggest that population surveys of this species should include riparian strips in drier habitats. (*The Victorian Naturalist* **120** (2), 2003, 61-64)

The Powerful Owl *Ninox strenua* is widespread in Victoria but is generally confined to foothill and coastal forests associated with the Great Divide, and usually in areas that receive an annual rainfall of more than 800 mm (Blakers *et al.* 1984; Emison *et al.* 1987; Higgins 1999). They are occasionally reported from open sclerophyll forests and much drier Box-Ironbark woodlands north of the Great Divide (Emison *et al.* 1987; Higgins 1999), and there is a single record of an immature from the southern Mallee, between Patchewollock and Hopetoun (Hyett 1979). Such inland records have been regarded as young vagrants dispersing in search of a territory (Schodde and Mason 1980; Blakers *et al.* 1984). However, some inland records from Queensland and New South Wales are of breeding birds (e.g. Rolls 1979; Pavey 1993), and in Victoria there are several reports of breeding in the dry Box-Ironbark forests north of the Great Divide (e.g. Traill 1993). Of 28 sites in central Victorian Box-Ironbark forests where Powerful Owls have been recorded, eight represent verified breeding pairs. In some instances, these pairs have successfully raised broods of two chicks, indicating that the breeding habitat is not necessarily marginal (T Soderquist pers. comm.).

Here, we report an observation of a single adult Powerful Owl on the Wimmera River in the south-eastern corner of the Little Desert National Park in western Victoria (36°34' S, 142°00' E). The bird was identified as an adult because, unlike immature birds, it lacked any trace of white in its plumage (Higgins 1999). The bird was initially heard, then seen at about 2030 h ESST on 31 January 2002, and was heard calling sporadically throughout the night. Presumably, the same bird was relocated roosting nearby at its diurnal perch at about 0830 h the following morning. Photographs of the bird and habitat were taken (Fig. 1), and regurgitated pellets were collected from the ground beneath the roosting bird. A diurnal return visit (by DQ and Richard Alcorn) on 19 February 2002 did not locate the bird, but fresh Powerful Owl feathers were found at that site.

On 9 March 2002, MW and Danielle Hart returned to the site, and discovered a single adult roosting in a Salt Paperbark *Melaleuca halmaturorum*, about 50 m north of the roost site of 1 February. The owl was heard all that night. A search of the diurnal roost site failed to locate the owl the next day, but a Powerful Owl was

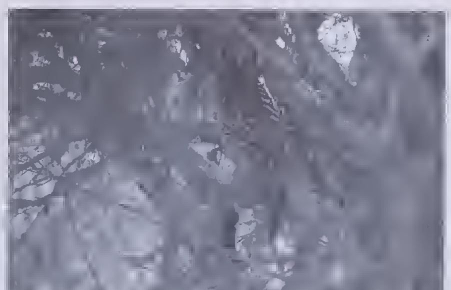

Fig. 1. The owl roosting in Salt Paperbark, clutching a Common Brushtail Possum, on the Wimmera River, 9 March 2002. Photo by MA Weston/Threatened Bird Network Collection.

[1] Threatened Bird Network, Birds Australia, 415 Riversdale Road, Hawthorn East 3123. Email c.tzaros@birdsaustralia.com.au

[2] Research and Conservation Department, Birds Australia, 415 Riversdale Road, Hawthorn East 3123

[3] Project Officer, Natimuk-Douglas Saline Wetland Management Plan, Birds Australia, 415 Riversdale Road, Hawthorn East 3123

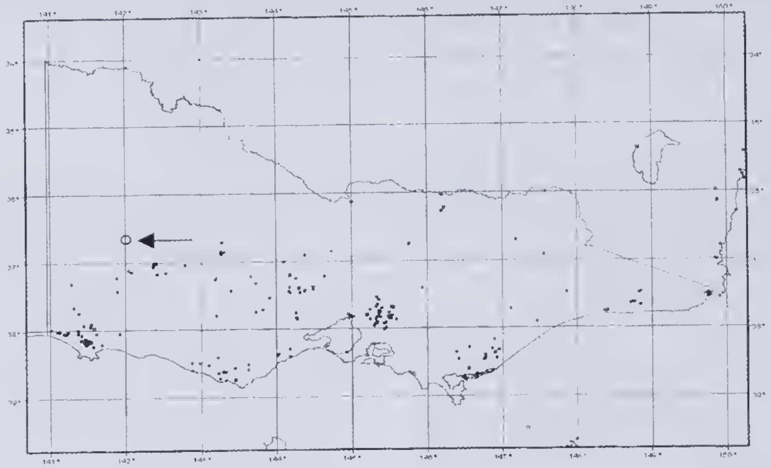

Fig. 2. Distribution of the Powerful Owl in Victoria (courtesy of the New Atlas of Australian Birds database). The arrow and circle indicate our record.

heard again calling all night (10 March) until just before dawn on 11 March. Another search of the diurnal roost site and other nearby patches of Paperbark failed to locate any owls on the morning of 11 March. On 13 April, DQ returned to the site on dusk (1840 h EST) and detected a single calling Powerful Owl in a Salt Paperbark thicket c. 100 m south-west of the roost site of 1 February. The owl flew south-east from the thicket into the open eucalypt woodland.

The observation of this Powerful Owl is considered noteworthy for three reasons: (1) it is the second published account of the species occurring inland to the edge of the Victorian Mallee Region, (2) it occurred in a dry open woodland which differed both floristically and structurally from more typical habitat types, and (3) the bird was an adult.

Range extension

The nearest known record of the species is in the northern part of the Black Range State Park (37°00' S, 142°08' E), 50 km south of the present site (Atlas of Victorian Wildlife and New Atlas of Australian Birds databases) (see Fig. 2). We are also now aware that the Powerful Owl has been previously recorded on the Wimmera River about five kilometres north of our observation site (36°31' S, 142°02' E) (N Marriott pers. comm.), but this has not been published. On that occasion a pair of adult birds, accompanied by a juvenile, responded to call playback at night. This observation suggests that the birds probably nested nearby.

Movements

Records of Powerful Owls from inland have been regarded as young birds dispersing in search of a territory (Schodde and Mason 1980; Blakers *et al.* 1984). The evidence for these claims is presumably that such birds are usually young. However, here we report an adult and a pair with young well inland, and below we propose an alternative hypothesis based on habitat.

Habitat

The habitat at our observation site was open eucalypt woodland dominated by Black Box *Eucalyptus largiflorens* and Grey Box *E. microcarpa*, with smaller amounts of Yellow Gum *E. leucoxylon*. This habitat is considerably drier and more open than typical habitats described elsewhere (Debus and Chafer 1994; McNabb 1996; Higgins 1999). Annual rainfall in the area is about 450 mm, considerably less than in other parts of the species' range. Along the river, there was a narrow riparian strip of slightly wetter River Red Gum *E. camaldulensis* woodland, and occasional dense thickets of Salt Paperbark, up to *c.* 12 m tall. This type of dense understorey would bear the closest structural resemblance to vegetation usually chosen for diurnal roosting in wetter forests, such as roosts in dense Blackwood *Acacia melanoxylon* or Cherry Ballart *Exocarpos cupressiformis* (Seebeck 1976; Schodde and Mason 1980; Debus and Chafer 1994; McNabb 1996; Higgins 1999). It was among this dense shady vegetation that we observed the bird roosting, and the scattered pellets we observed suggest that the bird had roosted there for some time.

Other Victorian sightings of Powerful Owls have been made in areas of riparian River Red Gum woodland, including three records along the lower Goulburn River (Atlas of Victorian Wildlife database), several records along the lower Ovens River (Atlas of Victorian Wildlife database), and a breeding record from near the confluence of the Ovens and Murray Rivers (CT pers. obs.). However, Webster *et al.* (1999) state that the species is absent from most riverine Red Gum forests and the dry northwest of the State. Tzaros (2001) documents the distribution of a number of bird species, typically of cool-climate moist forests, which occur along the Murray River. This suggests that mesic riparian strips possibly extend the geographic range of such species, and allow them to occur in otherwise inhospitably dry landscapes. Riverine woodlands along the Wimmera River may therefore play a role in the presence of the Powerful Owl in the Wimmera.

Another fundamental resource that the habitat must provide is foraging opportunities. Studies on the diet of the Powerful Owl throughout Victoria suggest that it prefers to prey on arboreal and semi-arboreal marsupials, mainly Common Ringtail Possum *Pseudocheirus peregrinus* and Sugar Glider *Petaurus breviceps*, and less often Common Brushtail Possum *Trichosurus vulpecula*, Squirrel Glider *Petaurus norfolcensis* and Brush-tailed Phascogale *Phascogale tapoatafa* (Seebeck 1976; Van Dyck and Gibbons 1980; Tilley 1982; Traill 1993; Lavazanian *et al.* 1994). It is also known to opportunistically prey on several bird species, mainly White-winged Chough *Corcorax melanorhamphos*, Australian Magpie *Gymnorhina tibicen* and Crimson Rosella *Platycercus elegans*, and large invertebrates (Seebeck 1976; Tilley 1982; Traill 1993; Lavazanian *et al.* 1994).

An analysis of two pellets collected from the present site revealed hair, teeth, facial bones and a humerus of a Common Brushtail Possum, and bones and feathers from unidentified birds. The observation made on 9 March was of a roosting bird clutching a Common Brushtail Possum. It seems from our scant data that the diet of the Powerful Owl in question is more or less typical, despite the atypical habitat. Several Common Brushtail Possums were seen and heard on each night of observations.

Webster *et al.* (1999) suggest that the estimation of the size and distribution of the Powerful Owl population in Victoria needs revising. We suggest that dry habitats, especially River Red Gum woodlands along inland watercourses, be appropriately surveyed and adequately reserved to ensure the preservation of the Powerful Owl at the northern edge of its Victorian range.

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The Southern Hemisphere Constellations

Ian D Endersby[1]

Introduction

In 1930 the International Astronomical Union defined the boundaries of 88 star constellations using the celestial coordinates of declination and right ascension but they have a history dating from antiquity.

Depicting figures and objects in the stars dates from the tribes living in the fertile plains of China, India, Mesopotamia and Egypt between 4000 and 1000 BC. Hipparchus is possibly the first Greek to have made a catalogue of fixed stars, but it has not survived. It contained nearly 850 stars and was included by Ptolemy in his own work three centuries later, to which he added another 170. Ptolemy published 48 constellations in his *Megale syntaxis tes astronomicus* better known under the Arabian title *Almagest*. These are listed in Table 1 and all but one has survived to the present. Argo, or the Ship, was the largest of Ptolemy's constellations; it was so large that it was divided into Carina (the Keel), Puppis (the Stern), Vela (the Sails) and Malus (the Mast). This action has been variously attributed to Sir John Herschel, Lacaille, or the American astronomer, Benjamin Gould, but it was probably the work of Lacaille. All but Malus are still used. The *Prodromus Astronomiae*, and its appendix with plates *Firmamentum Sobieskianum*, of Johannes Hevelius was published posthumously in 1690 and these included another seven (Allen 1963). Four more constellations are attributed to Plancius, Bartschius or Royer by different authors.

So, the original 48 constellations of Ptolemy, increased by a net two from the break-up of Argo, plus seven of Hevelius and four with more obscure authorship brings the total named by northern hemisphere observers to sixty-one. Twenty-seven constellations could be considered as belonging to the southern hemisphere. The stars which can be seen from any one location depend on the geographical latitude of the observer, for example, from either pole only half the night sky can ever be seen. Just as the constellation Ursa Major, or the Pole Star can never be seen from Melbourne, many of our constellations never rise above the horizon for northern hemisphere observers.

Southern constellations

Crux

Although the Southern Cross is probably the most obvious of the southern hemisphere constellations, no-one is credited with naming it. Probably in the late 16[th] century it was excised from the hind legs of Centaurus where the Greek astronomers had drawn it. Allen (1963) states that, although it is often attributed to Royer 1679, Mollineux in England illustrated it on his celestial globe in 1592, Bayer drew it and commented in his text *modernis crux, Ptolemaeo pedes Centauri* (1603). Bartchius had it separated from Centaurus in 1624, and Caesius catalogued it in 1662 as though it were well known. Pliny the Elder in his *Historia Naturalis* (c. 70 AD)

[1] 56 Looker Road, Montmorency, Victoria 3094

named a constellation *Thronos Caesaris*. Allen (1963) speculates as to whether this might not be the Southern Cross.

Bayer

Johann Bayer, a German astronomer, published his *Uranometria* in 1603. It contained drawings, after Dürer, of the ancient forty-eight figures, a list of 1709 stars and twelve new southern asterisms (Allen 1963). His new constellations are listed in Table 2. Ridpath (1998) attributes the discovery of these constellations to two Dutch navigators, Pieter Dirkszoon Keyser and Frederick de Houtman. Keyser was in Bantam (Java) in 1595 and Keyser was in captivity in Achin (or Atjeh, Sumatra) in 1600 (Pannekoek 1961). While Bayer was the first to chart these constellations, Allen (1963) quotes him as attributing their formation to the 16th century navigators 'Americus Vesputius, Andreas Corsalis, Petrus Medinensis and Petrus Theodorus [Pieter Dirkszoon Keyser]' giving to the last most of the credit. Willem Jansson Blaeu, a globe-maker from Amsterdam, credited de Houtmann with their introduction. If Allen's (1963) reading of Bayer is correct then Keyser made the greatest contribution. Technically, Bayer did not name Musca; he recognised the asterism but called it Apis, the Bee. Probably it was Edmund Halley who changed it to Musca Apis, then it was altered to Musca Australis by Lacaille, and is now simply Musca (Allen 1963).

All but the Southern Triangle are named for animate objects, seen as exotic, even mythical, from a 16th century Eurocentric view. Dorado is known either as the goldfish or swordfish.

This set of constellations is moderately bright compared with the later contribution of Lacaille. Magnitude of the brightest star in each ranges from 1.74 (α Gruis) to 4.07 (α Chamaeleontis) (a higher magnitude number is a fainter star). Fig. 1 shows the constellation boundaries and their relationship to the well-known landmarks of the Southern Cross and its Pointers.

Lacaille

The list of modern southern constellations was completed by the Abbé Nicholas Louis de La Caille who went to the Cape of Good Hope about 1750 and remained there for some years observing a large number of stars. In his *Coelum Stelliferum* of 1763 he introduced fourteen new groupings, listed in Table 3. The names he assigned to them are principally based on scientific instruments (Pump, Compasses, Furnace, Clock, Microscope, Level, Octant, Ship's

Table 1. The 48 constellations given in Ptolemy's *Almagest*.

Andromeda	Corona Australis	Lyra
Aquarius	Corona Borealis	Ophiuchus
Aquila	Corvus	Orion
Ara	Crater	Pegasus
Argo Navis	Cygnus	Perseus
Aries	Delphinus	Pisces
Auriga	Draco	Piscis Austrinus
Boötes	Equueleus	Saggita
Cancer	Eridanus	Saggitarius
Canis Major	Gemini	Scorpius
Canis Minor	Hercules	Serpens
Capricornis	Hydra	Taurus
Cassiopeia	Leo	Triangulum
Centaurus	Lepus	Ursa Major
Cepheus	Libra	Ursa Minor
Cetus	Lupus	Virgo

Table 2. New constellations depicted by Bayer from observations made by early Dutch navigators.

Latin Name	English Name	Abbr.
Apus	Bird of Paradise	Aps
Chamaeleon	Chameleon	Cha
Dorado	Goldfish	Dor
Grus	Crane	Gru
Hydrus	Sea Serpent	Hyi
Indus	Indian	Ind
Musca	Fly	Mus
Pavo	Peacock	Pav
Phoenix	Phoenix	Phe
Triangulum Australe	Southern Triangle	TrA
Tucana	Toucan	Tuc
Volans	Flying Fish	Vol

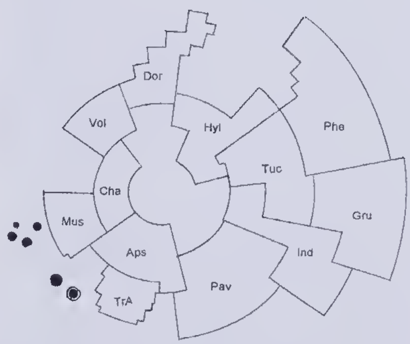

Fig. 1. Constellations depicted by Bayer. The Southern Cross and Pointers have been included for scale and orientation.

Table 3. New constellations introduced by Lacaille.

Latin Name	English Name	Abbr.
Antlia	Air Pump	Ant
Caelum	Chisel	Cae
Circinus	Compasses	Cir
Fornax	Furnace	For
Horologium	Clock	Hor
Mensa	Table (Mountain)	Men
Microscopium	Microscope	Mic
Norma	The Level	Nor
Octans	Octant	Oct
Pictor	Painter's Easel	Pic
Pyxis	Ship's Compass	Pyx
Reticulum	Net	Ret
Sculptor	Sculptor	Scl
Telescopium	Telescope	Tel

Fig. 2. Constellations introduced by Lacaille. The Southern Cross and Pointers have been included for scale and orientation. (Alpha Centauri is not in the constellation Circinus but the symbol overlaps due to the scale used to depict star magnitudes.)

Compass, Net, Telescope) or those of the fine arts (Chisel, Easel, Sculptor).

Mensa, the Table, was originally Mons Mensa, named for Table Mountain which was the backdrop to Lacaille's observing at the Cape of Good Hope (Allen 1963). The modern common name for Reticulum, the Net, is misleading as it refers to the graticule (or reticle) used in telescope eyepieces to record star positions (Ridpath 1998). Octant is a navigator's instrument, predecessor to the sextant, and the constellation contains the South Celestial Pole (SCP). The nearest naked eye star to the SCP is sigma (σ) Octantis but with a faint magnitude of 5.5 it is no longer visible from suburban locations. Pyxis, the Ship's Compass, was formed from part of Malus, the Ship's Mast, a constellation formed by Lacaille when he broke the original Argo into sections, but is no longer recognised (Bozman 1967).

All of Lacaille's constellations are faint with the brightest star in each ranging from 3.19 (α Circini) to 5.09 (α Mensae). For comparison, the faintest of the four stars which make up the Southern Cross (δ Crucis) has a magnitude of 2.8. The constellation boundaries are shown, in relation to the Southern Cross, in Fig. 2.

Summary

Twenty-seven constellations can be considered as belonging to the southern hemisphere. Of these the Southern Cross is conspicuous and has been known, if not formally named, for centuries. Dutch navigators, primarily Pieter Dirkszoon Keyser, made observations which allowed the German astronomer Bayer to add twelve to the list, mainly with animate shapes and names. The French priest Lacaille, observing from the Cape of Good Hope, filled more gaps in the heavens by forming fourteen more, depicted as instruments from the arts and sciences. These southern hemisphere constellations, added to those derived from antiquity in the northern hemisphere, bring the modern total, as recognised by the International Astronomical Union, to eighty-eight.

Acknowledgements

Star magnitudes were taken from Hirshfeld and Sinnott (1982). Two of the obscure references were borrowed from the Astronomical Society of Victoria library and Figs 1 and 2 are based on the freeware computer program Cartes du Ciel v 2.7 prepared by Patrick Chevalley (http://www.astrosurf.com/astropc). Thanks are due for the valuable comments of the anonymous referee who also provided the web address http://www.rasnz.org.nz/Constellations.htm.

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Planting the Nation

Edited by Georgina Whitehead

Publisher: *Australian Garden History Society, Melbourne, Victoria, 2001.*
xii + 196 pages, hardback, black and white and colour photographs and index.
ISBN 1 876473 44 4. RRP $42.90

Many FNCV members and other readers of *The Victorian Naturalist* are garden lovers. Some are interested in garden history. While reviewing this delightful collection of essays for *Historical Records of Australian Science*, I wondered whether *Planting the Nation* may also interest *Vic Nat* readers. So here are a few notes.

In response to an apparent absence of gardens in the Centenary of Federation's proposed activities, the book was initiated during planning for the Australian Garden History Society's annual national conference in Melbourne in 2001. Its theme is Australian gardens and horticultural landscapes during the peri-federation years, 1890-1914. Many of the nine essays are based on talks delivered at the Society's conference.

Naturalists have long carried their botanical interests from bush to garden, so I wondered whether *Planting the Nation* mentioned the FNCV. It is not in the index and I noticed only a passing reference. In 'Symbols of a New Nation: Australia's Flora in the Decorative Arts 1890-1914' Nina Crone mentions the FNCV's interest in Australia's indigenous flora long before suburban gardens commonly included native plants and states had official floral emblems. In discussing the consideration of a national flower she notes that 'Archibald Campbell founded a Wattle Club in 1899 to promote a Wattle Day ... to encourage the flower's recognition as a patriotic symbol' and in 1908 delivered a lecture entitled 'Wattle Times: or Golden Haired September' in which he claimed that 'the Wattle is almost exclusively Australian and should be our National Flower'. However she doesn't mention Campbell's membership of the FNCV, nor the publication of his Wattle Time talk in *The Victorian Naturalist*.

Archives Coordinator for the Australian Garden History Society's Victorian Branch, Suzanne Hunt, is working with the State Library of Victoria on the Garden History Archive. Apparently unwittingly, she mentions another FNCV member — 'the resourceful Mr Williamson'. His prize-winning garden at Hawkesdale State School features in her 'Where the Sweet Australian Peas Bloomed: State School Gardens in Victoria 1901-1914', without acknowledging that he was the botanist Herbert B Williamson.

Hunt includes splendid photographs of bygone school gardens and explains how Victoria's first Director General of Education, Frank Tate, made the school garden an integral part of the 'new' education which he was introducing into the state system. In the school garden students could learn by experience about nature, horticulture, botany, and other aspects of the curriculum. School garden produce was exhibited at the impressive and crowd-attracting State Schools Exhibition in Melbourne in 1906, which showcased the subjects taught under the new education philosophy.

Hunt mentions the principal (not director) of the School of Horticulture at Burnley, Charles Bogue Luffman. Luffman's 1902 *Education Gazette* supplement 'Gardening for Victoria's State Schools' provided practical advice on soil, planning drainage, plant selection, germination and transplanting. And Arbor Day (a USA concept) provided a timely incentive to plant trees in often treeless school grounds. It was initiated as part of Victoria's schools beautification program in 1901, the year that a Royal Commission report revealed vast forest destruction in Victoria.

Tate established the State Schools Horticultural Society, and transferred Cyril

Isaacs (an FNCV member in 1912), who had long argued for a cooperative scheme for seed and plant supply, to Coburg State School to establish the Society's plant nursery in 1912. Hunt mentions early assistance from 'RTM Pescott, Principal of Burnley School of Horticulture'. However EE (not RTM) Pescott was the principal. The Society encouraged better planned and planted grounds — just as the 'Playground Movement' (also from USA) was advocating provision of playing space for town and city children. Like William Guilfoyle, director and designer of Melbourne's Botanic Gardens, Isaacs was an exponent of the 'natural style' of garden design rather than formal linear rows of trees and shrubs.

In 'Arts and Crafts Gardens in Melbourne and their Legacy', Harriet Edquist explains how this new type of garden 'formed a bridge between the late nineteenth-century picturesque garden, exemplified by William Guilfoyle's designs, and Edna Walling's gardens of the 1920s'. They were formal architect-designed gardens, which often included an informal wild or wilderness area. Edquist notes that native gardens — Mrs Welshe's Wattle Park and John Watson's Maranoa Gardens — were established in Melbourne soon after federation, and describes (sometimes with plans) some of the extensive Arts and Crafts gardens that beautified Melbourne mansions. An area of Australian trees and shrubs often replaced the English wilderness section. At his Toorak residence, 'Miegunyah', Russell Grimwade transformed a tennis court into a plantation of Australian trees, and later wrote *Authography of the Eucalypt* (1920). Edquist mentions Guilfoyle's *Australian Plants Suitable for Gardens, Parks and Timber Reserves* (1911), but not whether it influenced any of her garden architects.

Thanks to David Jones, I now know who designed strange rock structures in various Melbourne gardens. Charles Robinette, 'Artistic Grotto and Horticultural Builder', was commissioned by William Guilfoyle to craft a rockery for the Botanic Gardens in 1886. Guilfoyle planted the grotto near the Anderson Street entrance with succulents and cycads. Robinette later designed grottoes elsewhere in Melbourne, including the (now Royal) Zoological Gardens, Malvern Gardens, Clifton Hill's Darling Gardens (demolished), and Melbourne General Cemetry (hijacked by Elvis Presley worshippers).

Susan Reidy's chapter on recreation and sport mentions concerts and cricket in Melbourne's inner and outer suburban parks. She discusses Elsternwick Park in some detail.

Planting the Nation also includes an historical overview of the period 1890-1914 by John Rickard, Oline Richards' perusal of WA (mainly Perth) parks and reserves, Jeannie Sim's exploration of Queensland's botanic and acclimatisation gardens and Robert Freestone's discussion of parks and gardens in the 'City Beautiful'. Freestone mentions, but does not explain, the formation in 1914 of the Victorian Town Planning and Parks Association and its aim 'to safeguard native animals and plants'. I thank him for introducing me to a Melbourne society whose name is derived from the Greek word kalos meaning beautiful (as in *Callistemon*), one of whose high profile supporters was 'landscape gardener WR Guilfoyle'. The Kalizoic Society was established in 1884 for:

> *The encouragement and cultivation of the beautiful, the planting of trees and flowers in promenades, and also in the city, suburbs, places of public resort, and the laying out of reserves; the protection of all ornamental plants, flowers, trees ... the encouragement of window, cottage or front gardening, the prevention of the pollution of our streams and reservoirs ... to enlist the sympathies of the professional and general public in improving the appearance of our city and its suburbs by the creation of an artistic taste, and by constituting every citizen a custodian of our gardens, trees and birds.* [p. 177]

Imagine that!

Linden Gillbank
History and Philosophy of Science Department
University of Melbourne, Victoria 3010
lindenrg@unimelb.edu.au

WATTLE: Acacias of Australia

Coordinator: BR Maslin

Publishers: *Australian Biological Resources Study, Canberra and Department of Conservation and Land Management, Perth, 2001. CD-ROM and 46 page manual. ISBN 0643066063. $110.00. Available from CSIRO Publishing.*

WATTLE is an extremely user friendly, interactive, LucID identification guide to 1165 taxa of Australian *Acacia*. Simple, easily understood installation instructions are provided in an accompanying booklet although, once installation is begun, on-screen prompts are provided. Even a technophobe such as myself can load this wonderful CD-ROM without raising a sweat and operating procedures are just as simple. The CD opens to the WATTLE homepage from which one has three choices: to obtain an overview of WATTLE, to identify a taxon or to browse information on any taxon.

When opening the key for the first time a tutorial appears. This takes about 10 minutes to complete and is strongly recommended. It goes through the basic operations needed to perform identifications and provides pointers on best practice; for example, it is important not to guess a character – if two or more character states match the specimen, select both and, when providing numeric states, give a range of values rather than a single value. Each page of the tutorial describes one or more features/functions of the LucID player and how one can most efficiently use WATTLE.

On completion of the tutorial, a screen divided into four windows appears with a menu and a tool bar, with each window displaying a list. The first is a list of 28 characters that may be chosen to describe the specimen to be identified. The second window initially will be empty but will list characters selected to describe the specimen. The window directly beneath this is the 'taxa remaining' list, which originally will contain 1165 taxa. As characters are selected, taxa that do not match the description will be transferred into the 'taxa discarded' list which forms the fourth window. The 28 characters originally supplied are a 'fast find' set allowing for rapid identification of specimens but, frequently, a number of taxa remain. In such instances WATTLE provides two important aids to help find the next appropriate character to use, namely 'character sets' and 'best'. The sets contain characters relevant to particular purposes, such as describing geographic regions, gland, inflorescence, leaf phyllode or vegetative characteristics and whorled phyllode taxa. When selecting 'best' LucID will either place characters with best discriminating power at the top of the list or highlight the next best character to use. These features are invaluable and allow for quick and easy identification of specimens when certain details may be lacking e.g. flowers and/or fruits.

One of the wonderful features of the key is that one can click on the information icon provided with each character to obtain either notes and/or illustrations of the character and its states. These are superb quality and make identification an enjoyable process, which is especially important for the beginner. Care still must be taken, however, as errors in identification can be caused because of misinterpretation of qualitatively defined character states, although the illustrations provided minimise this. For example, the character 'foliage type' includes the state 'phyllodes rudimentary'. When does a phyllode 'step over the line' and become rudimentary? Similarly, the difference between terete, sub-terete, compressed and flat phyllodes is a matter of the degree to which the lamina is flattened. The tutorial and accompanying booklet, however, highlight such potential problems and provide suggestions on how these can be minimised or overcome.

I have spent many enjoyable hours testing the key on local wattles and have had a 100% success rate. At times I was left with two or three taxa remaining but the species information and associated diagrams provided the further detail needed. These were of excellent quality, although I would have preferred colour images as well. Each illustration is annotated, highlighting critical features of the species which can then be checked against the specimen being examined. A distribution map of each species also is provided.

A number of minor problems were encountered. For example, with the character 'flower merous', one is asked to enter a value or range between **five** and **five**. Most *Acacia* flowers are four or five merous and the character has greatest discriminatory power when flowers are four merous. Similarly, with 'pulvinus length', a value between **0.5** and **0.5 mm** is required to be entered and values greater or less than this cannot be used, making this choice of character virtually useless. An even more minor error is the request to enter a value between one and two **millimetres** for gland number. These are minor mistakes and there are very few of them. Furthermore, they in no way prevented successful identification of the specimens tested.

The CD-ROM and accompanying booklet are impressive. Their ease of use, the advice provided, the hyperlinks allowing easy navigation between related taxa, and the netsearch option make this an extremely useful, stress-free means of identifying wattles. I highly recommend this CD-ROM for anyone even vaguely contemplating the identification of Acacias.

Maria Gibson
School of Biological and Chemical Sciences
Deakin University, 221 Burwood Highway
Burwood, Victoria 3125

How (not) to Catch an Octopus

I should tell you straight away that I've never caught an octopus in my life so I can't be thought of as an expert on octopus catching, but recently I nearly caught one. Anyway, at least I found one, which is more than most people can say.

It happened at a Field Nats general excursion at Mushroom Reef near Flinders on the Mornington Peninsula. I'd been ripping the arms and feet off sea stars for this bloke Mark who reckoned he was doing some research. He wanted the arms off *Allostichaster polyplax*, the little grey ones with eight arms, and the feet off *Coscinasterias muricata*, the big greeny-purply ones with eleven arms. For genetic sampling he said. Even I know feet don't grow on arms. You've got to wonder about whether this Mark guy was from the university or somewhere else.

Anyway I got bored with that so I went off hunting around in rock pools by myself. I turned a rock over in a small pool about a foot deep, and below where the rock had been was what seemed to be a pale sea star partly covered in sand. The surface of the water was roughed up by the wind making a clear view difficult so I reached down and gave the critter a couple of prods with my finger. It didn't move. It just sat there. But it felt soft and pliable, not like a sea star. And sea stars usually sit on top of the sand. I thought about what it might be. Was it attached to the rock? A sponge, an ascidian, algae? It still looked like a sea star. I reached down again and gave it a bit of a tug, not pulling too hard in case it was stuck to a rock under the sand and I damaged it. Suddenly it turned into a large Blue-ringed Octopus and I was squeezing its head. I let go in a hurry. The octopus had its arms outstretched and was flashing its neon blue bands. It went scuttling under the nearest rock. Phew! Well there you are. I nearly caught it didn't I?

In future I think I'll carry one of those plastic kitchen sieves and when I see something that looks a bit like a sea star I'll scoop it up before I try to grab it. The same goes for hunting around in sea grass. You never know what might be there.

Jim Walker
167 Balaclava Road
Caulfield, Vic 3162

For assistance in prearing this issue, thanks to Ann Williamson (label printing) and Dorothy Mahler (Administrative assistance).

Wilsons Promontory: a Field Guide to Wilsons Promontory

by David Meagher and Michele Kohout

Publisher: *Oxford University Press. 352 pages. RRP $34.95*

A Field Guide to Wilsons Promontory makes a new and significant contribution to the literature on an internationally famous and most popular National Park on the southernmost part of the Australian mainland.

The book begins with a map which indicates the tracks, and enables the reader to locate every fascinating feature referred to in the guide. All the bays, islands and mountains are extensively displayed on the map.

A striking introduction is made by mentioning the geological history of the granite boulder-littered land mass, then the geomorphology – the sands, rocks and mountains – is explored before the human history is detailed.

There is evidence of Aboriginal presence 6000 years ago. The Prom provided a land bridge to Tasmania. In 1798 George Bass, the first European to visit the Prom, arrived in his whaleboat at Sealers Cove. He named the Cove and suggested that it could be a good refuge for the sealers. In 1843 the first sawmill opened, followed by a pastoral period when sheep and cattle grazed the whole promontory. In 1859 the lighthouse was constructed and filled a vital role in guiding the shipping around that treacherous, rocky coast. The steep offshore islands are very close together, and because of the constant high winds in the area, were a threat to the sailing ships of the era. Gradually, tourism became popular. Early tourists went by horse-drawn buggy along the beach to Darby River. The authors report that in 1884 three prominent field naturalists, John Gregory, Arthur Lucas and George Robinson, completed an adventurous walking tour of the Prom, wrote a glowing report, and fought for its reservation as a National Park. This was achieved in 1905 and extended in 1908.

The main body of the *Field Guide* is an accurate and up-to-date account of most of the living organisms inhabiting the land or sea in this region. Mammals, birds, reptiles, frogs, freshwater fish, terrestrial invertebrates, intertidal invertebrates and finally the flora are all described. Three hundred and fifty species of plant are described, and each is compared with similar species. No keys are included, but most organisms have one or two paragraph descriptions, clearly labeled black and white drawings or coloured photographs, and the descriptions are simple and easy to follow. Appendices provide lists and further reading. Forty common mosses and liverworts are included but not fungi or algae. The book might well be called *Life of the Prom.* The authors regard the Prom as a possible Noah's Ark and a haven for organisms threatened by the local farming practices. However, the lack of high profile fauna such as tiger quoll, platypus, greater glider and lyrebirds detract from the ark idea.

An extraordinarily wide variety of plant communities co-exists on the Prom, ranging from rainforest to sand dune, from swamp to mangrove estuary, but the authors do not comment on the ecology. Inside the back cover of the *Field Guide* is a map denoting the different areas of each type of vegetation.

The *Field Guide* is well bound and on good quality paper. It contains superb photographs, both black and white and colour. Despite its soft cover, the book is heavy for those who walk and need to carry its 352 pages. The major disadvantage to a bushwalker is the lack of good quality maps with track details. These must be carried separately and in addition to the *Field Guide.* The authors claim to have walked every track, so the maps and track detail would have involved little extra work, and would have rendered the book indispensable to the backpacker.

Gretna Weste
1/361 Royal Parade
Parkville, Vic 3052

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A Note on the Dietary Habits of the Red-necked Wallaby *Macropus rufogriseus*

According to the notes accompanying the description of the Red-necked Wallaby *Macropus rufogriseus* in *The Complete Book of Australian Mammals*, this wallaby 'is essentially a grazing animal and subsists largely on grasses and herbs'. Its habitat is eucalypt forest and heath communities, mainly along the Divide and south and east from that barrier. The current range is from south-east Australia to just north of the Tropic of Capricorn.

Recently, during a short stopover at Troopers Creek in the Grampians National Park, it was possible to observe, at fairly close quarters, a female of this species with a well developed young one in the pouch.

It appeared from a short distance that she was browsing on the phyllodes of Golden Wattle *Acacia pycnantha*, but a closer examination when she moved on showed in fact that she had been stripping the large shrub of young, unripe pods. She then moved out of the picnic area, which in this dry season was practically devoid of grass and other herbage, onto the car parking area. Here she spent about fifteen minutes moving slowly about on the soil and gravel licking the surface (Fig. 1), and then moved a short distance to lick the bark of a Black Wattle *Acacia mearnsii*. Presumably these surfaces were the source of some mineral material.

While all this was going on, the joey spent most of the time just being patient with mother and made no attempt to lick, but occasionally reached down for a fragment of dead leaf, gave it an experimental tasting, and then dropped it to the ground.

Ron Fletcher
4/178 Matthews Rd
Corio 3214

Reference

Strahan, R (ed) (1983) *The Australian Museum Complete Book of Australian Mammals.* (Angus and Robertson: Sydney)

Fig. 1. Red-necked Wallaby and joey in the car park at Troopers Creek, Grampians National Park.

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Cover: Endangered Forest Red Gum Grassy Woodland now reserved as the 'Swallow Lagoon Nature Conservation Reserve'. See Contribution on p. 98. Photo by James Fitzsimons.

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Little Penguin *Eudyptula minor* at Middle Island, Western Victoria: Current Status

Rebecca L Overeem[1] and Robert L Wallis[1]

Abstract

We examined the status of the Little Penguin *Eudyptula minor* at Middle Island on the west coast of Victoria during the species' 1999/2000 breeding season. The vegetated upper surface of the island had 292 occupied burrows at a density of 0.02/m². Peak dusk arrival occurred in January with 502 penguins coming ashore during a one-hour period. Little Penguins at Middle Island displayed important differences in breeding ecology from penguins in other Australian colonies. Early breeding combined with heavier adult and chick weights resulted in high breeding success. However, as Middle Island is a popular destination for day visitors, during the 1999/2000 Little Penguin breeding season, tourism was found to cause detrimental effects, including deaths of some eggs and chicks. There are also concerns for the conservation of the Little Penguin colony as foxes or dogs may readily access the island. (*The Victorian Naturalist* **120** (3), 2003, 76-83)

Introduction

Little Penguins *Eudyptula minor* were first reported on the Victorian coast in 1860 (Hannaford 1982). Surveys conducted from 1959 (Marchant and Higgins 1990) demonstrated a broad distribution, however, numbers have declined due mainly to human induced mortality (Dann 1992). The effect of foxes, cats and dogs (Dann 1992), removal of vegetation (Norman *et al.* 1992), burrow trampling (Reilly 1977), residential developments (Harris and Bode 1981) and oil and plastic pollution have all affected Little Penguin numbers.

It is rare for a new Little Penguin colony to have established in the past 200 years (for example, St Kilda breakwater colony, Victoria). At Middle Island, near Warrnambool in western Victoria, however, a breeding colony of Little Penguins may have established in the early 1900s. Anecdotal records of Little Penguins inhabiting Middle Island began in the 1950s (Overeem 2000). Here we report on the colony's current status and factors that may influence this status. An important recent consideration is the 'sanding' of Stingray Bay, such that Middle Island now connects to the mainland at low tides, allowing dogs, foxes, cats and humans to access the island on foot.

Study site and methods

Middle Island is a small (1.5 ha) island located 75 m from the mainland coast (at high tide), near Warrnambool, Victoria (38°20' S, 142°30' E; Fig. 1). Exposed to the prevailing southwesterly winds and swells of the Southern Ocean, the island is a remnant of a calcarenite peninsula that is being broken into a series of islands, rock stacks and residual platforms (Rosengren 1998). Middle Island has an irregular, elongate outline and is about 240 m long and 115 m at its widest point on the upper surface. Wind and water have stripped the unconsolidated sand and tuff, exposing bare calcrete predominately on the northern and western sides of the island (Rosengren 1998).

Middle Island has been eroded to include a surrounding rock platform and a flattened upper surface about 17 m above high tide. Access to the island is gained by foot at very low tides.

The upper surface vegetation mainly comprises groundcover species such as Seaberry Saltbush *Rhagodia baccata*, Coastal Pigface *Carpobrotus glaucescens* and New Zealand Spinach *Tetragonia tetragonoides*. African Boxthorn *Lycium ferocissimum* and Mirror Bush *Coprosma repens* are also present in low numbers (Overeem 2000).

Native animals which frequent the island include the Little Penguin and the Short-tailed Shearwater *Puffinus tenuirostris* which breed on the upper surface of the island. Introduced mammals residing on Middle Island include the Black Rat *Rattus rattus* and House Mouse *Mus domesticus*. Foxes *Vulpes vulpes*, dogs *Canis lupus* and cats *Felis catus* have not been observed on the island. However, in 1993 (15 October)

[1] School of Ecology and Environment, Deakin University, Warrnambool, Victoria 3280

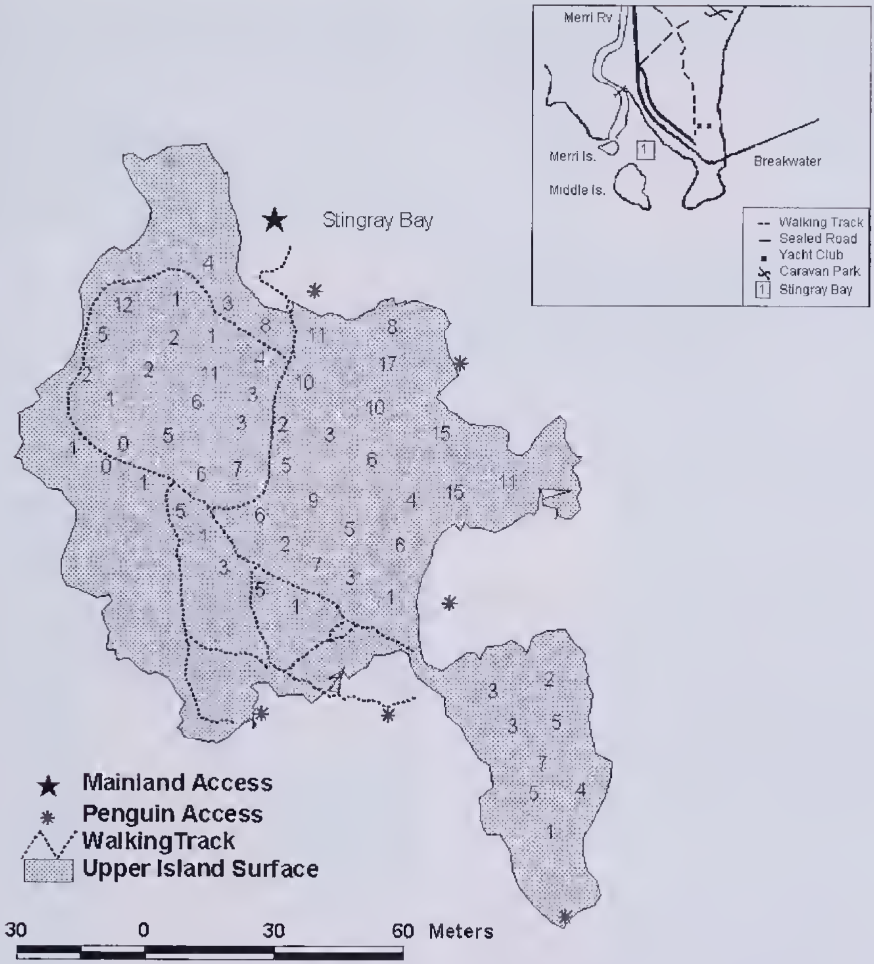

Fig. 1. The anthropogenic features of Middle Island, near Warrnambool, western Victoria, in 1999/2000. Numbers on the shaded area are the active burrow abundance for the Little Penguin.

a kill of 50 birds was recorded on Middle Island by the Phillip Island Penguin Study Group (Thoday 1993), and Swart and Mitchell (1995) found 72 Little Penguin carcasses on Middle Island over a 28 day period from 4 March to 27 April, 1995. Although the predator was never identified, both kills appeared to be caused by foxes or dogs.

In the mid 1980s, a partly-fenced earthen path was constructed around the upper surface of Middle Island, and limestone bricks and wooden sleepers created steps to the path (Fig. 1). Brush-matting was placed on the island, covering the bare areas of the north and west, and artificial burrows were placed throughout the island (Peter Goldstraw pers. comm.). Weather conditions have seen the path and steps fall into disrepair and the burrows sanded over. However, aerial photos suggest that the brush-matting scheme has been largely successful in prohibiting further erosion.

An estimated 300,000 tourists visit the Warrnambool area annually (Warrnambool Visitor Information Centre 1999). Middle Island is situated in a prime tourist area (Fig. 1), with the breakwater, swimming beaches, caravan parks and walking tracks in close proximity. Swart and Mitchell (1995) recorded 265 visitors crossing to Middle Island in a four hour period during January 1995. This visitation may increase with current development of the mainland foreshore opposite Middle Island.

Active burrow count

The entire upper surface of the island was divided into 10 m^2 squares where active penguin burrows (defined by the presence of a breeding pair in a burrow or if both tracks and scats indicated recent use) were systematically sought and mapped in August 1999. In order to georeference divisions, a marker visible in both the field and an aerial photograph was used. Burrow density of the island was then calculated based on the vegetated surface area of the upper part of the island.

Little Penguin night arrival

The landing sites that the Little Penguins use to access the upper part of the island were simultaneously observed by teams every two weeks from late August 1999 to early February 2000. Landing sites were initially located during day sampling by scat observation. Each landing site was then observed at night with penguin counting commencing visually when the first group accessed the island.

Breeding calendar

Fifty burrows were chosen throughout the island for intensive study according to the following criteria: the burrows were active, frequent visitation was unlikely to cause trampling of other burrows nearby, the burrow was typical of those in each vegetation type, and the nest chamber was accessible. The chosen burrows were individually identified with tags. Visits to each of the 50 burrows occurred on a weekly basis. Data on breeding biology, including times of egg-laying, hatching and fledging, breeding success and body condition were collected as per previous studies (Reilly and Cullen 1981; Gales 1988; Stahel and Gales 1991; Chiaradia 1999).

Management

Incidental observations relevant to management of the Little Penguin on Middle Island were made during each site visit. Tracks and scats were identified using Triggs (1998).

Results

Active burrow count

The vegetated upper surface of Middle Island had 292 active burrows, at a density of $0.02/m^2$ (Fig. 1). A further 50 burrows were located on the north and east facing cliffs. Some non-breeding penguins congregated in caves near the landing beach and in a sheltered cove. Burrow abundance was proportional to the abundance of each plant species (Table 1). Almost half of the burrows (46%) were covered by the most abundant plant species, Seaberry Saltbush and New Zealand Spinach. Structurally complex combinations of plants, with at least two of Variable Groundsel *Senecio lautus*, Beaded Glasswort *Sarcocrinia quinqueflora*, Cushion Bush *Calocephalus brownii*, and Coastal Daisy Bush *Olearia axillaris* also supported active burrows. Few burrows (2% of burrows, 9% plant coverage) were found under woody weeds (African Boxthorn).

Table 1. Per cent vegetation coverage and per cent vegetation preference of active burrows for the Little Penguin at Middle Island 1999/2000.

Vegetation Type	% Vegetation Coverage	% Active Burrow Abundance
Seaberry Saltbush *Rhagodia baccata*	60.5	46
New Zealand Spinach *Tetragonia tetragonoides*	10	17
African Boxthorn *Lycium ferocissimum*	9	2
Variable Groundsel * *Senecio lautus*	8	-
Beaded Glasswort * *Sarcocorinia quinqueflora*	7	-
Coastal Pigface *Carpobrotus glaucesescens*	5	3
Cushion Bush *Calocephalus brownii* *	<1	-
Mirror Bush *Coprosma repens* *	<1	-
Coastal Daisy Bush *Olearia axillaris**	<1	-
Combinations of plant species indicated thus *		32

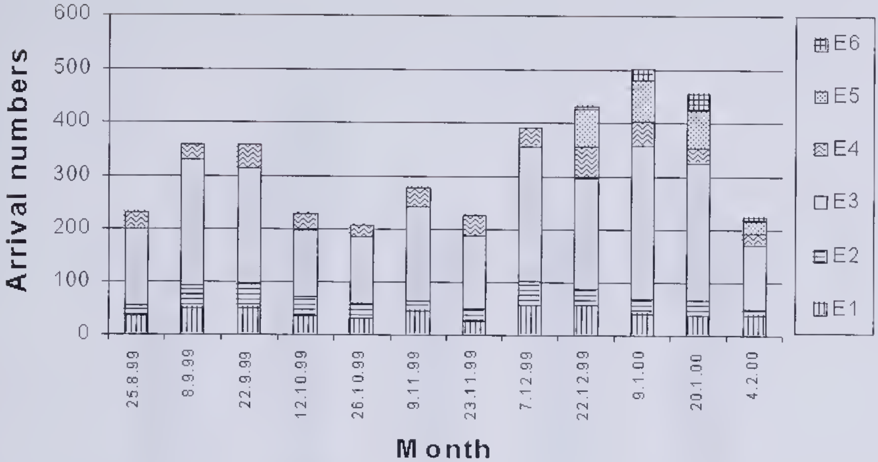

Fig. 2. Fortnightly numbers of Little Penguins arriving at Middle Island 1999/2000. E1 to E6 are the penguin landing sites.

Little Penguin night arrival

The Little Penguins arriving at Middle Island used six landing sites. The count data for each fortnightly observation from August 1999 to February 2000 are summarized in Fig. 2. The highest number of penguins observed coming ashore after dusk was 502 in January and the lowest was 207 (October). The proportion of birds using each of the six landing sites remained constant, with one site on the south west side of the island being the main landing site with up to 290 birds using it in a one hour period on 9 January.

Breeding calendar

Sampling at Middle Island began in August as per the Little Penguin breeding calendar established by Stahel and Gales (1991). Middle Island Little Penguins started breeding unexpectedly before sampling began and therefore dates for egg-laying, hatch and guard (adult present in the burrow with chicks) were missed for the 34 pairs already breeding when the study began on the island.

Egg-laying

During the 1999/2000 breeding season at Middle Island there was a minimum of 126 eggs laid (including replacement clutches) in the 50 burrows sampled. Ninety-two percent of pairs laid clutches of two eggs, while 8% of pairs laid one egg. Egg-laying for the colony is estimated to have begun as early as July and concluded in late December with a peak in late November (Fig. 3).

Incubation and Hatch

The mean incubation length for eggs that hatched was 34.1 ± 4.7 days (mean ± SD for all values, n = 18) with a range of 27 to 43 days (Table 2). Hatching began in September, with a majority of hatchings occurring in late November, bar one pair that hatched as late as 8 January 2000.

Post-guard and fledge

Chicks were an average of 15.8 ± 3.2 days old (n = 15) when left alone in the burrow. The youngest chick to be left unattended was 11 days old while the oldest was 22 days old (Table 2). Post-guard commenced in early October and by mid-January all chicks were unattended during the day with the peak occurring in mid-December (Fig. 3).

Chicks at Middle Island fledged at an average age of 58.9 ± 7.9 days old (n = 17; Table 2). Two peaks in fledge occurred: the chicks from early breeders left Middle Island in mid-October, while most fledglings left the colony in late January with the last chick fledging as late as March.

Breeding success

(i) Hatching: The hatching success of all eggs combined was 85%. Most (84%) of the egg mortalities were due to unknown

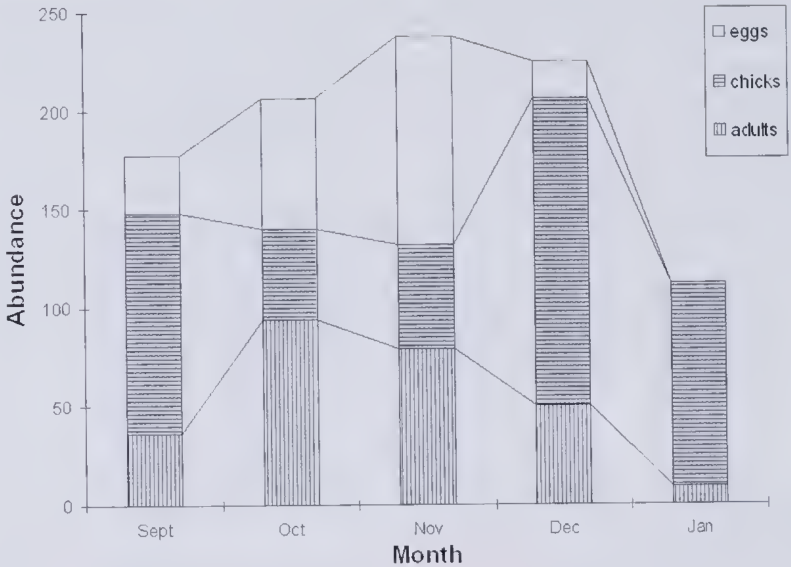

Fig. 3. Burrow contents for the Little Penguin sample at Middle Island 1999/2000.

causes, however 16% of egg loss was directly linked to human impact through burrows being trampled.

(ii) Fledging Success: Breeding success from egg-laying till fledge was 70%, while success from hatch was a higher 82%. Failure to fledge was thought to be attributable to starvation (11%) and burrow trampling (33%), with the remainder failing due to unknown circumstances. In total the breeding productivity for the Middle Island Little Penguin colony during the 1999/2000 breeding season was 1.49 per pair of breeding penguins. This total includes replacement clutches.

Morphology

Average weight of the adult female Little Penguin at Middle Island was 1215.3 ± 138.8 g (n = 76), while the average for males was 1318.3 ± 119.9 g (n = 83; Table 3). The male Little Penguin was the heavier of the two sexes throughout all stages of the breeding season. Chicks in this study were first recorded at a weight of 53.2 ± 18.3 g (n = 20). They grew rapidly and at the end of guard stage mean weight was 504.3 ± 201.3 (n = 39), with the lightest chick recorded at 110 g and the heaviest 890 g (Table 4). On average chicks fledging in September to November averaged a weight of 1114 ± 114 (n = 51) while chicks fledging in December to February fledged at a weight of 1035 ± 126.3 g (n = 25).

Conservation

Although foxes, dogs and cats were not directly observed, the footprints of all were identified on the island. A fox or dog killed 13 penguins, in various breeding stages, on Middle Island during the 1999/2000 breeding season. In addition, 33% of chicks and 16% of eggs were lost during the 1999/2000 breeding season when visitors to the island trampled their burrows.

The introduction of brush-matting has created new breeding areas for penguins. During the 1999/2000 Little Penguin breeding season on Middle Island four active burrows were located in the brush-matting on the northern tip of the island, while the western edge contained two.

Discussion

European settlement of Middle Island would have dramatically altered the vegetation during the eleven years that it was occupied (Douglas 1998). During the 1999/2000 Little Penguin breeding season, 51% of the island's upper surface was cov-

Table 2. Mean length and standard deviation (in days) for significant events throughout the breeding season for the Little Penguin at Middle Island 1999/2000.

	Incubation (days)	Post-guard (days)	Fledge (days)
Mean	34.1	15.8	58.9
Standard deviation	4.7	3.2	7.9
n	18	15	17
Minimum	27	11	43
Maximum	43	22	73

Table 3. Mean (and standard deviations) of bill lengths and body weights for the Little Penguin at Middle Island 1999/2000.

	Male			Female		
	Mean	SD	n	Mean	SD	n
Bill length (mm)	41.5	2.3	55	38.9	2.6	52
Bill depth (mm)	14.4	0.6	57	11.5	0.7	52
Weights (g)						
(i) Prior to egg laying	1326	117.8	23	1299.5	149.2	23
(ii) Incubation	1312.0	117.3	34	1160.0	81.8	35
(iii) Guard	1280	130.7	30	1120.2	69.9	20
(iv) Total [groups (i) to (iii)]	1318.3	119.9	87	1215.3	138.8	78

ered by groundcover vegetation. The burrow density of $0.02/m^2$ found in the vegetated groundcover at Middle Island, is comparable to the mean nest density recorded at Phillip Island of $0.041/m^2$ (Marchant and Higgins 1990). In contrast, Fortescue (1991) found that Little Penguin burrow density at Bowen Island averaged $1.5/m^2$.

The highest dusk arrival numbers occurred in September and January. This January peak is consistent with those recorded elsewhere in Australia (Fortescue 1991). The low count in October may be attributed to the pre-laying exodus (Chiaradia 1999) and the February low is consistent with adult Little Penguins returning to the sea for a period of pre-moult fattening after the chicks have fledged. Chiaradia (1999) found at Phillip Island that a majority of birds use the same track to move into the breeding area. Our data showed penguins used the six entrances in the same proportion through the 1999/2000 season, supporting Chiaradia's (1999) observations.

The breeding calendar for the Little Penguin at Middle Island varied from that of the Phillip Island Little Penguin. Egg-laying began in July (1999), two months earlier than the mean date of egg-laying recorded at Phillip Island for the same season (P Dann pers. comm.). This time of breeding was described by Reilly and Cullen (1981) as unusually early for Phillip Island rather than late.

Breeding calendar variability between locations and seasons has been attributed to a probable effect of food availability (Stahel and Gales 1991). The onset of the Little Penguin breeding season was recorded by Cullen *et al.* (1992) as coinciding with abundant fish stocks. In the breeding colonies at both Phillip and Lion Islands, the date of egg-laying affects the chance of successfully rearing young; late breeders are less likely to successfully fledge chicks (Reilly and Cullen 1981; Chiaradia 1999; Rogers *et al.* 1995). Thus the early breeding at Middle Island may be responsible for the higher fledging weights recorded from September to November when compared to the weights recorded from December to February.

Most (92%) breeding pairs of Little Penguins produced two eggs per clutch. The occasional (8%) observance of one egg and no clutches comprising three eggs is consistent with observations at Phillip and Bowen Islands (Reilly and Cullen 1981; Fortescue 1991).

Mean incubation period from laying to hatching spanned 34 days at Middle Island during 1999/2000. This length is similar to periods recorded for the species elsewhere (33.6 ± 0.70 days, Bowen Island, Fortescue 1991; 35.9 ± 2.5 days, Phillip Island, Chiaradia 1999; Kemp and Dann

Table 4. Weights for chicks at three life stages at Middle Island 1999/2000.

	Approximate Hatch Weight (g)	Post-guard (g)	Approximate Fledge Weight (g)
Mean	53.2	504.3	1081.4
Standard deviation	18.3	201.3	116.8
n	20	39	86
Minimum	25	110	840
Maximum	92	890	1370

2001). Hatching success of 85% recorded for Middle Island was slightly higher than that recorded at Phillip Island (72%; Kemp and Dann 2001). Kemp and Dann (2001) suggested that hatching success in Little Penguins may be linked to annual variations in food availability through a relationship between foraging success during incubation, nest-relief of the partner and nest desertion. Breeding adults at Middle Island recorded weights higher than those recorded at Phillip Island and London Bridge, also situated in western Victoria (P Dann pers. comm.). These differences suggest that food is plentiful, allowing greater foraging success and higher hatching success at Middle Island.

Times spent brooding the chicks at Middle Island are similar to those reported at Bowen and Phillip Islands by Fortescue (1991) and Chiaradia (1999) respectively. This means that the chicks were more likely to be of a suitable size to gain independence and regulate body temperature successfully (Chiaradia 1999). The weights achieved by post-guard chicks were higher than those recorded by Chiaradia (1999) at Phillip Island. This result is similar to that found by Cullen *et al.* (1992) at London Bridge.

Middle Island Little Penguin chicks were 58.9 days old (8.5 weeks) at fledging. Chiaradia (1999) found Phillip Island penguin chicks fledged in January at a mean age of 9.1 ± 1.1 weeks in 1995-96. Both are comparable with Reilly and Cullen's (1981) research, where the age at which the chick left the burrow for the sea depended on weight but occurred mostly under nine weeks.

The weights of Middle Island chicks at fledging averaged 1081.4 g (Table 4), which is higher than the weights recorded at Lion and Phillip Islands (Reilly and Cullen 1981, Rogers *et al.* 1995; Chiaradia 1999). This observation is consistent with the findings of Cullen *et al.* (1992) where a plentiful food supply was suggested as being the significant factor in determining the high fledging weight in western Victorian colonies.

Most breeding pairs at Middle Island successfully reared at least one chick. Five pairs (of the 50 studied) failed to breed while two pairs were successful after initially failing. The overall breeding success rate of pairs at Middle Island (1.49 chicks per pair) compares favorably with success rates reported for Little Penguins at other Australian locations. The highest success rate during the four year study on Lion Island was 0.85 (Rogers *et al.* 1995), while Dann (1992) found Phillip Island Little Penguins on average have fledged around 0.8 chicks per breeding pair over the previous 20 years. On Bowen Island, Fortescue (1995) found a breeding success rate of 1.07 chicks per pair, which is also, along with Middle Island's result, considered high.

It should be emphasised though, that the Middle Island data in this paper were collected during the greater part of a single season while the data collected elsewhere (Lion Island, Phillip Island and Bowen Island) are long-term data sets, so direct comparisons should be treated with caution. Nevertheless the data collected by us at Middle Island will be valuable for future comparisons at Middle Island or for comparisons within the same year at other locations.

The introduction of brush-matting onto Middle Island has reduced erosion and created more colony area in which the Little Penguin can breed. Native vegetation is establishing well in these sites and as it continues to grow this will significantly increase the amount of colony area available for burrows and breeding.

The high death rate of chicks (33%) and the destruction of 16% of eggs by tourists is cause for concern, especially when some deaths were caused by humans trampling burrows. A fox or dog killed 13 penguins in one night during the 1999/2000 breeding season (Overeem pers. obs.). We believe that increasing and unregulated visitation by tourists (some accompanied by dogs) will have a deleterious effect on penguin numbers in the long term and that management is urgently required. Complete closure of the island is not a viable option in order to protect the flora, fauna and other natural features of Middle Island. Successful management of the island should involve the formulation of a comprehensive management plan, incorporating visitor, pest and research issues. A visitor orientation and interpretation strategy should be implemented, including regulation of access to the island by visitors and control of movements to particular areas via boardwalks. The education and interpretation program should include signage on boardwalks and guided tours. Close monitoring of the presence and effects of dogs and foxes on the Little Penguins at Middle Island, and fox control in adjoining foreshore areas, will assist in the successful management of the island. The Little Penguin colony on Middle Island should be closely and continually monitored if it is to be managed sustainably in the long term.

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A Survey of the Reptile Fauna Inhabiting the Mt Meg Flora and Fauna Reserve, North-east Victoria

Geoffrey Heard[1,2] and Dennis Black[1]

Abstract
A survey of reptiles inhabiting a 5 km² study area incorporating the Mt Meg Flora and Fauna Reserve in north-eastern Victoria was conducted between September 2000 and March 2001. The study area was traversed systematically every week and diurnal observations used to detect reptiles that were either active or sheltering within microhabitats such as rock crevices, fallen timber or human rubbish. Fourteen reptile species were located. A further two species are known from this study area yet were not recorded. Large, diurnal species such as the Lace Monitor *Varanus varius* and Red-bellied Black Snake *Pseudechis porphyriacus* were most frequently encountered. Other notable records include Burton's Legless Lizard *Lialis burtonis* (considered regionally uncommon) and the Inland Carpet Python *Morelia spilota metcalfei* (listed as Endangered within Victoria). Composition of the reptile assemblage is discussed in terms of biogeographic and site-specific habitat associations. (*The Victorian Naturalist* **120** (3), 2003, 84-91)

Introduction

Granite uprisings within the Victorian Riverina provide a contrasting landform to the generally flat, alluvial plains that surround them. While these areas are known to be both geologically and floristically distinct (Conn 1993; Douglas 1993; Parks Victoria 2000), the vertebrate communities they support are poorly documented. This paper presents observations of the reptile fauna inhabiting the Mt Meg Flora and Fauna Reserve (Mt Meg FFR), a granite massif located in the south-east of the Victorian Riverina.

The Mt Meg FFR is an outlying reserve of the Warby Range State Park, located some 22 km west of Wangaratta in north-eastern Victoria, Australia. Mt Meg represents a northerly projection of the Chesney Vale Hills, a largely agricultural landscape punctuated by a series of steeply sloping, granitic hills. The reserve protects 239 ha of dry open woodland and shrubby heathland, habitat of state-wide significance for five threatened flora species and one endangered fauna species, the Inland Carpet Python *Morelia spilota metcalfei* (Parks Victoria 2000).

Materials and Methods

Study area

Fieldwork was conducted within a 5 km² study area incorporating the Mt Meg FFR and adjacent hills to the east (Dave's Hill) and south-east (Fig. 1). Mt Meg and Dave's Hill rise to maximum altitudes of 320 and 290 m respectively, and are divided by a narrow gully and north-flowing, spring-fed creek.

Land use varies within the freehold sections of this area. In lowland sections, past vegetation clearing has been extensive, particularly on land devoid of granite outcrops. The northern third of the study area has been subsequently converted to open pasture (see below). Additional clearing (primarily through ringbarking) has occurred on the slopes of Dave's Hill and adjacent areas in the south-east of the study area. This later clearing has often occurred within areas unsuited to pasture production (e.g. steep hill slopes where fractured rock is prolific), and has facilitated the establishment of several exotic weed species. The European Rabbit *Oryctolagus cuniculus* and Red Fox *Vulpes vulpes* are also abundant within these areas (Heard 2001). Currently, sheep, cattle, horses and deer are commercially grazed in various areas, while firewood collection for home heating continues on the wooded slopes (excluding Mt Meg). The eastern half of the study area is currently used as a nature retreat.

Six broad habitat types were described within this study area based upon variation in biophysical attributes, mainly vegetation, rock structure and hydrology (Heard 2001). Habitat descriptions are provided

[1] Department of Environmental Management and Ecology, La Trobe University, Albury-Wodonga Campus, PO Box 821, Wodonga, Victoria 3689
[2] Current address: Wildlife Profiles Pty Ltd, PO Box 500, Heidelberg, Victoria 3084

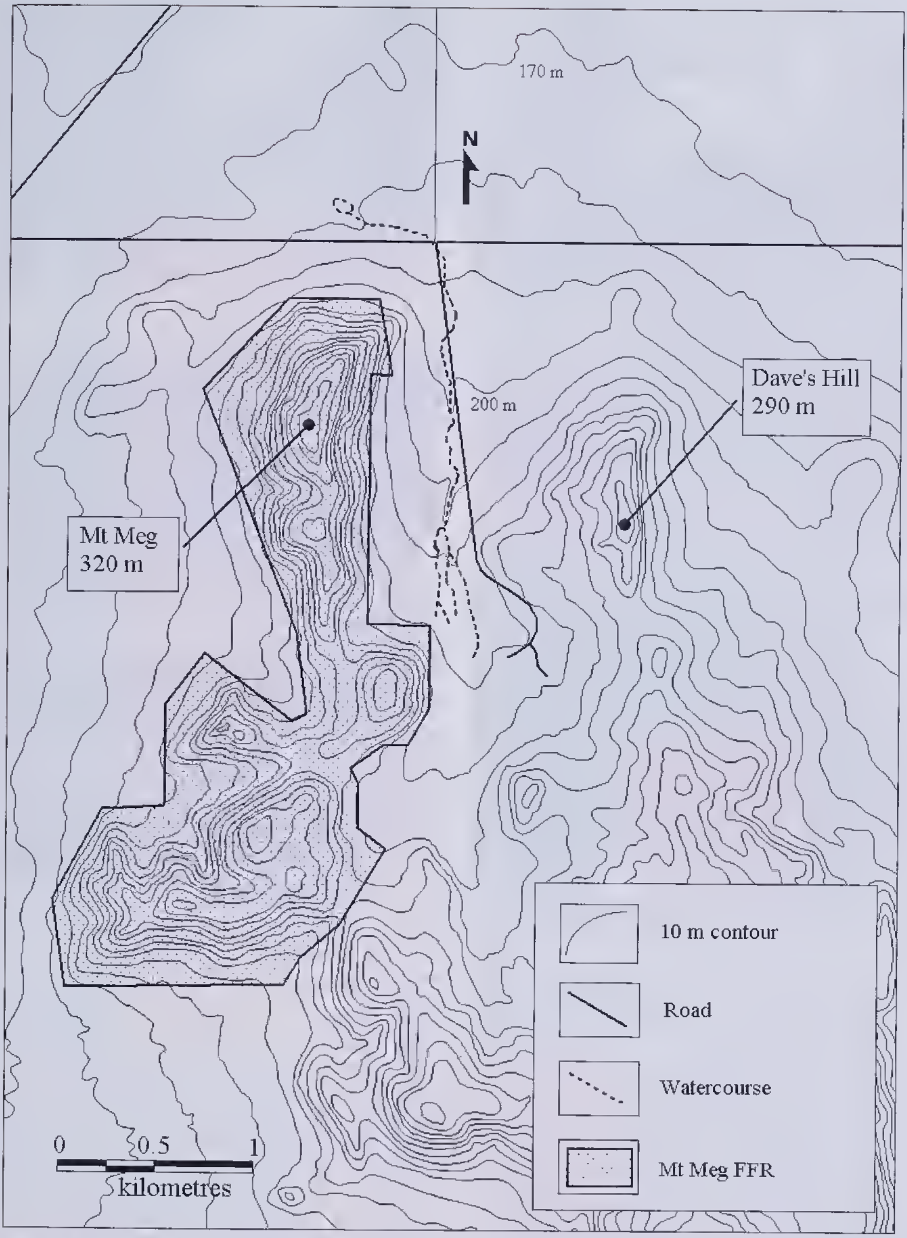

Fig. 1. Contour map of the Mt Meg study area.

below; estimates of habitat area (hectares) are given in parentheses.

• Granitic woodland (67 ha): restricted to the rocky slopes and hill summits, granitic woodland is dominated by Blakely's Red Gum *Eucalyptus blakelyi*. Dense stands of Fringe-myrtle *Calytrix tetragona* and Goldfields Grevillea *Grevillea alpina* form the shrub layer. Fallen timber and native lilies (Nodding Blue Lily *Stypandra glauca*, Flax Lily *Dianella* spp.) are present at ground level. Weathered granite outcrops,

Fig. 2. Examples of the six habitat types evident within the Mt Meg study area: (a) granitic woodland; (b) disturbed granitic woodland; (c) degraded woodland; (d) wetland; (e) gully; (f) grazed land.

consisting of boulder piles or fractured bedrock, are numerous on the steeper hill slopes (Fig. 2a).

• Disturbed granitic woodland (98 ha): occurs at marginally lower altitudes than granitic woodland and is distinguished by a predominance of weeds (Paterson's Curse *Echium plantagineum*, Horehound *Marrubium vulgare*) in the understorey and a mixture of *E. blakelyi*, White Box *E. albens* and Red Stringybark *E. macrorhyncha* in the overstorey. Complex granite outcrops are numerous (Fig. 2b).

• Degraded woodland (111 ha): woodland areas that have been largely cleared. Overstorey vegetation (*E. blakeyi, E. albens* and *E. macrorhyncha*) has been heavily depleted, while ground layer vegetation consists mainly of the weeds *E. plantagineum*, *M. vulgare* and St John's Wort *Hypericum perforatum*. Granite outcrops occur along scattered ridge lines (Fig. 2c).

• Wetland (11 ha): an area of dense Prickly Tea Tree *Leptospermum continentale* heath that surrounds several spring-fed waterbodies at the head of the gully. An open overstorey of River Red Gum *Eucalyptus camaldulensis* is also present. Sparse emergent vegetation (mainly Cumbungi *Typha* spp.) occurs within the water bodies (Fig. 2d).

• Gully (21 ha): a thin, uncleared riparian zone associated with the small, north-flowing creek. *Eucalyptus camaldulensis*, *E. albens* and Warby Swamp Gum *E. cadens*

Table 1. Broad habitat associations of reptile species recorded within the Mt Meg study area. Records indicate the number of individuals observed within each habitat type. Habitat key: GW, granitic woodland; DGW, disturbed granitic woodland; DW, degraded woodland; WL, wetland; GY, gully; GL, grazed land.

Species	Common Name	GW	DGW	DW	WL	GY	GL	Total
Chelidae								
Chelodina longicollis	Common Long-necked Tortoise	-	-	-	1	-	1	2
Gekkonidae								
Christinus marmoratus	Marbled Gecko	1	2	-	-	-	-	3
Pygopodidae								
Lialis burtonis	Burton's Legless Lizard	-	1	-	-	-	-	1
Agamidae								
Pogona barbata	Eastern Bearded Dragon	1	-	-	-	4	1	6
Varanidae								
Varanus gouldii	Sand Goanna	-	1	2	-	-	-	3
Varanus varius	Lace Monitor	4	7	2	-	1	-	14
Scincidae								
Carlia tetradactyla	Southern Rainbow Skink	-	1	1	-	3	-	5
Ctenotus robustus	Large Striped Skink	-	-	-	1	-	1	2
Egernia saxatilis intermedia	Black Rock Skink	2	-	-	-	-	-	2
Lerista bougainvillii	Bougainville's Skink	-	-	1	-	-	-	1
Tiliqua scincoides	Common Blue-tongue Lizard	1	-	1	-	-	-	2
Boidae								
Morelia spilota metcalfei	Inland Carpet Python	1	1	-	-	-	-	2
Elapidae								
Pseudechis porphyriacus	Red-bellied Black Snake	1	1	-	5	3	-	10
Pseudonaja textilis	Eastern Brown Snake	1	2	2	-	-	-	5
Total no. species		**8**	**8**	**6**	**3**	**4**	**3**	**14**
Total no. individuals		**12**	**16**	**9**	**7**	**11**	**3**	**58**

form the overstorey layer, while Lightwood *Acacia implexa* forms a sparse understorey. An open, grassy ground layer gives way to dense sedge growth along the creek line. Fallen logs are numerous (Fig. 2e).

• Grazed land (109 ha): agricultural land in the north of the study area, characterised by open paddocks of exotic and native pasture. Large, isolated specimens of *E. albens* occur throughout and represent the only remnant vegetation. A small number of sheep continue to graze this habitat and are watered by several shallow farm dams (Fig. 2f).

Reptile observations

Observations of the reptile fauna inhabiting the Mt Meg study area were made between September 2000 and March 2001. Observations were opportunistic and made while systematically traversing the study area on foot, four days each week between the hours of 0930 and 2000. The majority of reptiles were observed while they were diurnally active, or located when they were sheltering beneath or within exfoliating granite, rock crevices, fallen logs, tree hollows, exfoliated bark or human rubbish. The specific location, habitat association and microhabitat of each individual were recorded. Small, agile skinks were pursued only occasionally (often precluding positive identification), and are generally excluded from the following observations. Records from the *Atlas of Victorian Wildlife* (NRE 2001) were used to supplement field data. With the exception of the Inland Carpet Python *Morelia spilota metcalfei* (Barker and Barker 1994; Greer 1997), nomenclature follows Cogger (2000).

Results

Fourteen reptile species, representing eight families, were recorded within the study area (Table 1). An additional two species, Carnaby's Wall Skink *Cryptoblepharus carnabyi* and Boulenger's Skink *Morethia boulengeri*, are known from the study area (NRE 2001).

Three families (Scincidae, Varanidae and Elapidae) comprised the majority of reptile species recorded during this study (69%). Five families (Chelidae, Gekkonidae, Pygopodidae, Agamidae and Boidae) were each represented by a single species.

Large diurnal species were the most frequently encountered individuals. Varanids (predominantly *Varanus varius*) were the most commonly-located reptile, representing 31% of all observations. Both the normal and broad-banded ('Bells form') colour morphs of *V. varius* occur in this study area and were observed in equal frequencies. With the exception of *Pseudechis porphyriacus* and *Pogona barbata*, the remaining species were only observed sporadically (five or fewer individuals in total; Table 1).

The small number of records for many species limits the interpretation of their habitat and microhabitat associations. Nonetheless, the following patterns were noted. Two species, *Christinus marmoratus* and *Egernia saxatilis intermedia*, were associated with relatively intact woodland habitats where rock crevices, fallen timber and exfoliating bark may be used as shelter sites (Table 2). Conversely, *V. varius* and *Pseudonaja textilis* appear to be woodland generalists within this area. *Varanus varius* utilises all woodland habitats, while *P. textilis* was observed within all habitats on the rockier slopes (granitic woodland, disturbed granitic woodland and degraded woodland; Table 1). *Varanus varius* was recorded foraging amongst ground vegetation, litter and on the lower branches of eucalypts (*E. blakelyi, E. macrorhyncha*). Individual *P. textilis* were located amongst granite rock screes, sheltering within a dead tree trunk (*E. albens*) and under corrugated iron. Both species were seen on the surface of large rabbit warrens (Table 2).

Pogona barbata, *Varanus gouldii* and *Carlia tetradactyla* appear to favour open woodland, mainly degraded woodland and gully areas. *Varanus gouldii* and *C. tetradactyla* were observed within disturbed granitic woodland; however, both individuals were located on the periphery of this habitat. Five adult *P. barbata* were encountered in the gully and adjacent grazed land, mostly basking on fence posts and fallen timber. Two adult *V. gouldii* were observed basking close to large rabbit warrens, while all *C. tetradactyla* were encountered amongst ground vegetation or litter.

Only one species (*P. porphyriacus*) was frequently encountered in the wetland. Most specimens were observed close to water-bodies, and were seen foraging, moving or basking within or directly adjacent to standing water.

Few data were gathered for the remaining six species. An adult specimen of *Lialis burtonis* (considered regionally uncommon by Brown and Bennett 1995) was found moving through ground litter within disturbed granitic woodland on 8 December 2000. Two adult *M. s. metcalfei* (listed as Endangered in Victoria by NRE 2000) were observed during the study; one within granitic woodland on the north face of Mt Meg, the other within disturbed granitic woodland on the western face of Dave's Hill. Both individuals were observed basking amongst granite rock screes.

Discussion

The woodland habitats of the Mt Meg FFR and surrounding hills support a diverse assemblage of reptile species, several of which are of state or regional significance. The records collected during this study confirm the existence of sixteen reptile species in the reserve, while a further eleven may be expected from the area based upon broad distribution, known records and/or habitat requirements (Robertson *et al.* 1983; Coventry and Robertson 1991; Brown and Bennett 1995; Cogger 2000; D Hunter unpubl. data; P Robertson pers. comm. 15 May). These eleven species are: Wood Gecko *Diplodactylus vittatus*, Olive Legless Lizard *Delma inornata*, Tree Dragon *Amphibolurus muricatus*, Garden Skink *Lampropholis guichenoti*, White's Skink *Egernia whitii*, Yellow Bellied Water Skink *Eulamprus heatwolei*, Gray's Blindsnake *Ramphotyphlops nigrescens*, Woodland Blindsnake *Ramphotyphlops proximus*, Bandy Bandy *Vermicella annulata*, Eastern Tiger Snake *Notechis scutatus* and Mitchell's Short-tailed Snake *Suta nigriceps*. Two major factors influence this variety: biogeographic integration (landscape level) and habitat diversity (site level).

The Mt Meg FFR lies within an area of clear climatic, floristic and geological convergence. From a bioregional perspective,

Table 2. Microhabitat associations of reptile species recorded within the Mt Meg study area. Microhabitat abbreviations: FC, fence post; DT, dead tree; GV, ground vegetation; LT, litter; T, tree; W, water; OG, open ground; FL, fallen log; GR, ground rock (on); RC, rock crevice (in); ER, exfoliated rock (under); RD, road; EB, exfoliated bark; TN, tin; RW, rabbit warren.

Species	Common Name	FC	DT	GV	LT	T	W	OG	FL	GR	RC	ER	RD	EB	TN	RW
Chelidae																
Chelodina longicollis	Common Long-necked Tortoise			+			+									
Gekkonidae																
Christinus marmoratus	Marbled Gecko											+		+		
Pygopodidae																
Lialis burtonis	Burton's Legless Lizard				+											
Agamidae																
Pogona barbata	Eastern Bearded Dragon	+				+			+	+			+			
Varanidae																
Varanus gouldii	Sand Goanna			+	+											+
Varanus varius	Lace Monitor			+	+	+										+
Scincidae																
Carlia tetradactyla	Southern Rainbow Skink			+	+											
Ctenotus robustus	Large Striped Skink											+			+	
Egernia saxatilis intermedia	Black Rock Skink										+					
Lerista bougainvillii	Bougainville's Skink														+	
Tiliqua scincoides	Common Blue-tongue Lizard			+							+					
Boidae																
Morelia spilota metcalfei	Inland Carpet Python							+		+						
Elapidae																
Pseudechis porphyriacus	Red-bellied Black Snake			+			+	+		+						
Pseudonaja textilis	Eastern Brown Snake		+							+					+	+

the Mt Meg FFR and surrounding lands (Chesney Vale Hills, Warby Range) lie within the 'Northern Inland Slopes' and are immediately surrounded by the 'Central Victorian Uplands' (to the south east) and 'Victorian Riverina' (all other directions) (Conn 1993; Parks Victoria 2000). The reptile assemblage of the area reflects these coalescing influences, with typical Riverina fauna such as *D. inornata*, *L. burtonis*, *V. gouldii*, *C. carnabyi*, *M. boulengeri*, *R. proximus*, *M. s. metcalfei*, *S. nigriceps* and *V. annulata* overlapping with species displaying a primarily eastern Victorian distribution (e.g. *E. s. intermedia*, *L. guichenoti*, *P. porphyriacus*; Robertson *et al.* 1983; Coventry and Robertson 1991; Brown and Bennett 1995; Cogger 2000). This highlights a major feature of the Victorian reptile fauna. Rawlinson (1971) recognised that the Great Dividing Range heavily influences the distribution of reptile species in this state, and that a major zoogeographic transition occurs in the western foothills of this range. Here, reptile assemblages adapted to the cool, wet climates in the south-east meet with those from the dry, semi-arid interior of the north-west. Areas that lie within the centre of this gradient, such as the inland slopes of north-eastern Victoria, often support reptiles from both of these environments, as well as a range of taxa that are widespread in south-eastern Australia (Bennett *et al.* 1998). Within the Mt Meg study area, examples of the latter group include *C. marmoratus*, *D. vittatus*, *V. varius*, *Ctenotus robustus*, *C. tetradactyla*, *R. nigrescens* and *N. scutatus* (Cogger 2000).

Site-specific habitat factors, particularly the extent of intact woodland, also influence species richness in this study area. Structurally complex woodland habitats are known to support high numbers of reptiles in other Australian environments (Kitchener *et al.* 1980), apparently due to the range of retreat sites, basking and foraging areas they provide (Heatwole and Taylor 1987). Attributes such as granite outcrops, fallen timber, tree hollows and woody litter provide important microhabitats for *C. marmoratus*, *L. burtonis*, *E. s. intermedia* and *V. varius* within the woodland habitats studied here (see also Robertson *et al.* 1983; Brown and Bennett 1995). The endangered Inland Carpet Python *M. s. metcalfei* has been recorded utilising each of these microhabitats within the study area (Heard 2001; P Robertson unpubl. data), while the skinks *C. carnabyi* and *M. boulengeri* probably make use of those attributes found at ground level (Brown and Nicholls 1994).

Open, semi-cleared woodland supports fewer species but favours *C. tetradactyla*, *P. barbata* and *V. gouldii*. A preference for open habitats by Victorian populations of *P. barbata* has been recorded previously (Hadden and Westbrooke 1996; Michael 2001) and in this study area may be primarily due to an abundance of invertebrate prey amongst pasture grasses. Within degraded woodland, numerous rabbit warrens provide important shelter sites for *V. gouldii*, while patchy vegetation cover offers excellent thermoregulatory opportunities for the heliothermic skink *C. tetradactyla*.

Permanent water-bodies within the study area support *Chelodina longicollis* and *P. porphyriacus*. Although considerable effort was made to search each water-body for *C. longicollis* (looking specifically for basking and floating individuals), only two specimens were recorded. One of these was recorded within open pasture, presumably whilst moving between farm dams, a common behaviour for this species (Jenkins and Bartell 1980; Cogger 2000). Active specimens of *P. porphyriacus* were commonly observed around these water-bodies during spring and early summer. While this species' preference for wetland habitats is well documented (and related to that of their anuran prey), individuals are often located far from water (Jenkins and Bartell 1980; Coventry and Robertson 1991; Shine 1991; Cogger 2000). We observed two active specimens within woodland habitats during spring and presume mate-searching or terrestrial foraging was involved in each case (see Shine 1987).

The northern inland slopes support a diverse reptile fauna and must be recognised as priority areas for biodiversity conservation within the Victorian Riverina. Currently, the bioregion is poorly reserved (only 4% of the state total is currently protected; Parks Victoria 2000) and therefore vulnerable to ongoing degradation. Within the Chesney Vale Hills, privately owned woodland remnants are often subject to varying degrees of livestock grazing and firewood collection. Both factors severely reduce microhabitat availability and may expose many species, including threatened taxa such as *M. s. metcalfei*, to introduced predators (Heard 2001; P Robertson unpubl. data). Further land reservation and altered management regimes are urgently required to conserve these communities and the woodland environs that support them.

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First Record of Burrow Use by the Long-nosed Potoroo *Potorous tridactylus*

Inka Veltheim[1]

Abstract
Within the family Potoroidae, which includes potoroos and bettongs, only one species, the Burrowing Bettong, *Bettongia lesueur*, is known to construct and regularly inhabit burrows. This is the first reported incident of burrow use by the Long-nosed Potoroo *Potorous tridactylus*. Two individuals, one male and one female, were found to enter a burrow on separate occasions. The observations were made during a study into habitat use of *P. tridactylus* at the Ralph Illidge Sanctuary, Naringal East, in south-western Victoria. (*The Victorian Naturalist* **120** (3), 2003, 92-93)

Members of the family Potoroidae exhibit a range of nesting and sheltering behaviours. The Long-nosed Potoroo *Potorous tridactylus*, and Long-footed Potoroo *P. longipes*, utilise tussocks and dense grass thickets for diurnal shelter (Bennett 1993; Saxon *et al.* 1994) and do not construct complex nests (Seebeck *et al.* 1989; Bennett 1993). The Brush-tailed Bettong *Bettongia penicillata*, Tasmanian Bettong *B. gaimardi*, Northern Bettong *B. tropica* and Rufous Bettong *Aepyprymnus rufescens*, build nests using a variety of plant material (Seebeck *et al.* 1989; Wallis *et al.* 1989). The Burrowing Bettong *B. lesueur* differs in its sheltering behaviour from the other potoroids, being the only species that is known to construct and regularly inhabit burrows (Sander *et al.* 1997, Burbidge 1995). These burrows are often part of a more complex interconnected warren structure (Seebeck *et al.* 1989; Sander *et al.* 1997).

Over summer 1999-2000, I conducted a study into the foraging patterns and habitat use of *P. tridactylus*. The study was undertaken at the Ralph Illidge Sanctuary in south-western Victoria, south of Terang. During the course of this study, 30 animals were fitted with a spool-and-line package, which allows precise tracking of the animals' movements through their habitat. On two occasions the line was found entering a burrow. This observation is the first of its kind, as *P. tridactylus* has not previously been reported to utilise burrows.

The first individual to enter a burrow was a female (DA81). The female was fitted with a spool-and-line package and released from the side of a walking track on 5 November 1999 at 2320 hrs. At the time of release, the female was left inside a calico bag on the ground next to the trap to allow her to emerge voluntarily. The line was followed the next day and it was found entering a burrow, which had two entrances. She had entered a runway in thick sedge and emerged in a more open area before entering the burrow, 4.4 m from the site of release. The spool package was found inside the burrow, where the female had groomed it off. The burrow was near the base of a tree and the two entrances were partly concealed by leaf litter and twigs. The two entrances were 600 mm apart. The external width and length of the entrances was measured. One of the entrances was 100 mm wide and 100 mm long, and the other was 80 mm wide and 90 mm long.

A male (A612) was also released near a walking track, some 500 m from the burrow entered by female DA81. The male was released on 5 February 2000 at 0030 hrs and the line followed the next day. As for female DA81, the male was left in the

Fig. 1. Burrow entered by *Potorous tridactylus* (A612) at Naringal East, February 2000.

[1] c/- Broome Bird Observatory, PO Box 1313, Broome, WA 6725. Email inka_veltheim@hotmail.com

calico bag next to the trap to emerge voluntarily. The male travelled for 10.3 m before entering a burrow, which was located in dense shrub cover of Prickly Moses *Acacia verticillata*, with sparse undergrowth (see Fig. 1). Only one entrance was found and the spool package could not be retrieved as it was too deep in the burrow. The burrow entrance was 124 mm wide and 62 mm long. Several burrow entrances similar in external appearance were found nearby but it was not possible to determine whether these were also being used by *P. tridactylus* or whether they were connected to the one entered by A612.

Throughout its range, *P. tridactylus* is associated with dense understorey vegetation, which provides diurnal shelter and protection from predators (Bennett 1993). *P. tridactylus* shelters in shallow depressions (or squats) under tussocks and dense grass (Seebeck *et al.* 1989, Bennett 1993). The discovery of burrow use by *P. tridactylus* suggests that burrows may provide important additional shelter. From this record of burrow use by *P, tridactylus*, it is not possible to conclude whether burrow use in this species is regular, whether this species constructs burrows like *B. lesueur*, or whether it utilises burrows of other species. The importance, extent and function of burrow use by *P. tridactylus* warrants further research.

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Distribution and Density of the Hooded Plover *Thinornis rubricollis* Along a Remote Coastline in North West Tasmania

Mark Antos[1]

Abstract
The Arthur-Pieman Conservation Area, on the north-west coast of Tasmania, provides many kilometres of ocean beach habitat for the vulnerable Hooded Plover *Thinornis rubricollis*. Hooded Plovers were surveyed along a 43.5 km section of coast which included both rocky shores and sandy beaches. They were absent from the rocky portion of the coastline (17.0 km), but 65 individuals were recorded along the sandy portion of coastline (26.5 km). The recorded population density of 2.45 birds/km compares favourably with reported mean densities for most parts of south-eastern Australia. Careful management and monitoring are required if the current numbers of the Hooded Plover in this area are to be maintained. (*The Victorian Naturalist* 120 (3), 2003, 94-97)

Introduction

The Hooded Plover *Thinornis rubricollis* is an endemic shorebird which frequents high-energy sandy coastlines of southern Australia (Blakers *et al.* 1984; Lane 1987). It has declined in range, especially on the south-east coast of mainland Australia (Blakers *et al.* 1984; Cameron and Weston 1999; Garnett and Crowley 2000). The south-eastern population is classified as 'vulnerable' and the south-western population as 'near threatened' (Garnett and Crowley 2000). Although not officially listed as threatened in Tasmania, the Hooded Plover population has declined by 1.56% per year at key sites and may qualify for listing under Tasmania's Threatened Species Protection Act 1995 (Bryant 2002). Prime causes for the Hooded Plover's decline include predation by introduced predators and human disturbance. Coastal recreational activities such as pedestrian traffic, off-road vehicles and domestic animals have been implicated in population decline (Buick and Paton 1989; Marchant and Higgins 1993; Garnett and Crowley 2000; Weston 2001).

Tasmania is regarded as being a stronghold of the Hooded Plover with an estimated population of 1730 individuals (Marchant and Higgins 1993; Bryant 2002). However, many of the remote west coast beaches of Tasmania are not frequently surveyed and consequently, population densities are not well known (Schulz 1993). Although most of the west coast is relatively free of human disturbance, it is subject to increasing pressure from recreational and commercial users (Schulz 1993; Parks and Wildlife Service Tasmania (PWST) 2002). The remoteness of such areas, along with limited information regarding Hooded Plover densities, can present land managers with many challenges.

This study aims to contribute to the knowledge of the distribution and density of Hooded Plovers by reporting the results of a survey along a remote stretch of coastline, as well as discussing the threats faced by this remote population of Hooded Plovers.

Methods

The Arthur-Pieman Conservation Area (APCA) covers 100,135 ha on the north-west coast of Tasmania (Fig. 1). The coastal zone is exposed to strong westerly winds resulting in a high-energy coastline (PWST 2002). Despite a relatively flat and uniform topography, the coastline is varied with long sandy beaches, rocky shores, numerous creek mouths and mobile and vegetated dunes. The section of coast surveyed in this study was from the Pieman River mouth (41°40'07" S, 144°55'05" E) to Brooks Creek (41°18'47" S, 144°44'27" E), a total distance of 43.5 km. Of this distance, 26.5 km consisted of sandy ocean beaches and the remaining 17.0 km consisted of rocky shores. Distances were measured from 1:25 000 topographical maps.

The coastline was walked from south to north and over a period of four consecutive days (17-20 February, 2002), between 0800 and 1500 each day. All bird species observed were recorded but particular atten-

[1] School of Ecology and Environment, Deakin University, 221 Burwood Highway, Burwood, Victoria 3125

Fig. 1. Sandy Cape Beach. Typical ocean beach habitat of the Hooded Plover *Thinornis rubricollis* within the Arthur-Pieman Conservation Area.

tion was given to accurately recording numbers of Hooded Plovers. Three observers walked the transect as a group. On sandy shores, observers walked between the water's edge and the highest tide mark because Hooded Plovers carry out most of their foraging in this zone (Marchant and Higgins 1993). This zone was in excess of 100 m wide in some locations. On rocky shores, observers travelled between the water's edge and the coastal vegetation.

Results

A total of 65 Hooded Plovers was recorded during the survey. All observations were of foraging birds on, or immediately behind, sandy beaches. No Hooded Plovers were recorded along the rocky shorelines. Hooded Plovers were the most abundant plovers seen on the coast with an overall density of 2.45 birds per km of beach (Table 1). They were generally seen in either pairs or groups of 3-4 birds. Two exceptions were at Ordnance Point where two flocks of 7 and 8 birds respectively were seen concurrently, suggesting that this area may be an important roosting site. The flock of 7 birds was spotted in an extensive Aboriginal midden behind the foredune. The birds were difficult to see unless they moved owing to the camouflage of their plumage amidst the mass of bleached shell fragments. The flock of 8 birds was seen away from the water's edge in the middle of a sand-spit.

Red-capped Plovers *Charadrius ruficapillus* and Black-fronted Dotterels *Elseyornis melanops* were also encountered but at lower densities of 0.79 and 0.72 birds/km, respectively. These two species were also observed only along sandy beaches. Pied Oystercatchers *Haematopus longirostris* and Sooty Oystercatchers *Haematopus fuliginosus* were observed making use of both the rocky and sandy coasts at densities of 0.85 and 0.74 birds/km, respectively. A wide range of other shorebirds and bush birds was also observed on the shore and in adjacent vegetation (see Table 1).

Discussion

Bird densities

The reported densities of Hooded Plovers can vary with the time of year. For example, Hooded Plovers form autumn/winter flocks and group sizes are higher than at other times of the year (Weston 2000; Bryant 2002). The occurrence of large, mobile flocks can yield high density counts and may be subject to greater sampling error (Heislers and Weston 1993). In Victoria, Weston (2000) documented that average group sizes are at their lowest from August to February. The present survey was conducted at the end of the breeding season when group size and overall counts are at their lowest (Weston 2000; MA Weston pers. comm.)

The density of Hooded Plovers recorded along the sandy sections of coastline in the southern portion of the APCA (2.45 birds/km) is high when compared with other areas of Australia. Counts conducted during November over the coast of Victoria have yielded overall densities of 0.5-0.6 birds/km on ocean beaches (Weston 1993, 1995). During November in South Australia a total density of 0.46 birds/km was recorded over 699 km of coastline with a maximum of 1.46 birds/km recorded from Kangaroo Island (Natt and Weston 1995).

In Tasmania, densities range from 1.4-2.0 birds/km but up to 3.0 birds/km have been recorded on undisturbed beaches (Bryant 2002). During a survey of the west coast, which included the portion of coastline covered by the present study, Schulz (1993) documented an average density of 3.5 birds/km over 109 km of beach during April. High density counts of 6.6 birds/km over 36.9 km of beach have also been documented on the south-west coast of Tasmania where human disturbance is minimal and access difficult (Schulz and Kristensen 1994).

Table 1. Birds recorded on the coastline and coastal dunes of the Arthur-Pieman Conservation Area, Tasmania, along a 43.5 km transect (densities of birds per km were measured only for species observed to be actively foraging or roosting on the coastline, excluding gulls, which were ubiquitous).

Species	Abundance	Birds/km	Habitat
White-bellied Sea-Eagle *Haliaeetus leucogaster*	2	Not measured	Sandy, coastal dunes
Ruddy Turnstone *Arenaria interpres*	32	1.88	Rocky
Red-necked Stint *Calidris ruficollis*	approx. 200	Not measured	Sandy
Sanderling *Calidris alba*	approx. 100	Not measured	Sandy
Red-capped Plover *Charadrius ruficapillus*	21	0.79	Sandy
Black-fronted Dotterel *Elseyornis melanops*	19	0.72	Sandy
Hooded Plover *Thinornis rubricollis*	65	2.45	Sandy
Sooty Oystercatcher *Haematopus fuliginosus*	32	0.74	Rocky and sandy
Pied Oystercatcher *Haematopus longirostris*	37	0.85	Sandy and rocky
Silver Gull *Larus novaehollandiae*	Mod. common	Not measured	Entire coast
Pacific Gull *Larus pacificus*	Mod. common	Not measured	Entire coast
Crested Tern *Sterna bergii*	20	0.75	Sandy
Caspian Tern *Sterna caspia*	2	Not measured	Sandy
Yellow-throated Honeyeater *Lichenostomus flavicollis*	Common	Not measured	Coastal dunes
Dusky Robin *Melanodryas vittata*	Common	Not measured	Coastal dunes
Black Currawong *Strepera fuliginosa*	Uncommon	Not measured	Entire coast
Forest Raven *Corvus tasmanicus*	Uncommon	Not measured	Entire coast

Given that this survey was conducted over several days, it is possible that numbers were overestimated by double counting. Conversely, many sections of beach covered by the present survey were over 100 m wide and it was difficult to observe all birds along the entire width. The large, sparsely vegetated dunes which backed most of the coastline and extended over 1 km inland were not surveyed. Birds have been recorded roosting in sparse dune vegetation and blow-outs where they are difficult to detect (Lane 1987; MA Weston pers. comm.).

Threats and management

Although the APCA receives low levels of recreational usage, there is evidence of growth of recreational pursuits. Visitor numbers are highest over summer months, coinciding with the Hooded Plover breeding season (PWST 2002). Disturbance by dogs and trampling by horses have been identified as threats to the Hooded Plover (Dowling and Weston 1999; Garnett and Crowley 2000; Weston 2001). Dogs and horses are currently permitted within the APCA as long as an authority form is completed (PWST 2002). Trampling by stock and the additional disturbance associated with herd management and mustering (vehicle and horse-based travel, presence of dogs) also poses a threat to the Hooded Plover (Schulz 1993). Stock are agisted within the APCA between March and September (PWST 2002). This period is largely outside the breeding season of the Hooded Plover and nest disturbance and destruction is likely to be minimal and restricted to very early or late breeding attempts. The impact of cattle grazing on coastal vegetation, and consequently dune morphology, needs to be examined.

The use of off-road vehicles along ocean beaches can have negative impacts on Hooded Plovers by disturbing nesting birds and by directly crushing eggs and chicks (Buick and Paton 1989; Garnett and Crowley 2000). In a study in South Australia, Buick and Paton (1989) estimated that 81% of nests were susceptible to being run over on beaches exposed to vehicular traffic. Schulz (1993) found that beaches on the west coast of Tasmania which showed signs of vehicle activity supported lower densities of Hooded Plovers than beaches where vehicle use was minimal or absent. Guidelines have been set for vehicle operators to use only that part of the beach between high tide mark and the water's edge where Hooded Plovers do not nest (PWST 2000, 2002). However, it is difficult to achieve compliance and even a small number of vehicles driving above the high tide mark can have a major impact (Buick and Paton 1989; PWST 2002). During this survey, widespread evidence of vehicle use on all levels of the beach, on bare and partly vegetated dunes, through freshwater wetlands and streams, and over Aboriginal middens was observed.

Despite the remoteness of the area, many conservation challenges remain for the Hooded Plover. The recently released Arthur-Pieman Conservation Area Management Plan (PWST 2002) recognises the potential impacts of the aforementioned threats on natural values. In an attempt to balance a variety of uses with conservation, the plan aims to control and monitor the impact of activities which may have adverse environmental impacts. This is an important step in conserving the Hooded Plover and other natural values in the APCA; however, it may be necessary to review some uses and activities in future if they are shown to be detrimental to the Hooded Plover population.

Conclusion

The density of 2.45 Hooded Plovers per km of sandy coastline in the APCA is relatively high when compared to other areas of south-eastern Australia. Although the population of Hooded Plovers may be able to tolerate the current levels of disturbance, the level of recreational use in the reserve is likely to continue to rise (PWST 2002). However, appropriate management can be successful in alleviating threats to the Hooded Plover (Dowling and Weston 1999). The Hooded Plover population of the APCA will require careful management and monitoring if current population densities are to be maintained.

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Some Recent Strategic Additions to Victoria's Protected Area System 1997-2002

James A Fitzsimons[1,2] and Chris Ashe[1]

Abstract

The development of a comprehensive, adequate and representative reserve system is an objective of all Australian states and territories. In Victoria, land purchase is one means of increasing the reservation levels of some of the State's most endangered ecosystems. This article outlines the biological features of some new land purchases for addition to the Victorian protected area system. (*The Victorian Naturalist* **120** (3), 2003, 98-108)

Introduction

In a systematic process to increase the reservation levels of Victoria's most threatened ecosystems, particularly native grasslands and grassy woodlands, the Department of Sustainability and Environment's conservation land purchase program aims to acquire high quality samples of such ecosystems from private land for addition to the reserve system. While it is recognised that protection of land within national parks and conservation reserves will not conserve all or even most biodiversity within a region, strict protected areas have long been regarded as the most secure form of protection for biodiversity, and often the most effective (Pressey *et al.* 1994; Pressey and Logan 1997). All acquisitions are on a completely voluntary basis. Purchase priorities are derived from inventories of the most significant private sites throughout the State and assessed in relation to the comprehensiveness, adequacy and representativeness of the existing reserve system. Land purchase of park and reserve linkages and inliers also occurs in order to consolidate protected habitat and alleviate potential management problems.

This process complements regional assessments of public land in Victoria carried out by the Victorian Environment Assessment Council (and its predecessors, the Land Conservation Council (LCC) and Environment Conservation Council (ECC)) and the Regional Forest Agreement process.

Since the implementation of the National Reserve System Program (NRS) in 1992, all Australian states and territories have been working toward the development of a comprehensive, adequate and representative (CAR) system of protected areas. To provide a national and regional planning framework for the NRS, the Interim Biogeographic Regionalisation of Australia (IBRA) was developed. IBRA regions are derived by compiling climate, lithology/geology, landform, vegetation, flora and fauna, landuse and other attributes (Thackway and Cresswell 1995; Environment Australia 2000). IBRA regions are the base for systematically identifying deficiencies in the existing system of protected areas. Eleven IBRA regions (and 27 recently delineated sub regions) occur in Victoria, of which two are considered to be of particularly high priorities for increased reservation – the Victorian Volcanic Plain and the Riverina.

This paper outlines some of the more important recent land purchases for addition to the reserve system (from 1997 to mid 2002) and a brief description of their natural attributes. Fig. 1 indicates their location within Victoria. Parks Victoria manages most sites and all purchases listed are managed for the conservation of biodiversity. Blocks purchased and added to adjoining reserves are managed as part of the existing reserve. On some sites, such as the Terrick Terrick Grasslands and Balmattum Grassy Woodlands, which have a past history of grazing, a strictly controlled grazing regime has been retained as a management tool to enhance the biodiversity value of some grassy ecosystems.

The abbreviated threat status used for species in this paper is as follows (derived from CNR (1995), NRE (2000a,b) and references therein, the *Flora and Fauna*

[1] Parks, Flora and Fauna Division, Department of Sustainability and Environment, Level 14, 8 Nicholson Street, East Melbourne, Victoria 3002

[2] School of Ecology and Environment, Deakin University, 221 Burwood Highway, Burwood, Victoria 3125. Email fitzsimo@deakin.edu.au

Fig. 1. Location of recent land purchases for addition to the reserve system (existing reserve system shaded).

Guarantee Act 1988 and the *Environment Protection and Biodiversity Conservation Act 1999*):

Victorian Status – ce (critically endangered); e (endangered); v (vulnerable); r (rare); n (near threatened); k (poorly known/data deficient);

National Status – E (endangered); V (vulnerable); R (rare); K (poorly known/data deficient)

The conservation status of all species listed in this paper are outlined in Appendix 1, while Appendix 2 lists communities listed under the *Flora and Fauna Guarantee Act 1988* protected by the reserves.

1. Parrie Yalloak Plains Sedgy Woodland, Grampians

This 128 ha property comprises mostly Plains Sedgy Woodland Ecological Vegetation Class (EVC) and lies on the eastern side of the Grampians National Park, near Yarram Park. Once added, the site will represent the largest occurrence of the EVC in the park and is considered one of the highest quality areas of Plains Sedgy Woodland in the western Victorian Midlands.

Vegetation on most of the property remains largely intact and consists mainly of a mature age overstorey of River Red Gum *Eucalyptus camaldulensis*, Yellow Box *E. melliodora* with some Manna Gum *E. viminalis*, and a largely intact understorey. Grazing by cattle or sheep has not occurred in the recent past and the property has had minimal disturbance from weed species (Fig. 2).

2. Burrah Burrah Grassy Woodlands and Wetlands, Grampians

This 68 ha block was purchased in late 1999. It protects eight distinct EVCs including Grampians Alluvial Terraces Herb-rich Woodland and Red Gum Wetland, as well as the only known location of the Grampians Alluvial Terraces Herb-rich Woodland/Claypan Ephemeral Wetland Mosaic in the State.

Birds of state significance such as the Brolga *Grus rubicunda* (v) and Great Egret *Ardea alba* (e) have been sighted on the block. The property, to be added to the Grampians National Park, originally protruded into the south of the park north of the Wannon River near Brady Swamp. Its

Fig. 2. Parrie Yalloak Sedgy Woodland. Photo: James Fitzsimons.

addition will solve a number of potential management issues often associated with park inliers (e.g. provision of access, development or landuse impacting on the ecological or aesthetic attributes of the park or reserve).

3. Ridge Paddock Grasslands, Woorndoo

The purchase of the 130 ha 'Ridge Paddock', and its addition to the Cobra Killuc Wildlife Reserve significantly adds to the protection of endangered Western (Basalt) Plains Grassland (listed under the *Flora and Fauna Guarantee Act 1988*) and Plains Grassy Woodland in the Woorndoo district and Victorian Volcanic Plain.

The site was part of a larger grazing property and has retained its high natural values because of a lack of intensive agriculture and a grazing regime suitable to the maintenance of grassland values. Importantly, the adjacent 500 ha Cobra Killuc Wildlife Reserve contains one of the largest and most species-rich examples of western plains native grassy woodlands remaining in Victoria (Hastings 1983).

The 'Ridge Paddock' property contains a large population of Clover Glycine *Glycine latrobeana* (V) as well as Spurred Speargrass *Austrostipa gibbosa* (r), Hairy-tails *Ptilotus erubescens* and a suspected rare *Microtis* species.

The site is considered to be of high value for three nationally threatened fauna species. Webster (1996) recognised the site as one of the highest priority habitat sites of the nationally vulnerable Plains-wanderer *Pedionomus torquatus* on Victoria's Western Plains. The site contains substantial areas of habitat for the endangered Golden Sun Moth *Synemon plana*. Cobra Killuc Wildlife Reserve has also been the focus of a reintroduction program for the nationally vulnerable Eastern Barred Bandicoot *Perameles gunnii*. The addition of 'Ridge Paddock' to the reserve is likely to both increase suitable protected habitat for this species and buffer the threatening processes in other parts of the reserve.

4. Blacks Creek Grassland, Skipton

The purchase of the 221 ha Blacks Creek grasslands, Skipton, ensures the protection of a high quality sample of the Western (Basalt) Plains Grassland, which is considered a high priority for state and national conservation programs. Finer-scale vegetation units identified on the site include Red Soils Grassland, Black Soil (Gilgai Plain) Grassland, Plains Grassy Wetland, Grey Clay Flats Seasonal Wetlands, Creekline Tussock Grassland and Riparian Shrubland. Almost 70 species of indigenous plants have been recorded from preliminary surveys. Of these, one is nationally threatened (Clover Glycine), one vulnerable in Victoria (Small Milkwort *Comesperma polygaloides*), three of taxonomic significance, and a number considered to be regionally rare (Barlow 2000).

Brolgas regularly use the grasslands for feeding, as do a number of wader species. The size, diversity and condition of the grassland habitat suggests there is considerable potential to support other important fauna values. The extensive areas of *Poa*-dominated, high biomass grasslands could provide good cover for mammals such as the Eastern Barred Bandicoot which is present in a number of nearby reserves, linked by a habitat corridor along Blacks Creek (Barlow 2000). The site will be reserved as the Blacks Creek Nature Conservation Reserve.

5. Craigieburn Grasslands

The purchase of the Craigieburn native grasslands in 1999 and subsequent reservation as a nature conservation reserve makes it the largest protected area of native grassland communities in the Victorian Volcanic Plains (Ross 1998). The grassland is regarded as being of national significance for both flora and fauna conservation (Peake *et al.* 1996) and over 240 indigenous vascular plant species have been recorded on the site. These include major Victorian populations of Swollen Swamp Wallaby-grass *Amphibromus pithogastrus* (e, K), Gilgai Blown-grass *Agrostis aemula* var. *setifolia* (v), Curly Sedge *Carex tasmanica* (V), and Tough Scurf-pea *Cullen tenax* (e), as well as the nationally endangered Matted Flax-lily *Dianella amoena* (Peake *et al.* 1996; Ross 1998).

The Craigieburn Grasslands Nature Conservation Reserve now protects relatively large areas of Western (Basalt) Plains Grassland, Stony Knoll Grassland and Grassy Wetland vegetation communities, all of which are poorly or unrepresented in the reserve network and regarded as being amongst the most threatened communities in Victoria (Ross 1998).

Reflecting the range and rarity of the habitats available, the fauna recorded on the site is highly diverse and includes a number of species which are rare and threatened. In particular, the Striped Legless Lizard *Delma impar* and Plains-wanderer (both V), Black Falcon *Falco subniger* (e) and Red-chested Button-quail *Turnix pyrrhothorax* (v) are among the 19 mammal species, 106 bird species, 10 amphibian species, 17 reptile species and 10 fish species recorded on the site (Ross 1998).

In an important partnership for conservation, land owned by Pioneer Building Products Pty Ltd. to the north of the reserve will be managed for the conservation of native grassland values to complement the formally protected reserve.

6. Terrick Terrick Grasslands

This 1277 ha property north of Mitiamo contains the largest remnant of the endangered Northern Plains Grassland in the Riverina, and probably the largest area of high quality native grassland in Victoria.

Four general habitats occur on the property, all of which have been significantly depleted on the northern plains;

a) Spear-grass *Austrostipa* spp.–Wallaby-grass *Austrodanthonia* spp.–Spider Grass *Enteropogon acicularis* grassland;
b) Buloke *Allocasuarina luehmannii* grassy woodland;
c) ephemeral Lignum *Muehlenbeckia florulenta* wetland; and
d) Black Box *Eucalyptus largiflorens* – Lignum riparian woodland/forest (Foreman and Westaway 1994, NRE 1997).

The property supports the largest known breeding population of Plains-wanderer in Victoria (Maher and Baker-Gabb 1993), as well as providing habitat for other threatened species such as the Bush Stone-curlew *Burhinus grallarius* (e), Hooded Scaly-foot *Pygopus nigriceps* (ce), and Fat-tailed Dunnart *Sminthopsis crassicaudata* (k). Of the more than 100 indigenous plant species recorded on the property, twenty-seven are recognised as being of state significance and three are of national significance – Fragrant Leek-orchid *Prasophyllum suaveolens* (E), Murray Swainson-pea *Swainsona murrayana* and Red Swainson-pea *S. plagiotropis* (both V) (NRE 1997).

The grasslands were officially combined with the adjoining Terrick Terrick State Park to form the Terrick Terrick National Park in April 1999.

7. Terrick Terrick East Grassland

This 214 ha Northern Plains Grassland contains populations of two nationally threatened plants: Chariot Wheels *Maireana cheelii* (V) and Murray Swainson-pea, as well as a number of species of State and regional significance. It is considered to be a potentially important site for the Plains-wanderer in the Victorian Riverina (Maher and Baker-Gabb 1993), particularly as it is within a few kilometres of the Terrick Terrick National Park. The grassland also provides habitat for other threatened species such as Brolga, Fat-tailed Dunnart, and Little Button-quail *Turnix velox* (k).

The site is reserved as the Terrick Terrick East Nature Conservation Reserve.

8. Roslynmead Grasslands

This extensive 532 ha Northern Plains Grassland is dominated by Common

Wallaby-grass *Austrodanthonia caespitosa*, Rough Spear-grass *Austrostipa scabra*, Spider Grass and Windmill Grass *Chloris truncata*.

Six threatened plants have been recorded from the site: the Small Scurf-pea *Cullen parvum* (E), Murray Swainson-pea, Red Swainson-pea, Long Eryngium *Eryngium paludosum* (v), Woolly Buttons *Ixiolaena* sp. (r) and Buloke.

There is a high level of diversity and complexity in the habitats found across the site due to small changes in relief and varying soil types. There is a mix of shorter vegetation with open spaces in between slightly taller vegetation in the wetter areas. Significantly, there is a very low percentage of weed cover and few weed species present. The property has recently been managed with an appropriately light grazing regime, allowing many herbs to flower and the development of excellent structure.

In a survey of native grasslands in the northern plains, the property was identified as potentially significant in providing habitat for the Plains-wanderer (Maher and Baker-Gabb 1993). Recent surveys have confirmed the presence of this species. The purchase of suitable grassland habitat in the Mitiamo district for conservation is one of the management actions recommended in the Action Statement for the species prepared under the *Flora and Fauna Guarantee Act 1988* (Baker-Gabb 1995).

The property is in close proximity to other recent grassland purchases (Terrick Terrick, Terrick Terrick East and Pine Grove). The grasslands will be reserved with the adjoining Turrumberry North Flora Reserve (also known as the Patho Flora Reserve), to form the Roslynmead Nature Conservation Reserve.

9. Pine Grove Grasslands

This 36 ha Northern Plains Grassland at Pine Grove, to the east of Mitiamo, contains two sub-communities – a red soils annual grassland dominated by *Austrodanthonia* sp. and a wet grassland on the heavier soils.

The quality of the grassland habitats for plains fauna is moderate to excellent, particularly those habitats located on the hard red soils. The structure of these habitats remains largely intact as they have not been ploughed for at least 15-20 years. As a result, gilgais and drainage lines are still present, while the cracks in the heavier grey soils provide habitat for reptiles and Fat-tailed Dunnarts.

The property is considered to have enough suitable habitat that, if managed optimally, could support a number of pairs of Plains-wanderers. It is located only 5 km from areas of known Plains-wanderer habitat, including the Terrick Terrick National Park. The site is reserved as the Pine Grove Nature Conservation Reserve.

10. Kamarooka Mallee and Box-Ironbark Forest

A nationally significant stand of the threatened Kamarooka Mallee *Eucalyptus froggattii* (v, R) was just one of the features of the most recent purchase of 96 ha of land for addition to the former Kamarooka State Park (now part of the Greater Bendigo National Park). The property contains valuable stands of three EVCs – Gravelly-sediment Mallee, Box-Ironbark Forest (Fig. 3) and Sandstone-rise Broombush – all of which have been depleted and are highly fragmented at a regional scale.

The purchase follows two previous additions of whipstick mallee to the park in 1999, totalling 204 ha. The park has a number of private land inliers and irregular external boundaries and the purchase of these blocks both consolidate protected core habitat and alleviate a number of possible future management problems.

11. Balmattum Plains Grassy Woodland

The 221 ha Plains Grassy Woodland and Plains Grassy Woodland/Gilgai Wetland Mosaic at Balmattum (between Euroa and Violet Town), was purchased in late 2000. It was officially launched as the Balmattum Nature Conservation Reserve by the Minister for Environment and Conservation in September 2001.

The purchase of this property has increased the current reservation status of Plains Grassy Woodland/Gilgai Wetland Mosaic by 24% and Plains Grassy Woodland by 10.6% in the Goulburn-Broken section of the Riverina bioregion (Fig. 4).

The site is known habitat for two groups of Grey-crowned Babbler *Pomatostomus temporalis* and one pair of Bush Stone-curlews, both endangered species in

Fig. 3. Kamarooka Box-Ironbark Forest. Photo: James Fitzsimons.

Victoria. The property is centrally located within a district population of the Grey-crowned Babbler and has the potential to provide a focus of source habitat for that population (which accounts for one third of all Grey-crowned Babblers in Victoria) (D. Robinson pers. comm. 1999).

Nearly 100 indigenous plant species occur on the reserve and the adjoining roadside including Fragrant Leek-orchid, Swamp Billy-button *Craspedia paludicola* (v) and Buloke. The site is unique because it is at the eastern edge of the Riverina and contains temperate species not found in existing Riverina reserves - in particular, a greater number of lily species, and some different grass and understorey species.

12. Buck's Land and Bailey's Land, Warby Range

Two separate but adjoining purchases in the Warby Range, totalling approximately 340 ha, significantly enhance the connectivity of the Warby Range State Park. The blocks protect Heathy Dry Forest and Granitic Hills Woodland EVCs.

Both properties provide habitat for species such as the Turquoise Parrot *Neophema pulchella* (n), Powerful Owl *Ninox strenua* (e), Swift Parrot *Lathamus discolor* (E), Carpet Python *Morelia spilota variegata* (e) and is on the migratory flight path for the Regent Honeyeater *Xanthomyza phyrygia* (E). They also protect significant landscape values.

Buck's Land provides a link between the main body of the Warby Range State Park and the isolated Quarry block of the park, while Bailey's Land adjoins Buck's to the south and almost links the Glenrowan block with the main body of the park.

13. Moodemere Plains Grassy Woodland, Rutherglen

A 12 ha block supporting the severely depleted Northern Plains Grassy Woodland and Riverine Grassy Woodland/Riverine Sedgy Woodland Mosaic, adjacent to the Lake Moodemere Lake Reserve near Rutherglen, was purchased between 2001-2002.

The property contains a significant stand of Buloke and Buloke Mistletoe *Amyema linophylla* ssp. *orientale* (v). The presence of a large Buloke and Buloke Mistletoe stand associated with a slope above gully system is considered unusual and the site is also notable for its chenopod shrubland.

The adjoining 262 ha Lake Moodemere Lake Reserve also protects a number of significant species and ecosystems and the purchase of this site enhances these features.

14. Rutherglen Plains Grassy Woodland

This 35 ha site represents one of the few remnants of relatively undisturbed Plains Grassy Woodland dominated by Grey Box and Yellow Box in the eastern Riverina. The vegetation is considered to be in very good condition with an absence of any major weeds and an understorey dominated by Kangaroo Grass *Themeda triandra*. The site contains two plant species of State significance – Dark Wire-grass *Aristida calycina* var. *calycina* (r) and Slender Tick-trefoil *Desmodium varians* (k). A colony of Grey-crowned Babblers have been observed on the block and are nesting in the roadside adjacent to the block. The site is reserved as the Rutherglen Nature Conservation Reserve.

15. Duchers Swamp, French Island

The purchase of 75 ha of wetland and surrounding Swamp Scrub on western

Fig. 4. Balmattum Nature Conservation Reserve. Photo: James Ross.

French Island, including the 30 ha Duchers Swamp, was completed in 2002. Duchers Swamp is the largest wetland on French Island and the Island supports one of the largest relatively intact wetland areas remaining in south-eastern Victoria.

The Swamp Scrub EVC originally covered 163 000 ha of the Gippsland Plains subregion, yet clearing and draining of these areas has reduced the vegetation type to less than 8 000 ha, which occur mostly in small patches on private land.

The swamp provides habitat for three species of birds which are considered endangered in Victoria - White-bellied Sea-Eagle *Haliaeetus leucogaster*, Great Egret and Lewin's Rail *Rallus pectoralis* and one bird species which is critically endangered, the King Quail *Coturnix chinensis* (Quinn and Lacey 1999). Furthermore the swamp provides habitat for several species of birds listed under the JAMBA and CAMBA agreements, particularly waders, and enhances the habitat in the adjoining Western Port Ramsar site. The swamp also provides potential habitat for the nationally endangered Orange-bellied Parrot *Neophema chrysogaster*, which occasionally uses the saltmarsh and swamps of French Island when over-wintering. The land will be added to French Island National Park.

16. Swallow Lagoon Plains Grassy Woodland, Munro

The purchase of this 193 ha property at Munro on the Gippsland Plains creates a reserve for one of the largest unprotected stands of the endangered Forest Red Gum Grassy Woodland (listed on the *Flora and Fauna Guarantee Act 1998*). The Swallow Lagoon Road property also includes smaller areas of the endangered Damp Sands Herb-rich Woodland. Only 3% of the original 151 000 ha extent of Plains Grassy Woodland remains in the Gippsland Plains subregion, most of which occurs on private land.

Over 90 species of indigenous flora have been recorded on the property. The area has never been ploughed nor had superphosphate applied which is reflected in the intact ground cover with little or no weed invasion. Importantly, the variety of hollows in the mature Forest Red Gum *Eucalyptus tereticornis* and Red Box *E. polyanthemos* on the property provide important habitat for hollow-dependent fauna.

The property is close to the Providence Ponds Flora and Fauna Reserve and other recent purchases made by the Trust for Nature under the National Reserve System Program (the Bush Family, Frair's and West Billabong Reserves). Its reservation will form an important component of the

Gippsland Plains Conservation Management Network, a network aiming to coordinate management and account for conservation lands of all tenures on the Plains between Sale and Bairnsdale. The block will be reserved as the Swallow Lagoon Nature Conservation Reserve (see front cover).

17. Green Hills Grassland and Grassy Woodland, Gillingal

This property, totalling 522 ha, was purchased in two parts in 2000 and 2002. It comprises native grasslands on basaltic soils and represents one of the last and largest remaining stands of native grassland within East Gippsland. The property includes areas dominated by Kangaroo Grass and flora surveys have identified 105 plant species including a number listed as rare or threatened. The property supports the largest population in Australia of the Austral Toad-flax *Thesium australe* (V), a species which is semi-parasitic on Kangaroo Grass (Prober and Thiele 1998). Two additional species of note are the Hairy Anchor Plant *Discaria pubescens* (v, R), and the nationally endangered Slaty Leek-orchid *Prasophyllum frenchii*.

Middle-elevation (400-1400 m) grasslands are very uncommon and forest communities with shrubby understoreys predominate at these altitudes (Prober and Thiele 1998). The Grassy Woodland component of the property, occupying about 300 ha of the site, also has high flora diversity. The site has been reserved as the Green Hills Nature Conservation Reserve.

18. Murrindal Limestone Grassy Woodland

This 19 ha addition to The Potholes Cave Reserve at Murrindal in East Gippsland is significant due to the presence of the rare Limestone Grassy Woodland community (listed under the *Flora and Fauna Guarantee Act 1988*) and a cave system which contains 24 accessible caves.

More than 50 indigenous flora species have been recorded on the site. The Common Spleenwort *Asplenium trichomanes* ssp. *quadrivalens* (r) and Leafy Greenhood *Pterostylis cucullata* (V) occur on road and cave reserves adjacent to the property. Common Bentwing Bats *Miniopterus schreibersii* occur in the caves adjacent to the property. The cave network on the property is considered to have interesting geological and hydrological features, including speleothems (Boaden 1991), and further consolidates and protects vulnerable cave and karst resources in the Buchan and Murrindal area.

19. Anticline Caves, Murrindal

This 3 ha site at Murrindal near Buchan was purchased in 2000 to protect its significant conservation values. The above-ground component of the site supports Dry Rainforest, one of the rarest EVCs in the State with a total of less than 20 ha occurring on all of its six identified localities in East Gippsland (Peel 1999). The community, listed under the *Flora and Fauna Guarantee Act 1988*, is dominated by Sweet Pittosporum *Pittosporum undulatum*, with a native fern and grass understorey. Rare or threatened plants occurring on the site include Chinese Brake *Pteris vittata* (v), Common Spleenwort, Comb Wheat-grass *Australopyrum retrofratcum* (r), Limestone Blue Wattle *Acacia caerulescens* (V), and Limestone Pomaderris *Pomaderris oraria* ssp. *calcicola* (R).

The cave itself is an extremely important site for the Eastern Horseshoe Bat *Rhinolophus megaphyllus* (v) and the Large-footed Myotis *Myotis adversus*. The Eastern Horseshoe Bat is listed under *the Flora and Fauna Guarantee Act 1988* as a restricted colonial breeder and the Anticline Cave is only one of three maternity sites in the state for the species. The cave will be added to the Murrindal River Water Frontage Reserve.

20. Bendoc Grasslands

The particular montane grassland/grassy woodland community found on this 230 ha site at Bendoc, on the border of NSW in the State's far east, had not previously been conserved or even mapped anywhere in Victoria. The floristics, geology and altitude of the grassland are significantly different from other montane grasslands/grassy woodlands recorded in Victoria. It is probably one of the most intact examples of Monaro Plains grassland in Australia, which were once widespread across the Monaro Tablelands of New South Wales to the north. Such high quality grassy woodland remnants are recognised as a high conservation priority in the southeastern NSW section of the South Eastern Highlands IBRA region, where good quality samples on public land are confined to small flora reserves and several travelling stock routes.

The Bendoc property supports snowgum woodland and a tall grassland of *Themeda*, *Juncus*, *Poa*, *Chrysocephalum*, and *Acaena* species. Some 112 native plant species have been identified on the property, including 23 species of native grass, and two rare or threatened plants – the Hairy Anchor Plant and Dark Wire-grass (Trumbull-Ward 2001). The site is reserved as the Bendoc Nature Conservation Reserve.

Other purchases

Other purchases include a 183 ha property to link the Skinner's and Wychitella blocks of the Wychitella Nature Conservation Reserve which provides a potential protected link for Malleefowl *Leipoa ocellata* (E), a 16 ha Box-Ironbark inlier to the Mount Erip Flora Reserve, and a 130 ha property at Bornes Hill for addition to the Grampians National Park.

The ongoing purchase of small reserve inliers, often resulting from now-abandoned townships, aims to reduce both potentially threatening processes and resource requirements for park managers.

Future directions for land purchase and the protected area system

The funding and negotiation for purchase of other poorly represented ecosystem sites is currently in progress. Particular emphasis is on native grasslands and grassy woodlands. Areas for further investigation include Murray-Darling Depression and Red Gum Riverine Woodlands. The Trust for Nature (Victoria) has and continues to purchase properties containing grassy and other threatened ecosystems throughout the State as part of the National Reserve System Program. 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.

For further information on Victoria's Parks and Reserve System, visit the DSE web site: http://www.nre.vic.gov.au under 'Parks and Reserves'

For further information on the development of the National Reserve System, visit the Environment Australia web site: http://www.ea.gov.au/parks/nrs/index.html

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Appendix 1. Some species occurring in 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 on the *Flora and Fauna Guarantee Act 1988*; (Cmwlth Status) E, endangered; V, vulnerable; R, rare; K, poorly known/data deficient Note: This table does not represent all species occurring in the above mentioned reserves. Derived from CNR (1995), NRE (2000a,b) and references therein, *Flora and Fauna Guarantee Act 1988* and *Environment Protection and Biodiversity Conservation Act 1999.*

	Scientific Name	Common Name	Vic Status	FFG	Cmwlth Status
Mammals	*Miniopterus schreibersii*	Common Bentwing Bat			
	Myotis adversus	Large-footed Myotis	k		
	Perameles gunnii	Eastern Barred Bandicoot	ce	L	V
	Rhinolophus megaphyllus	Eastern Horseshoe Bat	v	L	
	Sminthopsis crassicaudata	Fat-tailed Dunnart	k		
Birds	*Ardea alba*	Great Egret	e	L	
	Burhinus grallarius	Bush Stone-curlew	e	L	
	Coturnix chinensis	King Quail	ce	L	
	Falco subniger	Black Falcon	e		
	Grus rubicunda	Brolga	v	L	
	Haliaeetus leucogaster	White-bellied Sea-Eagle	e	L	
	Lathamus discolor	Swift Parrot	e	L	V
	Leipoa ocellata	Malleefowl	e	L	V
	Neophema chrysogaster	Orange-bellied Parrot	ce	L	E
	Neophema pulchella	Turquoise Parrot	n	L	
	Ninox strenua	Powerful Owl	e	L	
	Pedionomus torquatus	Plains-wanderer	e	L	V
	Pomatostomus temporalis	Grey-crowned Babbler	e	L	
	Rallus pectoralis	Lewin's Rail	e		
	Turnix pyrrhothorax	Red-chested Button-quail	v		
	Turnix velox	Little Button-quail	k		
	Xanthomyza phyrygia	Regent Honeyeater	ce	L	E
Reptiles	*Delma impar*	Striped Legless Lizard	e	L	V
	Morelia spilota variegata	Carpet Python	e	L	
	Pygopus nigriceps	Hooded Scaly-foot	ce	L	
Insects	*Synemon plana*	Golden Sun Moth	e	L	

Appendix 1 cont.

Plants	*Acacia caerulescens*	Limestone Blue Wattle	v		V
	Agrostis aemula var. *setifolia*	Gilgai Blown-grass	v		
	Amphibromus pithogastrus	Swollen Swamp Wallaby-grass	e	L	K
	Amyema linophylla ssp. *orientale*	Buloke Mistletoe	v		
	Allocasuarina luehmannii	Buloke		L	
	Aristida calycina var. *calycina*	Dark Wire-grass	r		
	Asplenium trichomanes ssp. *quadrivalens*	Common Spleenwort	r		
	Australopyrum retrofractum	Comb Wheat-grass	r		
	Austrodanthonia caespitosa	Common Wallaby-grass			
	Austrostipa gibbosa	Spurred Spear-grass	r		
	Austrostipa scabra	Rough Spear-grass			
	Carex tasmanica	Curly Sedge	v	L	V
	Chloris truncata	Windmill Grass			
	Comesperma polygaloides	Small Milkwort	v	L	
	Craspedia paludicola	Swamp Billy-button	v		
	Cullen parvum	Small Scurf-pea	e	L	E
	Cullen tenax	Tough Scurf-pea	e	L	
	Desmodium varians	Slender Tick-trefoil	k		
	Dianella amoena	Matted Flax-lily	e		E
	Discaria pubescens	Hairy Anchor Plant	v	L	R
	Enteropogon acicularis	Spider Grass			
	Eryngium paludosum	Long Eryngium	v		
	Eucalyptus camaldulensis	River Red Gum			
	Eucalyptus froggattii	Kamarooka Mallee	v	L	R
	Eucalyptus largiflorens	Black Box			
	Eucalyptus melliodora	Yellow Box			
	Eucalpytus polyanthemos	Red Box			
	Eucalyptus tereticornis	Forest Red Gum			
	Eucalyptus viminalis	Manna Gum			
	Glycine latrobeana	Clover Glycine	v	L	V
	Ixiolaena sp.	Woolly Buttons	r		
	Maireana cheelii	Chariot Wheels	v		V
	Muehlenbeckia florulenta	Lignum			
	Pittosporum undulatum	Sweet Pittosporum			
	Pomaderris oraria ssp. *calcicola*	Limestone Pomaderris	r		R
	Prasophyllum frenchii	Slaty Leek-orchid	e		E
	Prasophyllum suaveolens	Fragrant Leek-orchid	e		R
	Pteris vittata	Chinese Brake	v		
	Pterostylis cucullata	Leafy Greenhood	v	L	V
	Ptilotus erubescens	Hairy-tails		L	
	Swainsona murrayana	Murray Swainson-pea	e	L	V
	Swainsona plagiotropis	Red Swainson-pea	e	L	V
	Themeda triandra	Kangaroo Grass			
	Thesium australe	Austral Toad-flax	e	L	V

Appendix 2. Some listed Flora and Fauna Guarantee Act communities occurring on recently purchased land.

Western (Basalt) Plains Grassland Community
Northern Plains Grassland Community
Forest Red Gum Grassy Woodland Community
Dry Rainforest (Limestone) Community
Limestone Grassy Woodland Community

Flora of the South West – Bunbury – Augusta – Denmark

by Judy Wheeler, Neville Marchant and Margaret Lewington

Volume 1: Introduction, Keys, and Ferns to Monocotyledons
Volume 2: Dicotyledons

Publisher: *Australian Biological Resources Study and Western Australian Herbarium in association with University of Western Australia Press, Crawley, WA 2002. Flora of Australia Supplementary Series Number 12. 972 pages, ISBN 0 642 56816 2 (set), RRP $165.00*

This two-volume work is a rare achievement in its combination of a very user-friendly format with authoritative botanical accuracy. The use of illustrated keys is reminiscent of the style of the well-known series *How to know Western Australian Wildflowers* by Blackall and Grieve, but with improved layout and easier to use keys. In this new publication 2060 species of vascular plants are described (1623 native and 437 alien). The area covered extends along the West Australian coast from just south of Bunbury to east of Denmark, and inland to Bridgetown and Manjimup. This is a continuation of the area dealt with in the *Flora of the Perth Region*, published in 1987.

The introduction includes a brief description of the vegetation of the area, information on the floristics and an explanation of the arrangement of the text.

The first half of Volume 1 comprises a key to the genera included in the work. Each step is illustrated with excellent small line drawings. A great deal of thought has gone into the construction of these keys, which are arranged in three stages. Stage 1, based on flower colour, is carefully constructed to avoid confusion due to the subjective interpretation of colour. Difficult shades, such as oranges and mauve can be keyed out in alternative groups. Methods for dealing with mixed colours are also explained. All drawings are black and white but the first page of each stage of the key based on colour has a coloured margin. Stage 2 deals with flower shape, a term broadly interpreted giving twelve clearly illustrated and described groups. Stage 3 is a more formal key, with every step illustrated. This should easily lead the user to the genus, which is followed by a page reference to the Plant Families Section.

The Plant Families Section (pp. 223-934) is arranged in broad groups: Fern Allies and Ferns, Gymnosperms, Angiosperms (Monocotyledons and Dicotyledons). Within these groups the families are arranged alphabetically and within families the genera are arranged alphabetically. The species descriptions are comprehensive, botanical terms are simplified wherever possible and in many cases a mini-glossary is given at the start of the family. This is particularly helpful in difficult families such as Cyperaceae and is more convenient than referring to the main glossary at the end of Volume 2. The species descriptions include distributional information for the area, the rest of WA, the rest of Australia and the world. In some cases additional notes include conservation status and toxicity. Both genus and species descriptions are prefaced by a sentence in bold or grey print that contains valuable diagnostic characters to aid identification.

Although the price is high for a work covering such a small area, I highly recommend it to all with an interest in the state's flora. The species descriptions are thoughtfully designed in a way that should meet the needs of both amateur wildflower enthusiasts and professional botanists. It is hoped that similar publications for other areas of the State will follow.

Margaret Corrick
7 Glenluss Street
Balwyn, Victoria 3103

Trees and the Basalt Plains

by Lionel Elmore. Edited by Christopher R Elmore

Publisher: *Basalt Books, Melbourne, 2002. 140 pp. RRP $30*

This worthwhile book has four main facets. For lovers of Western Victoria's volcanic landscapes, it contains interesting discussion on geology, original vegetation and land use. It presents helpful observations on tree establishment and growth for rural revegetators. It shows yet again how informally trained but gifted amateurs can contribute to our knowledge. Finally it exemplifies how a tenacious person can fulfill someone else's dream.

Many readers will remember Lionel Elmore: decent, alert, quiet, encyclopaedic, didactic – with his travelling collection of hand-captioned laminated photos, home-made gadgets and ecological demonstrations.

Chapter 1 – almost half the body of tbe work – links Lionel's lifetime observations with historical sources to chart the distribution of major plains species like Red Gum, Drooping Sheoak, Blackwood, Grey Box, Bursaria, and so on. Chapter 2 reinforces this material.

The remaining three chapters detail his ideas on tree growth. The first is a quirky and stimulating essay on how trees promote soil formation and sustainability. The next analyses how trees contribute to soil structure, aeration, salinity control and mineral recycling. Finally Lionel Elmore argues for retaining natural vegetation and reintroducing indigenous vegetation back into bare paddocks, especially by natural regeneration. Happily, many landowners share this view today. He also discusses mounding heavy soils, which has indeed been a common technique within the Blue Gum industry.

A major tbeme, which 'permeated' Lionel's conversation, is how sand content greatly influences tree growth on volcanic soils, the sand coming in regionally, and gradually mixing into the soil. The main source was wind-blown material during dry eras from eroding neighbouring geological systems: the coastal formations, the Grampians and the Cretaceous tablelands. This is very obvious from the fertile sandy lunettes to the east of each lake, ancient and modern, and when flying over or driving through Dunkeld, with the wonderful Red Gums growing from Mount Abrupt almost to Penshurst. The story is similar south of Mount Cole.

Although the very detailed notes refute a few of Lionel's ideas, we must admire his drive, incisive observations and multi-disciplinary instincts – for he moves easily from microclimate to macroclimate. What would he have achieved with university training, working in a team, rather than devoting his life – one suspects reluctantly – to farming?

What greatly inspired Lionel were the Royal Society of Victoria's symposium on the Western District in 1964 – vale Edmund Gill – and his standing as a regional advisor to tbe Land Conservation Council in the early to mid-seventies as it sought to change public land use in the Portland-Casterton area.

This provocative book is somewhat repetitive, however. Moreover, maps and tables would better depict plant distribution than does text. More photos, including 19th century material, are needed. The definitive book on the region will be much bigger! Modern mapping, graphic design and desk-top publishing are so good, the landscape is so beautiful, satellite photos are so clear when it comes to tracing the different lava flows, and there is new knowledge to impart.

The hero however is nephew Christopher Elmore, who, as his introduction recounts, had to sort out such a mass of notes, clippings, photos and other records. Work continues on another volume.

I knew Lionel Elmore quite well, taking him to landcare conferences and talking to him often about his work. I knew he desperately wanted it published but I could never see this being achieved without superhuman effort. Christopher Elmore had the unique skills and endurance necessary, as every reader will recognise in this tribute to a respected Victorian naturalist.

Rob Youl
Project Officer, Landcare Australia
24-28 Collins St, Melbourne, Victoria 3000

Green Over Gold: A Selection of Stories from the Bush

by Pat Coupar. Illustrations by Melanie Coupar

Publisher: *The Author, 2001. 111 pages. RRP $14.95*

On the back cover of this book are the words: 'Those who have been here will know this place. Those who have not must make the discovery for themselves.' 'Here' refers to Warrandyte State Park, the collective name for a number of reserves and a narrow strip along the Yarra River in the vicinity of Wonga Park and Warrandyte, the scene of Victoria's first officially proclaimed goldfield 151 years ago.

The book begins with a map of the area and a list of places to visit. A list of flora and fauna walks, including when to go and what to look for while you are there, is followed by an 'activities' section which includes picnic areas (facilities are noted), swimming, self-guided walks, historical walks, and places where you can take your dog or ride a horse.

The bulk of the book consists of a selection of 48 essays originally published monthly in *Warrandyte Diary*, followed by a bibliography for those who would like more information. The essays are simply and clearly written, and are arranged in groups of four per month, starting in January. On the left-hand side of the first page for each month is a summary of what happens in the Park at that time of year. Each essay deals with a particular topic, usually an animal or plant which lives in the Park, and is accompanied by a charming illustration by the author's daughter Melanie, who began the task when she was only fifteen.

A wide variety of life-forms are introduced, and not just those with general appeal. Nature, the author points out, is a never-ending source of wonder: 'By understanding the natural world, fear is replaced by respect and hatred by admiration.' Spiders, snakes, birds, mammals, frogs, insects and other animals as well as plants and fungi are all sensitively described. Discoveries made at home are also included, hence we meet 'Robbie' the yabbie and 'Toothbrush' the caterpillar.

Problems caused by introduced pests such as foxes, rabbits, Wandering Jew, Agapanthus and Cotoneaster are highlighted. The author even suggests eating Blackbird pie to decrease the numbers of this species! She also draws attention to degradation and loss of habitats, and water pollution. Hazards to wildlife, such as discarded fishing lines, are pointed out.

Regrettably, there is no index. Even in a small book such as this, one would have been useful. Also, some unfortunate typesetting errors and misplaced punctuation detract a little from an otherwise delightfully interesting and informative read.

This book should have wide appeal. It will certainly be both useful and informative for people visiting the Warrandyte State Park at any time of the year, and its infectious enthusiasm will surely inspire them to return. As the author remarks, 'It is often the simplest things in life that bring the deepest contentment.'

Virgil Hubregtse
6 Saniky Street
Notting Hill, Victoria 3168

For assistance in preparing this issue, thanks to Virgil Hubregtse (editorial assistance), Ann Williamson (label printing) and Dorothy Mahler (administrative assistance).

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After the Ark? Environmental Policy-Making and the Zoo

by Nicole A Mazur

Publisher: *Melbourne University Press, Carlton South, Victoria 2001. 262 pages. ISBN 0-522-84947-4. RRP $32.95*

Based on her studies of zoos in Australia and New Zealand, Mazur has produced a stinging account of the past, present and future of zoological gardens. Stinging? The fact that she was refused permission to interview staff at Taronga Zoo, Sydney, tells you something about the culture of fear and censorship that seems to pervade New South Wales Government agencies and departments and about Mazur's ability to critically analyse institutions and the individuals and policies that 'run them'. My experience and Mazur's analysis tells me that 'guide them' would be an inappropriate phrase. Not only does Mazur demonstrate her talents at critical analysis in *After the Ark?*, but she shows considerable skill at expressing herself clearly and forcefully. In fact, with her skills, I'm surprised Mazur was allowed to talk to anyone in government given the extent of internal censorship imposed on government scientists other than those who rubber stamp departmental policy. But then I'm also surprised that you need permission to speak to people paid from the public purse.

After the Ark? is not about what animals and plants are kept in zoos. Nor does it particularly describe the research and conservation programs at zoos. Instead, it is about zoos as social and environmental institutions and their relation to society. It is analytical and looks carefully at the changing role of zoos in the Western World and what they can contribute as conservation, education and scientific institutions, compared with what they think they can or would like to contribute. Mazur describes the policies and policy changes that led to the modern zoo and the problems zoos face in making themselves relevant in an environmentally damaged and changing world. If you thought zoos were just nice places to visit with the kiddies during school holidays, think again.

Zoos are complex institutions with staff and structures that most of us never see nor think about. Mazur has woven all this together in a way which allows any of us to begin thinking about zoos in a different way and what it is exactly that we expect from zoos. Are they just for recreation? Or do they have a contribution to make to education and conservation? Is their educative role limited to providing a venue where beleaguered school teachers can unleash their ill-disciplined hordes or should zoos be seeking a greater role in educating all of society (including those elected to office) about biology and our collective responsibilities towards conserving the Earth's living resources?

Mazur guides us to think deeply about all of these and more, but her analysis is equally apt when applied to museums, universities, and botanic gardens. As with zoos, all have been crippled by the advent of the modern bureaucrat, economic rationalism and 'managerialism'. I particularly enjoyed reading Mazur on the zoo as a corporation and the impact of 'managerialism' on the ability of zoos, as with other public institutions, to meet the expectations of society, as distinct from providing habitat for a bloated, inefficient and growing managerial elite. What Mazur writes about zoos also describes the modern university where teachers and researchers alike are increasingly distanced from the decision makers and where performance is counted (not measured) on outputs, not on quality nor on contribution to the present and future benefit of society and the environment.

If you want to read about why universities and other research and conservation institutions in Australia struggle to survive, read this book about zoos. It will also tell you a lot about their potential and what is needed to achieve that potential. It is rich in ideas and contains some of the best and clearest explanations of how the modern institutional workplace is structured that I have ever encountered. Not only would I recommend reading this book to anyone with an interest in zoos (or universities), but *After the Ark?* would be a brilliant adjunct to any course on public policy and/or conservation biology. It would be so useful, I almost regret having retired from teaching.

Harry F Recher
School of Natural Sciences
Edith Cowan University, Joondalup, WA 6027

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Cover: Warty Bell Frog *Litoria raniformis*. See Contribution on p. 147. Photo by G Glare.

Web address: http://www.vicnet.net.au/~fnev/vienat.htm
Email fnev@vienet.net.au

Desmids (Chlorophyta) from Two Freshwater Sites in Victoria with an Emphasis on New Records

Michael Dingley[1]

Abstract

During a trip through Victoria, two freshwater sites were sampled in order to check for microscopic green algae called desmids as part of a long-term study of their distribution within Australia. A total of 34 taxa, of which nine are newly recorded for Victoria, were identified and are listed. These new records together with *Euastrum cuspidatum* var. *goyazense* Förster et Eckert are described and figured in some detail. (*The Victorian Naturalist* **120** (4), 2003, 116-120)

Introduction

The most recent paper that included desmids from Victoria was that of Tyler and Wickham (1988) in which the algal flora in the Yan Yean reservoir were compared with algae found 80 years earlier by West (1909) in the same reservoir. Previous to this, Tyler (1970) compared the morphology of *Micrasterias* species from lakes and reservoirs in south-eastern Australia. Before this, Hardy (1905, 1906) and West (1905) provide the only glimpses of this fascinating group of green algae outside species lists.

As part of a long-term study of the distribution of desmids (microscopic green algae) within Australia, two freshwater samples from Victoria were collected so that an examination of the desmids present could be made.

The two sites sampled were:

1. Sheepwash Lagoon, 12 km east of Yea, pH 7.7; 37°11'00" S, 145°30'00" E. The lagoon was bordered by trees and there was little in the way of submerged macrophytes. The sample was collected by sweeping a fine mesh (40 µm) plankton net through submerged grasses.

2. A shallow stream flowing into Lake Nillahcootie, 6.6 km north of Mansfield and Bonnie Doon turnoff on the Midland Highway, pH 7.6; 36°55'30" S, 146°00'00" E. The slow-flowing stream was open to full sun and was approximately 15 cm deep, containing filamentous algae which was subsequently squeezed and the resultant water collected.

[1] Royal Botanic Gardens, Mrs Macquaries Road, Sydney, NSW 2000 (29 Addington Road, Hazelbrook, NSW 2779)

Materials and methods

The two samples were preserved in 4% formalin and filtered through a nylon net of hole size 80 µm to remove large amounts of detritus. A single drop of sample was placed on a clean slide and covered with a 22 ˜ 22 mm No 1 coverslip and the edges were sealed using clear nail polish. Each sample could then be examined for extended times without risk of the liquid evaporating. Drawings were made mostly using a 100˜ oil immersion objective and a Nikon drawing tube attached to a Nikon Optiphot2 microscope. The order in which the genera are treated is that used in Croasdale and Flint (1986): *Closterium, Euastrum, Cosmarium, Staurodesmus, Staurastrum.*

Taxonomic notes

Symbols and abbreviations used in the following notes are explained in Table 1.

Closterium *Nitzsch ex Ralfs*

Closterium parvulum Nägeli var. *cornutum* (Playfair) Willi Krieg.; Plate 1A.
Prescott *et al.* (1975:74), Pl. 24:7-8
Site 2.
L 124.0-160.3 µm, Br 24.6-27.5 µm, Ap 2.3-2.9 µm, °Arc 148°-155°, L:Br 5.8-7.1

This variety differs from the nominal being stouter and hence has a shorter L:Br ratio.

Records of the nominal variety have previously been found in all states within Australia but this is the first time that this variety has been recorded in Victoria.

Euastrum *Ehrenb. ex Ralfs*

Euastrum cuspidatum var. *goyazense* Förster et Eckert; Plate 1I
Viyakornvilas (1974:41), Pl. 7:9-11
Site 2.

Table 1. Explanation of symbols and abbreviations

L = Length	Br cpr = Breadth with processes
L csp = Length with spines	Br spr = Breadth without processes
L ssp = Length without spines	Isth = Isthmus
L cpr = Length with processes	Ap = Breadth of apices
L spr = Length without processes	L:Br = Ratio of length to breadth
Br = Breadth	Th = Thickness
Br csp = Breadth with spines	°Arc = Curvature in degrees
Br ssp = Breadth without spines	

L csp 24.7-26.5 µm, L ssp 20.9-21.7 µm, Br csp 22.9-28.3 µm, Br ssp 20.6-25.4 µm, Isth 4.5-5.1 µm, Th 11.3 µm

Viyakornvilas (1974) found this plant in Lakes Hume and Mulwala and says that it has also been seen in Lake Sorell in Tasmania (Dr PA Tyler pers. comm.). She identifies it under the present name and says that 'the closest plant that it looks nearly like is *Euastrum cuspidatum* var. *goyazense* Förster'. She goes on to say that her plants differ from Förster's plants in having 'three pyrenoids per semicell instead of one and they have less spines on the polar lobes'. Plants found at Site 2 agree with her plants but the polar lobes have a single long spine and a sub apical granule. More cells will need to be examined in order to place this taxon with certainty.

Euastrum praemorsum (Nordst.) Schmidle forma; Plate 1C
Croasdale and Scott (1976), Pl. 5:1
Site 1.
L 61.0-64.0 µm, Br 40.5-41.3 µm, Isth 9.8-11.6 µm, Th 28.9 µm, L:Br 1.5

This form differs from the nominal in being relatively broader and thicker. It resembles the plant figured in Croasdale and Scott (1976), Pl. 5:1.

A new record for Victoria.

Euastrum sinuosum Lenorm. ex Willi Krieg. var. *sinuosum*; Plate 1B
Croasdale and Flint (1986:96), Pl. 18: 3-4
Site 2.
L 73.7 µm, Br 41.7 µm, Isth 12.6 µm, L:Br 1.8

Plants were consistent in having five protuberances and only a single mucilage pore and agree with the plant figured in Croasdale and Flint (1986).

A new record for Victoria.

Cosmarium ***Corda ex Ralfs***

Cosmarium doidgei Fritsch et Rich; Plate 1D
Fritsch and Rich (1937:185), Fig. 12, G-I.
Site 2.
L 15.9 µm, Br 16.1 µm, I 6.0 µm, Th 10.2 µm

This taxon is remarkably similar to the one described by Fritsch and Rich (1937) in that the retuse character of the upper lateral margins, combined with the widening of the sinus towards the outside, gives the lateral angles of the semicells the appearance of being slightly upturned. Only one cell was found in the sample and more cells should be examined to make sure that it is the same taxon. If so, it will be a new record for Australia.

Cosmarium quadriverrucosum var. *supraornatum* Skuja; Plate 1F
Skuja (1949:139), Pl. 31:13
Site 2.
L 26.9 µm, Br 24.7 µm, Isth 6.8 µm, Th µm, L:Br 1.1

This plant differs from the nominal in having a slightly flattened apex, more elaborate ornamentation, more rows of intramarginal granules and larger granules forming its paired central tumours.

A new record for Australia.

Cosmarium speciosum P. Lundell var. *speciosum* forma; Plate 1G
Lundell (1871:34), Pl. 3:5
Site 2.
L 69.0 µm, Br 50.1 µm, Isth 17.9 µm, Th 29.8 µm, L:Br 1.38

Plants have three intramarginal rows of crenulae and reduce in size to single granules towards the smooth centre. There are nine lateral and four apical crenations and a single row of five or six granules across the base but just above the isthmus. The L:Br ratio was slightly shorter than other cells published in the literature.

A new record for Victoria.

Staurodesmus ***Teiling***

Staurodesmus brevispina (Bréb.) Croasdale var. *brevispinus* f. *minimus* Lütkem.; Plate 1E

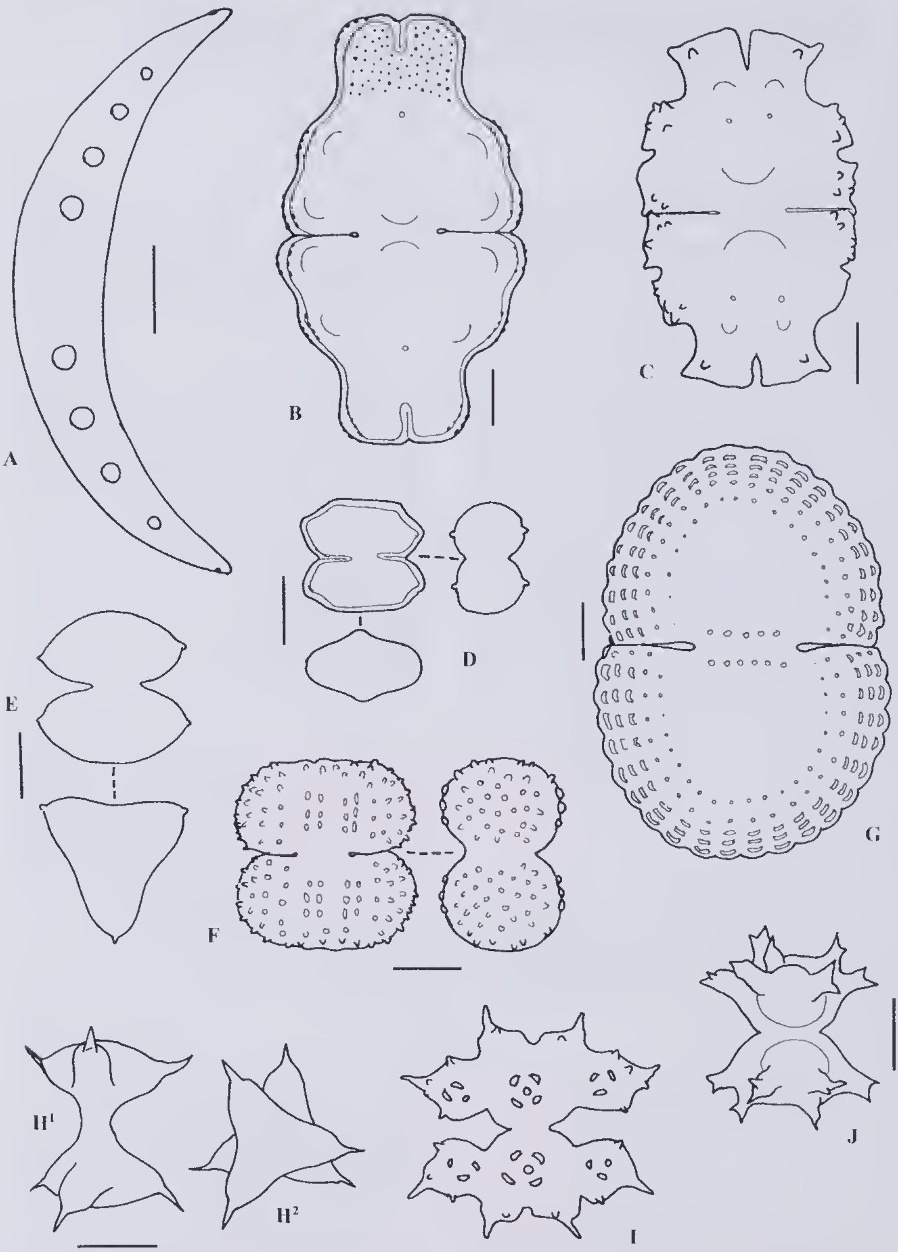

Plate 1. Desmids (Chlorophyta) from two freshwater sites in Victoria with an emphasis on new records. **A.** *Closterium parvulum* Nägeli var. *cornutum* (Playfair) Willi Krieg.; **B.** *Euastrum sinuosum* Lenorm. ex Willi Krieg. var. *sinuosum*; **C.** *Euastrum praemorsum* (Nordst.) Schmidle forma; **D.** *Cosmarium doidgei* Fritsch et Rich; **E.** *Staurodesmus brevispina* (Bréb.) Croasdale var. *brevispinus* f. *minimus* Lütkem.; **F.** *Cosmarium quadriverrucosum* var. *supraornatum* Skuja; **G.** *Cosmarium speciosum* P. Lundell var. *speciosum* forma; **H.** *Staurodesmus cuspidatus* (Bréb.) Teiling var. *cuspidatus* (H^1 face view, H^2 end view); **I.** *Euastrum cuspidatum* var. *goyazense* Förster et Eckert; **J.** *Staurastrum laeve* Ralfs var. *laeve*. Scale bar A = 20 µm, B-J = 10 µm.

Table 2. List of taxa found at collecting sites 1 and 2. * new records for Victoria and/or Australia.

Species name	Site 1	Site 2	Comments
Actinotaenium cucurbitinum (Bisset) Teiling	+	+	Recorded from NT, NSW and Vic
Closterium aciculare T. West	+		Recorded from NT, SA, NSW, Vic & Tas
Closterium dianae var. *dianae* Ehrenb.	+		Recorded from NT, SA, NSW, Vic, Qld & Tas
Closterium gracile Bréb.	+		Recorded from SA, Qld, NSW & Vic
Closterium incurvum Bréb.		+	Recorded from NT, Qld, NSW & Vic
Closterium kuetzingii Bréb.	+		Widely recorded from NT, SA, Qld, NSW, Vic & Tas
Closterium moniliferum (Bory) Ehrenb.	+		Recorded from Qld, NSW & Vic
**Closterium parvulum* var. *cornutum* (Playfair) Willi Krieg.		+	This variety is new to Australia
Closterium venus Kütz. Var. *venus*	+	+	Recorded from SA, Qld, NSW & Vic
**Cosmarium doidgei* Fritsch & Rich		+	This is a new record for Australia
Cosmarium impressulum Elfing	+		Widely reported from NT, SA, Qld, NSW, Vic
Cosmarium phaseolus Bréb.		+	Previously recorded from SA, NSW, Vic
**Cosmarium quadriverrucosum* var. *supraornatum* Skuja		+	This is a new record for Australia
**Cosmarium speciosum* P. Lundell var. *speciosum*		+	This is a new record for Victoria. It has previously been recorded from NSW
Cosmarium subspeciosum Nordst.	+		Previously recorded from NT, NSW, Vic
Euastrum cuspidatum var. *goyazense* Förster et Eckert		+	Previously recorded from VIC
**Euastrum praemorsum* (Nordst.) Schmidle forma	+		Previously recorded from NT, Qld, NSW
Euastrum pulchellum Bréb.		+	Previously recorded from NT, Qld
**Euastrum sinuosum* Lenorm. ex Willi Krieg. var. *sinuosum*		+	Previously recorded from NT, Qld, NSW
Gonatozygon kinahanii (Archer) Rabenh.	+		Previously recorded from Qld, NSW, Vic, Tas
Gonatozygon monotaenium de Bary	+		Widely reported from NT, Qld, NSW, Vic, Tas
Micrasterias mahabuleshwarensis J. Hobson	+		Widely reported from Qld, NSW, Vic, Tas
Micrasterias radiosa Ralfs var. *radiosa*	+		Previously recorded from Vic
Netrium digitus var. *lamellosum* (Bréb.) Grönblad	+		Previously recorded from NT, NSW
Pleurotaenium ehrenbergii (Bréb.) de Bary	+		Widely reported from NT, SA, Qld, NSW, Vic, Tas
Pleurotaenium trabecula (Ehrenb.) Nägeli	+		Reported from NT, Qld, NSW, Vic
Staurastrum excavatum W. West & G.S. West		+	Reported from NT, NSW, Vic, Tas
Staurastrum gracile Ralfs		+	Widely reported from NT, SA, Qld, NSW, Vic, Tas
Staurastrum hexacerum (Ehrenb.) Wittrock		+	Previously recorded from NT, NSW, Vic, Qld
**Staurastrum laeve* Ralfs		+	Previously recorded from NT, NSW
Staurastrum nodulosum Prescott	+	+	Recorded from NT, NSW, Vic, Tas
**Staurodesmus brevispina* (Bréb.) Croasdale var. *brevispinus* f. *minimus* Lütkem.		+	Previously recorded from NSW
**Staurodesmus cuspidatus* (Bréb.) Teiling		+	Previously recorded from NSW, Tas
Staurodesmus triangularis (Lagerh.) Teiling var. *minor* G.S. West	+		Previously recorded from Vic as *Arthrodesmus triangularis* f. *minor* G.S. West

Croasdale (1962:32), Pl. 6:108
Site 2.
L 22.4 µm, Br 20.5 µm, Isth 6.8 µm. L:Br 1.1

This taxon was recently found in NSW (Dingley 2001). They differ only in that the Victorian plants had smooth walls without any indication of pores.

A new record for Victoria.

Staurodesmus cuspidatus (Bréb.) Teiling var. *cuspidatus*; Plate 1H
Teiling (1967:534)
Site 2.
L 22.5-23.6 µm, Br esp 23.7-34.3 µm, Br ssp 19.5-24.5 µm, Isth 4.1-5.4 µm

This plant has 3 facies, semicell, triangular or fusiform, with divergent spines. The base of the semicell is elongated in some cells giving rise to a cylindrical elongated isthmus. In some cells the apex is slightly convex but this depends on the position of the cell.

Staurastrum *Meyen ex Ralfs*
Staurastrum laeve Ralfs var. *laeve*; Plate 1J
Ralfs (1848:131), Pl. 23:10
Site 2.
L cpr 28.3 µm, L spr 20.8 µm, Br cpr 24.1 µm, Isth 8.5 µm

A new record for Victoria.

Summary

Thirty-four different taxa were identified from the two sites; nineteen from site 1 and eighteen from site 2 (see Table 2). Three of these, *Actinotaenium cucurbitinum* (Bisset) Teiling, *Closterium venus* Kütz. var. *venus* and *Staurastrum nodulosum* Prescott were found at both sites. Without taking water conductivity measurements or determining the chemical composition of the water samples, no conclusions have been formulated as to why these two sites have different flora. The pH values were remarkably similar and the differences may be due to the dissimilar habitats. The site 1 sample was collected from submerged macrophytes and the site 2 sample was found amongst filamentous algae.

Nine of these taxa are newly recorded for Victoria with two being newly recorded for Australia. It is worthwhile mentioning that 26% of the taxa found in these two samples are new records which may appear quite surprising, but as has been stated by Tyler (1970), 'the known distribution of desmids is none other than the known distribution of desmidiologists and the latter have been scarce in the southern hemisphere'. The high percentage of new records is of sufficient interest to publish these findings.

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Vegetation of the Northern (1989) Addition to Greens Bush, Mornington Peninsula National Park

Nicholas SG Williams[1]

Abstract

The vegetation of the northern section of Greens Bush, Mornington Peninsula National Park, is described and mapped using a quadrat-based floristic survey and analysis, aerial photographs and extensive ground truthing. Eight vegetation communities were found to occur in the study area based on multivariate floristic classification and aerial photograph interpretation. The vegetation communities are described and the conservation significance and recovery of the study area from grazing are discussed. (*The Victorian Naturalist* **120** (4). 2003, 121-131)

Introduction

Greens Bush is the largest and most significant remnant of native vegetation on the Mornington Peninsula (Calder 1986; Parks Victoria 2000). It covers an area of approximately 900 ha at Main Ridge and is midway between Arthurs Seat and Cape Schanck, 80 km south east of Melbourne. The land is now part of Mornington Peninsula National Park and was purchased by the Victorian Government from the Green family in a number of stages between 1975 and 1989 (Fitzsimons 1989a, b).

As with many Victorian national parks there has been little detailed research or survey of the flora of Mornington Peninsula National Park. Early studies for planning purposes described the vegetation of the area using dominant species only (Environmental Resources of Australia 1974; National Trust of Australia 1974) but Calder (1972, 1986) did include Greens Bush in her detailed study of the vegetation communities of the Mornington Peninsula. The vegetation of the southern section of Greens Bush, purchased in 1975, has been surveyed and mapped on a structural formation basis (sensu Specht 1970) (Parr-Smith and Smith 1978). Although there have been a number of preliminary investigations (Carr *et al.* 1988; Schultz *et al.* 1988) there has been no comprehensive survey, mapping and assessment of the conservation significance of the vegetation in the northern sections of Greens Bush.

This paper presents the results of a flora survey of the northern sections of Greens Bush conducted on behalf of Parks Victoria in 1996. This area is defined by Rogers, Limestone and Baldrys Roads, with the southern limit of the study area being the northern edge of the block of remnant bushland purchased in 1975 (Fig. 1). However, a small parcel of vegetation on the southern boundary of the Park along an unnamed tributary of Main Creek was investigated due to its unique appearance during aerial photograph interpretation and the advice of local Parks Victoria staff and naturalists. The aims of the study were to identify, describe and map the vegetation communities within the northern section of Mornington Peninsula National Park. The conservation significance of the area's flora, the regeneration of previously cleared areas and any threats to the Park's vegetation were also assessed. This information was used to develop appropriate management strategies for the Park.

Climate

The climate of the Mornington Peninsula is determined by the broad-scale atmospheric characteristics of the Victorian coast and local physiography which produces orographic rainfall and valley microclimates (Environmental Resources of Australia 1974). The closest meteorological station to Greens Bush is at Cape Schanck, approximately 10 km from the study area. The mean annual rainfall is 750 mm with the wettest months occurring in winter. The coldest month is July with a mean maximum temperature of 12.2°C and mean minimum of 7.5°C. The warmest

[1] Australian Research Centre for Urban Ecology, Royal Botanic Gardens Melbourne, c/o School of Botany, The University of Melbourne, Victoria 3010

Fig. 1. Map of the vegetation communities occurring in the northern section of Greens Bush, Mornington Peninsula National Park.

month is February, mean maximum 22.1°C and mean minimum 14.9°C (Land Conservation Council 1991).

Geology and geomorphology

Greens Bush is located at the margin of two land system units (Land Conservation Council 1991). Elevated coastal dunes characterised by a complex system of low dune ridges and swales which become seasonally inundated with water occur west of Main Creek and its major tributaries, while gentle basaltic hills generally occur to the east of Main Creek (Environmental Resources of Australia 1974; Land Conservation Council 1991). There are steep-sided, sheltered gullies along several tributaries of Main Creek where they have cut through surface sands and into the underlying basalt. The altitude of the study area varies between 120 and 170 m ASL.

The geology of the area is dominated by Quaternary aeolian siliceous sands that overlie Tertiary basalt. In places, particularly the portion of the Park adjoining Baldrys Road, the basalt emerges as a surface outcrop. In areas of impeded drainage, swamp deposits of stream alluvium, sand and silt overlie the Quaternary sands (McInnes 1967). More detailed accounts of the geology and geomorphology of the Greens Bush area are given by Jenkin (1974) and Keble (1968). Siliceous sands form light to dark grey organic sandy loam soils, which become peaty in swamp areas, while basalt forms red and brown loam soils (Parr-Smith and Smith 1978).

History and land use

Although the Mornington Peninsula has suffered extensive clearing for agriculture, timber cutting and extraction of lime (Calder 1986), most of Greens Bush remained undisturbed until the 1970s due to the poor agricultural potential of its low nutrient soils (Fitzsimons 1989a). Recognition of the area's biological values and substantial vegetation clearance in the northern section of Greens Bush in the early 1970s prompted the purchase of approximately 500 ha by the government in 1975. The remainder of the Park continued to be used by the Green family for farming. No large scale clearing occurred and despite farming practices that included grazing, burning, slashing, fertilising and sowing fodder crops and exotic pasture grasses on a small scale, the property retained many of its conservation values (Fitzsimons 1989a; Tom Sault pers. comm.). In response to subdivision plans put forward by the Green family and a concerted public campaign to preserve the area's conservation values, the government purchased the remainder of Greens Bush in 1988 and 1989 and subsequently incorporated it into Mornington Peninsula National Park. The history of the campaign to conserve Greens Bush and previous land management is described in detail by Fitzsimons (1989a, b).

Methods

The vegetation of the study area was described and mapped through a quadrat based vegetation survey and aerial photograph interpretation with extensive ground truthing between 29 October and 1 November 1996. Quadrat locations were stratified according to vegetation patterns interpreted from colour aerial photographs (1:15,000 scale) taken in 1990. Eleven quadrats were subjectively placed in areas of homogeneous vegetation. These were typically 900 m^2 but were varied to restrict the sample to a homogeneous area in wetlands and along watercourses. Time and budgetary constraints restricted further sampling. All vascular plant species growing in or projecting over the quadrat were identified and recorded, and assigned a cover abundance value based on a modified Braun-Blanquet (1932) system. Voucher material for selected taxa has been lodged at the National Herbarium, Melbourne. Nomenclature follows Ross (2000). All quadrat data are stored on the Flora Information System of the Department of Sustainability and Environment.

Quadrat data was supplemented by data from nine quadrats retrieved from the DSE Flora Information System sampled for a Land Conservation Council (1991) study. Seven of the additional quadrats were not inside the study area, but were located in the large southern block of the Park purchased in 1975. They were completed using methods identical to those used in this study and were included in the analysis to further differentiate the vegetation communities at Greens Bush.

A floristic analysis was performed on the range standardised, median cover-abundance data using the PATN software package (Belbin 1994). Quadrats were compared to every other quadrat by calculating a matrix of dissimilarity using the Bray-Curtis coefficient. The hierarchical agglomerative clustering strategy Unweighted Pair Group Averaging (UPGMA) with a $\beta = -0.1$ was then applied to the matrix and a dendrogram produced to illustrate the floristic relationships between quadrats (Fig. 2). UPGMA was used because it has been shown to recover ecological community structure better than other methods (Belbin and McDonald 1993).

Results

One hundred and eighty-five species of vascular plants were recorded from the quadrat survey of the northern portion of Greens Bush during this study. This included 161 native species (87% of species) and 24 introduced species (13%). Species recorded were from 60 families: Cyperaceae, Poaceae, Asteraceae and Fabaceae contained the greatest number of representatives in the study area. One species of national conservation significance was located during this study. Purple Eyebright *Euphrasia collina* subsp. *muelleri* is a hemi-parasitic perennial herb that is listed as nationally endangered (2 EC) (Briggs and Leigh 1996), endangered in Victoria and has been nominated for listing under the Flora and Fauna Guarantee Act (Natural Resources and Environment 2000). One population of approximately 30 individuals was located in an area of Sand Heath during the survey. Sixteen taxa considered of regional conservation significance (Beauglehole 1983) have been located in the northern section of Greens Bush.

An additional 64 species (54 native, 10 introduced) have been recorded in the northern section of Greens Bush according to vegetation survey data held by the Flora Information System at the Department of Natural Resources and Environment. All species recorded in the study area are listed in the Appendix.

The cluster analysis (Fig. 2) groups the quadrats based on the similarity of the vegetation at each site. Eight vegetation communities were recognised. These groups represent the vegetation communities observed in the study area and can be delineated on the aerial photographs.

Two groups, the Riparian Thicket and Scented Paperbark *Melaleuca squarrosa* Heathland were defined by a single quadrat. *Melaleuca squarrosa* Heathland was not sampled in this study, but was identified in the southern section of Greens Bush from one of the quadrats sampled during the Land Conservation Council (1991) survey.

The dendrogram (Fig. 2) also illustrates the floristic relationships between the vegetation communities in the study area. These relationships were expected, with communities with similar environmental attributes being more closely related. For example, Sand Heathland and Heathy Woodland are grouped together as are those communities occurring in riparian environments.

The distribution of the eight vegetation types is shown in Fig. 1. Delineation of community boundaries was based on the location of sites and their position within the multivariate analysis, air photograph interpretation and extensive ground truthing.

Vegetation communities

Community 1: Swamp Sedgeland

Swamp Sedgeland occurs in broad swales between the siliceous sands that are seasonally or permanently inundated. Some examples of this community have been heavily disturbed by cattle grazing; however, others are in very good condition.

The floristic composition of Swamp Sedgeland is dependent on the length of water inundation which is in turn dependent on seasonal variations in precipitation and changes in the groundwater table. Water levels are known to vary in the Swamp Sedgeland at Greens Bush (Jenkins and Kershaw 1997). Compared to those that are dry for part of the year, areas inundated for longer periods contain few species. Running Marsh-flower *Villarsia reniformis*, Fine Twig-sedge *Baumea arthrophylla* and Square Twig-sedge *B. tetragona* can be abundant while Dark Swamp Wallaby-grass *Amphibromus recurvatus* is usually present. In seasonally flooded areas, Slender Twig-sedge *Baumea gunnii* and Pale Twig-sedge *B. acuta* are common while the shrubs Prickly Tea-tree *Leptospermum continentale*, Golden Spray *Viminaria juncea*, Paperbarks *Melaleuca* spp. and Spreading Rope-rush *Empodisma minus* occur at their margins. Herbs and grasses, such as Creeping Raspwort *Gonocarpus micranthus* and Bent-grass *Deyeuxia* spp. are more prevalent in seasonally inundated areas as are a range of weed species in disturbed areas. Pithy Sword-sedge *Lepidosperma longitudinale* is an important component of the community regardless of water level. The largest area of this community in the study area is known as the 'Big Swamp' (Jenkins and Kershaw 1997).

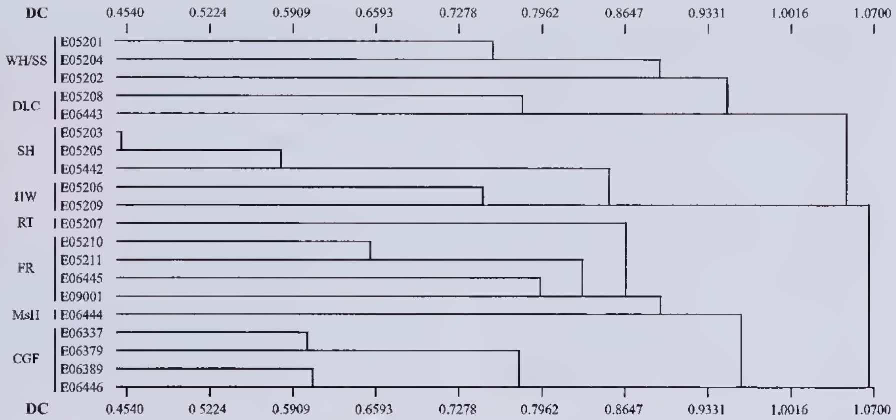

Fig. 2. UPGMA classification of Greens Bush quadrats. Quadrats with similar floristic composition are aggregated at lower values of the dissimilarity coefficient association values (DC). Labels indicate the community each aggregate of quadrats belongs to: WH/SS, Wet Heath or Swamp Sedgeland; DLC, Drainage Line Complex; SH, Sand Heath; HW, Heathy Woodland; RT, Riparian Thicket; RF, Riparian Forest; MsH, *Melaleuca squarrosa* Heathland; CGF, Coastal Grassy Forest. See text for definition of communities.

Community 2: Wet Heath

Wet Heath is confined to the headwaters of a tributary of Main Creek on the boundary of the Main Ridge Pony Club. It occurs in a broad open gully that has poorly drained silty soils which are probably waterlogged for much of the year. The community was once more extensive but earth works and horse riding by the pony club have reduced its size (Stefanie Rennick, pers. comm.).

The community is characterised by a diverse monocot flora. Pithy Sword-sedge *Lepidosperma longitudinale* and Spreading Rope-rush *Empodisma minus* are abundant and Common Rapier-sedge *L. filiforme*, Tall Sword-sedge *L. elatius*, Square Twig-sedge *Baumea tetragona* and Bog-sedges *Schoenus* spp. also occur. Scented Paperbark *Melaleuca squarrosa* is the most abundant tall shrub in the community and Prickly Tea-tree is also present. Pink Swamp-heath *Sprengelia incarnata*, Blunt-leaf Heath *Epacris obtusifolia*, Rigid Bush-pea *Pultenaea dentata* and Common Flat-pea *Platylobium obtusangulum* occur in slightly drier areas along with geophytes and herbs. Thick carpets of Scrambling Coral-fern *Gleichenia microcarpa* and Spreading Rope-rush are tangled through the community, often climbing into the shrub layer.

Community 3: Drainage Line Complex

The Drainage Line Complex is a distinct vegetation community that contains taxa found in the vegetation communities adjoining the drainage line and other species that require the moisture which accumulates in these areas. This community is widespread and is typically found in broad, well drained, shallow depressions that form the headwaters of the many creek tributaries in the study area.

Stunted Swamp Gum *Eucalyptus ovata* and Blackwood *Acacia melanoxylon* trees are present occasionally, but the dominant species of the Drainage Line Complex are the shrubs Prickly Tea-tree, Scented Paperbark and Swamp Paperbark *Melaleuca ericifolia*. These can be up to 3 m high but typically do not reach the size they attain in the Riparian Thicket community. The ground layer typically contains thick mats of Spreading Rope-rush and occasionally Scrambling Coral-fern with scattered sedges, grasses and herbs.

Community 4: Sand Heath

Sand Heath is restricted to infertile, siliceous sand dunes in the west of the study area. The community is dominated by Austral Grass-tree *Xanthorrhoea australis* with eucalypts, Narrow-leaf Peppermint *E. radiata* and Coast Manna Gum *E. viminalis* subsp. *pryoriana*, only occurring on the slopes of the dunes. Heath Tea-tree *Leptospermum myrsinoides* is the most abundant shrub, but Silver Banksia *Banksia marginata*, Common Aotus *Aotus ericoides*, Common Heath *Epacris impressa*, Prickly Broom-heath *Monotoca scoparia* and Common Beard-heath *Leucopogon virgatus* are also common in gaps between grass-trees. Sand-hill Sword-sedge *Lepidosperma concavum* and Tassel Rope-rush *Hypolaena fastigiata* are common components of the ground layer. Sundews *Drosera* spp., Heath Xanthosia *Xanthosia pusilla* and Hairy Centrolepis *Centrolepis strigosa* are also characteristic.

Community 5: Heathy Woodland

Heathy Woodland is found on areas of siliceous sands that appear to be of intermediate fertility to those on which Sand Heath and Coastal Grassy Forest occur. Much of the Heathy Woodland in the study area has been heavily disturbed by grazing, burning and slashing; however, intact examples occur in the section of the Park adjacent to Baldrys Road.

Messmate *Eucalyptus obliqua* is the most abundant tree present in Heathy Woodland while Narrow-leaf Peppermint and Coast Manna Gum can occur. The composition of the understorey is dependent on the degree of past disturbance. It usually includes Austral Grass-tree. Austral Bracken *Pteridium esculentum* is abundant at most sites, sometimes forming a complete cover. The abundance of shrubs is low in disturbed examples of Heathy Woodland as a result of past slashing but scattered mature and seedling Prickly Tea-tree, Heath Tea-tree, Smooth Parrot-pea *Dillwynia glaberrima* and Common Heath can be common. Other heathy shrubs may occur in undisturbed examples. Broom Spurge *Amperea xiphoclada* var. *xiphoclada*, Mat-rushes *Lomandra* spp. and Sword-sedges are also present. The abundance of herbaceous and weed species varies with soil fertility and disturbance.

Community 6: Riparian Thicket

Riparian Thicket occurs in the middle and upper reaches of Lightwood Creek and tributaries of Main Creek where topographical and soil conditions do not allow free water drainage. These conditions generally prevent the establishment of trees that characterise the Riparian Forest community.

Riparian Thicket is dominated by a closed cover of large Scented Paperbark and Woolly Tea-tree *Leptospermum lanigerum*. Very little light penetrates the canopy creating an open understorey except on the edges of the community where dense mats of climbing Scrambling Coral-fern are found. The sparse understorey is comprised of scattered sedges; Tall Sedge *Carex appressa*, Tassel Cord-rush *Baloskion tetraphyllum*, Twig-sedges *Baumea* spp. and Leafy Bog-sedge *Schoenus maschalinus*, Fishbone Water-fern *Blechnum nudum* and Hard Water-fern *B. wattsii* also occur.

Community 7: Riparian Forest

Riparian Forest occurs along Main Creek and in the incised valleys made by its tributaries. In addition to typical riparian species, the sheltered environment supports vegetation that is common in the wet forests east of Melbourne (Land Conservation Council 1991) but uncharacteristic of the Mornington Peninsula.

The overstorey is dominated by Blackwood and Messmate although Manna Gum *E. viminalis* subsp. *viminalis* are also present. Beneath this stratum are tall shrubs and small trees, Hazel Pomaderris *Pomaderris aspera*, Musk Daisy-bush *Olearia argophylla* and Victorian Christmas-bush *Prostanthera lasianthos* being most prominent. There is a sparse shrub layer, with only Prickly Currant-bush *Coprosma quadrifida* commonly occurring. Usually there is a thick fern layer of *Blechnum* species. Fishbone Water-fern, Hard Water-fern, Soft Water-fern *B. minus* and Mother Shield-fern *Polystichum proliferum* grow adjacent to the stream with Austral Bracken and Common Ground-fern *Calochlaena dubia* growing higher on the banks. Tall Sedge *Carex appressa*, Rough Tree-fern *Cyathea australis* and Soft Tree-fern *Dicksonia antarctica* occur in and around the stream, the latter being most abundant.

Community 8: Coastal Grassy Forest

At Greens Bush, Coastal Grassy Forest occurs on flat or undulating areas primarily on soils derived from Tertiary basalt.

However, it can also be present on areas of siliceous sands more fertile than those that support Heathy Woodland and Sand Heath. The most extensive areas of Coastal Grassy Forest occur in the sections of the Park adjoining Baldrys Road and Greens Road.

The community has an overstorey of eucalypts up to 25 m tall. Typically Messmate and Coast Manna Gum are the most common species with Narrow-leaf Peppermint and Swamp Gum also occurring. The understorey is open with many grasses and herbs with few shrubs. Tussocks of Kangaroo Grass *Themeda triandra*, Common Tussock-grass *Poa labillardieri* and Soft Tussock-grass *P. morrisii* are dominant whilst Slender Tussock-grass *P. tenera*, Weeping Grass *Microlaena stipoides*, Common Maidenhair fern *Adiantum aethiopicum* and herbs such as Prickly Starwort *Stellaria pungens*, Kidney-weed *Dichondra repens* and Common Raspwort *Gonocarpus tetragynus* grow in the inter-tussock spaces. Clumps of Spiny-headed Mat-rush *Lomandra longifolia* and Pithy Sword-sedge *Lepidosperma longitudinale* are common as is Austral Bracken, particularly in disturbed areas.

Discussion

Greens Bush is the largest relatively undisturbed example of native vegetation on the Mornington Peninsula. Prior to European settlement, the vegetation communities present at Greens Bush were more widespread, but clearing for agriculture and more recently urbanisation, changes in drainage patterns and weed invasion have left few good quality areas of remnant vegetation remaining on the Mornington Peninsula (Land Conservation Council 1991). Consequently, Greens Bush is of extremely high conservation importance due to the unique suite of intact, high quality vegetation communities present in the Park and the presence of a number of rare species.

Further sampling could be performed to further define the floristic communities at Greens Bush. For example, Wet Heath was considered to be a distinct community in the field but was not defined as a distinct community in the vegetation analysis where it was grouped with Swamp Sedgeland. This is probably because of the presence of a number of species characteristic of the drier Wet Heath in the Swamp Sedgeland (e.g. Prickly Tea-tree). Scented Paperbark Heathland was defined in the floristic analysis from a quadrat in the southern section of Greens Bush, but was not observed during survey work. It has many species in common with Wet Heathland, and the relationship between these two communities should be investigated further. Additional floristic analysis incorporating the data of Carr *et al.* (1988) and other quadrat data from the study area (uncovered and subsequently added to the NRE databases after the report this paper is based on was finalised) would further refine our knowledge of the relationships between the vegetation communities at Greens Bush.

Rare and restricted vegetation communities

A number of the vegetation communities that occur in the northern section of Greens Bush are of particular conservation significance. The Wet Heath community is floristically distinct from Wet Heath found in the Western Port region (Opie *et al.* 1984). It has affinities with the Wet Heath in the eastern Otway Ranges but occurs in areas of substantially lower rainfall. The Riparian Thicket community occurring on a spring adjacent to Main Creek contains numerous, very large, ancient Scented Paperbark and Woolly Tea-tree, and an understorey of ground ferns, tree-ferns, epiphytes and a diverse bryophyte flora. The only other known occurrence of Riparian Thicket of a similar age and structure in the region is the Endeavour Fern Gully at Red Hill.

The floristics of the Swamp Sedgeland have also been described by Jenkins and Kershaw (1997) who conducted palynological studies at Big Swamp, the largest wetland at Greens Bush. The swamp is considered of state significance because of its high ecological and conservation value (Larwill and Costello 1992). Unlike most wetlands, the Swamp Sedgeland at Greens Bush is located at a high point in the landscape on a broad divide between Port Phillip Bay and Bass Strait. Similar intact 'higher level' wetlands occur between Stradbroke and Gormandale in Central Gippsland (Rosengren *et al.* 1981).

The Sand Heath at Greens Bush is one of the few examples of this community remaining in a natural state on the Mornington Peninsula. The presence of the nationally endangered Purple Eyebright *Euphrasia collina* subsp. *muelleri*, many regionally threatened species and Austral Grass Tree *X. australis*, which does not occur in other heathlands on the Peninsula, is of conservation significance. This community is threatened by Cinnamon Fungus *Phytophthora cinnamomi* which is present at Greens Bush.

Weed invasion

Fifty-one exotic species were recorded from quadrats and as incidental records during this survey. Weed invasion is a major threat to the vegetation communities of Greens Bush (Parks Victoria 2000). Carr *et al.* (1988) recorded that overall the vegetation in the area contained very few weed species and no serious woody weeds. It is unclear if exotic pasture species have spread or declined since the cessation of agricultural disturbances but Sweet Vernal Grass *Anthoxanthum odoratum* is a very serious weed at Greens Bush. Since 1988 a serious woody weed problem has also developed. Sweet Pittosporum *Pittosporum undulatum*, Coast Wattle *Acacia sophorae*, and Sallow Wattle *A. longifolia* have invaded from neighbouring properties and are rapidly spreading. Some plants are up to 4 m tall and form sizeable thickets. These species are considered a very serious threat to native vegetation in Victoria and can dominate coastal heaths and woodlands (Carr 1993; McMahon *et al.* 1996). Control of invasive *Acacia* species and *P. undulatum* may be achieved through the prescribed use of fire (McMahon *et al.* 1996; Narayan 1993) which should be investigated as a management technique to control weeds and promote the regeneration of indigenous species.

Native vegetation regeneration

Regeneration of the native vegetation in previously cleared areas was subjectively assessed during traverses of the study area. Coastal Grassy Woodland and Heathy Woodland in the north and northwest of the study area typically have an open woodland structure as a result of past tree clearing and agricultural practices. Many of these areas are now dominated by thick swathes of Austral Bracken which have emerged following the cessation of slashing. More disturbed woodland areas had a greater abundance of Austral Bracken, fewer shrubs and sedges and a ground layer dominated by Sweet Vernal Grass and other exotic pasture species such as Yorkshire Fog *Holcus lanatus*, Cat's Ear *Hypochoeris radicata*, Hairy Birdsfoot Trefoil *Lotus uliginosus* and various clover *Trifolium* species. In some of these areas indigenous ground layer species are virtually absent. Scattered eucalyptus saplings up to 4 m tall indicate that recruitment of the overstorey is occurring.

Areas of sandier soils such as those adjacent to ridges of Sand Heath contain a greater indigenous understorey component and more regenerating eucalypts than other disturbed woodland areas. These areas typically had smaller amounts of Austral Bracken and more indigenous grasses, sedges (e.g. Spiny-headed Mat-rush, Pithy Sword-sedge) and shrubs (e.g. Heath Tea-tree, Prickly Tea-tree).

The broad drainage lines that form the headwaters of Drum Drum Alloc and Lightwood Creeks are regenerating well and support a dense cover of Scented Paperbark, Swamp Paperbark, and Prickly Tea-tree up to 3 m high. The ground layer appears to have a greater indigenous component than drier areas. Shallow, seasonally inundated, poorly drained depressions now support a weedy sedgeland but the dominant native species of these communities Sword-sedges *Lepidosperma* spp. and Twig Sedges *Baumea* spp. appear to be regenerating well.

This survey suggests that indigenous species are regenerating adequately in most of the study area. This confirms the predictions of botanists who commented on the resilience of the vegetation to disturbance by grazing. This is due to the low nutrient status of most of the soils, seasonal waterlogging effects that may exclude exotic species, and the ability of the vegetation, particularly Paperbark species, to regenerate in the moist depressions characteristic of the study area (Calder 1986; Carr *et al.* 1988; Schultz *et al.* 1988). However, due to the lack of a quantitative monitoring program, it is unclear if exotic species have declined in extent and abundance in the absence of disturbance and increased competition from native species.

Conclusion

The northern section of Greens Bush, Mornington Peninsula National Park is largely comprised of substantially intact native vegetation. Seven vegetation communities were identified, many of which are now rare on the Mornington Peninsula. The low percentage of weeds in the flora of the Park indicates the integrity of the area's vegetation and the progress of natural revegetation. Nevertheless several aggressive environmental weeds are present and the Park's vegetation will have to be actively managed to preserve its values.

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Appendix

Vascular plant taxa recorded in 22 quadrats in the study area, listed according to family. Species from eleven quadrats from this study, nine from the survey of Carr *et al.* (1988) and two from the Land Conservation Council (1991) vegetation survey are included. Exotic species are indicated with an asterisk, and endangered, vulnerable and rare species are noted.

Ferns and Allied Plants

ADIANTACEAE
Adiantum aethiopicum

ASPLENIACEAE
Asplenium flabellifolium

BLECHNACEAE
Blechnum nudum
Blechnum wattsii

CYATHEACEAE
Cyathea australis

DENNSTAEDTIACEAE
Histiopteris incisa
Pteridium esculentum

DICKSONIACEAE
Calochlaena dubia
Dicksonia antarctica

DRYOPTERIDACEAE
Polystichum proliferum

GLEICHENIACEAE
Gleichenia microphylla

LINDSAEACEAE
Lindsaea linearis

POLYPODIACEAE
Microsorum pustulatum

SELAGINELLACEAE
Selaginella uliginosa

Monocotyledons

CYPERACEAE
Baumea acuta
Baumea arthrophylla
Baumea gunnii
Baumea spp.
Baumea tetragona
Bolboschoenus spp.
Carex appressa
Carex fascicularis
Carex spp.
Eleocharis acuta
Gahnia sieberiana
Gahnia spp.
Isolepis cernua
Isolepis inundata
Isolepis spp.
Lepidosperma concavum
Lepidosperma elatius
Lepidosperma filiforme
Lepidosperma gunnii
Lepidosperma laterale
Lepidosperma longitudinale
Lepidosperma neesii
Schoenus apogon
Schoenus brevifolius
Schoenus lepidosperma
Schoenus maschalinus
Schoenus tesquorum

IRIDACEAE
Patersonia occidentalis
**Sisyrinchium iridifolium*

JUNCACEAE
**Juncus articulatus*
**Juncus bulbosus*
Juncus pallidus
Juncus pauciflorus
Juncus planifolius
Luzula meridionalis var. *flaccida*

JUNCAGINACEAE
Triglochin striatum

LILIACEAE
Burchardia umbellata
Caesia parviflora

ORCHIDACEAE
Chiloglottis valida
Corybas spp.
Cryptostylis leptochila
Cryptostylis subulata
Microtis unifolia
Pterostylis decurva
Pterostylis melagramma
Thelymitra media var. *media*
Thelymitra spp.

POACEAE
Agrostis avenacea
**Agrostis capillaris* var. *aristata*
**Aira caryophyllea*
**Aira cupaniana*
Amphibromus recurvatus
**Anthoxanthum odoratum*
Austrodanthonia racemosa
Austrodanthonia setacea
Austrodanthonia spp.
**Cynosurus cristatus*
**Cynosurus echinatus*
**Dactylis glomerata*
Deyeuxia minor
Deyeuxia quadriseta
Deyeuxia spp.
Echinopogon ovatus
**Ehrharta erecta*
Entolasia spp.
Eragrostis brownii
Hemarthria uncinata var. *uncinata*
**Holcus lanatus*
**Lolium perenne*
Microlaena stipoides var. *stipoides*
**Paspalum dilatatum*
Phragmites australis
**Poa annua*
Poa labillardieri
Poa morrisii
Poa sieberiana var. *hirtella*
Poa sieberiana var. *sieberiana*
Poa tenera
**Setaria gracilis*
Tetrarrhena distichophylla
Themeda triandra

RESTIONACEAE
Baloskion tetraphyllum
Empodisma minus
Hypolaena fastigiata
Leptocarpus tenax

XANTHORRHOEACEAE
Lomandra filiformis subsp. *filiformis*
Lomandra longifolia
Xanthorrhoea australis

Dicotyledons

APIACEAE
Centella cordifolia
Hydrocotyle hirta
Hydrocotyle sibthorpioides
Hydrocotyle spp.
Hydrocotyle tripartita
Lilaeopsis polyantha
Xanthosia leiophylla
Xanthosia huegelii

ARALIACEAE
**Hedera helix*

ASTERACEAE
Cassinia aculeata
Cassinia longifolia
**Cirsium vulgare*
Euchiton involucratus s.l.
Euchiton spp.
Helichrysum scorpioides
**Hypochoeris glabra*
**Hypochoeris radicata*
Lagenophora spp.
Lagenophora stipitata
**Leontodon taraxacoides*
Olearia argophylla
Olearia lirata
Ozothamnus ferrugineus
**Senecio jacobaea*
Senecio minimus
Senecio spp.
Senecio tenuiflorus
Sigesbeckia orientalis
**Sonchus asper* s.l.
**Sonchus oleraceus*

BORAGINACEAE
Cynoglossum latifolium

CAMPANULACEAE
Lobelia anceps
Wahlenbergia gracilis s.l.
Wahlenbergia stricta subsp. *stricta*

Appendix cont.

CAPRIFOLIACEAE
Sambucus gaudichaudiana

CARYOPHYLLACEAE
**Cerastium glomeratum*
**Stellaria media*
Stellaria pungens

CASUARINACEAE
Allocasuarina paludosa

CENTROLEPIDACEAE
Centrolepis strigosa subsp. *strigosa*
Centrolepis fascicularis

CLUSIACEAE
Hypericum gramineum

CONVOLVULACEAE
Dichondra repens

DILLENIACEAE
Hibbertia acicularis

DROSERACEAE
Drosera binata
Drosera peltata subsp. *auriculata*
Drosera whittakeri

EPACRIDACEAE
Acrotriche prostrata
Acrotriche serrulata
Brachyloma ciliatum
Epacris impressa
Epacris obtusifolia
Leucopogon australis
Leucopogon virgatus
Monotoca scoparia
Sprengelia incarnata

EUPHORBIACEAE
Amperea xiphoclada var. *xiphoclada*
Poranthera microphylla

FABACEAE
Aotus ericoides
Bossiaea cinerea
Bossiaea prostrata
Desmodium gunnii
Desmodium spp.
Dillwynia glaberrima
Glycine clandestina
Glycine microphylla
Hovea spp.
Kennedia prostrata
**Lotus corniculatus*
**Lotus suaveolens*
**Lotus uliginosus*
Platylobium obtusangulum
Pultenaea dentata
Pultenaea stricta
**Trifolium dubium*
**Trifolium repens*
**Trifolium* spp.
**Trifolium subterraneum*
**Vicia* spp.
Viminaria juncea

GENTIANACEAE
**Centaurium erythraea*
**Centaurium tenuiflorum*

GERANIACEAE
Geranium potentilloides

GOODENIACEAE
Goodenia geniculata
Goodenia humilis

HALORAGACEAE
Gonocarpus micranthus subsp. *micranthus*
Gonocarpus tetragynus
Myriophyllum amphibium
Myriophyllum spp.

LAMIACEAE
Prostanthera lasianthos
**Prunella vulgaris*

LAURACEAE
Cassytha glabella
Cassytha pubescens s.s.

LORANTHACEAE
Amyema pendulum subsp. *pendulum*

LYTHRACEAE
Lythrum hyssopifolia

MENYANTHACEAE
Villarsia reniformis

MIMOSACEAE
Acacia implexa
Acacia melanoxylon
Acacia suaveolens
Acacia verticillata

MYRTACEAE
Eucalyptus obliqua
Eucalyptus ovata
Eucalyptus radiata s.l.
Eucalyptus viminalis
Leptospermum continentale
Leptospermum lanigerum
Leptospermum myrsinoides
Melaleuca ericifolia
Melaleuca squarrosa

ONAGRACEAE
Epilobium spp.

OXALIDACEAE
Oxalis exilis
Oxalis spp.

PHYTOLACCACEAE
**Phytolacca octandra*

PITTOSPORACEAE
Billardiera scandens
Bursaria spinosa var. *spinosa*
Pittosporum undulatum

PLANTAGINACEAE
**Plantago coronopus*
Plantago debilis
**Plantago lanceolata*

POLYGALACEAE
Comesperma calymega
Comesperma volubile

POLYGONACEAE
**Acetosa sagittata*
**Acetosella vulgaris*
Persicaria decipiens
Rumex spp.

PRIMULACEAE
**Anagallis arvensis*

PROTEACEAE
Banksia marginata
Hakea nodosa
Isopogon ceratophyllus

RANUNCULACEAE
Clematis aristata
Ranunculus amphitrichus
Ranunculus spp.

RHAMNACEAE
Pomaderris aspera

ROSACEAE
Acaena novae-zelandiae
**Crataegus monogyna*
**Rubus fruticosus* spp. agg.
Rubus parvifolius
Rubus spp.

RUBIACEAE
Asperula scoparia
Coprosma quadrifida
**Coprosma repens*
Galium propinquum
Coprosma granadensis
Opercularia varia

SANTALACEAE
Exocarpos strictus

SCROPHULARIACEAE
Ee Euphrasia collina subsp. *muelleri*
Gratiola peruviana
Gratiola spp.
**Parentucellia viscosa*
Veronica calycina

SOLANACEAE
**Solanum nigrum*
Solanum spp.

STYLIDIACEAE
Stylidium graminifolium

THYMELAEACEAE
Pimelea humilis
Pimelea phylicoides
Pimelea spp.

TREMANDRACEAE
Tetratheca ciliata

VIOLACEAE
Viola hederacea subsp. *hederacea*

XYRIDACEAE
Xyris gracilis
Xyris operculata

Evidence of Leadbeater's Possum *Gymnobelideus leadbeateri* in the Macedon Region: An Example of the Use of Molecular Genetics in Fauna Survey

S Larwill[1,2], P Myroniuk[3], M Belvedere[4] and M Westerman[5]

Abstract

In 1995 a fauna survey was conducted in the Macedon region as part of an Environmental Effects Statement, and a tuft of hair was collected from the ground layer in Swamp Gum *Eucalyptus ovata* riparian woodland. The hair was analysed morphologically and identified as 'highly probable' to be Leadbeater's Possum *Gymnobelideus leadbeateri* McCoy 1867. This result was of particular importance because the location where the hair was found is over 85 km west of the species' known range. In addition, the evidence of a nationally threatened species had significant implications for the evaluation of potential impacts of the (then) proposed freeway upgrade of the Calder Highway. Morphologically, the unknown hair sample varied sufficiently from reference collections to cause some doubt over the identification. Molecular genetic analysis of the unknown hair sample was used to verify that the tuft of hair originated from Leadbeater's Possum. This is an example of the use of molecular genetics as an adjunct to morphometric hair analysis as a part of broad-scale fauna inventory surveys. (*The Victorian Naturalist* **120** (4), 132-139)

Introduction

A survey was undertaken as part of the preparation of an Environmental Effects Statement for the proposed upgrade of the Calder Highway (VicRoads 1995a). A tuft of hair (Fig. 1) was collected from the ground layer in Swamp Gum riparian woodland within the road reserve of Blackwood Road, Macedon, adjacent to Slatey Creek (37°26'6" S, 144°32'48" E). The purpose of the research presented in this paper was to identify the species from which the hair originated.

Leadbeater's Possum

Leadbeater's Possum *Gymnobelideus leadbeateri* McCoy 1867 is endemic to Victoria, occurring mainly in the Mountain Ash forests of the Central Highlands. It is a nationally endangered species (Menkhorst 1995; *Environment Protection and Biodiversity Conservation Act* 1999 (Commonwealth)).

Morphometric analysis of hair

Morphometric analysis of hair is the macroscopic and microscopic examination of hair fibres and the interpretation of diagnostic characteristics to identify mammal species (Brunner and Coman 1974). A combination of characters is used to identify the hair: hair-length, profile, medulla pattern, colour, and hair cross-section. Hair analysis is used as a component of biological field studies for broad-scale biological survey (e.g. Valente and Woolley 1982; Brunner and Coman 1974; Friend 1978) and ecological dietary studies (e.g. Brunner *et al.* 1975; Triggs *et al.* 1984; Lunney *et al.* 1990). Hair is collected in the field in a variety of ways: collection of predator scats and owl pellets, use of baited hair tubes or funnels (Winnett and Degabriele 1982; Scotts and Craig 1988) or collection of hair tufts found opportunistically in sprung traps, on fences, or inside nest hollows.

The advantage of hair analysis in mammal surveys is the detection of uncommon and inconspicuous species frequently not recorded in conventional surveys (Friend 1978). Hair analysis and scat analysis have higher recording rates for trap-shy, ground-dwelling species than conventional survey techniques (Friend 1978; Scotts and Craig 1988). However, hair analysis is limited by the difficulty in distinguishing between samples from some closely related taxa (Brunner and Coman 1974; Valente and Woolley 1982; Taylor 1985; Lobert *et al.* 2001).

[1] Biosis Research Pty Ltd, PO Box 489 Port Melbourne, Victoria 3207

[2] Current address: 6 John Street, Williamstown, Victoria 3016. Email sidsam@smartchat.net.au

[3] Department of Conservation and Research, The Royal Melbourne Zoological Gardens, PO Box 74, Parkville, Victoria 3052. Email pmyroniuk@zoo.org.au

[4] Wild Hair Analysis, 18 Stradbroke Road, Boronia, Victoria 3155

[5] Marsupial Evolution Unit, Department of Genetics, LaTrobe University, Bundoora, Victoria 3083

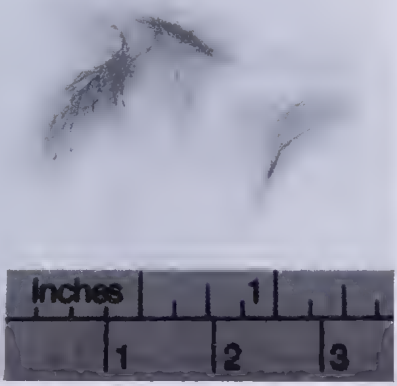

Fig. 1. The tuft of hair collected from the forest floor adjacent to Slatey Creek, Blackwood Road, Macedon. More than half of the original hair sample found was destroyed during the process of analysis. Lower scale in cm, upper scale in inches.

Molecular analysis of hair

The advent of automated techniques such as the Polymerase Chain Reaction (PCR) has seen a rapid advancement in molecular genetic analysis. The PCR procedure is an *in vitro* method that can be used to produce large amounts of a specific DNA fragment of usually a defined length from a specific gene region (Saiki *et al.* 1985; Erlich *et al.* 1988; Bourke 1989; White *et al.* 1989). It is an extremely sensitive technique that allows sufficient quantities of DNA to be amplified from very small amounts of tissue for molecular genetic analysis. For example, Higuchi *et al.* (1988) were able to extract, amplify and analyse DNA from single hairs. Sequences obtained from such samples can then be compared with DNA reference libraries for taxonomic identification.

Methods

Study area

The Macedon/Woodend region is located at the eastern limit of the Western Highlands of Victoria. Mammal surveys in the region include Elkington *et al.* (1985) and Yugovic *et al.* (1993). A survey of the Black Forest area west of Macedon township, concentrating on the Slatey Creek catchment (Fig. 2), was conducted between 29 November 1993 and 12 April 1995 (VicRoads 1995b). The vegetation in the survey area comprises Swamp Gum *Eucalyptus ovata* Riparian Woodland and Manna Gum *E. viminalis* Riparian Forest. Surrounding hill slopes support Messmate *E. obliqua* - Peppermint *E. dives* Dry Forest, which is the most extensive native vegetation community within the Black Forest area.

Morphometric analysis

The hair sample was collected opportunistically, and placed in a paper envelope at the point of collection. The remains of the hair sample after completion of all analyses, being approximately one third of the original sample collected, are shown in Fig. 1. Morphometric diagnosis was carried out in laboratory conditions according to standard hair diagnosis procedures (Brunner and Coman 1974). Analysis was completed independently in two separate laboratories.

Morphometric analysis required destruction of some of the hair sample.

Molecular analysis

Molecular analysis of the hair sample was initiated after morphometric analysis yielded equivocal results. The objective of the molecular analysis was to determine whether the hair sample was Leadbeater's Possum or Common Ringtail Possum *Pseudocheirus peregrinus*. The hair of other locally occurring species, for example the Sugar Glider *Petauris breviceps*, was not included in the molecular analysis because these species could be discounted by the morphometric analysis alone. In a standard inventory survey, molecular genetics would not be used.

DNA extraction from the hair sample followed the protocol outlined by Higuchi (1989). Approximately one third of the sample was used. Aliquots of this extraction were then used to amplify, via PCR, the 'universal fragment' of the 12s rRNA gene on the mtDNA (mitochondrial DNA).

The resulting PCR product was purified using Millipore Ultrafree 30 000 NMWL filter units. Asymmetric amplification of 8.5 μl of the purified PCR product was undertaken using oligonucleotide primer L1091 labelled with P33 reagents supplied with the New England Biolabs Thermal Cycle Sequencing Kit.

The samples were then loaded into 6%

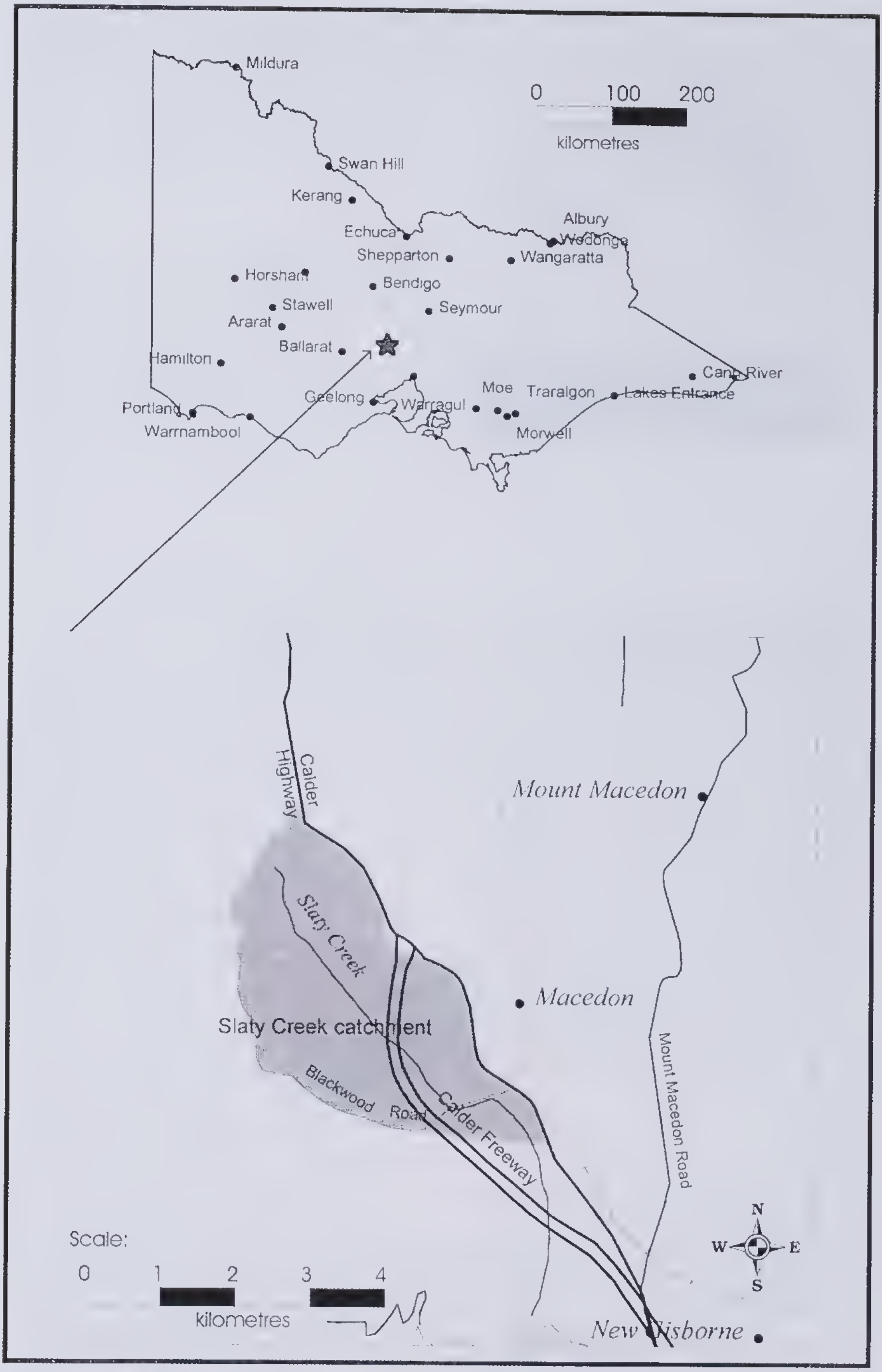

Fig. 2. The Slatey Creek catchment, Macedon region.

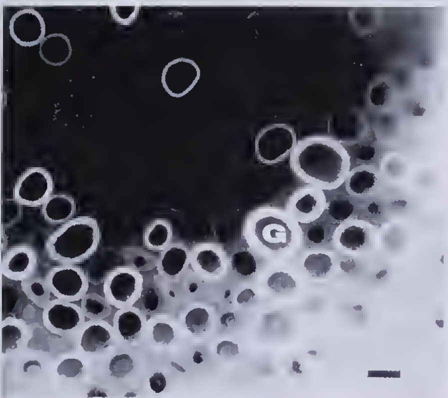

Fig. 3. Cross-section of unknown hair sample from Slatey Creek, Macedon. Mammal fur is made up of underhairs (most numerous), guard hairs and overhairs. Guard hairs have the most diagnostic features and are used for hair analysis. G indicates the cross section of a guard hair. Scale bar 20 µm.

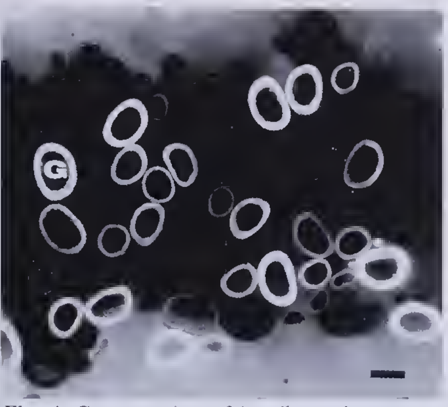

Fig. 4. Cross-section of Leadbeater's Possum hair (source of hair: Museum of Victoria). G indicates the cross section of a guard hair. Scale bar 20 µm.

polyacrylamide gels and run for 3-4 hours at a eonstant 50 watts and between 2000 and 2200 volts. The resultant sequenee was visualized by exposing the radioaetive gel to x-ray film.

The mtDNA sequenees from the unknown sample were aligned manually with a known sequence from Leadbeater's Possum and Common Ringtail Possum following Springer *et al.* (1995). These two species were seleeted beeause of the results of the morphometrie analysis.

Moleeular analysis necessitated destruction of some of the hair sample, the

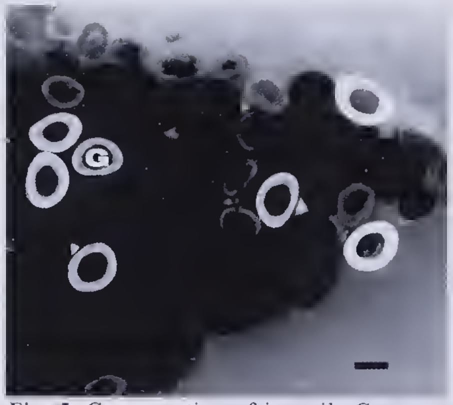

Fig. 5. Cross-section of juvenile Common Ringtail Possum hair (source of hair: Museum of Victoria). G indicates the cross section of a guard hair. Scale bar 20 µm. Juvenile Common Ringtail Possum hair was used because adult hair would be substantially wider in cross-section than Leadbeater's Possum hair, and could not be mistaken for Leadbeater's Possum hair. Note the cortex of the guard hairs (G), the outer border of the hair has an oval-like outer edge and a rounded inner edge, creating an eye shape. This eye shape is characteristic of guard hairs of larger possum species. Note the eye shape is absent in the unknown hair sample (Fig. 3) and the Leadbeater's Possum hair sample (Fig. 4).

remainder of whieh is held in the private eolleetion of one of the authors (MB).

Results

Morphometric analysis

The unknown hair sample was identified as the hair of Leadbeater's Possum. However, the hair sample showed slight variation from known samples held in referenee eolleetions on each of two morphometrie characteristies: hair width and hair colour. The unknown hair sample was slightly wider than the known range for Leadbeater's Possum (Figs 3 and 4) and more rufous in colour than referenee samples. Examples of intraspecifie variation in hair morphology between populations from different geographical regions has been previously reeorded for other species (e.g. Elgmork and Risser 1991). However, there is no systematie data on variation in hair morphology between populations of Leadbeater's Possum. The variation in the present sample was not sufficient to diseount Leadbeater's Possum, and on the basis of the combined characteristics, Leadbeater's Possum was the probable hair source.

The width and rufous colouration of the unknown hair sample suggested a possible alternative identification of the hair as juvenile Common Ringtail Possum *Pseudocheirus peregrinus* – morphologically the hair was too small for adult specimens. However this conclusion was not strongly supported by the hair cross-section (Fig. 5). All other known mammal species could be completely discounted on the basis of the combined morphometric attributes. The Common Ringtail Possum is locally common in the Macedon region.

The evidence based on hair morphology indicated an equivocal result – the conclusion that the hair source was 'highly probable' Leadbeater's Possum was qualified by alternative 'possible' identification of Common Ringtail Possum (juvenile). Thus to verify the identification of the hair a molecular genetic analysis was conducted.

Molecular analysis

A 434 base pair mtDNA 12s rRNA fragment was successfully amplified by the PCR from the hair sample supplied. A 266 base pair segment was sequenced and analysed. The unknown sequence, together with known Leadbeater's Possum and Common Ringtail Possum sequences, are shown in Fig. 6.

Of the 266 bases for the unknown sample which could be aligned with the two possums, a total of 50 base differences were seen between the known Common Ringtail Possum 12s rRNA sequence and the unknown hair sample. In marked contrast the known Leadbeater's Possum and the

```
Specimen              Sequence

Leadbeater's Possum   GCTTAGCCCTAAACCCAAACAGCTACCAAACAAGACTGCT
Ringtail Possum       ........T..........T.AT.CT.C.....A...AT.
Unknown               ........................................

Leadbeater's Possum   CGCCAGAGAACTACTAGCAAATGCTTAAAACTCAAAGGACTTGGCGGTGCC
Ringtail Possum       ....................TC.............................
Unknown               ...................................................

Leadbeater's Possum   CTAAACCCACCTAGAGGAGCCTGTTCTATAATCGATAAACCCCGATAAACC
Ringtail Possum       T....T...T.....................C...................
Unknown               ...................................................

Leadbeater's Possum   TTACCCCCTTTTGCCAATACAGCCTGTATACCGCCATCGTCAGCCCACCTC
Ringtail Possum       .....T.T.C...............A..................T....CT
Unknown               ...................................................

Leadbeater's Possum   ATCAGAGAACTAAAGTGGGCAAGATTATTATTCATAAAAACGTTAGGTCAA
Ringtail Possum       .A..AG...T......AA..G...CA..CCA....................
Unknown               ...................................................

Leadbeater's Possum   GGTGTAGCGTATAAGAGGGAAAGCAATGGGCTACATTTTCTATACTAGAAT
Ringtail Possum       ........A...G.AG.......T...................C......C
Unknown               ...................................................

Leadbeater's Possum   ACAACGAACTATCTCTTGAAAGCTAAGACATCCGAAGGAGGATTTAGTAGT
Ringtail Possum       .T......TATA.CTAATG..A.CCGAGGTATT..............C...
Unknown               ...................................................

Leadbeater's Possum   AAATTAAGAATAGAGAGCTTAATTGAATTAGGCAATAGGGCGCGC
Ringtail Possum       .............................T.......A.......
Unknown               .............................................
```

Fig. 6. Mitochondrial DNA 12s rRNA sequence from the unknown hair sample compared with 12s rRNA sequences from known Leadbeater's Possum and Common Ringtail Possum. Base sequence differences are specified; dots indicate that the base sequence is the same as the known Leadbeater's Possum sequence.

unknown hair sample sequence were identical over the region of DNA studied (Fig. 6). It was concluded that the unknown hair sample from the Black Forest, Macedon, originated from a Leadbeater's Possum.

Discussion

The use of molecular analysis as an adjunct to morphometric analysis to diagnose the unknown hair sample confirmed the identity of the tuft of hair as Leadbeater's Possum hair. In the context of the Environmental Effects Study, of which this research formed a part, this result was of considerable importance (VicRoads 1995a, 1995b). Leadbeater's Possum is a nationally endangered species. As such it was imperative that the identity of the hair be certain. To our knowledge, this is the first time that molecular genetics has been applied in this way – used as an adjunct to morphometric hair analysis to verify an equivocal result. It is one of very few examples of the use of molecular genetics in an Environmental Effects Study in Australia. We are aware of only one other example. Sydney Water (1996) used molecular genetics to identify a frog species (genus *Crinia*) in a Species Impact Statement at Kurnell, NSW.

The nearest extant occurrence of Leadbeater's Possum to the Macedon region lies over 85 km to the east in the Toolangi region (NRE 2001). The identification of a previously unknown population, so far from the documented range of this nationally endangered species, is of considerable importance for the species' conservation. A further targeted survey of the local area was urgently required, and was also carried out as part of the Environmental Effects Study (VicRoads 1995b). The results of the targeted survey will be reported in a subsequent article (Larwill in prep.).

The variation of the morphometric attributes of the hair sample from those of reference collections suggests the source population may be genetically distinct from known populations of Leadbeater's Possum. Although 12s rRNA sequences were adequate to identify Leadbeater's Possum sequences from hair samples, we note that analysis of other gene loci such as the more variable mitochondrial control region (CR) might be helpful in determining the genetic relationships between any Macedon-Woodend animals to other populations of this species. This is of importance given the geographic distance from previously reported populations as well as the hair differences noted above which suggest that a viable Macedon-Woodend population may be genetically distinct. Thus further molecular genetic research is recommended if a local population is found.

The use of molecular genetics as a supplement to morphometric analysis of hair has implications for future use of hair and scat analysis as a mammal survey tool, and provides new opportunities for use of molecular genetics in inventory-level fauna surveys. As a survey tool, morphometric analysis of hair is limited by the difficulty in distinguishing between closely related taxa, and the difficulty of identifying poor quality or small hair samples definitively. In the present study, the unknown hair sample varied sufficiently from reference collections to cause some doubt over the identification.

Lobert *et al.* (2001) examined the reliability of identifications from morphometric hair analysis of mammals from temperate regions of Victoria. They allocated 37 mammal species into three reliability categories for hair analysis. Leadbeater's Possum is one of 14 species in the 'unreliable' category, for which Lobert *et al.* (2001) recommend caution in interpretation of results if derived from morphometric analysis alone. The results of this study illustrate the use of molecular genetics to unambiguously identify samples when morphometric analysis produces equivocal results.

Although the molecular genetic techniques for hair analysis are more expensive than morphometric analysis in terms of time and resources, the costs are relatively modest. Therefore, wider use of molecular analysis as an adjunct to standard mammal survey techniques is possible. Certainly use of molecular genetics as a verification tool when morphometric analyses yield equivocal results for records of notable species, such as in the present case, is highly recommended. Hair collection and scat analysis remain important sampling techniques as standard practice in inventory survey, and particularly when a survey is targeted to rare or trap-shy species.

As a notable contrast to the present study, Brunner *et al.* (1976) identified Leadbeater's

Possum by morphometric analysis of hair contained in a predator scat collected from sclerophyll forests approximately 150 km north-east of the species' known range. Although the record was less than 30 km from Mt Wills where the species was recorded in 1909 (Brazenor 1932), the status of the record remains unconfirmed despite the potentially significant implications it has for the conservation of this endangered species. In such cases, molecular genetic analysis can be used to verify the results, and provide a catalyst for further surveys.

The ability to isolate DNA from hair provides an opportunity to use hair collection techniques, such as the use of hair tubes (Winnett and Degabriele 1982; Scotts and Craig 1988), in population genetics. This increases the feasibility of population genetics research into rare and trap-shy species. Through such techniques we can gain a further understanding of population genetics, and incorporate this knowledge into management strategies for conservation of threatened species (e.g. Taylor *et al.* 1998). Hair collection techniques have additional advantages, requiring fewer resources in costs and personnel, and being less intrusive for the subject animals than traditional techniques for the collection of genetic material such as trapping and collection of blood samples.

A substantial sequence database for cytochrome b and 12s rRNA genes as well as some nuclear genes is now available for many Australian marsupials in Genbank (e.g. Krajewski *et al.* 1994, 1996; Retief *et al.* 1995; Springer *et al.* 1994, 1997; Burk and Springer 2000). More species are being added and this inventory will be of immense use for future analyses. In the present study, reference DNA sequence material was available due to past research on evolutionary genetics of possums which included Leadbeater's Possum (Springer *et al.* 1994). If the full potential of the application of molecular genetics in applied conservation biology is to be realised, it is important that the development of a complete and centralised library of DNA sequences for Australian mammals be continued.

Acknowledgements

The authors would like to thank the following contributors: The hair sample was collected during fauna survey work conducted by Biosis Research Pty Ltd on behalf of, and funded by, VicRoads as part of investigations for the Environmental Effects Statement Calder Highway-Black Forest Section (Planning Investigations Department, VicRoads, Victoria). Neil Murray (Department of Genetics, LaTrobe University, Bundoora, Victoria) provided laboratory facilities and advice on molecular analysis. Yvonne La Rose (Department of Genetics and Human Variation, LaTrobe University) conducted sequencing reactions. Barbara Triggs (address: 'Dead Finish' Genoa, 3891) conducted the initial morphometric analysis of the hair sample and provided advice on interpretation of the results. Hans Brunner (Deakin University, School of Ecology and Environment, 221 Burwood Highway, Burwood 3125) provided a second opinion on hair identification. Judith Tomlin made the original suggestion to use molecular genetic techniques to verify the morphometric diagnosis of the unknown hair sample. Justine Wallace (4 Story Creations) photographed the hair sample for Fig. 1. Sally McCormick (Biosis Research Pty Ltd) prepared Fig. 2. Jeff Yugovic (Biosis Research Pty Ltd), Melinda Collinson (VicRoads) and Andrea Taylor (Department of Biological Sciences, Monash University) provided comments on an earlier draft of the manuscript.

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One Hundred Years Ago

ON THE SO-CALLED PETRIFIED MUSHROOM

BY D. M'ALPINE

(*Read before the Field Naturalists' Club of Victoria, 20th April*, 1903.)

In January of this year I received from Mr. M. B. Gray, of Hamilton, a specimen supposed to be a petrified mushroom, and on that account was asked to report upon it. It certainly somewhat resembled a hardened mushroom, consisting of a stalk and an expanded cap-like portion; but appearances are often very deceptive, and in this case it proved to be so.

The specimen … is of a brownish-black colour, and the cap-like portion is roughly round, measuring 4 in. in diameter, convex and broken up into numerous blunt tooth-like parts, somewhat resembling the overlapping scales of a pine cone…

I had already examined the woody portion under the microscope, and found it to consist, not of fungus filaments, but of cellular tissue. Hence the specimen could not possibly be a fungus. A small portion treated with sulphuric acid gave the well-known cellulose reaction. This proved that the substance had neither become petrified nor fossilized, but was perfectly normal. The specimen turned out to be interesting—not, however, as a petrified mushroom, but as one of those peculiar excrescences found on various trees, and known as "burrs," "gnaurs," "wens," or "extosis."

From *The Victorian Naturalist* **XX**, p 15, May 7, 1903

Clyde-Tooradin Grassland Re-discovered

Damien Cook[1] and Jeff Yugovic[2]

Abstract
Remnants of a formerly extensive, seasonally wet grassland in West Gippsland have been located and are discussed in this paper. The grassland represents an endangered ecosystem that previously occurred on the margins of swamps in the region. It may have been maintained by Aboriginal burning in the past. (*The Victorian Naturalist* **120** (4), 140-146)

Introduction

Lowland grasslands were settled and developed for agriculture early in the European history of south-eastern Australia. In many cases, ecologists, naturalists and historians are aware of these original grasslands (McDougall and Kirkpatrick 1993). However, in some highly developed regions, traces of the original ecosystems have all but disappeared. Here we report the discovery of remnants of a previously large grassland in West Gippsland and suggest that it may have been maintained by Aboriginal burning in the past.

Damien Cook encountered treeless remnant native vegetation on the rail reserve between Clyde and Tooradin in 1994 during a visit to a colony of Maroon Leek-orchid *Prasophyllum frenchii* discovered by field naturalist John Eichler. Subsequent searching for early land survey maps held by the State Government revealed the existence of a map showing the accurate location of a previously large and long-forgotten grassland on the Kooweerup Plain.

Current flora data

The Flora Information System of the Department of Sustainability and Environment (DSE) contains floristic data collected from the grassland by Damien Cook, comprising four quadrat records collected in 1994 and 1998 from the disused South Gippsland rail line (Appendix 1). The vegetation is a seasonally wet grassland, dominated by Common Tussock-grass *Poa labillardierei*, with several species tolerant of wet conditions such as Fine Twig-sedge *Baumea arthrophylla* and Swamp Billy-buttons *Craspedia paludicola*.

Although Kangaroo Grass *Themeda triandra* is common, the vegetation is not typical dry grassland as found elsewhere in southern Victoria (McDougall and Kirkpatrick 1993). Nor is it wetland vegetation as it lacks many wetland species and includes many species of drier habitats such as Chocolate Lily *Arthropodium strictum*, Milkmaids *Burchardia umbellata*, Spiny-headed Mat-rush *Lomandra longifolia* and Australian Buttercup *Ranunculus lappaceus*. The grassland is representative of the community listed under the Victorian *Flora and Fauna Guarantee Act 1988* as Plains Grassland (South Gippsland) (SAC 1994).

The recorded flora of the remnant grassland has 64 indigenous and 24 introduced species (Appendix 1). This includes two species of national significance (Matted Flax-lily *Dianella amoena*, Maroon Leek-orchid *Prasophyllum frenchii*) and three species of state significance (Swamp Billy-buttons *Craspedia paludicola*, Pale Swamp Everlasting *Helichrysum* aff. *rutidolepis*, Purple Blown-grass *Lachnagrostis punicea* subsp. *filifolia*). Several species of high regional significance are recorded, including Blue Grass-lily *Caesia calliantha*, Yam Daisy *Microseris* sp. and Smooth Rice-flower *Pimelea glauca*. Little is known of the fauna, which includes Copperhead snakes and bandicoots (B Freeman, local resident, pers. comm.). Apart from remnants in sections of the rail line, the grassland appears to have been converted to introduced pasture.

The composition of remnant vegetation on the rail line gives us an impression of what this grassland might have looked like: an open grassy plain stretching into the distance, mainly composed of blue-green Common Tussock-grass and purplish Kangaroo Grass. In spring this plain

[1] Wetland Ecosystems, PO Box 424, Patterson Lakes, Victoria 3197
[2] Biosis Research, PO Box 489, Port Melbourne, Victoria 3207

would have been studded with bright yellow Buttercups, shimmering purple and pink patches of Chocolate and Vanilla-lilies and clusters of pure white Smooth Rice-flowers.

Historical records

Explorer William Hovell was the first European to see the Clyde-Tooradin plain, describing it in January 1827 as an

> 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 (Hovell 1827).

On his next expedition the following month, Hovell referred to it as the 'Dumaresq Plains', although this name was evidently not adopted. The early (1844) grazing run centred on the plain was named 'Big Plains' (Gunson and Key 1968), presumably due to the open terrain.

Early surveyors recorded information on the 'economic topography' of the land, including water sources, tree cover and grass cover. This information has often proved extremely useful in uncovering vegetation patterns that have since been destroyed by European land use (e.g. Fensham 1989; Lunt 1997). In the mid-1800s, WS Urquhart (1847) surveyed the route between Dandenong and Tooradin via Cardinia Creek. Urquhart mapped in detail the boundary of Hovell's plain on the west side of the extensive 'Great Swamp'. His annotation was 'open grassy plain', signifying a lack of woody cover. The plain was approximately 5 km by 2-3 km and occupied approximately 1290 ha. It had arms extending beyond Urquhart's survey. The plain straddled the boundary of the present-day Clyde and Tooradin districts, and also extended into Cardinia and Devon Meadows (Fig. 1).

Urquhart (1847) mapped an extensive wetland at Hallam as 'open marshy plain inundated during winter'. Since this is on the same survey plan as the 'open grassy plain' at Clyde-Tooradin it serves to distinguish the Clyde-Tooradin Grassland from wetland vegetation.

However, wetland may have occupied part of the open plain since a small wetland dominated by Fine Twig-sedge *Baumea arthrophylla* and supporting Swamp Everlasting *Xerochrysum palustre* occurs at the intersection of Manks Road and the rail line. The evidence is equivocal since this site is an excavation approximately one metre below the level of the plain. However, another early survey plan describes the plain as 'Marshy Plain black alluvial soil' and 'marsh land displaying rich black soil, but very wet in winter' (Callanan 1858). Unlike the remnant grassland, no wetland appears to remain on the natural surface of the plain, and we may never know the original extent of grassland and wetland.

The grassland crossed the present-day South Gippsland Highway at Lynes Road, and was evidently connected to treeless, salt-influenced vegetation in the Rutherford Creek estuary, including *Poa poiformis* grassland, *Juncus kraussii* brackish wetland and coastal salt marsh.

Discussion

The existence of this large grassland adjacent to a vast swamp is intriguing. The Kooweerup Plain contained at least three distinct swamp complexes: the Kooweerup or Great Swamp, the Dalmore Swamp to the west, and the Tobin Yallock Swamp to the south (Rosengren 1984). The Clyde-Tooradin Grassland is, or was, on the western edge of the former Dalmore Swamp. It occurs on black Dalmore Clay (Recent swamp deposits), the same substrate as the Dalmore Swamp itself. Before it was drained and cleared, the Dalmore Swamp was known for its dense Swamp Paperbark *Melaleuca ericifolia* scrub, being almost impassable (Goudie 1942).

The deeper Kooweerup Swamp, on anaerobic fibrous peat, lacked woody cover except on its fringes and internal sand ridges, and was dominated by reeds and rushes. It evidently included a series of lake-like cells separated by dense vegetation that acted as slowly permeable barriers to the flow of surface water. This was the largest swamp in Victoria, but it was a massive peat bog rather than a typical swamp since it had an average surface slope of

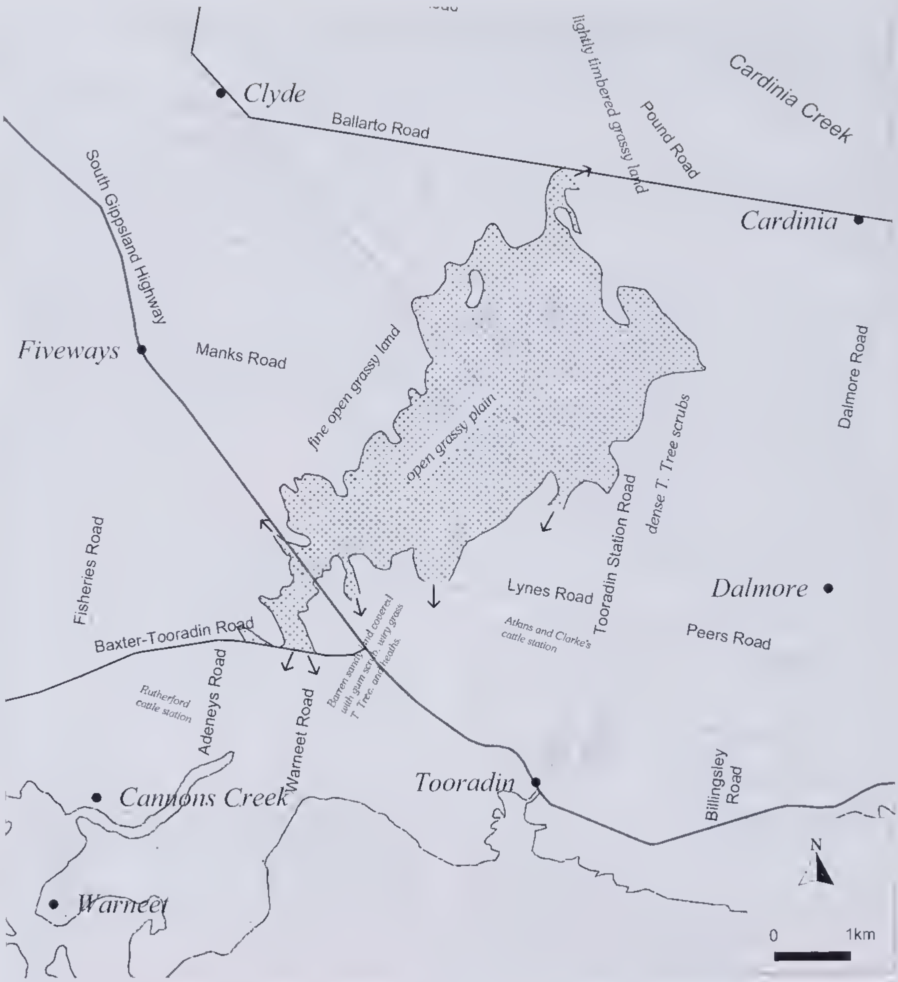

Fig. 1. Extent of the Clyde-Tooradin Grassland in 1847 (adapted from Urquhart 1847). Arrows indicate extensions or 'arms' of the grassland.

1.3 m per km and thus could not have held one continuous standing body of water. Fed mainly by the Bunyip River, it had risen 1.8 to 3.0 m as it had grown, and being resistant to erosion, had acted as a local base level for streams (Hills 1942, 1975).

The Clyde-Tooradin Grassland may have occupied an ancient lake floor, as suggested by an arcuate ridge of Cranbourne Sand on the southern margin (Rosengren 1984). The Kooweerup Swamp complex was evidently larger in the geological past until the western section lost part of its water supply due to geomorphologic change in its catchment. It then dried out to the extent that the Dalmore Clay was deposited, partly over Kooweerup Swamp peat. Swamp Paperbark then colonised, resulting in the formation of the Dalmore Swamp (Hills 1942).

From Urquhart's map and annotations, we can determine what vegetation types bounded the Clyde-Tooradin Grassland. On the east it was bounded by swamp scrub (Dalmore Swamp, then considered part of the unexplored Great Swamp), on the south by heathy woodland on Pleistocene sand dunes (Cranbourne Sand), and on the north and west by grassy woodland on Tertiary sediments. The grassy woodland was 'fine open grassy land' (which does not preclude an open woodland structure) and 'lightly timbered grassy land'. Where tree cover on the Tertiary sediments was low, the community would have been a dry grassland dominated by Kangaroo Grass. This dry grassland is another FFG-listed community, Central Gippsland Plains Grassland (SAC 1992). The two distinctive grassy ecosystems currently occur side by side on the rail reserve, with the transition at the change of geological substrate at the break of slope onto the plain. Plains Grassland (South Gippsland) occurs on the southern, Tooradin side.

There are two possible explanations for the presence of treeless grassland on the western edge of the Kooweerup Plain. The presence of grassland may have been due to soil or drainage factors, such as deep cracking clays that may have impeded *Melaleuca* growth. However, the available soil mapping (Sargeant *et al.* 1997) does not indicate a change of soil type between the 'open grassy plain' and the adjacent 'dense' *Melaleuca* scrub mapped by Urquhart (1847). Furthermore, *Melaleuca* is colonising the rail and road reserves on the plain today, although post-settlement drainage changes may have affected the distribution of *Melaleuca.*

An alternative explanation is that the grassland may have been anthropogenic in origin, the result of Koories burning back the edge of the Dalmore Swamp, which would have been effectively impenetrable and a major barrier to movement. All the early European explorers of Western Port noted that large areas of land were burnt, and many of the grassy areas observed by early Europeans may have been created by Aboriginal burning (Gaughwin 1981). Coastal areas of Western Port were Bun wurrung territory (Clark 1990).

Regular burning on the edges of the swamps may have kept access open and promoted a range of animals suitable for hunting and increased the abundance of food plants such as Murnong (Yam Daisy) and lilies with edible tubers. The 1847 open grassy plains had arms extending towards Tooradin associated with Recent swamp deposits (Fig. 1). These may also have been maintained by Aboriginal burning.

Swamp Paperbark can regenerate after fire from resprouts and seedlings although it may be greatly reduced in cover. Any reduction in *Melaleuca* is likely to have been a long-term response to repeated fire, possibly interacting with other physical and biotic factors. Callanan's 1858 survey map shows an area of 'Short Tea Tree scrub' (*Melaleuca*) within the Clyde-Tooradin Plain; this may have been *Melaleuca* responding to an absence of fire.

The role of Aboriginal burning in Australian ecosystems has been subject to much debate (Kershaw *et al.* 2002). While some consider Aboriginal burning to have been responsible for open structural forms in much Australian vegetation (Flannery 1994; Kohen 1995) others argue that the influence of Aboriginal burning on vegetation was minimal (Benson and Redpath 1997; Horton 2001). We hypothesize that Aboriginal burning is the most likely explanation for the presence of this grassland although no direct evidence is available.

While extensive grasslands such as those of western Victoria appear to have resulted from a combination of soil and regional climatic factors, smaller isolated grasslands may have been maintained by Aboriginal burning (Lunt and Morgan 2002). Similarly, post-settlement increases in tree densities in what was previously open grassy woodland on the Bellarine Peninsula have been attributed to the absence of regular burning by Aborigines (Lunt 1998).

Threats and management

The rail line remnants are experiencing a number of threats. Swamp Paperbark is colonising some sections. The rail line will be re-opened soon with the potential for associated disturbance. There is no signage or fencing. The grassland is in need of active management, as it is being invaded by weeds including Canary-grass *Phalaris aquatica* and is likely to require an ecologically suitable fire or slashing regime. A management burn was conducted in the 1990s with beneficial effects on Maroon Leek-orchid (D Cook, pers. obs.).

Management of the *Poa* grassland at Clyde-Tooradin poses a number of challenges. Little is known of the ecology of *Poa* grasslands except that the dominant *Poa* tussocks do not seem to require biomass reduction to maintain vigour, unlike *Themeda* (Lunt and Morgan 2002). However, *Poa* biomass reduction via an ecologically suitable fire, mowing or grazing regime is likely to be necessary to maintain inter-tussock space and associated plant species diversity.

Further research

Further research is needed to determine the prior and present extent of wet grasslands on the margins of creeks and swamps on the Kooweerup Plain and elsewhere in southern Victoria. Carbon and pollen studies in local swamp deposits may indicate prior burning patterns. Grassland appears to have occurred extensively in association with Tobin Yallock Swamp; an early survey map is reproduced in Key (1967). Large grassy areas beside Yallock Creek were described in glowing terms by Hovell (1827). Urquhart's (1847) map shows another 'open grassy plain', smaller than the Clyde-Tooradin Grassland, on the south side of Cardinia Creek just before it reached the Great Swamp. There are also indications that similar grassland vegetation occurs in association with remnants of the Carrum Swamp at Seaford and beside Brokil Creek at Safety Beach on the Mornington Peninsula.

Conclusion

This study shows how careful interpretation of small remnants, in combination with examination of early archival records, can greatly expand our knowledge of highly fragmented vegetation types such as native grasslands in many regions. It also demonstrates that existing roadside vegetation may be misleading with regard to pre-European vegetation patterns. Similar studies may provide useful insights in other heavily cleared regions.

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Appendix 1. Flora of the Clyde-Tooradin Grassland

Source: DSE Flora Information System (quadrats N26373, N26374, N26376, N26377). Collector D Cook 1994, 1998; [1] Denotes additional observation record. Status (DSE Flora Information System 2002 Version): E, endangered in Australia; V, vulnerable in Australia; e, endangered in Victoria; v, vulnerable in Victoria; r, rare in Victoria; * introduced species.

ANGIOSPERMS		
MONOCOTYLEDONS		
ANTHERICACEAE		
	Arthropodium milleflorum s.l.	Pale Vanilla-lily
	A. strictum s.l.	Chocolate Lily
ASPARAGACEAE		
	**Asparagus officinalis*	Asparagus
COLCHICACEAE		
	Burchardia umbellata	Milkmaids
	Wurmbea dioica	Common Early Nancy
CYPERACEAE		
	Baumea arthrophylla	Fine Twig-sedge
	Carex breviculmis	Common Grass-sedge
	Carex brownii	Stream Sedge
	Carex inversa	Knob Sedge
	Isolepis fluitans	Floating Club-sedge
	Schoenus apogon	Common Bog-sedge
	Schoenus tesquorum	Soft Bog-sedge
HYPOXIDACEAE		
	Hypoxis hygrometrica	Golden Weather-glass
IRIDACEAE		
	**Romulea rosea*	Onion Grass
	**Watsonia meriana*	Bulbil Watsonia
JUNCACEAE		
	Juncus amabilis	Hollow Rush
	Juncus holoschoenus	Joint-leaf Rush
	Juncus pallidus	Pale Rush
	Luzula meridionalis	Common Woodrush
JUNCAGINACEAE		
	Triglochin striatum	Streaked Arrowgrass
ORCHIDACEAE		
	Microtis unifolia	Common Onion-orchid
Ee	*Prasophyllum frenchii*	Maroon Leek-orchid
	Thelymitra pauciflora s.l.	Slender Sun-orchid
PHORMIACEAE		
	Caesia calliantha	Blue Grass-lily
Ee	*Dianella amoena*	Matted Flax-lily
	Dianella revoluta s.l.	Black-anther Flax-lily
	Tricoryne elatior	Yellow Rush-lily
POACEAE		
	Amphibromus archeri	Pointed Swamp Wallaby-grass
	**Anthoxanthum odoratum*	Sweet Vernal-grass
	Austrodanthonia laevis	Smooth Wallaby-grass
	**Briza maxima*	Large Quaking-grass
	**Briza minor*	Lesser Quaking-grass
	**Dactylis glomerata*	Cocksfoot
	Deyeuxia quadriseta	Reed Bent-grass
	Dichelachne crinita	Long-hair Plume-grass
	Elymus scaber	Common Wheat-grass
	Hemarthria uncinata	Mat Grass
	**Holcus lanatus*	Yorkshire Fog
	Imperata cylindrica	Blady Grass
	Lachnagrostis aemula	Leafy Blown-grass
r	*Lachnagrostis punicea* subsp. *filifolia*	Purple Blown-grass
	Notodanthonia semiannularis	Wetland Wallaby-grass
	Pentapogon quadrifidus	Five-awned Spear-grass
	**Phalaris aquatica*	Toowoomba Canary-grass
	Phragmites australis	Common Reed

Appendix 1 cont.

	Poa labillardieri	Common Tussock-grass
	Poa morrisii	Soft Tussock-grass
	Poa rodwayi	Velvet Tussock-grass
	Poa tenera	Slender Tussock-grass
	Themeda triandra	Kangaroo Grass
XANTHORRHOEACEAE		
	Lomandra longifolia	Spiny-headed Mat-rush
DICOTYLEDONS		
APIACEAE		
	Centella cordifolia	Centella
	**Daucus carota*	Carrot
	Eryngium vesiculosum	Prickfoot
ASTERACEAE		
	**Cirsium vulgare*	Spear Thistle
v	*Craspedia paludicola*	Swamp Billy-buttons
v	*Helichrysum* aff. *rutidolepis*	Pale Swamp Everlasting
	**Hypochoeris radicata*	Cat's Ear
	**Leontodon taraxacoides*	Hairy Hawkbit
	Microseris sp.	Yam Daisy
	Senecio squarrosus	Leafy Fireweed
	**Sonchus oleraceus*	Common Sow-thistle
	**Taraxacum officinale* spp. agg.	Garden Dandelion
CAMPANULACEAE		
	Wahlenbergia multicaulis s.l.	Many-stemmed Bluebell
CONVOLVULACEAE		
	Dichondra repens	Kidney-weed
DROSERACEAE		
	Drosera peltata subsp. *peltata*	Pale Sundew
FABACEAE		
	Dillwynia cinerascens	Grey Parrot-pea
	**Lotus angustissimus*	Slender Bird's-foot Trefoil
	**Lotus corniculatus*	Bird's-foot Trefoil
	**Medicago polymorpha*	Burr Medic
	**Vicia sativa*	Common Vetch
	**Vicia tetrasperma*	Slender Vetch
GENTIANACEAE		
	**Centaurium erythraea*	Common Centaury
GERANIACEAE		
	Geranium retrorsum s.l.	Grassland Cranesbill
GOODENIACEAE		
	Goodenia elongata	Lanky Goodenia
HALORAGACEAE		
	Haloragis heterophylla	Varied Raspwort
LAMIACEAE		
	**Prunella vulgaris*	Self-heal
MENYANTHACEAE		
	Villarsia reniformis	Running Marsh-flower
MIMOSACEAE		
	Acacia melanoxylon	Blackwood
OXALIDACEAE		
	Oxalis perennans	Grassland Wood-sorrel
PLANTAGINACEAE		
	Plantago gaudichaudii[1]	Narrow Plantain
	**Plantago lanceolata*	Ribwort
RANUNCULACEAE		
	Ranunculus lappaceus	Australian Buttercup
ROSACEAE		
	Acaena agnipila	Hairy Sheep's Burr
	**Rubus fruticosus* spp. agg.	Blackberry
RUBIACEAE		
	Asperula conferta	Common Woodruff
SCROPHULARIACEAE		
	Veronica gracilis	Slender Speedwell
THYMELAEACEAE		
	Pimelea glauca	Smooth Rice-flower

A Reptile and Amphibian Survey of the Wonthaggi Heathland and Coastal Reserve

Peter Homan[1]

Abstract

A survey of the reptiles and amphibians at the Wonthaggi Heathland and Coastal Reserve was carried out between February 2001 and February 2002. Eight species of reptiles and six species of amphibians were identified, resulting in new locality records for the threatened skinks, the Swamp Skink *Egernia coventryi* and the Glossy Grass Skink *Pseudemoia rawlinsoni*. One of the study sites within the reserve was subjected to a control-burn twelve months prior to this survey and post-fire colonisation of this site is discussed. (*The Victorian Naturalist* **120** (4), 2003, 147-152)

Introduction

The township of Wonthaggi is situated in South Gippsland, approximately 104 km south-east of Melbourne, Victoria. The Wonthaggi Heathland and Coastal Reserve covers an area of 811 hectares to the southwest of the township. This reserve stretches for 10 km along the coast from Harmers Haven in the south-east to the mouth of the Powlett River in the north-west.

The survey was carried out over a thirteen month period from February 2001 to February 2002 and was commissioned by Parks Victoria. The purpose of the survey was to determine which species of reptiles and amphibians inhabited the reserve and to provide data on the effects of control burning within the reserve.

The survey was restricted to the south-east section of the reserve in the vicinity of the public track to the Cutler's Beach camp site (Fig. 1) and is bounded by 38°38'00" N, 38°38'40" S, and 145°32'30" W, 145°35'10" E. This section of the reserve is approximately 20 m above sea level (Fig. 2).

Vegetation

The south-east section of the reserve contains four distinct vegetation communities:

Coastal Heathland contains a diverse range of species, including Scrub Sheoak *Allocasuarina paludosa*, Scented Paperbark *Melaleuca squarrosa*, Common Heath *Epacris impressa*, Pink Swamp-heath *Sprengelia incarnata*, Prickly Tea-tree *Leptospermum continentale*, Myrtle Wattle *Acacia myrtifolia*, Prickly Moses *Acacia verticillata*, Coast Tea-tree *Leptospermum laevigatum*, Common Flat-pea *Platylobium obtusangulum*, Austral Grass Tree *Xanthorrhoea australis*, Silver Banksia *Banksia marginata*, Yellow Hakea *Hakea nodosa* and Horny Cone-bush *Isopogon ceratophyllus*.

Tertiary Sand-dune contains Coast Tea-tree *L. laevigatum*, Coast Banksia *Banksia integrifolia*, Coast Beard-heath *Leucopogon parviflorus*, Coast Wattle *Acacia sophorae* and Coast Daisy-bush *Olearia axillaris*.

Coastal Woodland contains Coastal Manna Gum *Eucalyptus pryoriana*, Silver Banksia *B. marginata*, Prickly Tea-tree *L. continentale*, Scented Paperbark *M. squarrosa*, Kangaroo Apple *Solanum aviculare*, Spiny-headed Mat-lily *Lomandra longifolia* and Austral Bracken *Pteridium esculentum*.

***Poa/Gahnia* Sedgeland** contains Coast Saw-sedge *Gahnia trifida*, Coast Tussock Grass *Poa poiformis*, Swamp Paperbark *Melaleuca ericifolia* and Coast Wattle *A. sophorae*.

Methods

Several techniques were used to survey the reptiles and amphibians of the reserve, with pitfall trapping being the principal method. Six pitfall lines were established, three in February 2001 (line 1, in an area covering 4.5 ha of coastal heath subjected to control-burn in March 2000; line 2, in an area of old heath to 2 m that has not been burnt for 25 years; line 3, in short heath to 0.5 m that has not been burnt for 20 years), two in March 2001 (line 4, in low-lying area of *Poa/Gahnia* vegetation to 1.5 m; line 5, in tertiary sand-dune), and one in April 2001 (line 6, near a wet gully in coastal woodland). Each line consisted of ten 20 litre plastic buckets, spaced 5 m

[1] 409 Cardigan Street, Carlton, Victoria 3053

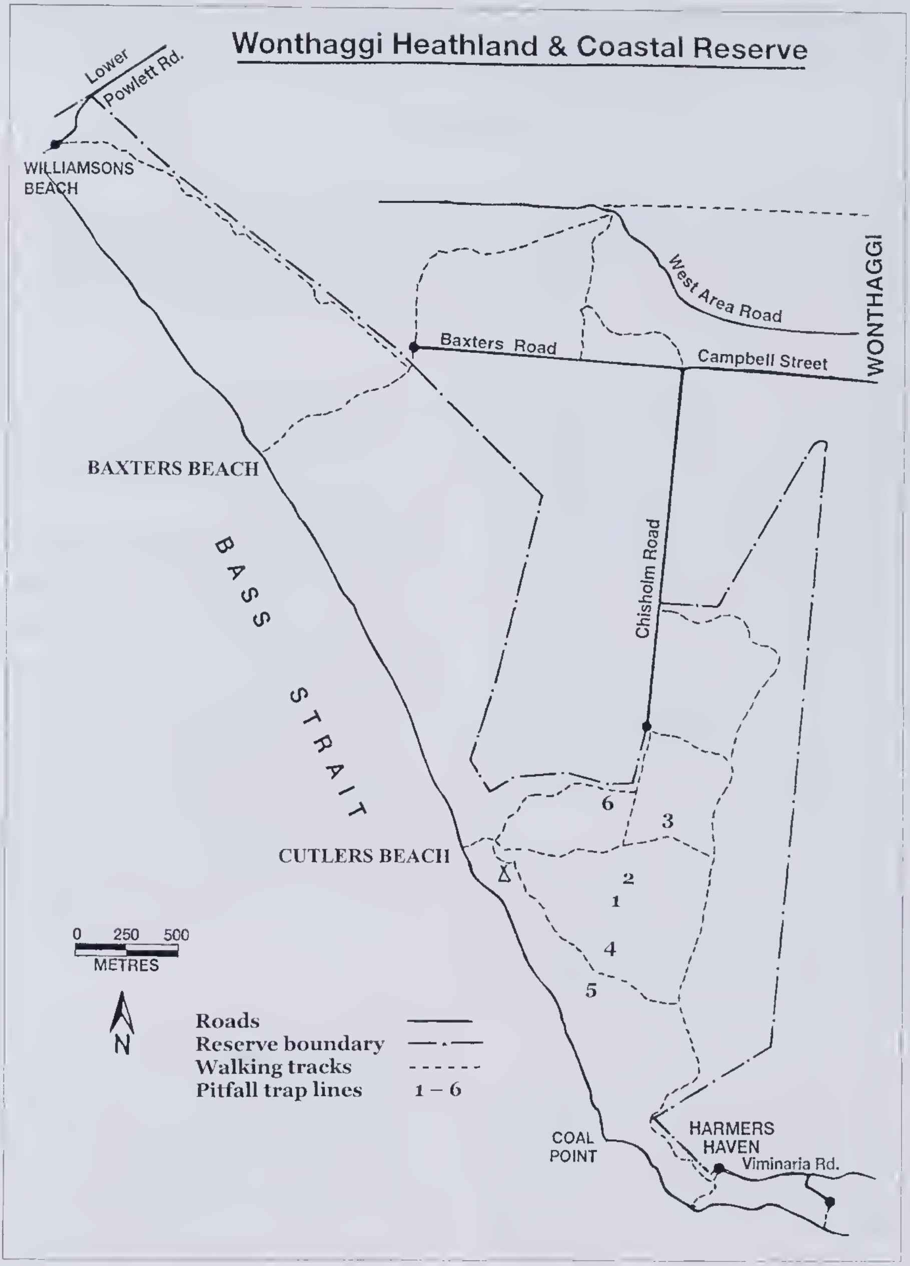

Fig. 1. Map of Wonthaggi Heathland and Coastal Reserve.

apart, with a 30 cm high aluminium fly-wire drift fence extended along each line and over each bucket for a distance of 60 m. The traps were closed between visits.

A tin survey was undertaken in the tertiary sand dune adjacent to pitfall line 5, between October 2001 and February 2002. Eight pieces of galvanised iron, measuring 40 ˘ 50 cm, were positioned flat on the ground approximately 20 m apart in a line

Table 1. Dates of each visit and number of pitfall trap nights completed for each trapping site.

Dates reserve visited	Pitfall 1	Pitfall 2	Pitfall 3	Pitfall 4	Pitfall 5	Pitfall 6	Total
12-16/2/01	40	30	30				100
19-23/3/01	30	30		40	30		130
30/4-4/5/01		30		40	40	25	135
8-12/10/01	30	30	40			40	140
28/11-2/12/01			40	40	30	40	150
18-21/2/02	30	30		30			90
Total	**130**	**150**	**110**	**150**	**100**	**105**	**745**

Fig. 2. Wonthaggi Heathlands, October 2001.

over 140 m and one other piece of galvanised iron measuring approximately 70 ˘ 80 cm was placed in *Poa* tussocks near the Cutler's Beach campsite in March 2001. Each piece of galvanised iron was turned over and checked on each subsequent visit.

Triangulation was used at night to search for calling male frogs. This method involves two observers each pointing a torch beam from different positions in the direction of a calling frog. The point where the two torch beams cross indicates the position of the frog. General observations were recorded during each visit to the reserve.

The reserve was visited on six occasions, for five consecutive days on each occasion, and 745 pitfall trap nights were completed. Triangulation was carried out during May, October and December 2001 and February 2002 for a total of 10 hr.

Table 1 shows the dates of each visit and the number of pitfall trap nights completed for each pitfall site.

Results

Prior to this survey, records for only two species of terrestrial reptiles, White's Skink and the Garden Skink, were available for this reserve (Atlas of Victorian Wildlife). The only other reptile records are of a beachwashed specimen of the Leathery Turtle *Dermochelys coriacea* from 1989 and an unidentified grass skink from 1977 (Atlas of Victorian Wildlife).

This survey recorded the two previously known skinks, plus a further four species, including the vulnerable Swamp Skink *Egernia coventryi* (Fig. 3) and the Glossy Grass Skink *Pseudemoia rawlinsoni*, which is categorised as lower risk, near threatened (Table 2).

Two species of elapid or venomous snake were also recorded during the survey. The Metallic Skink *Niveoscincus metallicus* and the Blotched Blue-tongued Lizard *Tiliqua nigrolutea*, which are both common species in the local district and the nearby Bunurong Coastal Park (Homan unpubl. data), were not recorded in this reserve during this survey. However, photographic evidence supplied by Mr Geoff Glare of Cape Paterson of the presence in 1991 of the Blotched Blue-tongued Lizard was obtained during the survey.

The Atlas of Victorian Wildlife does not include any records for members of the Agamidae (Dragon) or Varanidae (Goanna) families in this reserve and no species of these families were seen or captured during the survey.

Records for six species of frogs were available for this reserve before this survey (Atlas of Victorian Wildlife), including the vulnerable Warty Bell Frog *Litoria raniformis.* Five of these species were recorded during the survey and one further species of southern frog, the Southern Toadlet *Pseudophryne semimarmorata* was identified (Table 3). The Warty Bell Frog was not recorded during the survey; however, photographic evidence of the presence of this species in February 1991 was obtained. The photograph (front cover) was taken by Mr Geoff Glare.

Table 2 shows the list of reptile species

Table 2. List of reptiles and total number recorded during survey. [a] indicates new species record for Atlas of Victorian Wildlife.

[a] Lowland Copperhead	*Austrelaps superbus*	1
[a] Eastern Three-lined Skink	*Bassiana duperreyi*	45
[a] White-lipped Snake	*Drysdalia. coronoides*	4
[a] Swamp Skink	*Egernia coventryi*	4
White's Skink	*Egernia whitii*	5
Garden Skink	*Lampropholis guichenoti*	1
[a] Southern Grass Skink	*Pseudemoia entrecasteauxii*	19
[a] Glossy Grass Skink	*Pseudemoia rawlinsoni*	7

Table 3. List of amphibians and total number recorded during survey. [a] indicates new record for Atlas of Victorian Wildlife. E = estimated number.

Common Froglet	*Crinia signifera*	6E
Southern Bullfrog	*Limnodynastes dumerilii*	124
Striped Marsh Frog	*Limnodynastes peronii*	7
Spotted Marsh Frog	*Limnodynastes tasmaniensis*	2
Southern Brown Tree Frog	*Litoria ewingi*	6E
[a] Southern Toadlet	*Pseudophryne semimarmorata*	2

Table 4. Number of specimens of each species recorded for each vegetation community. E = estimated number.

Species		**Burnt Heath**	**Tall Heath**	**Short Heath**	***Poa/ Gahnia***	**Sand-Dune**	**Coastal Woodland**
Austrelaps superbus	Lowland Copperhead	-	1	-	-	-	-
Bassiana duperreyi	Eastern Three-lined Skink	3	7	12	11	5	7
Drysdalia coronoides	White-lipped Snake	-	3	-	1	-	-
Egernia coventryi	Swamp Skink	-	-	-	4	-	-
Egernia whitii	White's Skink	2	3	-	-	-	-
Lampropholis guichenoti	Garden Skink	-	-	-	-	1	-
Pseudemoia entrecasteauxii	Southern Grass Skink	1	17	-	-	-	1
Pseudemoia rawlinsoni	Glossy Grass Skink	-	-	1	6	-	-
Crinia signifera	Common Froglet	-	-	5E	-	-	1
Limnodynastes dumerilii	Southern Bullfrog	71	22	8	8	11	4
Limnodynastes peronii	Striped Marsh Frog	1	1	2	1	-	2
Limnodynastes tasmaniensis	Spotted Marsh Frog	-	-	1	1	-	-
Pseudophryne semimarmorata	Southern Toadlet	-	-	-	-	-	2
Litoria ewingi	Southern Brown Tree Frog	-	-	-	2	-	4E

recorded during the survey. Table 3 shows the list of amphibian species recorded during the survey. Table 4 shows the number of each species recorded for each vegetation community. Species names are those currently recognised by the Atlas of Victorian Wildlife, Department of Natural Resources and Environment, Victoria.

Discussion

The oldest and tallest heath (to 2 m), which has not been burnt for 25 years, and the area of *Poa/Gahnia* vegetation produced the most diverse records of reptiles during the survey, with all species except the Garden Skink being found in at least one of these areas. In particular, the Swamp Skink was found only in the *Poa/Gahnia* vegetation and most Glossy Grass Skinks were recorded in this vegetation community. The Swamp Skink was recorded in March and December 2001 and February 2002 and Glossy Grass Skinks were recorded in May and December 2001 and February 2002. These two species are known to inhabit other low-lying areas in southern Victoria

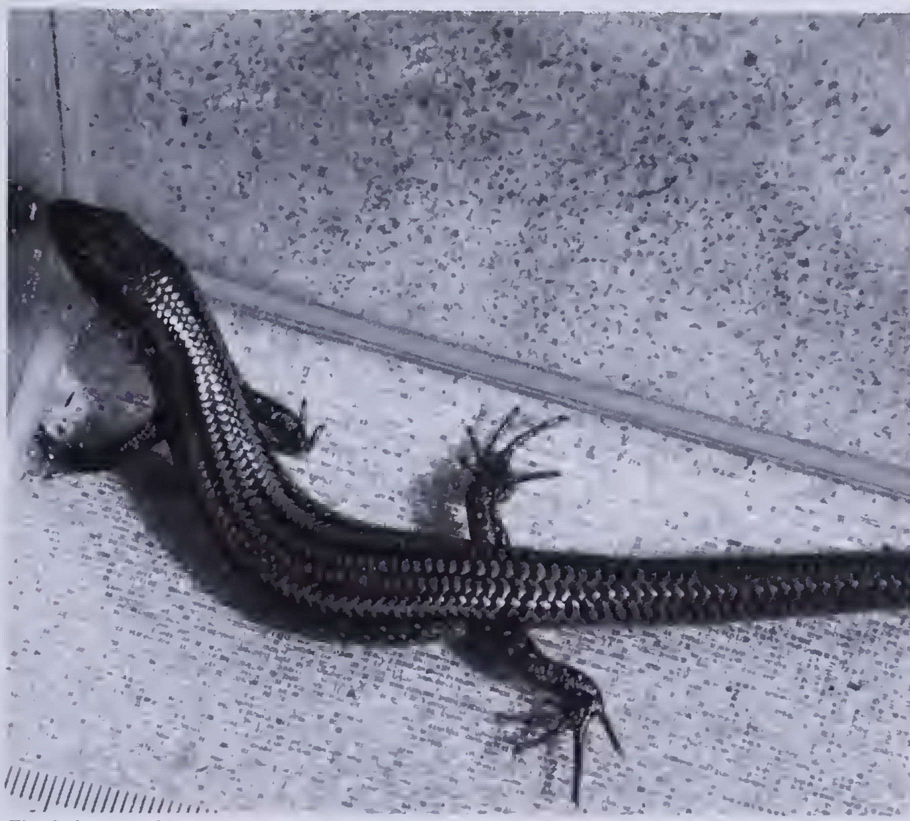

Fig. 3. Swamp Skink *Egernia coventryi* at Wonthaggi Heathland, March 2001.

(Cogger 2000). The tall heath produced the highest number of Southern Grass Skinks, the only record of the Lowland Copperhead and most captures of White's Skink and the White-lipped Snake. One other White-lipped Snake was captured in the *Poa*/*Gahnia* vegetation. The single Lowland Copperhead was seen on a walking track in tall heath at 0645 hr during December 2001. This species is known to be active both day and night and at low temperatures (Cogger 2000).

The most common reptile encountered during the survey was the Eastern Three-lined Skink. This species was recorded during each visit and in each vegetation community, although was not captured in pitfall line 5 (tertiary sand-dune). Despite this, five specimens were found under tin during the tin survey in this sand dune, within 50 m of the pitfall line. These results show that it can be useful to employ a variety of survey methods within the same survey area. The Garden Skink and the Eastern Three-lined Skink were the only species seen basking during the survey and the latter was the only species recorded during the tin survey in the tertiary sand-dune. One Swamp Skink was found under the single piece of tin in *Poa* tussocks near Cutlers Beach in December 2001.

Frogs recorded during the survey were more evenly distributed throughout the study area, although the Southern Bullfrog was the only species found in the tertiary sand-dune. Of the six frog species recorded, four were heard calling at different times during the survey (Littlejohn 1987). Two Southern Toadlets and several Southern Brown Tree Frogs and Common Froglets were heard in the wet gully in coastal woodland in May 2001. Southern Bullfrogs were heard after rain in February 2001 in the burnt area and Common

Froglets were heard calling in short heath in October and December 2001. Southern Brown Tree Frogs were heard in *Poa/Gahnia* vegetation in May 2001. The Warty Bell Frog, photographed in 1991, was found in coastal woodland.

The Southern Bullfrog was the most common amphibian recorded, being found during each visit and in all vegetation communities, although those captured in the tertiary sand-dune were much larger than specimens from the other sites. Fifty-six Southern Bullfrogs were captured in pitfall line 1, in the burnt area, in one night following a thunderstorm in February 2001 less than twelve months after the control-burn. Two other species, the Eastern Three-lined Skink and the Striped Marsh Frog, were also captured in pitfall line 1 during this first trapping session. During the February 2002 trapping session White's Skink and the Southern Grass Skink were captured in the burnt area, so that by the conclusion of the survey, the three skink species that were recorded in the adjacent unburnt tall heath, 100 m to the north-east, were also recorded in this regenerating area.

Control burning in this reserve has been restricted to relatively small areas so as to produce a mosaic of different aged heath. Results of this survey, from the area of oldest heath, show the importance of retaining significant areas of this vegetation. Data collected from the burnt site appears to show that, at this early stage, this method of control burning may have no long-term effect on the reptiles and amphibians found in this reserve.

Acknowledgements

The late Mr Charles Collins of Wonthaggi provided invaluable assistance with information on vegetation communities and siting of pitfall lines. The staff at Parks Victoria, Wonthaggi, especially Dan Drummond, provided extensive advice and assistance. Peter Robertson, Wildlife Profiles Pty Ltd, provided much appreciated assistance with identification of several skinks. The assistance of Maryrose Morgan, Geoff Glare (Friends of Wonthaggi Heathland), Lori Worthy and Terri Allen is much appreciated. The survey was carried out under Research Permit No. 10001200 issued by the Department of Natural Resources and Environment.

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Biodiversity Symposium

Burning Issues – Fire in South Eastern Australia

Venue: University of Melbourne, Architecture Building 133, Prince Phillip Theatre, Swanston Street, Parkville

Time: Sunday September 14, 9:30 am – 4 pm

The aim of the symposium is to facilitate informed discussion and debate on the management of fire in our environment. The symposium will bring together experts and practitioners to discuss the importance of fire.

Speakers include:

David Cheal – Plant Responses to Fire

Gordon Friend – Fire Impacts on Fauna

Mike Leonard – Managing Fire in Victoria's Parks and Forests

Dianne Simmons – On the Edge: How well do bushfire mitigation strategies work on the urban fringe?

Our program of speakers will be followed by an afternoon forum.

For more information contact:

The Field Naturalists Club of Victoria, 9877 9860, fncv@vicnet.net.au

Fires

On 8 January 2003, raincoated against the weather, I was collecting data loggers in the Whites River Valley towards Schlinks Pass. A wild electrical storm moved across from west to east in front of me with multiple lightning strikes going to earth. I sought refuge from the rain in the Landcruiser, the last time I would have to shelter from the rain for another two months. Settling down to watch the spectacle I listened in as the fire towers reported in 'smokes' on the two way radio – sightings of the first small plumes from fires with a bearing. It was a long litany as bearing followed bearing.

In a 30-minute period the storm started an estimated 34 fires across the Snowy Mountains. On the higher ground of the Main Range these were small and easily extinguished. The lightning strikes leading to problem fires were all north and west of the Main Range. Fires moved in various directions under different landscape and wind conditions and with a complexity that was hard to follow. It was clear from the start that this was going to be big; 2002 was one of the five hottest years ever recorded in Australia, the drought was being called a one-in-a-hundred-year event and the last fire of this size had been in 1939 when the fires had burned right to the coast. Just three days after the fires commenced, their importance was recognised. Alec Costin commented to me, 'These fires will set the pattern for the vegetation and associated fauna and ecosystems for the next hundred years.'

Because I was recovering from a broken leg I was placed in the role of 'Field Intelligence' for these fires (I never did find an intelligent field) so was able to roam the mountains getting into areas where we had no firefighters. However, following my medical clearance I was returned to a more restricted role on the fireline, so my knowledge of the fires became more second-hand. As expected, the Main Range acted as a fire break. Most of the western faces were burnt but as the flames came over the main ridge line and hit the alpine herbfields they petered out. In the Mt Carruthers-Twynam area the fire only progressed 30-50 m into the grassed area. Most of this grassland was only flammable because it consisted of drought-affected introduced species used in the revegetation of the 1960s. At the same time (on two of the worst days of the fire) a spotover burned on the south western side of Blue Lake. When I arrived at the location it had burned only 10-15 ha and the active edge ('crowning' through the snowgrass with a 10 cm flame height) was easily extinguished. There were a number of other spotovers – some burning areas as small as a carpet or rug. There was a slightly larger one near the walkway between Thredbo and the summit of Mt Kosciuszko. Snowgrass wasn't particularly flammable and snow daisies and pineapple grass almost achieved fire retardant status! These fires burned very little and a tourist at the lookout at Charlottes Pass would see an alpine area of wildflowers and probably wouldn't even notice (or at least recognise) the few visible burnt areas. However, some other alpine areas burned; fires spread up from Guthega Creek onto the Rolling Grounds and onto the Kerries. On these two alpine areas the fire, patchy as elsewhere, burned about 40-50% of the ground cover, mainly the heaths.

Even plant specimens were threatened. A spotover across the Snowy River burned downstream towards the Park's accommodation and workshops at Waste Point which contains the Kosciusko herbarium with material dating back to the 1940s. We evacuated the residents to the lakeside and had to contend with three spotovers among the cottages. It was amazing how quickly the fire spread in this area, which has fuel

reduction burns every couple of years. Luckily the herbarium was not threatened at any stage (if you exclude five metre flames on a 300 m front just 200 m away). That was stopped at a freshly cut bulldozer line. We had just emptied the whole water supply for Waste Point onto it and were setting up a quick-fill pump on the shores of Lake Jindabyne when the easterly came in and things quietened down.

Fire fighting then became a slog as the battlefield moved out onto the plains until finally the fires were out. But what of the effects? People talked of 'devastation' as if the bush would never come back. Well, by between 15 000 and 8 000 years BP the flora – and subsequently fauna of the alpine area of the park would have been similar to those existing today (Costin *et al.* 1979, Green and Osborne 1994). We can assume that at lower altitudes, where there were no glaciers, this time period would extend back further. The biota that exists in the park would have been exposed to 'one in 100 year' fire events of the order of a hundred times or more in that period. The biota in the park exist *because* it has passed the test of selection with regard to this fire regime. Therefore, in the natural course of events the biota should recover from the recent fires with little impact upon diversity, and consequently we need only sit back and hope for light rains, mild frosts and generally good growing conditions. However, there are some concerns about the regeneration because, excluding infrastructure (which brings its own selective pressures), there are three aberrations against which the fauna and flora have not been tested in an evolutionary sense. These are: recent depletion of population reserves/habitat of endangered fauna and flora, weed invasion and feral animals.

The main concerns in rehabilitation after the fires were quickly addressed. The impacts of bulldozer activity both on and off established fire trails were repaired. Immediate tasks were the establishment of drains to minimise erosion and replacing topsoil and sod where required. The fires created a large seedbed, ideal for the invasion of weeds. Weed spraying was conducted as a priority. With feral animals the main immediate concern was the survival of isolated remnant populations of endangered fauna. Luckily only one major Mountain Pygmy Possum *Burramys parvus* habitat, on Mt Blue Cow, was burned. Cat trapping and fox baiting commenced immediately and dog baiters were released from fire duties to resume baiting.

In terms of threatened species, the issue of long-term impacts is more complicated. To determine whether the fires had a major impact, the question that should be asked is what species or habitats were significantly reduced in numbers/area by the fire such that recovery to pre-fire numbers/area is considered unlikely. I can only think of the Southern Corroboree Frog *Pseudophryne corroboree* in this respect. No other species had its numbers/habitat reduced in the recent fires beyond its natural resilience. Evidence from the past ten years however is that the Southern Corroboree Frog is heading for extinction in the wild. A survey of the forty sites which have been monitored annually since 1999, showed 22 with no responding males (ten sites had no males last season). In all, 18 of the 40 had fewer males than previously but surprisingly six sites had more. Overall, however, these results suggested a continuation in the general rapid decline in Southern Corroboree Frogs and the likely imminent extinction of this species in the wild.

So now, as winter takes its grip on the mountains, how did other species bear up? A fire burned to the west of Thredbo in the South Ramshead–Dead Horse Gap area, which includes the area surveyed only last year for the Biodiversity Blitz (see *The Victorian Naturalist* **119** (1), 2003, 36-37). A re-survey of the area showed that no expected species were missing. I was also able to retrap five small-mammal trapping grids. Three that had burnt had lost 73-80% of animals compared to the same period last year, one that was half burnt had lost 45% and the one completely unburnt grid had gained 16.5%. What was of concern was that the Broad-toothed Rat *Mastacomys fuscus* whose populations had crashed across the mountains in winter 1999 had declined on all sites regardless of the fire history.

While we were at the mop-up stage of the fire I took a morning tour of the fires by helicopter. Even with the extreme weather conditions the fire had burned in a complex mosaic. The vegetation will show a variety of ecological responses to fire intensities varying from regeneration from seed in the ash forests, through resprouting from epicormic shoots to the regeneration from lignotubers in snowgums. Some grasses even sprang back while the fire was still burning nearby. Luckily we had some rainfalls soon after the fires and the resprouting from epicormic shoots and the regrowth of shrubs soon became evident in well-travelled areas such as along the Alpine Way between Jindabyne and Thredbo. After a very mild autumn at the higher altitudes, a wander through the bush even in the blackest areas of the mountains reveals vigorous ferns and everywhere shoots from the bases of blackened shrub stalks. Now these are being buried beneath the snow and protected against cold and killing frosts, waiting for the real period of growth which will come with spring warmth and rains.

Ken Green
National Parks and Wildlife Service
PO Box 2228, Jindabyne, NSW 2627

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Australian Natural History Medallion Trust Fund

Donations were gratefully received during 2003 from the following:

Australian Plant Society (SGAP) Victoria Inc	$150
Field Naturalists Club of Ballarat	$25
Royal Society of Victoria Inc	$100
Victorian Ornithological Research Group	$25
Margaret and Ian Endersby (in memory of Marjorie North, long term member of FNCV and Montmorency FNC)	$200

If you would like to contribute to this fund, which supports the Australian Natural History Medallion, donations should be sent to: The Treasurer, Field Naturalists Club of Victoria, Locked Bag 3, Blackburn, Victoria 3130. Cheques should be made payable to the 'Australian Natural History Medallion Trust Fund'.

The medallion is awarded annually to a person who is considered to have made the most significant contribution to the understanding of Australian natural history in the last ten years.

Australia: 300 Years of Botanical Illustration

by Helen Hewson

Publisher: *CSIRO Publishing, Melbourne 1999. 240 pp. colour plates throughout. Hardback, ISBN 0643063668. RRP $64.95*

Feather and Brush: Three Centuries of Australian Bird Art

by Penny Olsen

Publisher: *CSIRO Publishing, Melbourne 2001. 240 pp. colour plates throughout. Hardback, ISBN 0643065474. RRP $69.95.*

How fortunate – for European science, gardens and art – that so much of Australia's flora and fauna was documented and illustrated during the golden age of natural history – when the world was scoured for 'new' and beautiful plants and animals for possession and classification. Living and dried specimens from Australia reached Britain and continental Europe when the scientific naming system was becoming binomial and illustrations could be reproduced for publication.

These two beautiful books show how, across three centuries, images of Australia's plants and birds were prepared and published, and how they were associated with the documentation of Australia's flora and fauna. The beautiful, sometimes stunning, images impressively represent a complex strand of Australia's heritage in which art and science are profusely and profoundly entwined.

With today's destructive drive toward privatisation it is timely to acknowledge the importance of public institutions in preserving the collections which constitute that heritage – specimens and illustrations of Australia's indigenous flora and fauna. Hewson and Olsen have selected hundreds of illustrations (some not previously published) from a wide range of public libraries, museums and herbaria – the Royal Botanic Gardens at Kew in England, Australian state and national herbaria and botanic gardens, Australian national and state libraries, and museums in Brisbane, Melbourne, Launceston, London, Cambridge and Vienna.

Dr Helen Hewson is a taxonomic botanist, who contributed to the multivolume *Flora of Australia* as researcher, writer, illustrator, editor and manager. Passionate about botanical art, she has co-authored books about John Hunter and Ellis Rowan. Penny Olsen is a wildlife consultant, researcher, author and editor. A raptor expert, she recognises that Australia's fascinating ornithological history requires proper recognition of the contribution of illustrators and artists.

Hewson and Olsen show how explorers, convicts, naval draftsmen, naturalists, scientists and artists, have shaped the history of collecting, recording and classifying Australian plants and birds. Driven by the excitement of discovery and description of flora and fauna new to European eyes and science, the illustration of Australian plants and birds flourished during the late 18th and early 19th centuries. In recent decades an increased interest in conservation has fuelled a revitalisation of Australian natural history art, and Olsen devotes half her book to the work of contemporary artists.

Not surprisingly some artists appear in both books. Using mere words, I shall not attempt to convey the beauty of the illustrations. Instead, in the hope of exciting your interest in history and natural history, I shall tease out some of the early threads which Hewson and Olsen weave.

Hewson begins by describing the techniques used to illustrate plants, from early *Herbals* to current computer scanning. She discusses metal-engraving and lithography which were widely used in the illustration of Australian plants and animals, and quotes Stafleu's interesting claim: 'The art of making herbaria developed from botanical illustration: pressed plants were originally used as material for the botanical artists.'

The first published illustrations of Australian birds and plants were from William Dampier's expedition along the western coast of New Holland. Sketches by unnamed draughtsmen near Shark Bay in 1699 were published in Dampier's *A Voyage to New Holland* (1703). An earlier Dutch depiction of black swans on the 'Swane Rivier' was published later.

The next illustrations were made many decades later on the other side of the continent – in 1770, during Captain Cook's first Pacific voyage. The expedition included Joseph Banks and Sydney Parkinson (who died during the voyage). Banks was so impressed with the local flora that Botany Bay was named for it. Olsen selected from the British Natural History Museum pencil and watercolour drawings, including the Superb Fairy-wren and Blue Petrel, by artists on Cook's three Pacific voyages. While Parkinson's beautiful drawings languished unpublished, other artists used material Banks brought back. Peter Brown's hand-coloured engraving of a Rainbow Lorikeet in his *New Illustrations of Zoology* (1776) is the first published illustration of an eastern Australian bird and the first published coloured illustration of an Australian bird – possibly from a live, rather than stuffed, specimen captured in Botany Bay in 1770. Hewson shows how one of Parkinson's drawings (of the plant now called *Dillenia alata*) was used across the centuries. She juxtaposes Parkinson's drawing with a painting and copper engraving prepared in 1778 for Banks' proposed *Florilegium*, its black and white print which was eventually published in *Illustrations of the Botany of Captain Cook's Voyage Round the World* (1900-05), and the relatively recent colour print in *Bank's Florilegium* (1981-88).

Although he never published his *Florilegium*, Banks made his rich herbarium accessible to European botanists, including Charles-Louis L'Héritier de Brutelle, who employed Pierre-Joseph Redouté to illustrate his taxonomic work and led him from flower painting to botanical art. Hewson includes Redouté's noteworthy illustration of a specimen collected in Van Diemen's Land (Tasmania) during Cook's ill-fated third voyage. Redouté's engraving illustrates L'Héritier's original taxonomic description (now called type description) of *Eucalyptus obliqua* which was published in 1792. The genus as well as the species was new, so the great Redouté's first drawing of an Australian plant accompanies L'Héritier's original description of Australia's iconic genus *Eucalyptus*.

Inspired by the flora of eastern New Holland, Banks was influential in having a British penal settlement established at Port Jackson (which grew into Sydney). Not surprisingly there was no official botanist or zoologist. But natural history collections made during Cook's voyages had stimulated such enormous interest in the flora and fauna of the new colony of New South Wales, that numerous specimens and illustrations were sent 'home' to curious England. Governor Phillip sent specimens to Banks, and observant amateur naturalists among the government officials, prisoners and their guards, illustrated plants and animals during their stay at Port Jackson. John Hunter, a naval officer (later governor), and George Raper, a midshipman, learned to draw in the navy, where the chartmaker's palette was limited to two greens, two browns, crimson, yellow, blue and black. The surgeon, John White, hired Port Jackson residents as artists, including the convict, Thomas Watling, who had used his considerable artistic skills to forge money. Their numerous illustrations in the 1790s include birds which Europeans quickly hunted to local or general extinction – the Norfolk Island Kaka, Providence Petrel, and Lord Howe Island's endemic White Gallinule.

The technique of pressing and drying plants produced enduring herbarium specimens which botanists could use to name and describe new species. However zoological preservation techniques were less satisfactory, and illustrations were sometimes used instead of specimens. In England Dr John Latham, the 'grandfather of Australian ornithology', used Watling's watercolour, 'Semipalmated Duck', to describe *Anseranus semipalmata*, the Magpie Goose. The accomplished artist and careful copyist, Sarah Stone, prepared watercolours of many birds for surgeon White's *Journal of a Voyage to New South Wales* (1790). Some, including the Australian King-Parrot and Swift Parrot, were used to name and describe new species.

In the 1790s the naturalist, artist and engraver, James Sowerby, prepared many illustrations of Australian plants and animals. His hand-coloured engravings illustrate the original taxonomic descriptions of the now endangered Regent Honeyeater, and the Topknot Pigeon which Banks and Parkinson had observed and eaten in 1770.

James Edward Smith (who founded the Linnean Society of London) examined White's plant collection and described new species in White's *Journal* and in his own *A Specimen of the Botany of New Holland* (1793-95), which is Australia's first Flora. Hewson presents several of the beautiful hand-coloured engravings which Sowerby prepared, from drawings and herbarium specimens, to illustrate Smith's taxonomic descriptions. Next to Sowerby's published engraving of the New South Wales Waratah (now *Telopea speciosissima*) are Watling's watercolour paintings which Sowerby used.

As French citizens revolted and Britain and France waged war, British and French expeditions charted Australia's coast-line and extracted floral and faunal specimens from it. Many illustrations were published in the plethora of natural history and horticultural magazines which flourished on both sides of the English Channel. Hewson shows how revolution and war affected the documentation and illustration of Australia's flora, and how Australia's second Flora is French. A French expedition naturalist, Jacques Julien Houton de Labillardière, marvelled at forest trees in Van Diemen's Land in 1792, and added a new species to the recently established genus, *Eucalyptus*. In his published account of the voyage Labillardière named and described *Eucalyptus globulus*, with an engraving from Redouté's drawing to illustrate it. Labillardière's subsequent *Novae Hollandiae Plantarum Specimen* (1804-06) is Australia's second Flora – with 265 plates prepared from herbarium specimens by an impressive team of artists and engravers.

In 1802, while mapping the coast of the continent he would call Australia, Matthew Flinders met a French scientific expedition under Nicholas Baudin – at Encounter Bay. With Banks' support, Robert Brown, botanist, and Ferdinand Bauer, artist, accompanied Flinders to collect and depict Australia's plants and animals. Bauer drew, painted, engraved and hand-coloured his own work. To ensure the subsequent use of correct colours, his colour code included over 1000 distinct hues! Olsen includes Bauer's watercolours of the Eastern Rosella, Hooded Parrot and Noisy Friarbird, and Hewson his hand-coloured engraving of *Banksia coccinea* and *Brunonia australis*. Brown and Bauer were a formidable taxonomic team at the Natural History Museum, but only the first parts of their complementary artistic and taxonomic volumes were ever published. Consequently Australia's third Flora is incomplete and only sparingly illustrated.

Living and dried specimens from Banks' collectors, including George Caley, continued to enrich taxonomic systems, gardens and magazines. Magazine illustrations often included magnified floral parts to satisfy taxonomic interests. Hewson presents the hand-coloured engraving of William Jackson Hooker's drawing of *Grevillea caleyi* in *Curtis's Botanical Magazine* (which Hooker edited) in 1832. Robert Brown had named it for Caley.

Presumably the father of Australian ornithology is John Gould. On his return to England after visiting Australia during 1838-40, Gould, like Banks, sponsored and supported antipodean collectors. His seven volume *The Birds of Australia* (1840-48) and *Supplement* (1869) dominated the market and subsequent public memory. With accounts of 681 bird species, each illustrated by a hand-coloured lithograph, it significantly increased the number of known species. Gould made sketches and designed the plates for his bird books, and his wife, Elizabeth, and other artists completed the illustrations. The style was naturalistic. Two males are depicted attending a female Superb Fairy-wren, a century before the recognition of co-operative breeding. After Elizabeth's death in childbirth in 1841, Gould named a beautiful new finch for 'my late wife, who for many years labouriously assisted me with her pencil, accompanied me to Australia, and cheerfully interested herself in all my pursuits', and prepared a watercolour from a specimen which John Gilbert collected on islands in the Gulf of Carpentaria, where the Gouldian Finch, *Erythrura gouldiae*, is now seriously endangered.

Birds were also being illustrated in Australia – often by women. The Scott sisters, Harriet and Helena, prepared watercolours for various books, and Louisa Atkinson prepared pencil and watercolour illustrations of birds and plants for her *Illustrated Sydney News* articles. Sylvester Diggles, helped by his artistic niece, Rowena Birkett, produced *The Ornithology of Australia* (1866-70) with over a hundred plates. Gracius Broinowski, with artistic help from his wife, produced *The Birds of Australia* (1887-91), whose six volumes describe over 700 species and include over 300 chromolithographic plates.

Meanwhile the prodigious taxonomic work of Victoria's government botanist was shifting the centre of Australian plant taxonomy from Europe to Australia. Uncommonly for botanists of his time, Mueller did not draw. He depended on artists and lithographers to illustrate his taxonomic work. Hewson presents several lithographs prepared under Mueller's direction, including one of the first botanical illustrations published in Australia – *Macadamia ternifolia* which Becker drew and lithographed to accompany Mueller's taxonomic description in 1857. Hewson also includes Becker's nature print of two leaves of *Macadamia ternifolia* – apparently the first published nature print of an Australian plant. Some of Mueller's huge network of collectors also produced illustrations, including Louisa Ann Meredith, Fanny Ann Charsley, Helene Forde (née Scott), Louisa Atkinson and Ellis Rowan.

Well this is just the beginning. I leave you to read about the botanical illustrators used by Joseph Henry Maiden in Sydney and Professor Alfred Ewart in Melbourne, the ornithological publications of John Albert Leach and Neville William Cayley (whose artist-ornithologist-author father signed his work Neville Caley), and living artists.

You can learn a lot of history from these books. Hewson's book has a section on plant nomenclature, a glossary of terms and endnotes which explain many taxonomic honours – so you can discover the origins of names such as *Billardiera*, *Bauera*, *Grevillea* and *Richea*. However, except for quotations, endnotes rarely include references, making it difficult to use the book as a literary launch from which to explore further the huge range of fascinating material that Hewson discusses. Each book has a list of references and an index. Olsen's index includes common but not scientific names. Surprisingly Hewson's index includes neither. But don't let this or minor errors about the origins of Tasmania's Royal Society and Mueller's early Victorian expeditions deter you.

CSIRO is to be congratulated for publishing these two superbly illustrated histories of Australian botanical and bird art. Their stunning covers – Margaret Stones' (1973) *Rhododendron lochiae* and Richard Weatherly's (1984) Mountain Ash and Crimson Rosellas – show the magnificence of relatively recent works. Both books make great presents for anyone interested in Australia's remarkable flora and fauna. And they should be in every Australian library.

You may also like to read Des Cowley's article 'Women's Work: Illustrating the Natural Wonders of the Colonies' in the Autumn 2002 issue of *The La Trobe Journal*, which is published by the State Library of Victoria Foundation. It includes some of the people Hewson and Olsen discuss. If you are interested in botanical art I hope you saw the spectacular work at the exhibition 'The Art of Botanical Illustration' presented by the Friends of the Royal Botanic Gardens, Melbourne, in Spring 2002. The Friends made the 148 paintings available on a CD and their website, www.rbg.vic.gov.au/friends.

Linden Gillbank
History and Philosophy of Science Department
University of Melbourne
Victoria 3010
lindenrg@unimelb.edu.au

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F.N.C.V.

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Flora of Australia, Volume 58A, Lichens 3

Publisher: *ABRS/CSIRO, Melbourne. Paperback or hardback, xviii + 242 pages (including maps, dichotomous keys, black and white and colour photographs) ISBN 0 643 06713 2. RRP $85 (HB);$70 (PB).*

In a field of natural history, such as lichenology, where so little information is available, the arrival of the much awaited 'next addition' of the *Flora of Australia* is greeted with great joy and enthusiasm. This is the third volume of the *Flora of Australia* to cover lichens, with the previous volume (55) having been published seven years ago. A new, and less rigid, approach to the publication of these lichen treatments has now been adopted, and is best described in the first paragraph of the Introduction:

> *'It has become apparent that the rigid systematic arrangement and the five volumes as originally proposed are not conducive to making reliable information available in a timely fashion. A more flexible and pragmatic approach is being adopted whereby a total of up to ten smaller volumes will be published at intervals of 1-2 years, as sufficient treatments of complete families become available.'*

Volume 58A covers some of the larger, wet forest lichen groups such as *Lobaria*, *Pseudocyphellaria* and *Sticta* (Peltigerales: Lobariaceae), *Bunodophoron* and *Lefidium* (Lecanorales: Sphaerophoraceae). Furthermore, this volume also contains the first of the treatments of crustose lichens, with the Leotiales, Trichotheliales and Verrucariales consisting of lichens from this growth form. The 56 colour plates presented convey an appreciation of the great diversity of form and colour that lichens possess. These photographs, coupled with PM McCarthy's exquisite stippled drawings of genera such as *Porina*, *Endocarpon* and *Verrucaria*, make the book very pleasant to simply flick through. However, it is the dichotomous keys, descriptions, distribution information and nomenclatural details that really put this book on the shelf of any serious cryptogamic naturalist or scientist.

Identification of lichens has always been problematic for the lay-person, due to the requirements for compound microscopes and, for many groups, chemical spot testing (few of us have chemicals such as potassium hydroxide (K test) and para-phenylenediamine (P test) in our homes!). The keys presented in the *Flora* are probably as straightforward as possible, given these complications with the identification process. For the most part, where chemical detail is requested, the remainder of the couplet characterises other visual features such as spore size and colour, hence some progress can be made. The descriptions are detailed and thorough, covering thalline features on upper and lower surfaces, vegetative propagule types and location, photobiont type and arrangement, sexual reproductive structures and spore size, type, colour and arrangement. Distributional information and extra notes distinguishing similar species complete each description.

In the field of lichenology (as in many fields of biology), terminology can be quite complex, especially as many features are unlike those seen in vascular plants. The keys and descriptions presented in Volume 58A include this complex terminology, as is expected for this kind of taxonomic treatment of species. However, the omission of a glossary in this volume means that the reader must refer back to Volume 54 in order to check the definition of technical terms. This could be problematic for readers who do not have Volume 54!

Overall, *Flora of Australia, Volume 58A* maintains the same impeccable standard that we have come to expect from the *Flora* series. It is an essential aid to identification of Australian lichens, although it is most certainly geared towards those with access to microscopes. The descriptions and keys, while heavy with terminology, are definitely not beyond the ability of the field naturalist, especially with the aid of a good glossary.

Sharon Morley
20 Crowley Road
Healesville, Victoria, 3777

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This issue is dedicated to the memory of John H. Seebeck, who died on 8 September 2003.

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Cover: Snow Gum Open-forest at Heathy Spur near Mt Nelse, which was severely burnt during the late summer fires of 2003. See story on page 201. Photo by David Cheal.

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Terrestrial Vertebrate Fauna of Grasslands and Grassy Woodlands in Terrick Terrick National Park, Northern Victoria

Damian R Michael[1], Ian D Lunt[1] and Wayne A Robinson[1,2]

Abstract

A survey of terrestrial grassland and woodland fauna was conducted in Terrick Terrick National Park in northern Victoria. A total of 91 sample sites, consisting of 1132 log refuges, was distributed over three vegetation communities, including two woodland communities and four grassland sub-communities, to sample vertebrates. The newly introduced log refuges and an additional 271 pre-existing old refuges were checked on eight occasions, once per month between June 2000 and January 2001. A total of 346 faunal observations were recorded beneath the refuges, encompassing 15 species from eight families and including three species threatened with extinction in Victoria: Tessellated Gecko *Diplodactylus tessellatus*, Striped Legless Lizard *Delma impar* and Curl Snake *Suta suta*. The elapid Curl Snake was the most commonly recorded species (17% of observations) followed by Common Eastern Froglet *Crinia signifera* (16%) and Fat-tailed Dunnart *Sminthopsis crassicaudata* (15%). Two species were encountered significantly more frequently in woodlands than grasslands (Boulenger's Skink *Morethia boulengeri* and Common Eastern Froglet), whereas three species (House Mouse *Mus musculus*, Fat-tailed Dunnart and Curl Snake) were significantly more frequent in grasslands. Few species were recorded in recently cropped paddocks, and all were in low numbers. This study documents the importance of Terrick Terrick National Park for conserving threatened herpetofauna, and demonstrates the effectiveness of log refuges as a survey method for vertebrate grassland fauna. (*The Victorian Naturalist* **120** (5), 2003, 164-171)

Introduction

Since European settlement, lowland native grasslands in south-eastern Australia have been drastically altered and reduced in extent (Stuwe 1986; McDougall and Kirkpatrick 1994). Over 95% of native grasslands in many regions has been cleared and converted into landscapes dominated by agriculture and livestock production (McDougall and Kirkpatrick 1994). This fate has befallen native grasslands and grassy woodlands in the Riverina or Northern Plains region of Victoria. Most of this region has been developed for agriculture and few large uncultivated remnants of the original native grasslands remain (McDougall and Kirkpatrick 1994; Foreman 1996). Northern Plains Native Grassland is now considered a threatened ecosystem under the Victorian *Flora and Fauna Guarantee Act* (1988) and four species of reptile that occur in this ecosystem are considered to be threatened with extinction in Victoria (Bennett *et al.* 1998).

The declaration of Terrick Terrick National Park in 1998 represented an important step for grassland conservation, as it was the first national park in the Riverina bioregion of south-eastern Australia and the first national park containing temperate grasslands in southern Australia. The 3780 ha reserve includes approximately 1280 ha of grassland, including the largest areas of high quality native grassland known to exist on the Northern Plains (Lunt *et al.* 1999). The contribution of the reserve to fauna conservation is also important. Approximately 10 species of native mammal (including bats) and 22 reptiles are known to occur in the reserve (M Tscharke pers. comm. 2002), including six species that are rare, threatened or data deficient in Victoria: Tessellated Gecko *Diplodactylus tessellatus*, Striped Legless Lizard *Delma impar*, Hooded Scaly-foot *Pygopus nigriceps*, Lace Monitor *Varanus varius*, Carpet Python *Morelia spilota variegata* and Curl Snake *Suta suta* (Bennett *et al.* 1998). However, little is known of the distribution or abundance of fauna in the reserve. This information is important for conservation management as well as for indicating the importance of the reserve for fauna conservation in a broader regional context.

The aims of this study were: (1) to document the distribution and relative abundance of terrestrial vertebrates within

[1] The Johnstone Centre and School of Environmental and Information Sciences, Charles Sturt University, PO Box 789 Albury, NSW 2640

[2] Current address: Faculty of Science, University of the Sunshine Coast, Maroochydore DC, Queensland 4558

grassland and grassy woodlands in Terrick Terrick National Park using active searches beneath log refuges as a survey method and; (2) to determine the habitat preferences of terrestrial vertebrates in grasslands and grassy woodlands in the reserve.

The survey was conducted by searching for animals beneath log refuges that were manually laid out across all major vegetation types in the reserve. Artificial refuges, including corrugated iron, wooden boards, roof slates and tiles, have proved to be a valuable method for surveying grassland fauna and observing aspects of animal behaviour (Goddard 1984; Braithwaite *et al.* 1989; Reading 1997; Webb and Shine 2000). Previous studies have used artificial refuges to determine the presence of reptiles in grassy ecosystems (O'Shea 1996; O'Shea and Hocking 1997). In a companion paper (Michael *et al.* in press), we document the preferences of different fauna species for refuges with different attributes, including size, shape, and decomposition status.

Methods

Study area

The study was conducted in the newly acquired eastern half of Terrick Terrick National Park (36°08'S, 144°17'E), approximately 60 km west of Echuca in the Northern Plains of Victoria. The 1280 ha study area is mostly native grassland, but contains small patches of remnant woodland. The western section of the park (the old Terrick Terrick State Forest), which is dominated by White Cypress-pine *Callitris glaucophylla* and Yellow Box *Eucalyptus melliodora* (Parker and Lunt 2000) was not sampled.

The study area contains three broad vegetation communities: (1) open woodland dominated by Yellow Box and Buloke *Allocasuarina luehmannii* on gently sloping, outwash slopes of the Terrick Terrick range; (2) riparian woodland along Bendigo Creek, dominated by Black Box *Eucalyptus largiflorens* and River Red Gum *E. camaldulensis* above Tangled Lignum *Muehlenbeckia florulenta*; and (3) extensive open grasslands on the flat riverine plains.

Five intergrading grassland associations occur in the reserve, according to soil gradients and past land use (Table 1): (1) recently cropped paddocks dominated by exotic species such as Wimmera Rye-grass *Lolium rigidum*, Bearded Oat *Avena barbata* and Subterraneum Clover *Trifolium subterraneum*; (2) low-lying depressions dominated by Brown-backed Wallaby Grass *Austrodanthonia duttoniana* and Wimmera Rye-grass; (3) gilgai complexes dominated by Bearded Oat and the subdominant native Plump Spear-grass *Austrostipa aristiglumis*; (4) species-rich grassland dominated by Bristly Wallaby-grass *Austrodanthonia setacea* and Common Wallaby-grass *A. caespitosa* with large amounts of bare ground interspersed with bryophytes; and (5) a widespread grassland of moderate floristic richness dominated by combinations of Bristly Wallaby-grass, Common Wallaby-grass and Bearded Oat (Lunt *et al.* 1999). Low-lying depressions and gilgai mounds were combined in this study due to similarities in landscape position and vegetation composition. Lunt *et al.* (1999) and Michael (2001) provide more detailed descriptions of vegetation patterns in the reserve.

Sampling and analysis

Fauna were sampled at 91 permanently marked vegetation quadrat sites, stratified across major soil types, established by Lunt *et al.* (1999). In May 2000, approximately 12 (and up to 20) weathered logs were placed alongside each vegetation quadrat (Fig. 1), giving 1132 log refuges in total. Log refuges consisted of White Cypress-pine and *Eucalyptus* fence posts which were salvaged when new fences were erected around the reserve. Additionally, a 2 km long fallen fence line in widespread grassland in the east of the reserve containing 271 fallen fence posts was sampled. Reptiles, amphibians and small mammals were surveyed once a month, from June 2000 to January 2001, and between the hours 0800 and 2000, by overturning and searching beneath every refuge. Logs were returned to their original positions after searching. Mark-recapture methods were not employed in this study.

Statistical analysis was performed using SPSS® Version 10 for Windows (Coakes and Steed 1996). A generalised linear model for a Poisson distribution (Dobson 1996) was used to compare vertebrate

Table 1. The number of hectares and number of log refuges laid at quadrats in each vegetation type in Terrick Terrick National Park, Victoria. Old refuges were only surveyed in widespread grassland. Vegetation types follow Lunt *et al.* (1999).

Vegetation type	No. of hectares	No. of quadrats	No. of new refuges	No. of old refuges
Recently cropped grassland	255	14	170	-
Widespread grassland	437	34	414	271
Species rich grassland	142	12	148	-
Gilgai and drainage line complex	346	20	258	-
Woodland complex	100	11	142	-
Total	**1280**	**91**	**1132**	**271**

abundances between vegetation types, using all species that were observed on more than ten occasions. The analysis was weighted for differences in sampling intensity (number of logs at each sampling site). The two woodland communities were pooled in the study to compare against the four grassland sub-communities. Data from old refuges were not used in this analysis, as old refuges were only present in one vegetation type, widespread grassland.

Results

Active searching of refuges (n = 1403) on eight occasions between June 2000 and January 2001 revealed the presence of 15 vertebrate species from eight families (Table 2). Most (60%) of the 346 observations were reptiles, especially skinks (33% of observations). Five species accounted for 79% of observations: Curl Snake *Suta suta*, Common Eastern Froglet *Crinia signifera*, Grey's Skink *Menetia greyii*, Boulenger's Skink *Morethia boulengeri* and Fat-tailed Dunnart *Sminthopsis crassicaudata*. By contrast, several species (e.g. Plains Froglet *Crinia parinsignifera*, Eastern Bearded Dragon *Pogona barbata*, Eastern Blue-tongued Lizard *Tiliqua scincoides* and Eastern Brown Snake *Pseudonaja textilis*) were only observed beneath refuges once or twice. Three additional species not recorded beneath refuges were observed incidentally within the reserve: Lace Monitor *Varanus varius*, Southern Marbled Gecko *Christinus marmoratus* and Peter's Blind Snake *Ramphotyphlops bituberculatus*.

The number of vertebrate observations varied greatly between vegetation types (Table 3). Five species (Common Eastern Froglet, Boulenger's Skink, Curl Snake, House Mouse and Fat-tailed Dunnart) were significantly more abundant in some vegetation sub-communities than would be expected by chance. Boulenger's Skink and Common Eastern Froglet were encountered more frequently in woodlands than grasslands (G = 65.26, df = 4, $p < 0.001$ and G = 204.5, df = 4, $p < 0.001$ respectively). Whilst not apparent from Table 3, the two species had different habitat preferences; Common Eastern Froglet (and also Plains Froglet and Spotted Marsh Frog *Lymnodynastes tasmaniensis*) were recorded in Black Box riparian woodland, whereas Boulenger's Skink was most abundant in Yellow Box - Buloke woodland.

By contrast, the Curl Snake and House Mouse occurred more frequently than would be expected in the species-rich grassland (Table 3: G = 13.79, df = 4, $p < 0.01$ and G = 12.22, df = 4, $p < 0.05$, respectively). The Fat-tailed Dunnart was abundant in species-rich and widespread grassland but was never recorded from the woodland (G = 25.08, df = 4, $p < 0.001$). Only five species were recorded from recently cropped grasslands, all in low numbers (Table 3).

Discussion

These results highlight the importance of Terrick Terrick National Park for fauna conservation on the Victorian Northern Plains. Thirteen of the 48 species of reptile known to occur in the Victoria Northern Plains bioregion (Bennett *et al.* 1998) were recorded during this 8-month field survey. Some of these species have rarely been recorded in previous studies in the region due to the survey effort, survey method or poor species detectability (Brown and Nicholls 1994). One species considered to be vulnerable in Victoria (Bennett *et al.* 1998), the Curl Snake, was commonly encountered within

Fig. 1. Example of log refuges (old fence posts) used to sample terrestrial vertebrates in native grassland in Terrick Terrick National Park.

the reserve. Two other species that are rare or threatened in Victoria (Bennett *et al.* 1998) were recorded in this survey, but only in low numbers: Striped Legless Lizard and Tessellated Gecko.

The only native mammal recorded during the study was the Fat-tailed Dunnart, which occurs in grasslands and shrublands over much of southern Australia (Dickman and Read 1992; Morton 1995). Until recently it was considered widespread but uncommon in the Northern Plains of Victoria (Bennett *et al.* 1998), but Hadden (2002) recently found it to be common in sites that are lightly grazed and contain open vegetation cover, as was found in this study.

Habitat preferences

Most species recorded commonly in this study occurred in both grasslands and woodlands. However, a small number of species were recorded significantly more abundantly in woodlands than grasslands (Common Eastern Froglet and Boulenger's Skink) or vice versa (Curl Snake, Fat-tailed Dunnart and the introduced House Mouse). These habitat preferences generally conform with those documented previously. For example, the Common Eastern Froglet was most frequently recorded in the riparian woodlands beside an ephemeral water body, Bendigo Creek. The occurrence of frog species in rural landscapes is often closely correlated with the extent of native canopy cover and the proximity of permanent or ephemeral water bodies (Bennett *et al.* 1998; Hazell *et al.* 2001).

Over 60% of observations of the skinks Boulenger's Skink and Carnaby's Wall Skink *Cryptoblepharus carnabyi* were from woodlands. Previous studies have shown that these reptiles prefer sites with high densities of fallen timber and dead standing trees (Brown and Nicholls 1994; Halliger 1994). However, Boulenger's Skink also occurred at low frequencies in all grassland types, which appears to be atypical (Hadden and Westbrooke 1996; Brown 2001). Whilst it is possible that some small oviparous lizards may have been sequestered within logs when they were placed in the grasslands, Boulenger's Skink (and Grey's Skink) were also recorded from old refuges, which suggests that the refuges may themselves provide adequate habitat for the persistence of these skinks in open grasslands.

The Fat-tailed Dunnart was abundant in grasslands (especially the widespread and

Table 2. Number of observations of each species beneath new and old log refuges in Terrick Terrick National Park between June 2000 and January 2001. Observations may include individuals recorded on more than one occasion.

Family	Scientific name	Common name	New logs n = 1131	Old logs n = 271	Total
Myobatrachidae	*Crinia parinsignifera*	Plains Froglet	2	-	2
	Crinia signifera	Common Eastern Froglet	54	-	54
	Lymnodynastes tasmaniensis	Spotted Grass Frog	7	1	8
Gekkonidae	*Diplodactylus tessellatus*	Tessellated Gecko	5	4	9
Pygopodidae	*Delma impar*	Striped Legless Lizard	1	2	3
	Delma inornata	Olive Legless Lizard	10	8	18
Agamidae	*Pogona barbata*	Bearded Dragon	1	-	1
Scincidae	*Cryptoblepharus carnabyi*	Carnaby's Wall Skink	5	-	5
	Menetia greyii	Grey's Skink	50	5	55
	Morethia boulengeri	Boulenger's Skink	41	12	53
	Tiliqua scincoides	Eastern Blue-tongued Lizard	1	-	1
Elapidae	*Pseudonaja textilis*	Eastern Brown Snake	-	2	2
	Suta suta	Curl Snake	21	38	59
Dasyuridae	*Sminthopsis crassicaudata*	Fat-tailed Dunnart	42	10	52
Muridae	*Mus musculus*	House Mouse	22	1	23

Table 3. Number of observations of each vertebrate species under new refuges in each vegetation sub-community in Terrick Terrick National Park. Species in bold differed significantly from their expected abundance between vegetation types. Only those species observed on more than ten occasions were analysed statistically.

	Cropped Grassland	Gilgai Complex	Species Rich Grassland	Widespread Grassland	Woodland Complex	Total
No. quadrats	14	20	12	34	11	91
Amphibia						
Crinia parinsignifera	-	-	-	-	2	2
Crinia signifera	-	-	3	-	**51**	54
Lymnodynastes tasmaniensis	-	-	-	-	7	7
Reptilia						
Diplodactylus tessellatus	-	-	1	2	-	3
Delma impar	-	-	-	1	-	1
Delma inornata	-	3	-	6	-	9
Pogona barbata	-	-	-	1	-	1
Cryptoblepharus carnabyi	-	-	-	-	6	6
Menetia greyii	2	8	7	23	6	46
Morethia boulengeri	3	3	2	6	**27**	41
Tiliqua scincoides	1	-	-	-	-	1
Suta suta	-	3	**8**	7	3	21
Mammalia						
Sminthopsis crassicaudata	2	7	14	20	**0**	43
Mus musculus	1	2	**8**	10	1	22
Total observations	9	26	43	76	103	257

species-rich grassland sub-communities) but was never recorded in woodlands. Previous studies have found that the Fat-tailed Dunnart prefers open environments (Morton 1978a; Hadden 2002). The House Mouse was relatively abundant in widespread grassland and significantly more abundant in the species-rich grassland. On several occasions House Mouse seats and discarded exotic grass husks were found beneath refuges together with Fat-tailed Dunnart seats and discarded insect wings. Although nest sharing between these two species has been recorded previously (Morton 1978b) it was not observed during this study. However, it is quite likely that this phenomenon, along with dunnart predation on the House Mouse, occurs in the reserve. House Mice are unlikely to have a negative effect on the native vertebrates within the reserve, and may even supplement the diets of the elapid snakes (Shine 1988, 1998).

The threatened Curl Snake was recorded in all vegetation types except the cropped paddocks during this study. This species lives in diverse habitats and is often associated with fallen timber and surface rocks, which it uses for shelter during the day (Shine 1988; Cogger 2000). The high number of observations beneath the refuges and lack of incidental sightings away from refuges during the day are consistent with its nocturnal behaviour and suggests that its current distribution within the reserve may be closely related to the available ground debris. Furthermore, Curl Snakes were recorded more frequently beneath log refuges that covered many subterranean invertebrate tunnels (Michael *et al.* in press) which suggests that subterranean refuges may also provide important habitat for this species.

Subterranean invertebrate tunnels (mostly constructed by Lycosid spiders and Stenopelmatid King Crickets) (Brunet 2000) are common in grasslands in the reserve, and occur at mean densities of 1–5 tunnels/m^2 in different grassland sub-communities (Michael 2001). On several occasions the discarded epidermis of the Hooded Scaly-foot *Pygopus nigriceps* has been found extruding from invertebrate tunnels within native grasslands in the reserve (M. Tscharke, pers. comm., 2001). Other grassland fauna, including the Striped Legless Lizard, Fat-tailed Dunnart, Southern Lined Earless Dragon *Tympanocryptis pinguicolla* and Pygmy Blue-tongued Lizard *Tiliqua adelaidensis*, are known to use invertebrate tunnels (Hutchinson *et al.* 1994; Robertson 1999; Hadden 2002), and it is possible that microhabitats such as subterranean refuges may influence the distribution and abundance of grassland dependent fauna in the reserve (Robertson 1999).

Survey methodology

The survey method used during this study is seldom employed in fauna surveys. By contrast, pit-fall traps, cage traps and active searches are usually used to survey reptiles and small terrestrial mammals (Fellar and Drost 1994). Log refuges have a number of advantages over pitfall traps, since holes do not need to be dug, a large number of sites can be surveyed relatively easily, and refuges do not need to be monitored daily.

Few studies have regularly monitored artificial refuges or natural refuges (Heenar and M'Closkey 1998; Shine *et al.* 1998; Goldingay and Newell 2000; Webb and Shine 2000), making direct comparisons with other studies difficult. However, a total of 346 observations over eight months in this study is comparable to other studies using conventional census techniques in similar vegetation classes, climatic zones and disturbance regimes. For example, Brown and Nicholls (1994) recorded 357 individuals over 1 year from disturbed woodlands in Gunbower Island State Forest (50 km NE of Terrick Terrick), using three census techniques. Hadden and Westbrooke (1996) recorded more than 500 individuals over nine months from disturbed Buloke woodlands in the Wimmera Plains (200 km west of TTNP), again using three census techniques. Recently, Brown (2001) recorded just 126 individuals over two spring-summer seasons in disturbed box-ironbark forest in Rushworth (80 km SE of TTNP) using active searches.

Like many survey techniques, one method may not detect the entire range of species. This was apparent as some species known to occur within Terrick Terrick NP such as the Hooded Scaly-foot, Bougainville's Skink *Lerista bougainvillii* and Common Spadefoot Toad *Neobatrachus sudelli* were not detected (P. Robertson, pers. comm., 2001). It is possible that the former two species will use log refuges within their ranges and on-going surveys may eventually reveal their presence. However, the Hooded Scaly-foot is considered to be nocturnally active only during the warmer months of the year making it extremely difficult to detect using the log refuge technique (Robertson 1999). Greater success has been achieved by spotlight transects during warm summer nights (M. Tscharke, pers. comm., 2001). In addition, conducting surveys after heavy rain may increase the chance of detecting burrowing frogs and blind snakes that may emerge from the water-soaked ground.

This study highlights the importance of Terrick Terrick National Park for fauna conservation on the Victorian Northern Plains. Many rare and threatened species occur within the reserve and appear to have persisted with moderate levels of grazing over the past century. Log refuges proved to be a highly effective survey method, and provide a simple technique for long-term monitoring of many animal species in the future.

Acknowledgments

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Reproduction in *Sphacelaria biradiata* Askenasy (Sphacelariales, Phaeophyceae) in Southern Australia

Maria Gibson[1]

Abstract

Sphacelaria biradiata Askenasy is a little known but common brown alga of southern Australian coasts. This paper describes its reproduction. Populations of *S. biradiata* reproduced asexually by vegetative propagules in all localities examined. The propagules were produced throughout the year and did not appear to be affected by season, although, if sexual structures occurred, propagule numbers declined. Sexual reproduction can occur and involves an alternation of generations, but it is a rare event. Gametophytes may produce male gametangia, female gametangia or both. Male gametangia, however, are extremely rare and are described for the first time. Production of female gametangia was influenced by season and occurred at all areas studied. The sexual behaviour of the male and female gametes is described. (*The Victorian Naturalist*, **120** (5), 2003, 171-178)

Introduction

Sphacelaria biradiata Askenasy (Fig. 1) is a small brown alga which is mainly epiphytic on larger algae or seagrasses but occasionally is epilithic (grows on rock) or epizoic (grows on animals). Many erect filaments arise from monostromatic or polystromatic basal discs (Fig. 2) forming soft, isolated to densely aggregated tufts.

Sphacelaria biradiata is a common and yet little known alga of southern Australian coasts. Askenasy (1894), Sauvageau (1900-1914) and Womersley (1967, 1987) provided brief descriptions of the species but nothing is known of its ecology or reproduction.

Sexual reproduction in the Sphacelariales typically involves an 'alternation of generations' where a diploid plant, the sporophyte generation, produces reproductive

[1] School of Biological and Chemical Sciences, Deakin University, Burwood, Victoria 3125

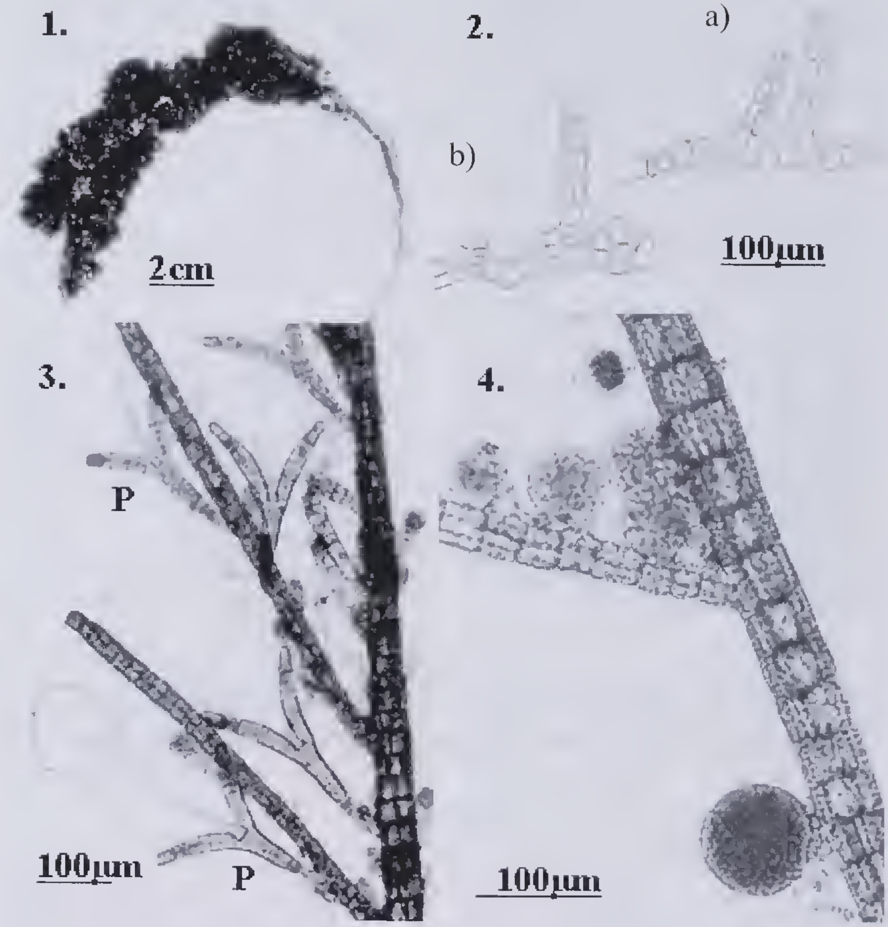


Fig. 1. Dense tufts of *Sphacelaria biradiata* epiphytic on *Caulocystis uvifera*. **Fig. 2.** *Sphacelaria biradiata* (a) monostromatic and (b) polystromatic discs with erect filaments. **Fig. 3.** Propagules (P). **Fig. 4.** Unilocular sporangia.

structures (sporangia) in which haploid spores are produced by meiosis. These haploid spores, sometimes called meiospores, germinate and grow into haploid plants, which constitute the gametophyte generation. Gametophytes produce reproductive structures (gametangia) in which haploid gametes are produced by mitosis. The male gametes fuse with the female gametes resulting in a diploid zygote, which grows into another sporophyte. An alternation of generations occurs in most brown algal orders. In most species, gametangia are plurilocular (having many compartments) and sporangia are

Table 1. Culture conditions.

Temp (^{0}C)	Daylength (hours)	Corresponding season
11	9.5	
12	10.5	
13	9.5	mid Winter
13	10.5	late Winter–early Spring
13	12.5	mid Spring
15	10.5	late Autumn
15	14.5	late Spring–early Summer and late Summer–early Autumn
20	14.5	mid Summer

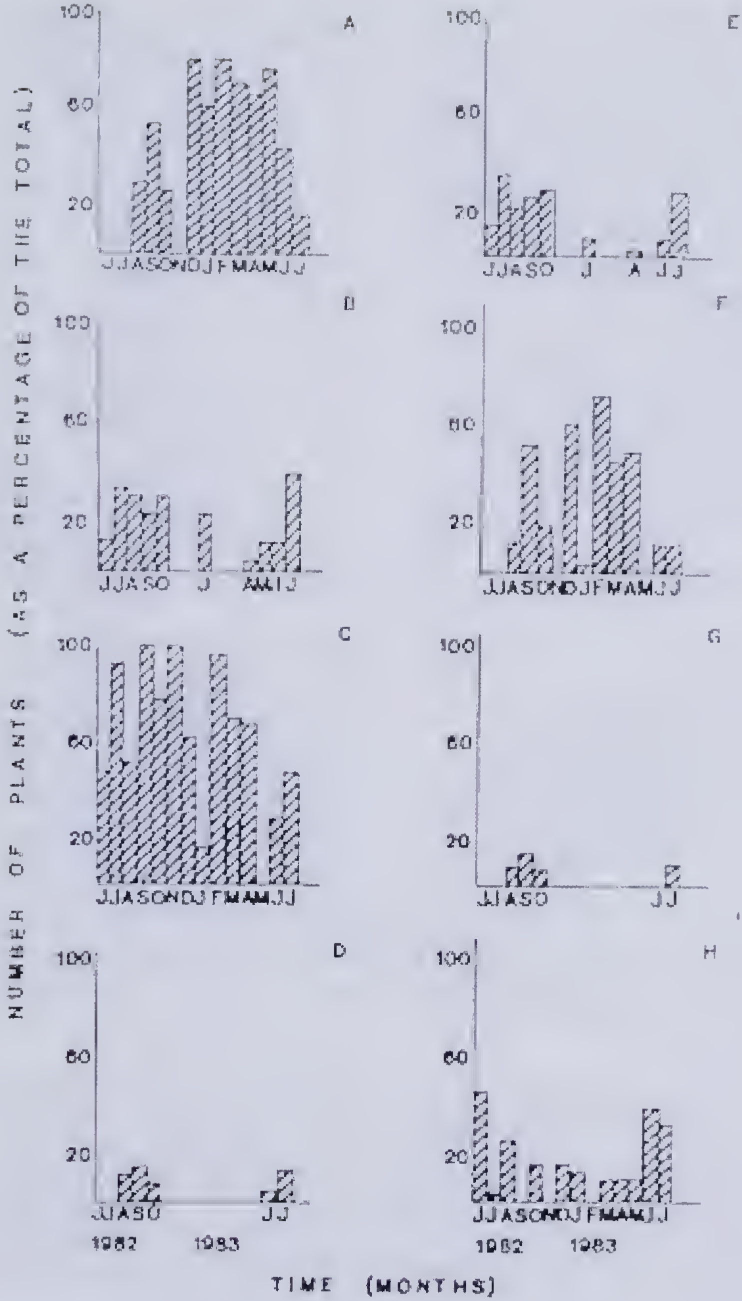


Fig. 5. Reproduction of a population of *Sphacelaria biradiata*, Point Lonsdale, Victoria. showing the percentage of plants with **A.** unilocular sporangia, **B.** plurilocular organs, **C.** propagules, **D.** plurilocular and unilocular organs, **E.** plurilocular organs and propagules, **F.** sporangia and propagules, **G.** sporangia, propagules and plurilocular organs, and **H.** no reproductive structures.

unilocular (having one compartment) (Clayton and King 1990), however, plurilocular organs producing asexual zooids (motile reproductive cells) also occur, for example, in *Ectocarpus siliculosus* (Dillwyn) Lyngbye (Ectocarpales) (Müller 1967). *Sphacelaria plumosa* Lyngbye, *Sphacelaria cirrosa* (Roth) C.A. Agardh and *Sphacelaria plumigera* Holmes (Prud'homme van Reine 1982).

Askenasy (1894), Sauvageau (1900-1914) and Womersley (1967, 1987) described plurilocular organs for *S. biradiata* but they did not state whether zooids were gametes or spores. Askenasy (1894) and Womersley (1967, 1987) also described unilocular sporangia and propagules, deciduous vegetative reproductive structures (Fig. 3). The presence of plurilocular and unilocular organs suggest that an alternation of generations may occur, but in the Sphacelariales a sporophyte generation may follow another sporophyte generation as meiosis fails to occur (Gibson 1989), for example in *Halopteris pseudospicata* Sauvageau, or a gametophyte generation may follow another gametophyte generation, for example in *Cladostephus spongiosus* (Hudson) C. Agardh (Gibson 1994).

This paper describes asexual reproduction by propagules and sexual reproduction in southern Australian *S. biradiata* and establishes that the zooids released by the plurilocular structures are gametes.

Methods

Monthly collections of 30 plants of *Sphacelaria biradiata* were made from Point Lonsdale, Victoria from June 1982 to July 1983 and transported to the laboratory in plastic bags on ice and in the dark. Fertile plants also were collected from Point Lonsdale on two other occasions (7/7/1985 and 9/9/1988), from Flinders (22/9/1981, 9/2/1982), Sorrento (9/2/1983), Apollo Bay (3/7/1984), Wilsons Promontory (2/8/1984) and Walkerville (3/8/1984), all in Victoria, from Cape Rabelais (January 1984) in South Australia and Wedgebay (26/10/1983) in Tasmania. The type of reproductive structures was noted and the behaviour of zooids from the plurilocular structures observed to determine any sexual nature.

Unialgal cultures were established from apical tips of filaments, propagules, spores and zooids from plurilocular organs and maintained in Provasoli's (1968) enriched seawater medium, initially in 10 cm diameter glass petri-dishes and, as plants became larger, in 250 ml pyrex culture dishes. Before use, petri-dishes and culture dishes were thoroughly washed in tap water and then in a dishwasher (without detergent) with five rinses, the last being distilled water. They were then autoclaved. Cultures were illuminated by Sylvania Grolux WS fluorescent tubes emitting a photon fluence of 60-70 $\mu mol\ m^{-2}\ s^{-1}$. Controlled environment cabinets were used to provide temperature/daylength regimes corresponding approximately to conditions prevailing at various times of the year (Table 1) (Clayton 1980). Cultures were examined daily for the first week and then weekly for development of propagules, unilocular and plurilocular structure.

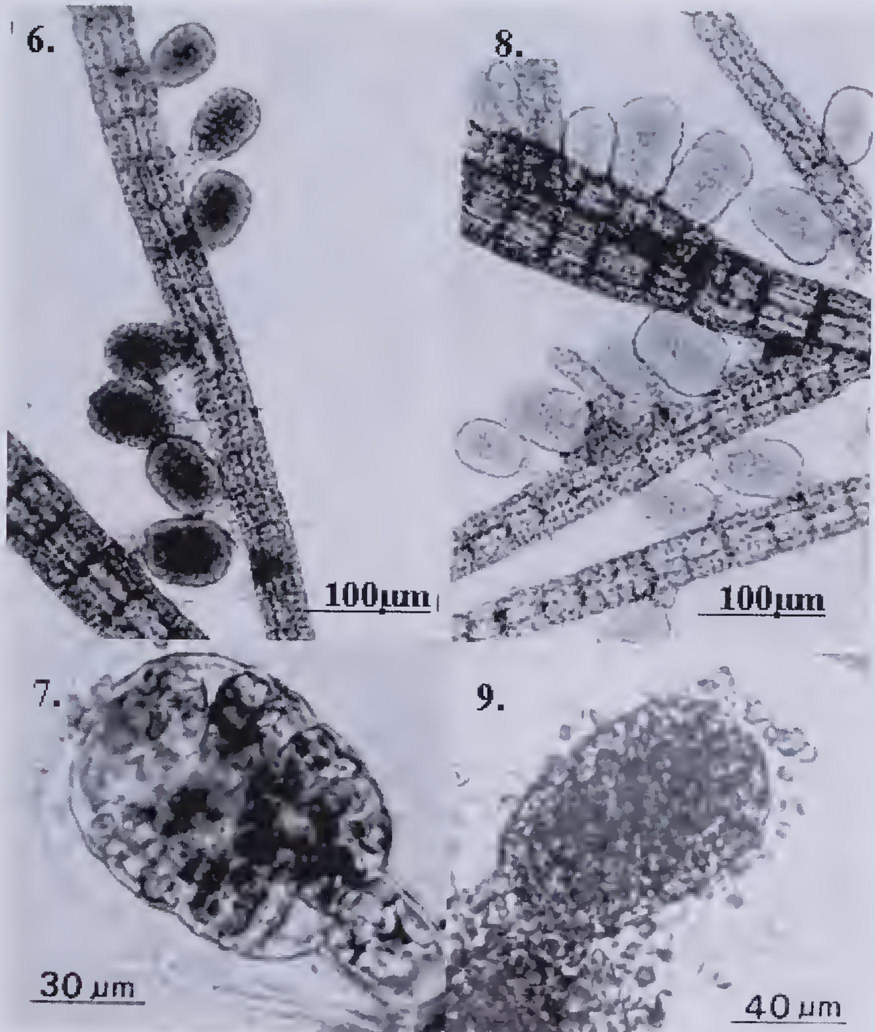
Results

Sexual reproduction

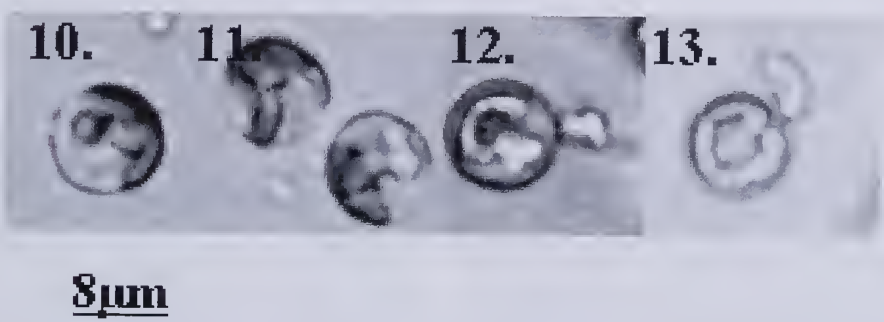
Plants of *Sphacelaria biradiata* from Point Lonsdale bearing unilocular sporangia (Fig. 4) were common throughout the year but most abundant during summer and autumn (Fig. 5). Plants bearing plurilocular structures also occurred throughout this period but were more common during winter and spring although they did not occur in very high numbers. Both plurilocular and unilocular structures were occasionally found on what appeared to be the same plant but were never found on the same filament. Plants having unilocular and/or plurilocular structures commonly also had propagules but, generally, fewer than plants without unilocular or plurilocular structures. Plants that were not reproductive, that is, without propagules and unilocular or plurilocular structures, were most frequent during winter.

Unilocular and plurilocular structures were borne on single celled pedicels that curved upward (Figs 4, 6-9). They were scattered singly along axes or in rows on either or both sides of axes.

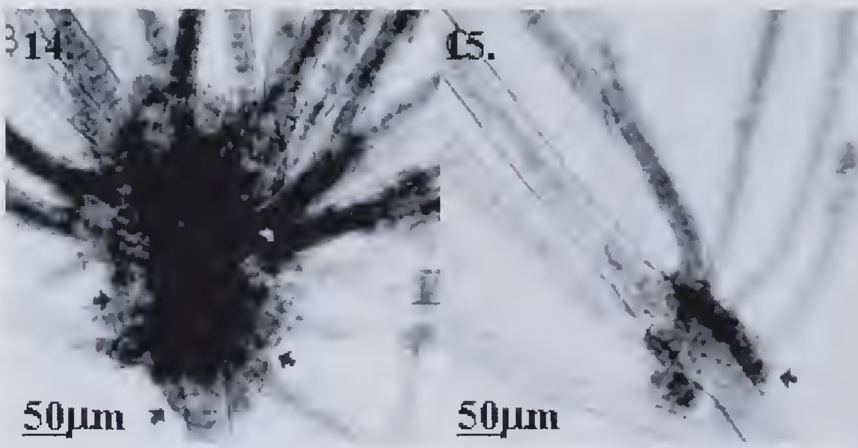
Mature unilocular sporangia were spherical and measured 48-67 µm in diameter. Spore release was observed a number of times on several different occasions. Zoospores



Figs 6 and **7.** *Sphacelaria biradiata* Female gametangia. **Figs 8** and **9.** Male gametangia.



Figs 10 and **11.** Settled female gametes of *Sphacelaria biradiata*. **Figs 12** and **13.** Fertilization of gametes.



Figs 14 and 15. Secondary attachment discs of *Sphacelaria biradiata*.

ranged from 3-10 µm in length, had one chloroplast with an eyespot and two flagella. Some remained motile for up to two hours but the majority settled after a few minutes. Germination did not occur. Plurilocular gametangia were ovoid. Their length ranged from 37-74 µm, width 36-63 µm.

Plurilocular structures proved to be of two types, male and female. Male gametangia were found only twice, on 7/7/1985 and 9/9/1988, at Point Lonsdale. Female (Figs 6 and 7) and male (Figs 8 and 9) gametangia were easily distinguished. Male gametangia had smaller loculi (2.5-6 µm) than female gametangia (5-8 µm in diameter). Male gametes were extremely pale and had one small chloroplast with an eyespot whereas female gametes had one large to several small chloroplasts and one eyespot (occasionally two). Female gametes were pyriform but only 2-6 µm long. Male and female gametangia could occur on one filament or on separate plants.

Fertilization was observed several times on 9/9/1988. Gametes were released through pores present in the outer wall of each locule. The female gametes initially moved rapidly in straight lines but then slowed and moved in ever decreasing circles. As they slowed they rounded up until, finally, they became stationary (Figs 10 and 11). Male gametes were then attracted to them and fertilization occurred (Figs 12 and 13). Germination and subsequent development of zygotes was not followed. Although unfertilized female gametes were frequently isolated and placed into culture, they did not germinate.

Plants grown in culture did not become fertile. Cultured plants did not attach to the culture vessel and as the unattached state was known to adversely affect fertility in some plants (Gibson 1989), the culture experiment was repeated using a variety of substrata in the hope that cultured plants would become attached. The various substrata used included a variety of filter papers of different pore sizes, glass wool, cotton wool, dental wax, beach sand, granite rocks, asbestos cement, coverslips and plastic and glass culture vessels. Attachment of cultured plants did not occur under any circumstances and cultured plants did not become sexually reproductive.

Vegetative reproduction

Propagules were found on the majority of specimens collected from all localities and did not show seasonality (Fig. 5). They were generally produced in the upper regions of plants. Of several thousand propagules isolated and placed into culture, approximately ten germinated. They did not attach to the culture vessels. The propagule arms and/or stem elongated and formed a prostrate or stolon-like system from which erect filaments developed. In shallow dishes, plants developed into large, flat, round mats, but in deeper dishes they formed into round balls, reaching about 10 cm in diameter.

16.

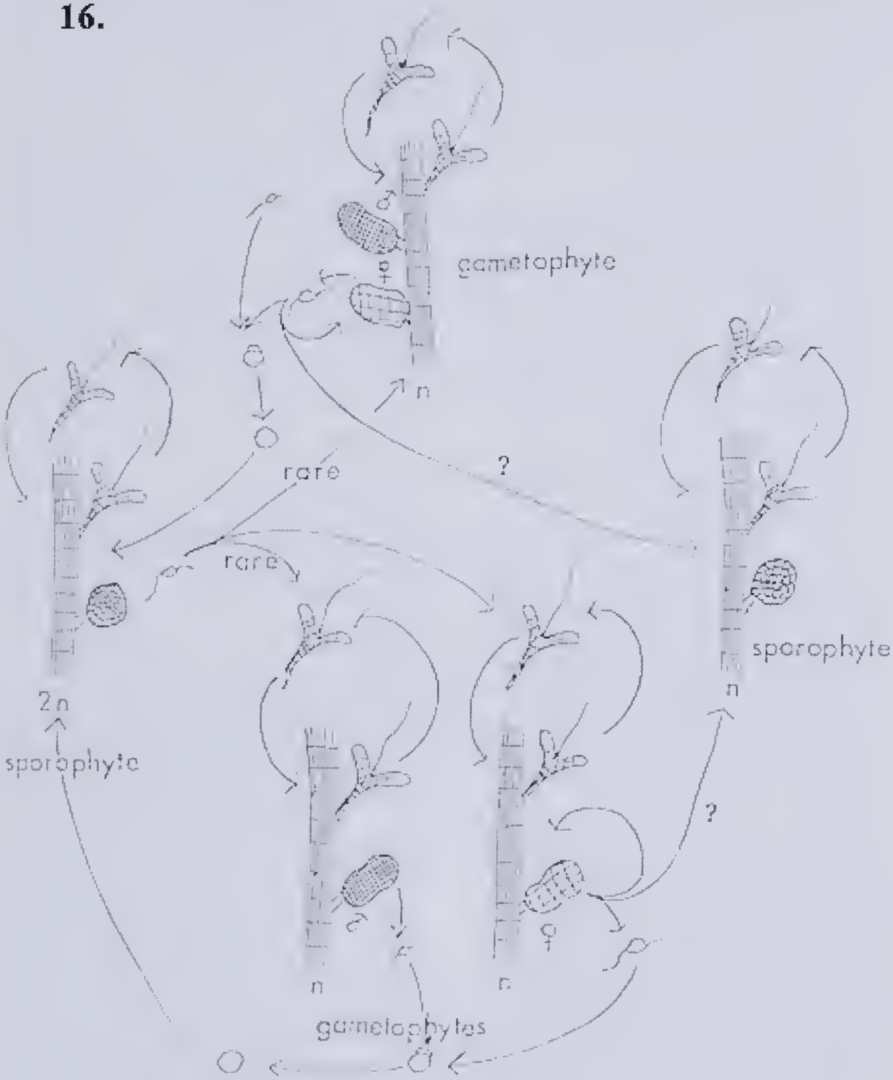


Fig. 16. Possible reproductive cycle of *Sphacelaria biradiata*.

After two to six weeks in culture (depending on the conditions) secondary attachment discs formed (Figs 14 and 15), and often the thallus was a continuous mass of these discs which developed on first, second and even third order laterals. These formed the nucleus of new plants when the thallus deteriorated between discs. Plants never became fertile or produced propagules. Secondary attachment discs were not found on wild plants.

Tips with intact apical cells did not attach to the culture vessels. Elongation commonly occurred from the intact apical cell but a second apical cell or cells would frequently form from the cut end and growth would occur in two directions. After seven days in culture, many erect filaments were produced from the original stem. Plants derived from apical tips formed free floating mats like those derived from propagules and did not develop propagules, sporangia or gametangia.

Discussion

The life history of *Sphacelaria biradiata* is still uncertain. The scarcity of male gametangia suggests that sexual reproduction and, therefore, the alternation of generations is a rare event. Gametophytes presumably develop from viable spores produced from diploid sporophytes but, they may, also, be derived from unfused gametes by parthenogenesis. The rarity of male plants suggests that parthenogenesis may occur in the life history of *S. biradiata*. However, female gametes did not germinate in cultures using various media, substrata, temperatures and daylengths. Parthenogenesis occurred readily in other members of the Sphacelariales (Gibson 1989, 1994; Hoek and Flinterman 1968; Prud'homme van Reine 1982). Also, plants of *S. biradiata* bearing female gametangia were common, although not numerous, in all localities examined in this study and release of gametes was achieved easily and gametes were active.

Plants bearing unilocular sporangia are typically diploid but haploid sporophytes are known in the Sphacelariales. In *Sphacelaria rigidula*, unfertilized female gametes developed into either haploid gametophytes, as would be expected from parthenogenesis, or haploid sporophytes (Gibson 1989, Hoek and Flinterman 1968). Haploid gametophytes produced viable gametes but the haploid sporophytes, which were morphologically identical to the normal diploid sporophytes, produced unilocular sporangia with infertile spores. Considering the number of wild plants of *S. biradiata* with unilocular sporangia in summer and autumn, more gametophytes would be expected in winter and spring, but gametophyte populations only ever reached half the size of sporophyte populations. This suggests the possible presence of haploid sporophytes with unilocular sporangia containing inviable spores, as occurs in *S. rigidula* (Gibson 1989).

Each generation produced propagules and, therefore, can vegetatively reproduce its own generation. However, few propagules germinated in culture. This also was noted by Prud'homme van Reine (1982) for *S. rigidula*. Germination of propagules in the field was not observed but this is not surprising considering their small size.

Askenasy (1894) and Womersley (1967, 1987) described plants with only one type of plurilocular organ. This study has demonstrated that two types of gametangia occur, those with small (male) and large (female) loculi, and also that plants may be monoecious or dioecious. Fusion of gametes, observed for the first time, confirmed the sexual character of the gametes. A possible reproductive history is given in Fig. 16.

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Diet of Carp (*Cyprinus carpio* L.) Larvae and its Influence on Plankton in the Lakes of Western Victoria

Tariq A Khan[1], Michael E Wilson[1] and Minal T Khan[1]

Abstract

Diets of larval carp *Cyprinus carpio* L. were analysed at weekly intervals from two western Victorian lakes (Lake Colac and Lake Modewarre) over two consecutive seasons (1999-2000 and 2000-2001) using numerical method of gut contents analysis. Carp larvae <2 cm in total length fed exclusively on microcrustacea (Cladocera and Copepoda). At a mean total length of >2 cm carp larvae shifted their diet to include benthic food resources but microcrustacea still dominated the larval diet. A decline in zooplankton abundance especially Cladocera (*Daphnia carinata*) was observed in Lake Modewarre between November-March for the two consecutive years (1999-2000 and 2000-2001). This decline in *Daphnia* abundance in Lake Modewarre coincided with high algal biomass (chlorophyll *a* concentration ~25 μg/L) and high abundance of carp larvae following carp spawning. No such clear pattern was observed in Lake Colac but the evidence from Lake Modewarre increases speculation of a carp-mediated 'top-down' trophic cascade. (*The Victorian Naturalist* **120** (5), 2003, 179-186)

Introduction

Exotic Carp *Cyprinus carpio* Linnaeus has been in Australia for over one hundred years. Carp is assumed to cause most detrimental impacts on Australian aquatic ecosystems including causing algal blooms (Gehrke and Harris 1994; Khan *et al.* 2003). However, the evidence is weak (Koehn *et al.* 2000). Carp can cause algal blooms through the excretion of large amounts of nutrients and resuspension of nutrient rich sediments in the water column, leading to damage to the aquatic vegetation which competes with phytoplankton for nutrients and light. Direct predation by carp on zooplankton decreases the amount of zooplankton grazing on phytoplankton (Lamarra 1975; Crivelli 1983; Lougheed *et al.* 1998; Lougheed and Chow-Fraser 2001; Angeler *et al.* 2002; Khan *et al.* 2003).

'Top-down' trophic cascade theory predicts that a reduction in the biomass of planktivorous fish in a lake increases zooplankton biomass and their grazing pressure consequently decreases phytoplankton biomass (Carpenter *et al.* 1985). This ability of fish to regulate zooplankton populations has been used in attempts to control algal blooms in northern hemisphere lakes through 'top-down' biomanipulation (Shapiro and Wright 1984; Jeppesen *et al.* 1990; Søndergaard *et al.* 1990; Horppila *et al.* 1998; Meijer *et al.* 1999).

No studies have investigated the role of carp in causing trophic cascades in Australia (but see Khan *et al.* 2003). Juvenile carp are planktivorous and are efficient predators of zooplankton (Hume *et al.* 1983; Khan *et al.* 2002; Khan 2003a). Similarly, larvae of many native Australian freshwater fish tend to feed on zooplankton, and switch to other prey as they grow older (Koehn and O'Connor 1990). Gehrke and Harris (1994) state that none of the studies they reviewed indicated significant predatory impact of native fish on zooplankton communities in Australia and they concluded that although no research has been done in turbid Australian systems, it is possible that carp could cause algal blooms more so than any other species in Australian freshwaters because they are relatively abundant. However, in Australia little has been studied on the 'top-down' trophic cascade theory and the results appear debatable (Matveev *et al.* 1994 vs Boon *et al.* 1994).

In Australia, despite studies on the diet of juvenile and older carp (Hall 1981; Hume *et al.* 1983) little is known about the food of carp larvae. The only published study on the diet of carp larvae in Australia under natural conditions is that of Vilizzi (1998) which reported that planktivory was the feeding mode of carp larvae at all developmental stages. Juvenile and larval carp in Australia have been reported to feed largely on microcrustacea (Hall 1981; Hume *et al.* 1983; Vilizzi 1998; Khan *et al.* 2002; Khan 2003a). This is important because a high abundance of juvenile and

[1] Centre for Environmental Management, University of Ballarat, P O Box 663, Ballarat, Victoria 3353

larval carp, particularly after carp spawning, could have a strong effect on the zooplankton abundance and may cause a sudden decline in their abundance, which could subsequently cause 'top-down' trophic cascades. The aim of this investigation was to understand the diet of carp larvae and identify the size at which carp larvae shift their diet from planktivory to benthivory. This study also determined the influence of larval diet on the zooplankton community and the role of larval carp in initiating a 'top-down' trophic cascade in the lakes.

Methods

The study lakes were Lake Colac and Lake Modewarre, located on the Volcanic plains of south-west Victoria approximately 150 km west-south-west of Melbourne. The two lakes are permanent, relatively large (surface area 29.6 and 5.35 km^2), shallow (mean depth 1.9 and 3.9 m) and slightly saline (3 and 8‰) for Lakes Colac and Modewarre respectively. The climate of the region is temperate with warm dry summers and cool wet winters (Williams 1981). Land in the vicinity of the lakes has been largely cleared for pasture and broad acre cropping. The lakes have a high recreational value and support both amateur and commercial fisheries.

Carp larvae were collected at approximately weekly intervals throughout the carp-spawning season over two consecutive seasons from the two lakes. The spawning season was from October-January in 1999-2000 and 2000-2001. Carp larvae were collected using glass eel nets with a mesh size of 5 mm. The total length of each carp larva collected was measured to the nearest mm. At each sampling event carp larvae were dissected and the whole gut preserved in a plastic jar in 80% alcohol. The number of guts analysed at each weekly sampling interval varied from a minimum of 6 to a maximum of 34 in Lake Colac and from a minimum of 14 to a maximum of 31 in Lake Modewarre. To evaluate the relative importance of various food items, Hyslop's (1980) numerical method of gut content analysis was employed. Numerical method of gut content analysis provided reliable estimates and did not lead to any bias towards any food category because the majority of the food items consumed by larvae were uniform in size (plankton). Percentage composition was used to provide an indication of the proportion of each food type in the diet. Examination of the contents of the entire gut was undertaken. Empty and fully digested guts were rejected.

In the laboratory, gut contents were stripped into a petri dish and all the dominant food categories visible under a dissecting microscope were sorted, species identified (Williams 1980; Shiel 1995; Ingram *et al.* 1997), counted and total number of each prey item in all the guts at each sampling event recorded. However, carp larvae largely fed on small prey (Cladocera and Copepoda) and their guts often contained such high numbers that counting all numbers directly was impractical. Under these circumstances, sub-sampling was necessary. A known volume of sample (1 ml) was transferred to a Sedgwick Rafter counting cell and counting under an Olympus inverted microscope at a magnification of ×100. The total number of small prey was estimated by multiplying the numbers in the sub sample (1 ml) by sample volume divided by sub sample volume.

Phytoplankton biomass in the study lakes was determined by measuring the concentration of chlorophyll *a* at bi-monthly intervals between November 1999-September 2001. Water samples for this were collected from four sites in each lake using an integrated water sampler, collecting samples from surface to a depth of one metre. A spectrophotometric method of chlorophyll *a* determination was used as outlined in APHA (1989). Pheophytin corrections were made by acidifying the sample with 0.1 M HCl and reading the absorbance at 665 and 750 nm. The corrected values were used to calculate chlorophyll *a*.

Zooplankton samples were collected using an integrated water sampler as above. Triplicate samples were collected at four sites in each lake. Each triplicate comprised five litres of sample, filtered through a mesh of 80 μm. Samples were preserved by adding 90% alcohol (APHA 1989). The zooplankton enumeration involved mixing the sample, taking an aliquot and transferring the aliquot into an open 5 cm² glass counting tray and counting at a magnification of ×100. The results of each replicate were then averaged, and zooplankton per litre calculated for each site and later for the whole lake along with standard errors.

Results

Based on information of carp hatching time and growth rates, carp spawning was assumed to begin in the month prior to the appearance of 1.1 cm larvae in the nets. In 1999-2000, carp larvae were observed in both lakes in November and spawning was assumed to have begun in October, but in 2000-2001 carp spawning was earlier and larvae were seen in the lakes in late October 2000 (Figs 1 and 2).

Very small carp larvae (<2 cm) fed almost exclusively on Cladocera (*Daphnia carinata*) which constituted 85-100% of the diet of carp larvae in both lakes in two years (Figs 1 and 2). The other food items consumed by carp of this length were Copepoda (*Boeckella triarticulata* and *Mesocyclops leuckarti*) and Amphipoda (*Austrochiltonia subtenuis*) though their proportion in the gut was low.

Gut analysis of carp larvae showed that a dietary shift from microcrustacea to increasing proportions of benthic macroinvertebrates occurred at different mean total lengths in the two lakes. In Lake Colac the shift occurred at 2.4-2.5 cm in both years whereas in Lake Modewarre the shift occurred at 4.1 cm in 1999-2000 but at 2.3 cm in 2000-2001. When carp larvae shifted

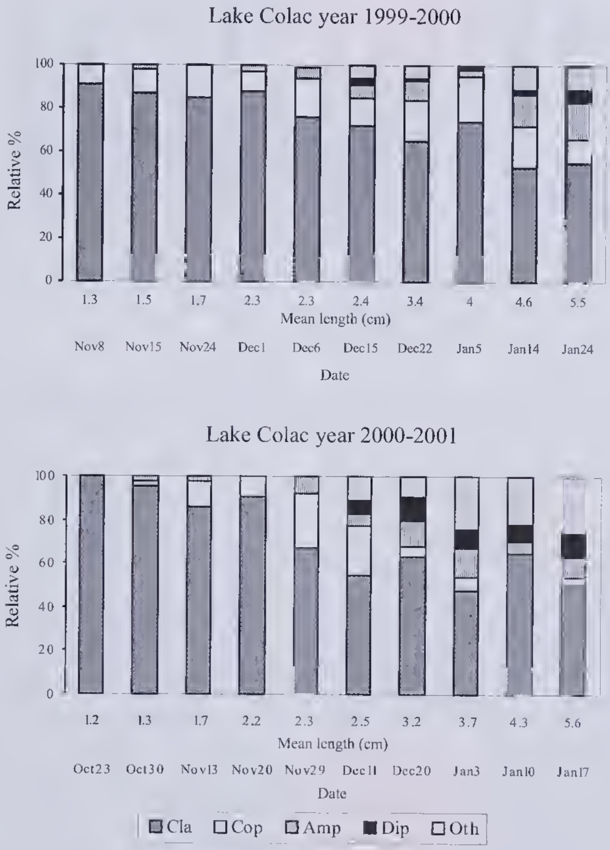

Fig. 1. Mean percent numerical abundance of important food items recorded in guts of carp larvae in Lake Colac for the year 1999-2000 and 2000-2001. Cla = Cladocera, Cop = Copepoda, Amp = Amphipoda, Dip = Diptera and Oth = others, and refers to Ostracoda, Gastropoda, Hemiptera, Oligochaeta and Trichoptera.

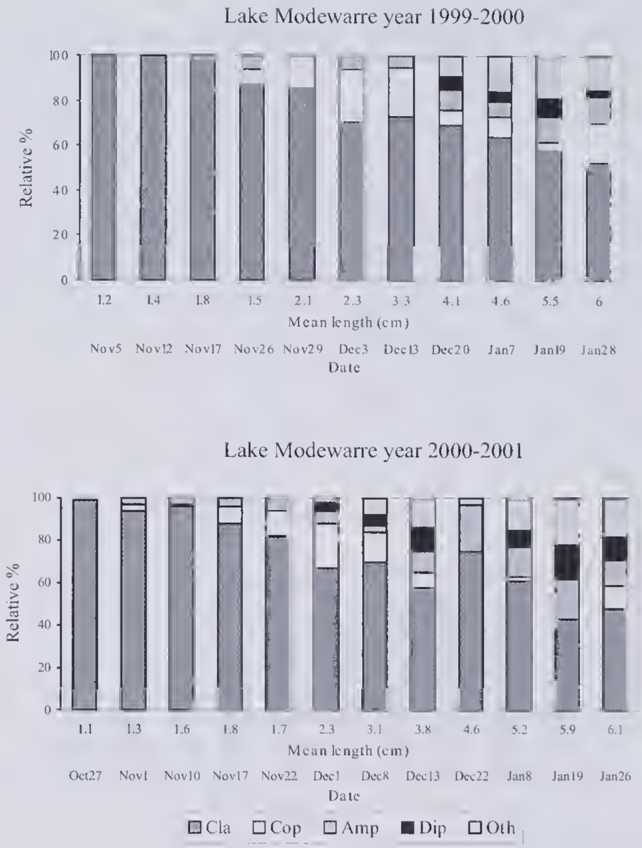

Fig. 2. Mean percent numerical abundance of important food items recorded in guts of carp larvae in Lake Modewarre for the year 1999-2000 and 2000-2001. Abbreviations as in Fig. 1.

their diet they included benthic food resources such as Diptera (*Chironomus australis* and *C. duplex*) and Oligochaeta (*Antipodrilus* sp.). Carp larvae also started feeding on swimming insects such as Hemiptera (*Micronecta* sp. and *Sigara* sp.). As carp larvae grew, they fed on an increasing variety of food items such as Ostracoda (*Cypricercus* sp., *Mytilocypris* sp. and *Ilyocypris* sp.), Gastropoda (*Coxiella* sp. and *Physa* sp.) and Trichoptera (*Alloecella* sp. and *Triplectides* sp.). However, Cladocera remained the dominant component (50-70%) of the diet of carp at a mean length of 5-6 cm (Figs 1 and 2).

The average concentration of chlorophyll *a* was 15 and 16 µg/L for Lakes Colac and Modewarre respectively. The chlorophyll *a* concentrations in the lakes ranged from a minimum of 6 µg/L to a maximum of 30 µg/L. The maximum values of chlorophyll *a* for both the lakes were recorded in the month of March (Figs. 3 and 4). There was a distinct seasonal pattern in the concentration of chlorophyll *a* in Lake Modewarre. During late summer and early autumn (January-March) chlorophyll *a* concentration was high (~25 µg/L) and was low (~8 µg/L) during winter (May-September). This trend was similar in 1999-2000 in Lake Colac but weak in 2000-2001.

The zooplankton population structure showed strong seasonal variation. The abundance of zooplankton also varied during the study, with ranges of 86-368 and 49-163 numbers per litre (N/L) for Lakes Colac

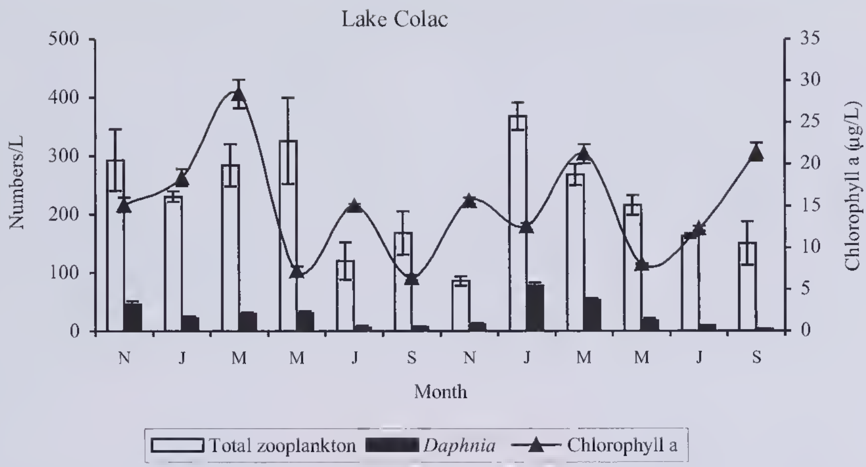

Fig. 3. Total zooplankton and *Daphnia* abundance (N/L ± SE), and chlorophyll *a* concentration in Lake Colac between November 1999-September 2001. Arrows indicate months with high relative abundance of carp larvae.

and Modewarre respectively. Zooplankton numbers, especially Cladocera, were slightly higher in summer (November-March) than the rest of the year for Lake Colac (Fig. 3). However, a contrasting trend was observed in Lake Modewarre where zooplankton numbers, including *Daphnia*, were slightly lower in summer (November-March) than the rest of the year (Fig. 4).

Discussion

Microcrustacea were the most important food items in the diet of carp larvae in accord with other Australian studies on the diet of juvenile and larval carp (Hall 1981; Hume *et al.* 1983; Vilizzi 1998; Khan *et al.* 2002; Khan 2003a). Hall (1981) found zooplankton formed a large proportion of the diet of small carp. Hume *et al.* (1983) found microcrustacea to be the only food items eaten by carp of 1.5-2.5 cm standard length. Similarly, Vilizzi (1998) showed that microcrustacea formed 100% of the diet of larval carp up to a mean standard length of 1.5 cm. Overseas studies have also reported that the young carp feed predominantly on microcrustacea (Vass and Vass Van Oven 1959; Lammens and Hoogenboezem 1991; Gophen *et al.* 1998).

In the present study, carp larvae (<2 cm) fed almost exclusively on Cladocera. Vass and Vass Van Oven (1959) recorded that from commencement of feeding to a length of 13 cm carp larvae in Indonesian carp ponds fed on Copepoda, Cladocera and Ostracoda and these formed the most important food items. In the present study, when carp larvae reached lengths >2 cm, they shifted their diet to include benthic food resources. Adzhimuradov (1972) stated that carp larvae become capable of probing the bottom and cited studies where benthivory was observed as early as 4-5 days post hatch. The presence of sand in the digestive tract of carp larvae in the present study was an indication that a bottom feeding behaviour had been acquired. Vass and Vass Van Oven (1959) showed that chironomid larvae were ingested by carp larvae even from the very first day of feeding and remained one of the most important food items. Other aquatic insects and their larvae were eaten in increasing numbers as the larvae grew.

The present study has shown that larval carp feed predominantly on microcrustacea. Thus there is a possibility of carp causing 'top-down' trophic-cascades in the lakes which could subsequently cause algal blooms. In addition, carp were further implicated in causing algal blooms in Lake Modewarre when there was a coincidence in high numbers of carp larvae, low zooplankton and *Daphnia* density and algal blooms in summer. There were no estimates of density of carp larvae in the two

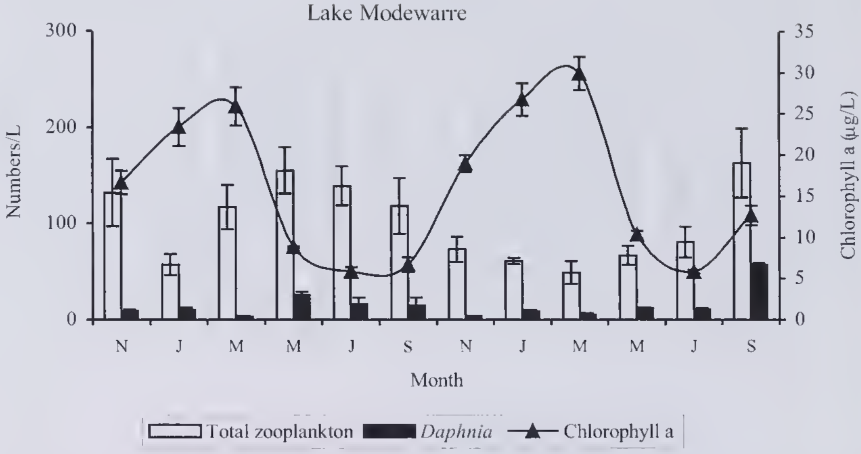

Fig. 4. Total zooplankton and *Daphnia* abundance (N/L ± SE), and chlorophyll *a* concentration in Lake Modewarre between November 1999-September 2001. Arrows indicate months with high relative abundance of carp larvae.

lakes but the catch per unit effort of larval carp was relatively more than any other species in the two lakes (Khan 2003b). It was hypothesised that carp were enhancing the algal blooms in this lake through a 'top-down' trophic cascade, especially as nutrients appeared non-limiting and low zooplankton density would not be expected in summer in the absence of a planktivore.

Chlorophyll *a* concentration increased through summer and remained high in the early autumn and then tended to decrease in winter with fluctuations through to late spring. Grazing pressure from zooplankton may cause a decline in phytoplankton abundance as reflected in low chlorophyll *a* concentration (Gehrke and Harris 1994). The relationship between chlorophyll *a* concentration and zooplankton density was weak in Lake Colac suggesting that the decline in phytoplankton was not due to zooplankton grazing in this lake. However, in Lake Modewarre, high zooplankton numbers were recorded between May-September, which coincided with low algal biomass. Low zooplankton numbers were recorded between November-March, which coincided with high algal biomass. Separating the relative roles of light and temperature from zooplankton grazing is thus difficult in this lake.

Separating the relative importance of controlling factors for zooplankton abundance was not an aim of the present study but a few observations can be made. A potential cause for the observed summer decline in *Daphnia carinata* in Lake Modewarre was predation by either invertebrates or vertebrates. In the absence of fish, invertebrate predators may reduce the abundance of *Daphnia* in the littoral zone. Among the vertebrate predators, larval carp was the most abundant fish in Lake Modewarre during summer, and it consumed *D. carinata*. Small carp can substantially alter zooplankton community structure by reducing the abundance of large bodied cladocerans (Gehrke and Harris 1994; Khan *et al.* 2003). The low density of *D. carinata* in Lake Modewarre in the summer of both the years coincided with carp spawning and potentially intense predatory pressure by small carp.

However, this pattern of a decline in *Daphnia* abundance in summer when larval carp were abundant was not observed in Lake Colac. It is possible that either total carp predation pressure on zooplankton is less or that zooplankton escape predation through vertical or horizontal migration (Lauridsen and Lodge 1996). There are no estimates of the density of carp larvae in the two lakes, but Lake Colac is a much larger water body. Lake Colac would need to carry a much larger larval carp population to have the same predation pressure on zooplankton as Lake Modewarre. In addition, visual predators such as fish are affected by turbidity and studies have suggested that *D. carinata* is able to persist in the presence of fish if turbidity is high (Geddes 1984). In the present study, secchi depth was low in Lake Colac (7-25 cm; Khan 2003b). In contrast, Lake Modewarre had a high secchi depth (48-80 cm), this higher transparency may have made large bodied *Daphnia* more vulnerable to fish predation.

The role of carp in enhancing algal blooms, either through 'top-down' trophic cascade or 'bottom-up' nutrient recycling has not been tested in Australia. Since carp have a widespread distribution throughout south-east Australia and their abundance is high in most waterways, there is an imperative to identify their role in algal blooms. Even if 'bottom-up' processes are considered the primary cause of the increasing incidence of algal blooms (Gehrke and Harris 1994), a small risk of carp mediated 'top-down' impacts is magnified by the extent of carp invasion. In addition, the role of carp in 'bottom-up' processes in Australia is itself poorly understood, but is considered to be significant (Gehrke and Harris 1994). Research on the effects of carp should aim to identify the mechanisms responsible for changes in the status of such system parameters.

If carp have a role in enhancing algal blooms in these lakes, then managing them has two-fold benefits. Their reduction or elimination could avoid their direct impacts on lake environment and secondly, could lead to reduced algal blooms in these lakes. The latter has implications for economic and recreational water usage. For example, the consistent presence of algal blooms in Lake Modewarre has resulted in restrictions being placed on water usage from the lake and recreational use of the lake over the past few years (LMAC 1997). Future research should focus on determining whether carp can be conclusively implicated in causing algal blooms and whether carp biomanipulation is a useful tool in the management of algal blooms in Australian waters.

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Editorial Changes

Congratulations to Dr Alistair Evans whose PhD thesis, *Functional Dental Morphology of Insectiverous Microchiropterans*, has been accepted.

The October 2003 issue of *The Victorian Naturalist* is the last for which Alistair Evans and Merilyn Grey will be part of the editorial team. Al and his wife Gudrun (who many of you will know from the Fungimap mapping project) are off to Helsinki, Finland for a year, where Al will pursue postdoctoral studies. Merilyn has resigned as executive editor in order to complete her studies on the Noisy Miner.

Anne Morton remains as editor, along with Virgil Hubregtse as assistant editor in charge of proof-reading. Two new editors, Gary Presland and Dr Maria Gibson have been recruited. Gary is a PhD student in the History and Philosophy of Science Department at the University of Melbourne and is researching the natural history of Melbourne. Maria is a Senior Lecturer in the school of Biological and Chemical Sciences at Deakin University, where she specialises in plant biology and ecology. We welcome them both to the team.

Thank you to the editorial committee and the authors, referees and proof-readers who have contributed to *The Vic Nat* during our time as editors. The most enjoyable part of the job has been communicating with you. Thank you especially to Steve Kitto from BPA Print Group (the journal's printers) who has never wavered in his support of the journal and its editors.

It has been a pleasure to be part of the editorial team of *The Victorian Naturalist*. We wish Gary and Maria all the best and hope that they enjoy it at least half as much as we have.

Merilyn Grey and Alistair Evans

The Rufous Bristlebird: Defining the Eastern Limit of its Range

John Peter[1]

Abstract

Most published records of the Otway subspecies of the Rufous Bristlebird *Dasyornis broadbenti caryochrous* suggest that it occurs only as far east as Point Addis, or sometimes Bell's Beach, both south-west of Torquay, Victoria. This paper documents several recent records from farther north-east along the Victorian coast, around the vegetated margins of Half Moon Bay, Jan Juc, and describes the habitats used at each of these sites. The value of revegetating degraded areas is also discussed.
(*The Victorian Naturalist*, **120** (5), 2003, 187-191)

Introduction

The subspecies of the Rufous Bristlebird *Dasyornis broadbenti* which occurs in the Otway Basin in southern Victoria, subspecies *caryochrous*, is classified as Vulnerable (Garnett and Crowley 2000). Though the species' overall range is considered to be stable, the distribution within that range is becoming increasingly fragmented both by residential development around coastal resort towns and the slashing, clearing and controlled burning of heathland and coastal scrub, both favoured habitats, for the prevention and mitigation of bushfires (Reilly 1991a; Garnett 1993; Peter 1999; Garnett and Crowley 2000). The western Australian subspecies, *D.b. litoralis*, which occurred in coastal scrubby habitats similar to those inhabited by *D.b. caryochrous*, is thought to have become extinct because of too-frequent burning of its habitat (Carter 1924).

Though not always applicable, one method of determining the robustness of a population is to examine the boundaries of its range. Once these have been established with a reasonable degree of accuracy, the shifting of such boundaries sometimes reflects changes in the vigour of that population, and can be used as a key indicator in determining the population's status: contraction of the known range of a species is probably an indication that the population is in decline.

Distribution: How far east?

Historical records of Rufous Bristlebird, from the early part of the 20th century up to the mid-1960s (e.g. Campbell 1908; Favaloro 1931; Somerset 1965) were almost invariably from no farther east than around Point Addis (38° 23'S, 144° 15'E) and the hinterland of the nearby Addiscott Beach, approximately 10 km south-west of Torquay. This, however, is possibly an artefact of limited access to potentially suitable sites farther north-east: the species probably always occurred farther north-east along the coast, but passage through dense, tangled clifftop vegetation ensured that access for observers was extremely difficult. The first record from Bell's Beach, 6 km south-west of Torquay, was not published until 1983 (Pescott 1983), though the record itself was made some time before 1975 (Trevor Pescott, pers. comm.). These days, Bristlebirds are regularly recorded around Bell's Beach (38° 22'S, 144° 16'E) and the adjacent point known locally as 'Winkipop' (e.g. Hewish 1997; pers. obs.), though it is unclear whether this is a recent phenomenon or whether they were always present there. Bell's Beach was 'discovered' by local identities Peter Troy, Owen Yateman and George Smith in 1953, and a rough track was bulldozed through to the beach in 1958, but a sealed road, providing general access, was not built until 1966 (Wynd 1992). Therefore, it seems reasonable to assume that the lack of general access to this site ensured that little birdwatching was done there before the mid-1960s. There is, however, a historical record that clearly states that the species occurred farther north-east: in the early 1900s, Belcher (1914) recorded a Rufous Bristlebird in 'a patch of scrub about two miles [3.2 km] south-west of Torquay', which is approximately 1 km north-east of Bell's Beach (this site was originally referred to as being west of Torquay

[1] Birds Australia, 415 Riversdale Road, East Hawthorn, Victoria 3123

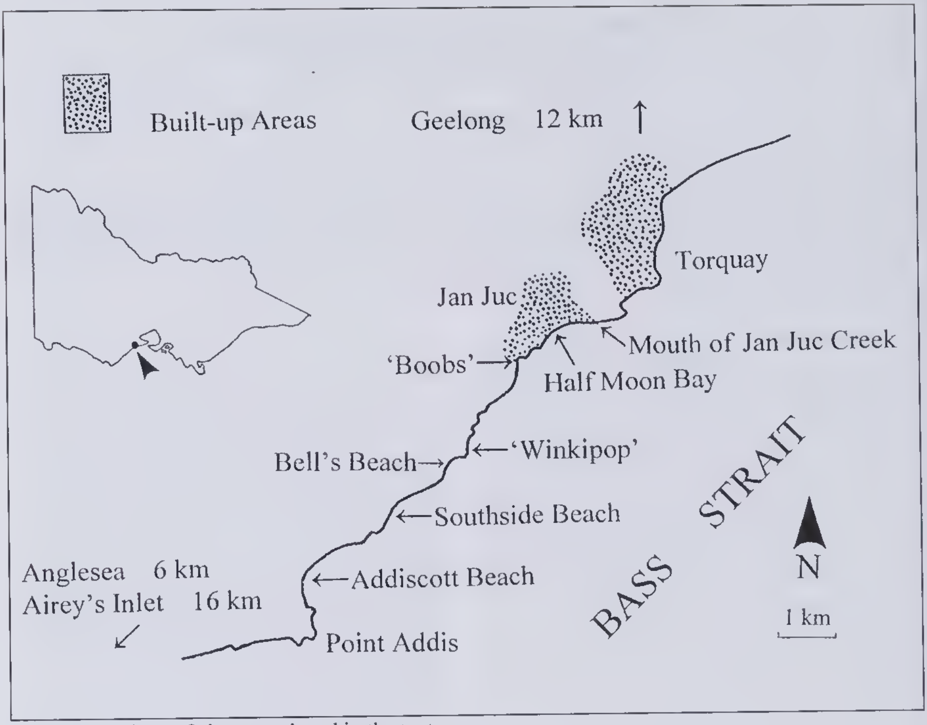

Fig. 1. Locations of sites mentioned in the text.

[Belcher 1913], but was subsequently corrected); since the mid-1990s, Bristlebirds have regularly been heard calling from an area of coastal scrub roughly half-way between Torquay and Bell's Beach (on the clifftop above the popular surfing area known locally as 'Boobs' [38° 21' 25"S, 144° 17' 36"E]) that closely coincides with Belcher's decription of this site; up to three birds can be heard calling there (pers. obs.; Ian Edwards, pers. comm.; Geoff Morgan, pers. comm.). These temporally disjunct records suggest that, on a broad scale, the limit of the species' range appears to have remained relatively constant, but some fluctuation on a more local scale is also reflected, with a period of 90 years or so when there were no records from around 'Boobs'. Notwithstanding this long period of apparent absence, this site appears to have been the easternmost extremity of the distribution of the Rufous Bristlebird, both in the early and late 20th century.

There are, however, several published reports of the Rufous Bristlebird from farther east, including Gippsland, but all are either unconfirmed, doubtful or erroneous; see Peter (1999) for discussion of these eastern reports.

Records from the lower reaches of Jan Juc Creek

I have previously published a record of a Rufous Bristlebird farther east, at Jan Juc (38° 20' 48"S, 144° 18' 27"E) (Peter 1999), but this was treated as a 'one-off' or accidental occurrence; however, subsequent records of the species in the same area indicate that Bristlebirds occur there more often and more regularly than previously thought.

1. January 1997. The first published record was of a Bristlebird that I heard calling (a loud, characteristic song, which I have rendered as *see-saw, see-saw, see-saw, see-o-wee*) from a large thicket (hereafter referred to as 'Thicket 1') at the edge of a residential area, near the southern boundary of the Torquay golf course, around the lower reaches of Jan Juc Creek (c. 1.5 km north-east of 'Boobs'). This thicket is situated between a house and a

road with a busy car park, and varies in height from 1.5–4 m tall. It consists mostly of Coast Wattle *Acacia sophorae* and Coast Beard-heath *Leucopogon parviflorus*, mixed with some Coast Tea-tree *Leptospermum laevigatum* in varying proportions. There is clear space for about 30 cm above the ground. The projective foliage cover (the proportion of the ground that would be shaded by the foliage if lit from directly above) of the vegetation in this thicket is 80% (Peter 1999). I subsequently heard a Bristlebird calling vigorously from this thicket on 28 January 2002.

2. 26 March 1999. A Bristlebird was heard calling from low, densely vegetated sand-dunes near the Jan Juc Surf Life Saving Club, about 100 m north-east of 'Thicket 1' (pers. obs.). The dunes are about 150 m long, and are situated at the mouth of Jan Juc Creek, in a gap in the cliffs of Half Moon Bay. The vegetation is mostly low, dense coastal scrub, reaching up to about 3 m tall in the swale, but quite stunted and prostrate, and less than 30 cm tall on the crest of the fore-dune. It is dominated by Coast Wattle, and has a large patch of Coast Tea-tree, with scattered Coast Beard-heath around the edges and a few scattered Common Rice Flower *Pimelea humilis*. The overall projective foliage cover is 80–90%. There is quite a diverse ground-cover, comprising mainly Marram Grass *Ammophila arenaria*, tussocks of Knobby Club-rush *Isolepis nodosa*, Cushion Bush *Leucophyta brownii*, Karkalla *Carpobrotus rossii* and Hairy Spinifex *Spinifex sericeus*, all of which proliferate in areas not vegetated by taller shrubs. There is much tangled, dead monocotyledonous vegetation below the shrubs; this patch of coastal vegetation, therefore, appears to be sub-optimal habitat, as although the shrubs provide a high level of foliage cover overhead, there is little open space in the area about 30 cm above the ground below the shrubs (preferred habitats have low dense [>60% projective foliage cover] overstorey and sparse or no undergrowth, forming an open area up to 1 m above the ground; see Peter 1999).

In addition, since 2000, a pair has been regularly recorded in a residential garden, c. 150 m south-west of 'Thicket 1', and was thought to have bred there in 2001, as Bristlebirds were seen carrying food (Ian Edwards, pers. comm.). This garden adjoins a patch of coastal scrub which is linked with 'Thicket 1' by a narrow linear strip of low coastal vegetation that has been progressively replanted since about 1996. This strip was previously a gravel road that had become overgrown with environmental weeds, especially Coast Wattle, Coast Tea-tree, New Zealand Mirror-bush *Coprosma repens* and Boneseed *Chrysanthemoides monilifera* (Ian Edwards, pers. comm.), all of which were removed before the area was planted with a diverse range of indigenous shrubs, though predominantly Moonah *Melaleuca lanceolata*, Coast Pomaderris *Pomaderris paniculosa*, Coast Beard-heath and Drooping Sheoke *Allocasuarina verticillata*. The vegetation is up to 2.5 m tall, and the projective foliage cover in this corridor varies greatly; in some thickets, it exceeds 80%, but other areas are much more open, lack a shrub layer, and are vegetated with sword-sedge *Lepidosperma*, sedges *Ghania* and tussocks of grasses. Bristlebirds can be clearly heard calling as they move along this corridor. The garden itself, on the landward side of the corridor, is relatively newly-planted and comprises over 50 species of trees, shrubs and ground-covers that are locally indigenous. As the garden is in an embryonic stage, its structure is still rather low and open, though some shrubs, situated at the end nearest to the corridor, are denser and more prolific than in the remainder of the garden. Adjacent to the garden, on the other (seaward) side of the corridor, there is an extensive patch of extremely dense low (generally <1.5 m tall) scrub which consists almost exclusively of Coast Pomaderris, with a few scattered Moonah and Coast Beard-heath shrubs. Bristlebirds occur in all three areas (scrub, corridor, garden); when in the garden, they appear to occur mostly among the vegetation nearest the corridor, especially in a dense clump of Seaberry Saltbush *Rhagodia candolleana*, though they have also been seen among tussocks, and even bathing in the open in a shallow water-feature (Ian Edwards, pers. comm.).

Clifftops at Half Moon Bay, Jan Juc

The lower reaches of Jan Juc Creek are separated from extensive tracts of coastal scrub farther south-west by a large, more-or-less continuous belt of scrub along the top of the cliffs bordering Half Moon Bay, Jan Juc. The clifftop vegetation is generally stunted, mostly <1.5 m tall, and varies in its degree of cover; in some places it is particularly dense, but elsewhere it is extremely degraded and eroded, where thickets or individual shrubs are sparsely scattered, with much bare ground, grass or weedy growth separating them. The vegetation consists largely of salt-pruned Moonah or dense banks of salt-pruned Coast Pomaderris, interspersed with, in a few places, some sparsely scattered Common Rice Flower and Coast Beard-heath. In addition, as indicated earlier, many degraded areas have been densely planted out with indigenous species of shrubs and groundcovers. As this planting has occurred in stages since 1987, it has created a mosaic, largely dominated by mature scrub, interspersed with scattered patches of vegetation of varying age, and some open degraded areas. The aim of this revegetation is to link isolated patches of mature vegetation with a continuous corridor (Ian Edwards, pers. comm.; Geoff Morgan, pers. comm.).

In addition to the records around the lower reaches of Jan Juc Creek, Rufous Bristlebirds have been recorded along these clifftops. On 6 September 1998 a Bristlebird was heard calling from the clifftop near Bird Rock, at south-western end of Half Moon Bay (pers. obs.). It was heard from the beach, c. 100 m below, so it was impossible to pinpoint the exact location of the bird. Subsequent examination of the clifftop revealed that in the general area where the Bristlebird was calling from there were sections of dense scrub and open degraded areas with no shrubs, and heavily infested with invasive weeds. It would seem unlikely that it was present in the open weedy area, but, as this section separates patches of coastal scrub, Bristlebirds must have passed through this area to reach the sites around the mouth of Jan Juc Creek. Even though Bristlebirds occasionally cross open areas, such as roads (Higgins and Peter 2002), they are known to be reluctant to traverse extensive open areas between habitable patches of vegetation (see below).

Discussion

The presence of Rufous Bristlebirds at a site is usually betrayed by their distinctive strident call (e.g. Wilson *et al.* 2001; Higgins and Peter 2002). At various locations in the eastern part of the species' range, such as at nearby Point Addis and at Airey's Inlet, Bristlebirds call throughout the year and can be heard calling at any time of day (Peter 1999; Wilson *et al.* 2001). That there had been so few records of calling Bristlebirds round Jan Juc before their apparent establishment nearby in 2000 strongly implies that the species was not usually present there. The occurrence of calling birds there was sporadic, though there was some degree of seasonality, as all records around the lower reaches of Jan Juc Creek were in either January or March, which roughly coincides with the end of the breeding season. This timing raises the possibility that the birds recorded in 1997 and 1999 may have been young ones forced out of their natal territory. The record in January 2002 also fits this pattern, but, as the species had apparently become established in the area by then, it might also have been a member of the breeding pair (whose territory could, theoretically, encompass this area) or some other bird altogether.

As the records detailed above are just a few kilometres north-east of the easternmost published records, they may appear to be of little consequence. However, the species is considered resident or sedentary, with pairs maintaining permanent territories of up to 3 ha (Wilson *et al.* 2001; Higgins and Peter 2002). In addition, the Rufous Bristlebird rarely flies, and its flight is feeble when it does (e.g. Belcher 1914; Du Guesclin *et al.* 1995; Higgins and Peter 2002); thus, Bristlebirds move mainly by running along the ground (with paces that are only a few centimetres long!). This limited power of dispersal brings into perspective the magnitude and potential significance for a small terrestrial species such as this to disperse over a distance of several kilometres.

These records also give a good indication of the importance of revegetation activities. As some of the clifftop vegetation at Half Moon Bay is patchy, with a few large areas of depauperate scrub or open degraded areas, these might usually restrict any potential dispersal by Bristlebirds. This has been illustrated at a site near Port Campbell, where an area of suitable habitat remained uninhabited by Bristlebirds, even though it was separated from an occupied area by only 200 m of open paddocks, with the birds apparently unwilling to traverse the section of inhospitable habitat (Du Guesclin *et al.* 1995). That they have been able to extend into previously uninhabited areas round Jan Juc means that the worth of revegetated areas cannot be underestimated. The value of revegetation to create corridors between blocks of suitable habitat has been further illustrated at Port Campbell, where a disused road reserve was revegetated by seeding it with indigenous species collected from nearby (O'Shea 1993; Du Guesclin *et al.* 1995); Bristlebirds were recorded in this revegetated area 5 years later (Du Guesclin 1998). Another indication that Bristlebirds readily inhabit densely-planted habitats which have been allowed to become established is that the species is often recorded in bushy gardens at Airey's Inlet (Reilly 1991a; Wilson *et al.* 2001). This ability to occur in regenerating habitat has also been illustrated after fire. Following the Ash Wednesday bushfires of 1983, Bristlebirds were not recorded in some burnt areas for 2 years, until after the vegetation had regenerated to such an extent that it provided dense overhead cover and clear space underneath; presumably the burnt areas had been too open for individuals to traverse from nearby unburnt refuges (Reilly 1991a,b, 2000).

Thus, it appears that the vulnerable Victorian population of the Rufous Bristlebird is able to exploit new areas of habitat made available by the revegetation of corridors which were previously unsuitable or degraded. If put into practice, the results of this lesson could have a dramatically positive effect on the welfare of the species in Victoria, the range of which has become severely fragmented in the past.

Acknowledgements
I am especially endebted to Ian Edwards of Jan Juc Coast Action for his enthusiasm in overseeing the revegetation of the coastline between Bell's Beach and Jan Juc, thus making it possible for Bristlebirds to occur in Jan Juc, and his willingness to impart much information on the Bristlebirds in his garden and the implementation and progress of the revegetation. Also, many thanks to Philip Du Guesclin of the Victorian Department of Natural Resources and Environment and Geoff Morgan of Jan Juc Coast Action for providing information of their efforts in revegetation at their prospective ends of the Bristlebird's range. I am also most appreciative of the assistance provided by Trevor Pescott, who helped clear up the timing of the occurrence of Bristlebirds at Bell's Beach. Thanks also to Dr Mike Weston of Birds Australia and Kristine Kerr, as well as two anonymous referees, for their comments on various drafts of this paper.

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An Observation of Possible Carnivory in the Common Brushtail Possum

John Peter[1]

Abstract
The author discusses a case of canivorous behaviour in the Common Brushtail Possum. He reviews the literature on the subject and concludes that such feeding is opportunistic. (*The Victorian Naturalist*, **120** (5), 2003, 192-193)

The Common Brushtail Possum *Trichosurus vulpecula* is often depicted as being strictly herbivorous, eating foliage, buds, flowers and fruits of a wide range of native trees and shrubs, especially eucalypts and acacias, and exotic plants as well as various herbs and grasses (e.g. Fitzgerald 1984; Statham 1984; Menkhorst 1995; Kerle 2001; Menkhorst and Knight 2001). While this is largely the case, there is a growing body of evidence which indicates that at least some individuals are opportunistically omnivorous.

On 25 December 1999, I was conducting a regular spotlighting survey along a road that bisects a depauperate remnant patch of Shining Peppermint *Eucalyptus willisii*-Swamp Gum *E. ovata* woodland, which is surrounded by open farmland, about 2.5 km south of Freshwater Creek, Victoria. At about 21:30 hr I observed a Common Brushtail Possum on the roadside at the carcass of a European Rabbit *Oryctolagus cuniculus*. The possum was on the ground, hunched over the rabbit, and appeared to be eating it, though it was quickly disturbed and fled into the branches of a nearby eucalypt. The rabbit appeared not to have been recently killed, as its eyes were missing, and probably had been struck by a vehicle a night or two earlier. There was a small gash in the rabbit's side which revealed some flesh, but no internal organs were exposed.

Similar foraging behaviour has also been observed on Flinders Island, in Bass Strait, where a Common Brushtail Possum was seen feeding on a road-killed Tasmanian Pademelon *Thylogale billardierii* (Lumsden 1997). However, on that occasion, the possum was thought to have been maintaining a vegetarian diet by consuming the plant material contained within the pademelon's stomach and intestines; in the current instance, it is possible that either the possum was eating the flesh of the rabbit, or it was disturbed before it could gain access to the rabbit's alimentary tract.

Common Brushtail Possums also prey on birds, especially eggs and young (Gilmore 1967; Brown *et al.* 1993; Major *et al.* 1996; Garnett *et al.* 1999; Sadleir 2000). Indeed this is a major concern in the conservation of the endangered subspecies of the Glossy Black Cockatoo *Calyptorhynchus lathami halmaturinus* on Kangaroo Island in South Australia: predation by possums was found to be responsible for most nest failures (Garnett *et al.* 1999; Garnett and Crowley 2000). In New Zealand, where Common Brushtail Possums were first introduced in 1858 (Thomson 1922) and now occur at unnaturally high population densities, they have been recorded feeding opportunistically on meat from various sources, such as nestlings and fledgelings (and eggs) of various species of birds, carcasses of other possums, sheep and deer, dead Black Rats *Rattus rattus* caught in traps, scraps of meat (either raw or cooked) around camps, and whale-meat hung out to dry in trees (Gilmore 1967; Brown *et al.* 1993; Sadleir 2000).

In addition, possums kept in captivity will readily accept meat (Murray 1977; Cowan 1990; How 1983), either as a carcass (Brown *et al.* 1993) or butchered or cooked meat (Seebeck *et al.* 1984; Janey Jackson pers. comm.). They will also feed on the dead bodies of birds inserted into their enclosure (Brown *et al.* 1993), and one was observed actively capturing a live House Sparrow *Passer domesticus* that had become accidentally trapped inside the cage (Morgan 1981). There are also observations of a captive possum deliberately catching and eating a blowfly (Insecta: Diptera) (Murray 1977). Further, insects have also been recovered from the stomachs and scats of wild Common Brushtail Possums (Gilmore 1967; Kerle 1984 and references therein; Sadleir 2000); of 15

[1] Birds Australia, 415 Riversdale Road, East Hawthorn, Victoria 3123

studies cited by Kerle (1984), six reported insects in the diet of Common Brushtail Possums. Remains of arthropods have also been detected in faecal pellets of the closely-related Mountain Brushtail Possum *T. caninus* (Seebeck *et al.* 1984). Although some insects are thought to have been taken incidentally when feeding on foliage, others were probably eaten deliberately (Gilmore 1967; Kerle 1984; Seebeck *et al.* 1984).

Therefore, although Common Brushtail Possums are largely herbivorous, it is clear from these numerous examples that at least some will opportunistically consume animal proteins from both vertebrates and invertebrates, or other animal products such as eggs, when they are available.

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Australian Natural History Medallion

The Australian Natural History Medallion for 2003 will be presented to Dr Clive Minton on Monday 10 November 2003 at the FNCV Hall in Blackburn. The award recognises Dr Minton's substantial contribution to the study of Waders in Australia and the Asian Flyway and his influence on and guidance of a generation of bird banding enthusiasts. After the presentation the recipient will give an address entitled "Studies of Migratory Shorebirds". The successful nomination was made by the Victorian Ornithological Research Group.

Vale

Club members will be saddened to learn of the death recently of

Frederick Barton

Steve Marshall

Elsbeth Sacco

John Seebeck

Our sympathy is extended to their families and friends.

Weeds Set to Flourish Following Fires

Frances M Johnston[1] and Stuart W Johnston[2]

Abstract

The effects of the recent fires of 2002-2003 caused extensive damage to large area of thre Australian Alps. One of the secondary impacts of these fires observed during a recent survey of Kosciuszko National Park was the proliferation of weed popultions. The weed populations have the potential to negatively impact on native vegetation recovery, posing a serious management issue. (*The Victorian Naturalist* **120** (5), 2003, 194-197)

Fires in the subalpine and alpine regions of the Snowy Mountains occur only in rare and exceptional circumstances – such as the severe drought and extreme fire weather conditions seen across south-eastern Australia during last summer. The fires that began with a series of lightning strikes in early January 2003 have been the worst fires in the Kosciuszko National Park area for at least 60 years. At their peak, the number of fires in the area reached 50, with one bushfire complex stretching some 1.8 million hectares burning from Talbingo, in the north of the Park to Bright at the foot of Mount Buffalo in Victoria's Alpine National Park (NPWS Press Release, 2003). Now that the fires have finally been extinguished the assessment of their impacts has begun.

During a trip through the Snowy Mountains from Jindabyne (through Guthega, Talbingo, Khancoban, Cabramurra) to Tumut, the damage from the 2003 fires was plainly evident. Along this route approximately 85% of the Park has been affected to some degree by the fires, with a mosaic of effects from low intensity fires (where the effects were only a partial burn of the undergrowth) to high intensity fires, where everything including the organic topsoil has been burnt. The high intensity fires have left large areas of vegetation reduced to charred, twisted sticks and mounds of grey ash with the complete loss of all vegetative cover and litter, and a change of soil structure. This change to the soil has left the area highly prone to future soil erosion (SW Johnston pers. obs.).

Of course, fire is a natural process in Australia with much of the landscape covered by fire-adapted flora. Many of the characteristic plants found at the lower elevations of the Australian Alps are adapted to survive and regenerate following fires, whilst other plant species require fire to germinate their seed. So, despite the extensive fires there is already new growth appearing in the blackened surroundings. Eucalyptus trees, which after the fires appeared as lifeless sticks, were alive with new green-red epicormic shoots a few weeks later. Grass tussocks which were just charred lumps in the landscape are now sprouting with new green shoots. These areas, where new plant life is now appearing, were exposed to low or moderately low intensity fires. In areas where the fires were particularly intense, for example around Cabramurra, the landscape remains a black desert of ash and dead timber. It will take many years for these areas to fully recover.

In less severely affected areas the regeneration of the natural flora is a wonderful sight to behold. However, along with native species there has also been an explosion of weeds. Weeds are often able to germinate from seeds stored in the soil or reshoot from rootstocks in soil now enriched with nutrients. Native flora is often slow to germinate and grow, particularly in the harsh conditions found in the high altitude areas of the Snowy Mountains (Stock 1999). With the removal or reduction of native vegetation and exposure of bare soil the fire affected areas are ripe for colonisation by weeds (Zammit

[1] School of Environmental and Applied Sciences, Griffith University, PMB 50, Gold Coast Mail Centre, Queensland 9726
Email: frances.johnston@bigpond.com
[2] Forestry Department, School of Resource and Environmental Science, Australian National University, Canberra, ACT 0200

and Zedler 1988; Wahren *et al.* 2001). In areas with high intensity burns, this threat could be even more pronounced because competition for the weed species is even less. The organic topsoils have been (partially) lost, making establishment of natives even slower in these areas. This effect has been noted in the past in the Australian Alps after much smaller fire events (Morgan and Lunt 1999; Maret and Wilson 2000; Wahren *et al.* 2001).

Exotic plant species are common in the Australian Alps (Johnston and Pickering 2001a). A total of 175 alien vascular plants are recorded in the subalpine and alpine areas, representing 41 families and 122 genera. Within Kosciuszko National Park 165 exotic taxa are recorded, with 136 (80%) of these found along roadsides and paths, and 79 (58%) around resorts. These exotics vary in their life histories and tolerance to environmental and disturbance conditions (Johnston and Pickering 2001a). During the recent fires, one area where the majority of vegetation survived unscathed was the verges of the roads and trails, which are scattered across the Snowy Mountains. Unfortunately these areas, which often act as fire breaks, are mostly dominated by weeds (Fig.1). These weeds now have the opportunity to spread into the fire-disturbed surroundings. The weeds which may spread will depend on several factors including the biology of the weed (vegetative versus seed regeneration, adaptation to fire and life history) and the fire regime (intensity, frequency of occurrence, season of occurrence and scale of the fire) (Briese 1996).

A brief survey of the road verges after the fires revealed a suite of weeds including most commonly the species, Clover *Trifolium* spp., Sweet Vernal Grass *Anthoxanthum odoratum*, Brown Top Bent *Agrostis capillaris*, Sheep Sorrel *Acetosella vulgaris* and Dandelion *Taraxacum officinale*) (species already present before the fire events). One particular weed, found along the roads is Yarrow *Achillea millefolium*. Prior to the fires Yarrow was identified as a serious threat to the integrity of the high altitude vegetation

Fig. 1. Some of the fire damage observed across the Snowy Mountains. The vegetation in the foreground is predominantly Yarrow *Achillea millefolium*, Paterson's Curse *Echium plantagineum* and Sweet Vernal Grass *Anthoxanthum odoratum*. Photo by Stuart Johnston.

Fig. 2. Distribution of fire damage. Note that the vegetation along the roadsides was relatively untouched by the fires. This vegetation is predominantly exotics, the white flowers are those of the weed, Yarrow *Achillea millefolium*. Photo by Stuart Johnston.

communities (Johnston and Pickering 2001b). This exotic dominates many roadsides throughout the Park, particularly at higher elevations, in areas of high water, sediment and nutrient runoff (Johnston and Johnston, unpublished data). Yarrow with its high seed output, extensive rhizome growth and tolerance to a wide range of environmental conditions is highly competitive in bare ground (Bourdot and Field 1988; Csurches and Edwards 1998; Johnston and Pickering 2001b). It is able to grow and flower at high altitude, flowering and setting seed even in the alpine zone (Johnston and Pickering, unpublished data). With its rapid growth rate and resulting strong root competition, Yarrow also appears to out-compete the dominant grass of the natural herbfields, Snow Grass *Poa fawcettiae* (Johnston and Pickering unpubl. data). However, shading from shrubs and trees can limit the spread of Yarrow (Bourdot *et al.* 1984). With competition and shading from native vegetation removed due to the fires, Yarrow may spread into the burnt and now nutrient enriched areas of subalpine woodlands. During our trip, we travelled along Schlinks Pass (the road that passes from Guthega to Geehi), where we stopped at permanent sites set up to study the spread of Yarrow in December 2000 (Fig. 2). Yarrow was identified as having already moved into previously natural areas where it had never been recorded before the fires. This occurred in a period of only four weeks after the fires were extinguished.

The establishment of undesirable exotic plants will cause difficulties for restoration of the fire affected areas (Maret and Wilson 2000). In the next couple of years the rapid germination and growth of the many exotics may limit the germination and establishment of early successional native species in bare areas created by the fires (Morgan and Lunt 1999; Maret and Wilson 2000; Wahren *et al.* 2001). For the various agencies' staff associated with the Australian Alps National Parks, the fires of 2003 will have many ramifications at many levels. One will be the increase in the number and perhaps diversity of serious weed species and their spread into areas previously not affected by weeds, and the corresponding increased threat to conservation of the native flora communities. The adult weeds that survived the fire are an obvious visible focus for weed control (currently underway by NPWS and other similar agencies, D Woods, pers. comm.). Given their potential threat to spread into previously natural areas away from the formal roads, tracks and other infrastructure, the emphasis of land conservation in the Australian Alps should be to monitor and control the weeds in these new areas before they get the chance to establish. Follow up programs will also be needed to exhaust the future source of weed propagules in the soil until the natural areas have a chance to re-establish.

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Does Alpine Grazing Reduce Blazing?

RJ Williams[1]

Abstract
The 2003 fires burnt thousands of hectares of treeless alpine and subalpine vegetation on the Bogong High Plains. Much of the Bogong High Plains is subject to summer grazing by cattle, and there is a common perception that such grazing reduces the incidence or severity of fire in alpine environments, or, as popularly expressed, 'Alpine grazing reduces blazing'. But is this simple, even logical, proposition correct? I address this question, in the light of past and current research on the dynamics of alpine vegetation, the behaviour of both cattle and fire, and some preliminary observations of the extent and severity of the 2003 fires on the Bogong High Plains. I conclude that the extensive body of scientific evidence lends no support to the proposition that alpine grazing reduces blazing. (*The Victorian Naturalist* **120**(5), 2003, 197-200)

Introduction

The widespread fires of January 2003 burnt large tracts (tens of thousands of hectares) of the Victorian alpine and subalpine country. The treeless heaths, grasslands and bogs of the Bogong High Plains and surrounding peaks were extensively burnt. These vegetation types are typically short, due to the extreme climatic conditions - low temperatures, winter snow, frost, wind - that characterise high altitude environments. Although fire is infrequent in alpine landscapes (Williams and Costin 1994; Costin *et al.* 2000; Williams *et al.* 2003), there is a common perception that

[1]CSIRO Sustainable Ecosystems PMB 44 Winnellie NT 0821 Email: dick.williams@csiro.au

grazing by domestic livestock reduces the incidence and/or severity of fire in alpine environments, or, as popularly expressed, 'Alpine grazing reduces blazing'. As someone who has been conducting research in alpine environments for over two decades, I have been asked to comment on this proposition. In so doing, I will briefly mention the strong research tradition that exists in the alps, the nature of the alpine fire regimes, and then address the specific issue of alpine grazing and blazing.

Research in Australian alpine environments

There is a long history of ecological research in the Australian Alps (Good 1989) and their basic ecology is currently well understood. Research has addressed the evolution of the landscapes, the climate and soils, vegetation dynamics, the fauna, conservation values (soil, water and nature conservation), and, importantly, the responses of alpine ecosystems to disturbance, including grazing by domestic livestock and fire (Williams and Costin 1994; Costin *et al.* 2000; Williams *et al.* 2003). This research has described the basic processes by which alpine landscapes function, and is central to the current questions of fire and land management.

Fire regimes in Australian alpine landscapes

When thinking about fire we must think about *fire regimes*. A fire regime, and the associated impacts of regimes on flora and fauna, is much more than an individual fire, no matter how large and intense. Fires may vary in spatial aspects such as intensity and aerial extent, and these components of a regime are usually very apparent, especially at the time of any fire! However, the temporal aspects of fire regimes, such as time of year that a fire occurs, the frequency of fire, and, importantly, the interval between fires, are less apparent, but equally important to soils, plants and animals as the spatial aspects (Bradstock *et al.* 2002).

Historically, fire in alpine environments is infrequent, with many decades between fires, because the combinations of events that are needed for alpine country to burn – an ignition source, drought conditions, and severe fire weather – only occur several times per century (Leigh *et al.* 1987; Banks 1989; Wahren *et al.* 2001). Aboriginal people are known to have used the high country, but the extent and frequency of Aboriginal burning in alpine vegetation is unknown.

Prior to 2003, the Victorian high country was last burnt extensively in 1939 (Carr and Turner 1959). On both occasions fire weather was severe, and there was widespread drought. On both occasions on the Bogong High Plains, most of the snowgum woodlands were severely crown-scorched or crown-killed, extensive areas of heathland were also burnt, some areas of grassland burnt, as did some sphagnum bogs (Carr and Turner 1959; Parks Victoria, unpublished data).

Landscapes, and the various components of landscapes, are differentially flammable, and the alpine landscape is no exception. The most flammable parts of the alpine and treeless subalpine landscape are the closed heathlands. Experimental work by Roger Good in Kosciuszko (Good 1982) has shown that the shrubs are more flammable than the grasses. The closed heathlands also occur on steeper slopes (Williams *et al.* 2003) and a fundamental feature of fire behaviour is that, if fire is burning up hill, then potential rate of spread, and therefore intensity, increases with increased slope (Luke and McArthur 1978).

Thus, where the 2003 fires burnt alpine vegetation, the heathlands were severely burnt, causing 100% shrub canopy kill, and virtually 100% exposure of bare ground. At the time of writing the extent of burning, by vegetation type, had yet to be quantified, but it was apparent from initial inspections that the most severely burnt areas were the heathlands. This was also the case on the Wellington and Holmes Plains following the so-called Caledonia Fire of 1998 (Wahren *et al.* 2001). Even relatively low intensity fires in alpine heathland can cause such canopy kill and exposure of bare ground, as shown by a small scale fire in the Mount Fainter region in 1984 (Wahren *et al.* 1999a).

Grasslands, on the other hand, occur on gentle slopes, and the grass fuels are less flammable than the shrub fuels. There are numerous examples from the Bogong High Plains where fire has burnt dense heathland, causing 100% scorch in the shrub canopy, but has petered out as it reached the adjacent grasslands. There are even examples on steep slopes, e.g. on Spion Kopje where 0.1 - 1 ha areas of snow patch herbfield/grassland were unburnt, even though the surrounding heath was severely burnt.

The 2003 fires also burnt many sphagnum bogs on the Bogong High Plains, despite the peaty soils being moist at the time. The bogs are dominated by shrubs and are often surrounded by closed heath (Wahren *et al.* 1999b). Thus, if the surrounding closed heath burnt, the bog invariably burnt. This pattern also occurred in subalpine heathlands and bogs of the Wellington and Holmes Plains following the 1998 Caledonia fire.

Does alpine grazing reduce blazing?

The proposition that 'Alpine grazing reduces blazing' is based, amongst other things, on an assumption that grazing reduces fuel such that, across the landscape, fire intensity and/or extent in the event of fire is reduced. Does the field evidence support this view? I argue, on the basis of what we know about cattle diet and behaviour, and the biology of alpine vegetation, that it does not.

First, consider the cows. Studies on the diet and behaviour of cattle showed quite clearly that they have preferences about which species they eat, and where they graze (van Rees 1982; van Rees and Hutson 1983). Cattle prefer the open grassy communities, where there is the greatest abundance of palatable species, and cattle can move freely. In contrast, cattle spend little time in the closed heath communities, because there are few palatable herb species, and the dominant shrubs (*Prostanthera cuneata, Phebalium squamulosum, Orites lancifolia*) are not palatable. If they are avoiding the closed heath, and do not graze the shrubs, by what mechanism do cattle reduce the fuel loads in this part of the alpine landscape?

Next, consider the ecology of the heathlands. Long term monitoring plots set up in the open- and closed-heathlands around Rocky Valley in 1946, and which have been monitored ever since, show quite clearly that there has been no effect of cattle grazing on shrub cover – and therefore fuel loads – over this 60 year period (Wahren *et al.* 1994; Wahren 1997). This was also the case for shrub cover at Mt Fainter, on the Bogong High Plains, over a 15 year period following a low intensity fire in 1984 (Wahren *et al.* 1999a). These results – no effect of grazing on overall shrub cover, as would be predicted from van Rees' diet and behaviour work – have been shown from several other long-term monitoring sites in heathland on the Bogong High Plains (Wahren *et al.* 1994; Williams *et al.* 1997).

On the Bogong High Plains, the closed heath communities cover about 25% of the treeless plains, and shrubs dominate the understorey of much of the snow gum woodlands. Thus, heathlands are the natural conduits through which fire will pass, whether grazed or not. This was the case in both 2003, and 1939, when, incidentally, the stocking rates on the Bogong High Plains were much higher than today. The notion that cattle 'keep the country open', and 'control the undergrowth' and thereby 'reduce the fire risk' is therefore contrary to our knowledge of both the biology of alpine heathlands, and the behaviour of cattle within those heathlands.

By contrast, in the grasslands, herbfields and open heaths, cattle *do* reduce vegetation cover, and thus potential fuel. These are the places where cattle prefer to graze, and where the abundance of the preferred species, such as snow grasses, snow daisy, most other herbs, and some palatable shrubs (e.g. Alpine Star Bush, *Asterolasia trymallioides*; Alpine Grevillea, *Grevillea australis*), is highest. However, even though grazing does reduce grass and herb biomass, (Williams *et al.* 1997; Wahren *et al.* 1994) and may have local impacts on fire behaviour, grazing is highly unlikely to have an effect on fire extent and severity at the landscape scale. The herbaceous species constitute the least flammable fuel types, and the grasslands also occur on the gentle slopes. Thus, any fuel reduction effect as a result of cattle grazing is occurring in the least flammable part of the landscape.

Finally, preliminary data from the Bogong High Plains, collected soon after the 2003 fires, indicate that there are no consistent effects of grazing on fire severity and extent at the landscape scale (RJ Williams, C-H Wahren and WA Papst, unpublished data). Surveys were undertaken in burnt, ungrazed country in the Mount Nelse/Heathy Spur/Watchbed Creek region (which has been ungrazed for 12 years) and burnt, grazed country in the Rocky Knobs/Cope Creek region. I cannot present the data in detail here, and further analyses are needed, but two patterns are noteworthy. First, the pattern of burnt heath abutting unburnt grassland, as described above, appears to be common in both grazed and ungrazed country. Indeed, some unburnt, or very patchily burnt, areas of grassland, may be interspersed with patches of burnt closed heathland, indicating that fire can jump dozens of meters over grassland, whether grazed or not, and burn the heath. The second is the pattern of minimum diameter of the charred branches of the burnt shrubs, which is a measure of fire intensity, within the areas of burnt heath. We found no difference between grazed and ungrazed sites in the mean diameter of thousands of twigs sampled from hundreds of shrubs (data available on request). Thus, at least in our sample regions, where the heathlands burnt, they burnt with the same intensity regardless of grazing. Much more detailed examination of these and other patterns is obviously needed in coming years, but these observations of the patterns of burning thus far indicate that there are no obvious variations in burning patterns at the landscape scale that can be attributed solely or primarily to grazing.

'Alpine grazing reduces blazing' is a very simple proposition; it seems logical, even obvious. However, given our knowledge of alpine ecology, the behaviour of both cattle and fire, and preliminary observations of fire impact and extent on the Bogong High Plains, I can but only conclude that, across the landscapes of the Bogong High Plains, the proposition is not supported by the current body of evidence.

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Bogong High Plains After the 2003 Fires

Introduction

The late summer fires this year (2003) were the most extensive wildfires since 1939. The two largest fires were in the north-eastern ranges of Victoria and the Big Desert. There was a scattering of other fires elsewhere in Victoria, notably around Beechworth and the Pilot Range in north-eastern Victoria.

I inspected the Bogong High Plains and approaches over two days (17 and 18 February), just after the fires had passed. These are my first impressions of the most readily apparent ecological impacts of the fires. A comprehensive scientific statement of all the impacts of these fires is a matter for the future.

Situation

Slopes

The forests on the slopes that lead up to the Bogong High Plains, from the Ovens Valley, were among the areas first burnt by the extended north-east fires. The fires were often of high intensity and burnt rapidly. None of this is surprising, given the steep slopes and the high fuel loads of these wetter forests that are dominated by Alpine Ash *Eucalyptus delegatensis* and other wet forest trees. In some areas, for example around Howmans Gap and Bogong township, fires burnt up to the edge of the settlements two or three times, on separate days and from different directions. Nevertheless, large areas of forest remained unburnt or only partially burnt. The lower slopes, which had lower fuel levels, tended to be less intensely burnt, and there are many unburnt patches and hillsides. The upper slopes were severely burnt. I estimate that perhaps around 20% of these wet forests were unburnt and a further 30% were burnt in the lower strata only. That is, the tree canopy remained unburnt as the fire did not 'crown'. Both of these conditions would be mapped as 'unburnt' from aerial surveys, because it is very difficult for aerial or satellite mapping to 'see' through the green canopy. Current forest management processes in Alpine Ash forests are largely based on the premise that such forests are either completely consumed in a wildfire or essentially untouched, and do not take into account partly burnt forest.

High Plains

These were the first major fires to burn across the High Plains since at least the 1920s or 1930s. They started from lightning strikes in high summer after many years of drought, in a year of near-record low rainfall. To this extent, they were 'natural' fires. Some areas were very severely burnt, notably Mt McKay and Heathy Spur leading towards Mt Nelse, while other areas remained completely unburnt.

Likelihood of being burnt

Many factors contributed to the likelihood of a site being burnt. Some of the most important are discussed below:

Fuel quantity

High levels of standing fuel increased the likelihood of being burnt. Shrubby areas generally supported higher fuel levels than surrounding grasslands and so were more likely to burn. Indeed, in many areas isolated shrubs within grassland were burnt, while the surrounding grasslands were unburnt. Snow Gum-dominated areas were more readily burnt, and in higher intensity fires, than surrounding treeless vegetation. Many of these Snow Gums *Eucalyptus pauciflora* will now regenerate from lignotubers because the standing trunks have been killed. Few Snow Gums escaped being burnt.

Burnt heathland and woodland, grazed by stock before the fire (note the stock trail, lower left to upper right) approaches to Mt McKay.

Fuel type

The drier slopes and tops of hills were more likely to be burnt than were damp bogs, but this was such a dramatically dry season that many bogs did burn. A fortnight after the fire front had passed, bogs on the southern slopes of Mt Nelse were still issuing smoke from the burning peat. In some bogs, the fire skimmed the shrubby upper layer but did not burn into the underlying peat, while in others the elevated and drier *Sphagnum* peat burnt.

Slopes

Steeper slopes were more likely to burn than flatter areas. Protected exposures (such as south-facing slopes) were less likely to burn, presumably due to higher moisture levels in the soil and vegetation. The Mt Nelse snow patch, although unburnt in these fires, is now completely surrounded by burnt vegetation.

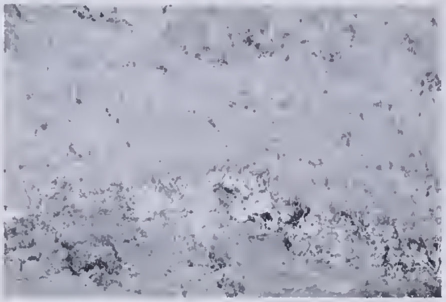
Fire conditions

The site characteristics mentioned above affected the likelihood of being burnt. But perhaps the overriding impression is that it was the nature of the fire front and the time it hit that most determined whether a site was burnt and how intense that fire was. If the fire front arrived towards evening (when temperatures and wind speeds were often lower) there was a high likelihood of the fire being patchy and not burning damper vegetation, such as bogs. If the fire front arrived towards the middle of the day, and when wind speeds were higher, then the fire was likely to burn all vegetation at that site. As a result, some highly susceptible sites (such as steep, north-facing slopes covered by dense shrubs) were unburnt and some moist, flat bogs were burnt. Thus, chance played a major rôle.

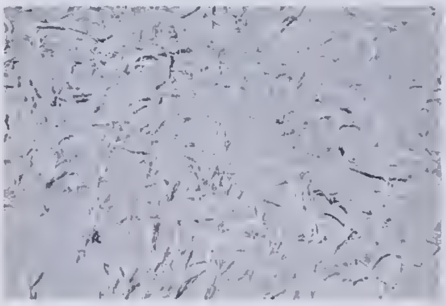
Regeneration

Depending on seasonal conditions, the forests of the slopes will regenerate successfully. Intervention may be necessary in small areas adversely affected by suppression operations (such as firebreak or fireline construction) and where long-lived weeds have been able to establish and spread after the fires. Recently-logged forests dominated by Alpine Ash that were burnt in these fires may need to be reseeded to re-establish the Alpine Ash canopy.

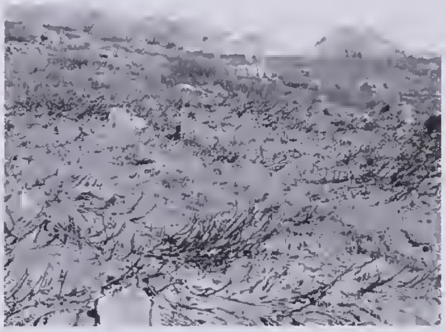
Ankle-high heath on Mt Nelse (plus Dick Williams, CSIRO).



Burnt peat bog, Rocky Valley.



Sedge *Carex gaudichaudiana* regenerating in burnt peat bog, Rocky Valley.



Burnt Heathland, Heathy Spur.

Sadly, it is a different story on the High Plains proper.

Bogs and mossbeds

Many bogs were burnt, in both grazed and ungrazed landseapes. High altitude bogs, although not heavily visited by stoek, are peeuliarly suseeptible to damage from grazing stoek. Stoek do not readily enter bogs because the footing is uneertain and there are few suitable food plants in bogs. Nevertheless, when a community is as suseeptible to disturbance as are alpine bogs, even oceasional visits have a damaging impaet. After these fires, previously unpalatable speeies have regrown rapidly, and now have lush, palatable foliage. At the same time, *Sphagnum* moss has been burnt and removed faeilitating stoek aeeess. Thus the bogs now contain far more palatable forage than usual and are both easier for cattle to aeeess, and even more suseeptible to degradation due to peat removal by the fires. Bog reeovery in burnt areas is even more dependent on stoek exelusion than in areas of unburnt vegetation.

Grasslands and heathlands

Shrub establishment is greatly faeilitated by burning (and some speeies are further faeilitated by stoek grazing). In the long-term absenee of fire, many shrubby areas mature to grasslands and herblands, and dense mallee-like Snow Gum matures to open grassy woodlands. These non- (or less) shrubby mature eommunities are far less flammable than highly shrubby vegetation. Huge areas of the High Plains will now return to an immature state with a high(er) shrub eomponent. As a result, they will be more flammable in the ensuing years.

Snow Gum *Eucalyptus pauciflora* burnt in either 1926 or 1939. Central stem burnt in earlier fire and surrounded by many stems of lignotuberous regrowth. These will now die and the lignotuber will vegetatively regenerate again.

Centuries-old plum pine *Podocarpus lawrencei* (habitat of Mountain Pygmy-possum) on Mt McKay.

Conelusion

There were many impressions from these fires some of whieh inelude:

- the annihilation of eenturies-old Plum-Pines on Mt MeKay;
- the fiereeness of a fire that burnt ankle-high heathland on Mt Nelse;
- the drying up of Watehbed Creek (not previously seen in two deeades of field work);
- the laek of any obvious relationship between areas that were burnt and areas that were aeeessible or inaeeessible to grazing stoek;
- the 60-year-old Snow Gums that are now regenerating from lignotubers (as they did after the 1939 fires);
- the minimal damage from fire suppression operations.

I've presented here just a few impressions in far too few words. But vegetation and habitat change is at its most aetive immediately after fires. The eoming Spring and Summer should be faseinating. It will be a rare opportunity to visit the High Country in one of the most interesting times.

David Cheal
Arthur Rylah Institute for Environmental Research
123 Brown Street
Heidelberg, Victoria 3084

The Waterbug Book

by John Gooderham and Edward Tsyrlin

Publisher: *CSIRO Publishing, 2002. 240 pages, colour illustrations. ISBN 0643066683. RRP $39.95*

The Waterbug Book aims to 'introduce the often-ignored diversity of freshwater macroinvertebrates that can be found in temperate Australia'. In this, it succeeds admirably, filling a near empty niche in this area. When the authors John Gooderham and Edward (Eddie) Tsyrlin approached EPA Victoria looking for sponsorship, we weren't sure of the need for such a book, following as it did hard on the heels of the excellent book by Hawking and Smith on the same general subject. But, after seeing a few of their wonderful photographs we were convinced and we have been greatly pleased with the final product. The freshwater sciences laboratory at EPA contains the latest invertebrate keys and diagrams but suffice to say that more than half of the scientists here have purchased their own copy of *The Waterbug Book* and the lab copies are frequently used.

The Waterbug book begins with a general overview of different types of waterbodies, a very brief introduction to freshwater ecology and the life cycles of aquatic invertebrates. It also provides a very simple introduction to taxonomy. All of this is necessarily short and may be frustrating to some readers who want to learn more. But the references at the end of the book are organized according to subject which should allow an interested reader to easily pursue their interest. There is also a glossary, an essential feature of a book like this. The book also provides a guide to the simple collection of water beasties which should enable any reader to adequately collect and preserve their specimens. One feature that I'm uncertain about is their simplified key to the major groups of aquatic macroinvertebrates. The line drawings are very cute and clearly designed not to frighten the novice user but it could be that the more experienced user will be irritated by them or (more likely) ignore the 11 pages of keys entirely.

The book then describes the beasts group by group. This is where the real strength and appeal of *The Waterbug Book* lies as the pictures John and Eddie have produced are marvellous. There are pictures of both the aquatic larval and nymphal forms as well as many pictures of the aerial adult stages (where appropriate, of course!). These are some of the best pictures of aquatic beasts that I have seen and the book is worth it just for them. Many of the larger orders have conventional keys to their families with useful and accurate notes as to their habitat, natural history and, most usefully, possible mis-identifications. An aspect of this section which at times is strange is the inclusion at various places of the supposed 'common name' of the invertebrate family. I must admit that some of these were new to me (e.g. killer mayflies or purple perils for the Family Ameletopsidae) so I wonder as to how common they really are. Some were quite amusing such as leptophlebs for the family Leptophlebiidae! Perhaps other readers will be encouraged to come up with more inventive names for future publications.

The book finishes with a listing of the scores given for many of the families as used in the biotic index SIGNAL. This simple approach of providing a pollution tolerance rating for these families and then averaging the scores for the families collected at a stream site provides a very good assessment of stream condition or health, one that EPA uses regularly. It will enable the non-professional aquatic ecologist to make simple and probably reasonable interpretations of their data.

The book is written in a quirky, amusing style, clearly reflecting the dry humours of both John and Eddie. I found it very readable and clearly designed to appeal to the non-specialist. At the same time, the quality of the pictures is a joy and the written notes are useful for the professional aquatic ecologist. I recommend *The Waterbug Book* for anyone.

Leon Metzeling
Freshwater Sciences, EPA Victoria
Ernest Jones Drive
Macleod, Victoria 3085

Victoria's Box-Ironbark Country – a Field Guide

by Malcolm Calder, Jane Calder and Ian McCann

Publisher: *Victorian National Parks Association, 2002. 120 pages, 237 photographs. ISBN 187100229. RRP $29.95*

Victoria's Box-Ironbark region extends from Stawell in Western Victoria to Wodonga in the state's north-east and takes in the central goldfields area around Castlemaine and Bendigo.

This book is a timely revised edition of the VNPA's guide to the Box-Ironbark region, first published in 1994 as *The Forgotten Forests*. Timely because 83% of these beautiful, productive and complex communities have been destroyed but the remaining forests are at last being recognised and protected in national parks.

There are many threats to these forests, with problems such as timber cutting, clearing for farming, grazing and mining. These activities have created a fresh crop of problems such as rising water-tables, increased surface salinity, soil erosion, algal blooms and the subsequent and ongoing loss of habitat for native plants and animals.

Barry Traill's photo of harvested firewood from Box-Ironbark forests and photos of the landscape after mining are horrifying.

The format of this book is excellent. There is a very good introduction to the natural history of the region, and descriptions of the six broad vegetation and landscape types. The photographs that accompany this section are extremely good as is the stunning cover lay-out and photo of Kingower State Forest by David Tatnall.

The size is perfect for backpack, trousers or coat pocket.

The updated maps and data since the 1994 edition will be appreciated by all who use this Field Guide, and can be used as an inspirational and persuasive tool when writing to Governments to plead for the protection of the forests not yet protected by national parks.

I was pleased to see the geology explained in section one, under the subheadings 'Landscape and Landform' and 'Climate and Soil'. This is a topic sometimes neglected or given scant mention. The attention to detail in the text is not surprising given the experience and dedication of the two authors Malcolm and Jane Calder.

Now to the photography. Who among us has not used one or more of Ian McCann's wonderful Field Guides? The photos are the perfect complement to Malcolm and Jane's text. Photographs are also provided by other well-known and expert photographers with a full list of picture credits at the back of the book. There is also a list of up-to-date nomenclature.

The clarity, definition and good colour reproduction of the photos makes it easy to identify most of the plants, although I would have liked closer shots of the flowers of *Stipa scabra* subsp. *falcata*, *Austrostipa mollis* and *Joycea pallida*. Granted, grasses are hard to photograph compared to most other colourful flowering plants.

George Stolfo has provided illustrations for a few species with minute detail to confirm identification. Perhaps an enlargement of the eucalypt fruit would also have been helpful.

I found the key community symbols next to each photograph very useful, providing instant recognition of the plant community in which each plant can be found.

This book is a 'must have' for the beginner or experienced observer and certainly for anyone visiting the exciting and beautiful Box-Ironbark country.

Reference

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Cecily Falkingham
27 Chippewa Ave
Donvale, Victoria 3111

Conservation of Birdwing Butterflies

Editors Don Sands and Sue Scott

Publisher: *SciComEd Pty Ltd and THECA (The Hut Environmental and Community Association Inc)(2002). 48 pp. RRP $22 (plus $4 postage within Australia). Order from SciComEd Pty Ltd., 2 Emily Street, Marsden, Queensland 4132*

The number of books written about threatened birds and mammals, if continued at the current rate of publication, could eventually exceed the number of species of threatened birds and mammals! On the other hand, the number of books about threatened invertebrates is miniscule and most of these are highly technical, so a popular publication about invertebrate conservation is most welcome. This book (or more correctly, booklet) is a summary of the conservation of birdwing butterflies, with a strong emphasis on the Richmond Birdwing butterfly in Queensland (one of the popular species seen in the Butterfly House at the Melbourne Zoo). Butterflies are arguably the most popular group of insects, and there are 34 species of birdwing butterflies found from Asia through to sub-tropical Australia. There are two Australian species: the Richmond Birdwing *Ornithoptera richmondia* and the Northern Birdwing *Ornithoptera priamus*.

The book covers a variety of subjects from several contributors, ranging from the importance of birdwing butterflies as a flagship for insect conservation, the food plants of birdwing butterflies, the natural history of the Richmond Birdwing butterfly and community participation in its conservation, the Paradise Birdwing butterfly in Papua New Guinea, to birdwing butterflies in Taiwan.

Of greatest interest is the case of the Richmond Birdwing butterfly which is endemic to south-eastern Queensland and north-eastern NSW. It was formerly distributed from Maryborough in Queensland south to Grafton in NSW in both lowland and upland rainforest. The main foodplants are the vines *Pararistolochia laheyana* in the uplands and *P. pravenosa* in the lowlands. The Richmond Birdwing's abundance and range have declined as a result of clearing the rainforest for farming, forestry and urban expansion. Another threat is that the females will also lay their eggs on the introduced plant Dutchman's Pipe vine *Aristolochia elegans*, which is poisonous to the caterpillars. The recovery programme for this species has involved protecting remnant rainforest patches in which it is found, replanting the appropriate food plants, and removing the Dutchman's Pipe. There has been a lot of community based support for the recovery programme with input from schools, community groups and the aboriginal cooperative Balunyah nursery. The early results indicate that the Richmond Birdwing is returning to gardens of southern Queensland and northern NSW.

I found a few deficiencies in the presentation of the booklet. First, the images could be better. This is a production issue as I have seen examples of Don Sands's butterfly photos and they are excellent. Secondly, I think that the order of the chapters could have been altered, with the last chapter about the natural history and recovery of the Richmond Birdwing near the front. Finally, the geographical coverage should have either included more information about the conservation of birdwings through the rest of its Asian distribution or restricted itself to Australia. Regardless of these criticisms, the booklet is well worth having because it does provide a lot of detailed information about conservation of birdwing butterflies, including recent references. One interesting point for discussion is the dilemma posed by Tim New in his contribution: the issue of breeding threatened birdwing butterflies to sell to collectors (which is the basis of the butterfly ranching programme in Papua New Guinea, the aim of which is to conserve rainforests by encouraging villagers to ranch butterflies instead of putting in coffee plantations) and the contradictory ban on importing them into Australia because they are on the CITES (Convention on International Trade in Endangered Species) list.

Alan L Yen
52-54 Brushy Park Road
Wonga Park, Victoria 3115

Hair ID: an Interactive Tool for Identifying Australian Mammalian Hair

Hans Brunner, Barbara Triggs and Ecobyte Pty Ltd

Publisher: *CSIRO Publishing, Collingwood, Victoria, 2002. ISBN 0643068260. RRP $195*

The identification of hair has been a useful technique to aid in mammal surveys and dietary analyses in Australia ever since Hans Brunner and Brian Coman produced their excellent book *The Identification of Mammalian Hair* in 1974 (Brunner and Coman 1974). The book was especially useful in providing a chapter on the techniques of preparing the hairs for examination. It relied on the user visually matching their samples with photographs of known Victorian mammals, although a diagnostic key helped in the initial sorting process. Subsequently there have been a number of publications which have added the characteristics of hair from species in different regions in Australia (e.g. Valente and Woolley 1982). The uses of hair identification and its applications in, for example, predator scat analysis, have been reviewed and evaluated (Brunner and Wallis 1986; Lobert and Lumsden 1991).

There are no doubts there were some disadvantages in using Brunner and Coman in the early days and that these partly contributed to a reluctance in the technique gaining widespread acceptance as a valuable accessory tool in mammalogy. Certainly there were some who had difficulty in mastering the technique and who considered it not worth the trouble! However, as the concern of the public for ethical treatment of subject animals grew, so too did the need for the development of non-invasive survey techniques and gradually more and more people turned their hand to hair identification. There were problems in using the book, however. It only covered Victorian mammals and because it quickly went out of print, it failed to keep up with taxonomic and distributional changes of species which occurred rapidly. The book was unable to finely discriminate between hairs of certain taxonomically close species (probably because the differences were indeed small) and being in black and white limited the use of pigmentation which can be a useful diagnostic aid.

For some time now, leaders in the field of hair identification – Hans Brunner and Barbara Triggs – have been working towards an updated version of the book. This has culminated in the production of an interactive CD Rom which will be a huge benefit to mammalogists. The CD has a searchable database of hair characteristics of 110 Australian mammal species that uses an excellent library of colour photographs. As well, the CD has a *Learn* section which explains the structure of hair and describes techniques used to obtain scale imprints, cross-sections, whole mounts and profiles.

Why a CD Rom? The publishers state further species' records can be added to the database as they become available. The CD Rom means much more information can be stored (than in book form) but undoubtedly the strength of the format is its searching facility. One can start with an unknown sample of hair, enter its features (maximum width, cross-section profile, scale type etc.) and a suite of possible species is provided. The location of your unknown sample is another characteristic that can be entered and matched with known distributions of possible species.

This is an excellent resource. It is easy to use (a tutorial is provided which demonstrates the program's features), the photomicrographs sharp and useful, the taxonomy up to date and the range of species adequate (although more would be useful). The *Learn* feature has some strengths, such as a photographic guide to making cross-sections (including where the materials can be obtained) and descriptions of how hair samples can be obtained. The bibliography, however, is very dated, with few references from the 1990s and beyond.

In all, I would strongly recommend this as a very useful tool for the researcher as well as in appropriate teaching programs. The authors are to be congratulated and reassured this contribution will ensure their skills and knowledge will be passed on to the new generation of field ecologists!

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Robert L Wallis
Deakin University, PO Box 423
Warrnambool 3280

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F.N.C.V.

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From the Editors

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Web address: http://www.vicnet.net.au/~fncv/vicnat.htm
Email fncv@vicnet.net.au

Introduction

Tom May[1]

The papers in this special issue arose from, a symposium entitled "A Review of the Victorian Flora and Fauna Guarantee (FFG) Act - 14 years since implementation", organised by the Field Naturalists Club of Victoria and held as part of Biodiversity month in September 2002. When passed in 1988, the FFG Act was a pioneering piece of legislation, but after being in place for more than a decade, it is timely to review the Act and to consider developments in conservation legislation, both in Victoria and elsewhere, that could improve the content and implementation of the Act.

The Symposium attracted a diverse audience, including field naturalists, researchers and representatives from government agencies and conservation and political groups. Published versions of most of the presentations at the Symposium are included in this special issue, with the addition of a paper from Lawyers for Forests (LFF).

The first objective of the FFG Act is to 'guarantee that all taxa of Victoria's flora and fauna can survive ... in the wild'. Other objectives relate to conservation of communities and genetic diversity, sustainable utilisation of flora and fauna, threatening processes, education and co-operative conservation efforts. These objectives are summarised by **Moorrees**, and the article by **Walker** also includes a summary of the FFG Act objectives.

Moorrees provides a perspective from the Department of Sustainability and Environment (DSE), the agency responsible for administering the Act. He assesses progress in implementation, noting that there are currently 532 items listed under the Act, including 465 individual taxa, and that Action statements for about 250 of the listed items have been prepared. He also outlines some current developments in how the Act is implemented by DSE, including the use of annual Protected Flora licences for groups such as rail agencies, the development of a Priority Actions Information System and the use of Biodiversity Action Plans at a catchment management level.

Sutton, who played a vital role in drafting the original legislation, critiques the Act against the original expectations of those interested in protecting Victoria's native biota. He finds that the Act has encouraged a strategic and holistic approach to flora and fauna conservation, but highlights several areas of concern, notably lack of use of the powers of the Act and decline in funding to apply the Act. He suggests that the Act needs improvement in a number of areas, such as the distinction between private and public land, and recommends strengthening of enforcement provisions, introduction of compensation, integration with the Wildlife Act, and enabling members of the public to enforce activities under the Act through the courts ('third party rights'). These same defects and suggestions are raised in the review of the FFG Act by LFF (**Walker**), particularly the lack of government commitment and resourcing. LFF also raise concerns about the Forest Produce Harvesting Order, which excludes logging operations from FFG controls. In addition, they suggest specific time-frames for actions and decisions, introduction of annual reporting on progress of the Act, and expansion of the role of critical habitat declarations and interim conservation orders (which have been very rarely used up to now). The disappearance of the Conservation Advisory Committee is noted.

Wilson writes on the NSW Threatened Species Conservation Act. This Act appears to provide a very useful source of ideas for improving the FFG Act, in areas such as third party rights, the ability to list endangered populations, and the setting of time-frames for preparation of recovery and threat abatement plans. Wilson makes the important point that management of a large number of threatened species is a complex challenge, which requires development of data management systems to monitor progress and allow evaluation of effectiveness of the Act.

[1] Royal Botanic Gardens Melbourne, Birdwood Ave, South Yarra 3141

Conservation of lesser-known groups, such as invertebrates and fungi, has lagged behind protection of the more charismatic flora and fauna. It was a feature of the FFG Act when first introduced that nomination of all kinds of plants and animals was possible. **May**, **New**, **Walsh** and **Yen** consider the Act in relation to conservation of lesser-known groups, noting that mass listing in these highly diverse groups may not be the most practical strategy. They suggest ways that conservation of these groups might be advanced, such as through use of plant communities as umbrellas or surrogates, consideration of threatening processes, and creation of invertebrate and non-vascular plant policy positions in DSE. They also discuss the listing of communities under the Act, and suggest that the concept of 'community' as applied under the Act needs to be better defined. These authors also make the suggestion that published threat lists for whole groups could be listed *en bloc* under FFG, and note that an inventory of Victoria's biota would allow monitoring of progress in describing the biota, and in assessing it for conservation status.

This special issue is a valuable resource for understanding the history and current implementation of the Victorian FFG Act. **Moorrees** calls on the community and experts in biodiversity conservation to judge progress in species and community conservation under the FFG Act. It was the intention of the 2002 symposium to stimulate debate on the Act among a broad range of groups, and dialogue with DSE, leading to updating of the Act and improvements in its implementation. The papers in this special issue contain many suggestions for how the Act might be modified, such as those mentioned above under each paper. The will of governments to implement the Act, and the importance of effective resources are recurring themes in most of the papers. Creation of a body similar to the NSW Biodiversity Advisory Council is one way that constructive debate on the Act and its implementation could be fostered. In any case, it is important that Government and all those with an interest in the Act continue to work on improvements to the Act so that there is the greatest chance of meeting the objectives of the Act in guaranteeing the survival of all Victoria's flora and fauna.

In addition to acknowledging the speakers at the symposium for their contributions and (along with Lawyers for Forests) for providing versions of their presentations for publication, thanks are due to Maria Belvedere for organising the symposium; Malcolm Calder for chairing the discussion session of the Symposium; and Anne Morton for working tirelessly to bring the special issue to publication.

One hundred years ago, D. McAlpine, a government vegetable pathologist wrote in the *Victorian Naturalist* Vol. XX, page 160:

'Now, there are 11 different species of fungi to be recorded on Lobelias for Australia alone, and when I state that 9 of them have to be added from having been found on a single species of Lobelia (*L. gibbosa*, Labill.) collected during the past season by a single member of this Club, you may be able to form some faint idea of what a wealth of new forms awaits the investigator in this fascinating field of fungi, and how much still remains to be done in connection with the fungus-flora of Australia.'

Not much has changed! In this issue, May *et al.* states "For macrofungi, recent taxonomic treatments in south-eastern Australia for genera such as *Amanita*, *Galerina*, *Gymnopilus*, *Hygrocybe* and *Mycena* have revealed that at least 50% of taxa were previously undescribed, and most are Australian endemics. For microfungi, particularly leaf-inhabiting fungi of native plants, many thousands of species are expected to occur, but very few have been described."

Unfortunately or, perhaps fortunately, we will never know how many we have lost! Conservation is vital.

Victoria's Flora and Fauna Guarantee Act: A Perspective from the Department of Sustainability and Environment

Adrian Moorrees[1]

Abstract

This paper discusses the Flora and Fauna Guarantee Act 1988 from the perspective of the Department of Sustainability and Environment. (*The Victorian Naturalist* **120** (6) 2003, 214-216)

Introduction

The purpose of this paper is to discuss progress in implementing the **Flora and Fauna Guarantee Act 1988** (the Act) from the perspective of the Department of Sustainability and Environment (DSE). The paper is divided into sections dealing with three fundamental questions:

- How far have we come?
- Where are we heading?
- Are we succeeding?

How far have we come?

The Act was passed in 1988 and the inaugural Scientific Advisory Committee was appointed in the same year.

The first Flora and Fauna Guarantee Regulations were made two years later. The delay in making the Regulations was mainly a result of the Act's requirement for the Scientific Advisory Committee to establish criteria for listing in regulations. The FFG Regulations were renewed in January 2002. The new Regulations included only minor changes, principally in the area of structure and clarity of language.

The first nomination, for a taxon of marine opisthobranch, was received in 1991. Seven hundred and two have been submitted to date (November 2003). The first batch of listings was made in 1991. There are now 532 listed items, comprising 465 taxa, 35 communities and 32 potentially threatening processes.

The first Action Statement, for the Buxton Gum, was published in 1991. There are now Action Statements for approximately 250 items either published or approved, with a further ~100 in preparation.

Other achievements to date include the release of the Flora and Fauna Guarantee Strategy in 1997 and the establishment of some key authorisations in respect of the Protected Flora Controls, mainly for activities managed by DSE or the Department of Primary Industries, such as timber harvesting, exploration, mining and extractive industry operations. Authorisations have also been established for the taking, trading and keeping of listed fish.

One Critical Habitat Determination was made in 1996 and subsequently revoked. None is currently in force, although several have been prepared to draft stage. No Interim Conservation Orders have been made.

Where are we heading?

The Department of Sustainability and Environment is mindful of the need to maintain momentum in implementing the Act. To this end, key nominations, such as those for important, potentially threatening processes, will be prepared by DSE. Steps have also been taken to streamline Action Statements, including reducing their length and shifting the focus towards the actions and away from the background text. There are also fewer, more achievable actions with clearer accountability for implementation.

DSE is working to extend compliance with the protected flora controls within the Flora and Fauna Guarantee Act, by developing a two-tiered approach of FFG Protected Flora licences and permits. To date, this approach is being pursued with rail agencies and operators, and it is hoped to extend it to apply to the managers of road reserves throughout Victoria. The two-tiered concept involves protected flora licences being issued to cover routine activities outside areas of significant vegetation over, for example, a twelve month period. Licences would be accompanied by a set of standard works guidelines. Application of the guidelines would be a

[1]Manager, Threatened Species and Communities, Department of Sustainability and Environment, 250 Victoria Parade, East Melbourne.
Email Adrian.Moorrees@dse.vic.gov.au.

condition of the licences. Separate permits would be issued for areas of significant vegetation, including site-specific conditions to avoid or minimise impacts on protected flora. This approach allows for tight controls over important sites and general improvement in environmental management in other areas, without imposing an excessive paperwork burden.

DSE is also developing a Priority Actions Information System. This is an information system designed to deliver semi-automated Action Statement preparation and review, priority setting based on item, action and location, a link to site by site threat assessment and population monitoring, as well as monitoring and reporting on implementation. This should be implemented in 2005. The system will be able to deliver lists of priority actions by region, land tenure, responsible manager and action type. Land managers and other authorities will receive this advice on an annual basis for consideration in their business plans and works programs. Species and location monitors will update the system annually, recording progress on implementation and changes to actions and/or priorities.

Another major innovation sweeping DSE and the Catchment Management Authorities is integrated catchment management – the notion that actions to address soil degradation, salinity, water quality, river health, coastal and estuary management, pest plants and animals, native vegetation management and biodiversity conservation across catchments should be integrated, or, at the very least, work in concert rather than in conflict.

Victoria is divided into ten catchments and each is managed by a Catchment Management Authority. These Victorian Government statutory authorities are required to prepare a Regional Catchment Strategy which identifies land, water and biodiversity outcomes and targets. The Catchment Management Authorities are also required to report periodically on catchment condition. While they are at arm's length from DSE, there is close co-operation in the development of the strategies and the setting and monitoring of targets. The significance of the Regional Catchment Strategy is that, in addition to setting strategic direction and broad priorities, it is the vehicle for obtaining funding from both Commonwealth and State Governments under a range of programs including the Natural Heritage Trust and National Action Plan for Salinity and Water Quality.

In response to the need for integrated catchment management, DSE's Biodiversity and Natural Resources Division has developed a means of building actions to conserve biodiversity and manage threatening process into Regional Catchment Strategies - the Biodiversity Action Plan. Biodiversity Action Plans are strongly based on maps rather than lengthy reports, and are designed to incorporate action at a range of scales: from site-specific action to protect a threatened plant on a roadside through to sub-catchment-wide priorities for vegetation restoration and enhancement to benefit threatened species and communities, or broad programs to control introduced species. In particular, Biodiversity Action Plans stress the importance of engaging with local communities to 'design' local landscapes, linking the technical information about species and communities and their requirements with the vision of the local community for their district.

Are we succeeding?

After more than 10 years of operation, it is timely that the performance of the Flora and Fauna Guarantee Act and the associated programs be reviewed. Such a review should seek to answer the following questions:

- Has sufficient progress been made?
- Could resources have been better targeted?
- What were the barriers to greater success?
- If the conclusion is that more could or should have been achieved, does the answer lie in more Government funding, or somewhere else?

Perhaps the best test is to evaluate progress to date against the objectives of the FFG Act:

- to guarantee that all taxa of Victoria's flora and fauna ... can survive, flourish and retain their potential for evolutionary development in the wild
- to conserve Victoria's communities of flora and fauna
- to manage potentially threatening processes
- to ensure that any use of flora or fauna is sustainable

- to ensure that the genetic diversity of flora and fauna is maintained
- to provide programs for:
- community education,
- encouraging co-operative management
- assistance and incentives to people to conserve flora and fauna
- to encourage conservation through co-operative community endeavours

Conclusion

I believe that progress has been made against each of the FFG Act objectives. Whether that progress is sufficient to arrest the decline of threatened species and communities, to prevent the decline of other species and communities and to manage successfully potentially threatening processes is a judgment for the community, including experts in the field of biodiversity conservation, to make. However, I also believe that there is a range of innovative approaches being taken within DSE and beyond to increase community awareness, to integrate actions to conserve threatened species and communities into broader catchment-wide activities, to improve compliance with the FFG Act and to streamline its operation, to the extent that, in future, the early years of the twenty-first century might be viewed as a period of accelerated and more effective progress.

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Has the Flora and Fauna Guarantee Act achieved what we hoped for?

Philip Sutton*

Abstract

This paper discusses the Flora and Fauna Guarantee Act from its introduction in 1988 to the present, its successes, its failures and future directions. (*The Victorian Naturalist* **120** (6) 2003, 216-223)

Note about the author and the paper

This paper is my personal reflection on the implementation of the Flora and Fauna Guarantee Act. I developed the original policy concept for the Act in 1980, designed the legislation and worked on its introduction into Parliament and its successful passage (1984-88) and went on to lead the initial implementation program (1988-90). So the reader should not be surprised if I have strong views on how the Act has fared since.

Introduction

At the time that the Flora and Fauna Guarantee Act 1988 (FFG)[1] was developed and enacted by the Parliament of the Australian State of Victoria, the expectations for flora and fauna conservation were not high. Hardly anyone thought the legislation would make it through Parliament, let alone be passed with any useful powers intact. The impact of the Act has exceeded those early expectations. But the purpose of the FFG was both to increase the capacity to protect native species and ecological communities, and to raise Victorian's expectations about what should be accomplished. Expectations for conservation indeed have been raised and the powers available to government were significantly increased, but *implementation* of the FFG Act has fulfilled, perhaps, less than a tenth of its potential. While some provisions have been implemented steadily, the key regulatory controls or mechanisms – protected flora, critical habitat, interim conservation orders – have not. Manifestly inadequate funding has resulted in lack of essential 'on-ground' management action, policy and planning, research and enforcement. This criticism is not directed in any way at the public servants at the 'coal face'

* Green Innovations, 195 Wingrove Street, Fairfield, Victoria 3078.
Email Philip.Sutton@green-innovations.asn.au

who have worked very hard to do their best in diffieult eircumstanees. Instead, it is direeted at successive governments and their most senior public servants who could have made the Act do much more, and also at people like myself who have not yet ereated the climate in which governments and senior publie servants feel compelled to achieve the Act's objectives.

The hopes and expectations behind the Act

The original hopes for the FFG Act were that it would:

- act as an engine to drive forward flora and fauna eonservation work in Vietoria;
- provide needed powers; and
- make it easier for people coneerned about the eonservation of native species and ecological communities to actually aehieve something.

The Aet arose out of some very personal factors. From 1974 until the early 1980s I was actively engaged in the Conservation Couneil of Victoria[2] (now Environment Vietoria) as an executive member and then as Deputy Director. During this time the Council's member group representatives met onee a quarter to share their experienees of trying to protect Victoria's natural environment. At meeting after meeting I would hear heart-rending stories of environmental destruction and how people were struggling desperately to turn the tide. As we came up to the 1980s, conservationists were getting a less and less sympathetic hearing eompared to the time when Premier Dick Hamer, Minister for Conservation Bill Borthwick and Minister for Planning Alan Hunt were at the height of their powers.

By 1980 it beeame clear that a change of government was likely. Popular mythology of the day held that Labor Governments were or should be energetic reformers. With John Cain taking over the reins as Leader of the Opposition in 1980, it looked as if the reality might at last match the mythology.

I felt there might be an opportunity to do something for nature conservation by taking advantage of this rare moment of change. What would be the one thing I eould do as an individual that would have the greatest long-lasting impact for nature eonservation? It seemed to me, at the time, that the most effeetive thing I eould do would be to try to get some legislation though to 'guarantee the survival of our native species'. The inspiration for this dream came from the operations of Victoria's Land Conservation Couneil and the US Endangered Species Act.

Through a FFG Act, I wanted to put into people's hands a powerful tool to proteet the state's native species.

In developing the details of the FFG Aet, I tried to reconcile two apparently opposing ideas. On the one hand, Stephen Yaffee in his 1982 book on the US Endangered Species Act[3] showed how administrations were able to take the most prescriptive legislation that Congress could hand them and find ways to water down the intent if the will was not there to implement the legislation. On the other hand, the importanee of establishing effective machinery of government, with legislation driving it as the highest form of public poliey, was seen as eritical by public sector reformer, Peter Wilenski[4].

I felt that the best way forward was for the legislation to actively limit government discretion in eertain eritical areas and to recognise the tendency of governments to wriggle out of mandatory commitments where they were desperate to do so. I felt that legislative machinery could be used to set up the agenda for conservation, but that the political process would have to be responsible for the big wins for eonservation where major political or economie challenges were involved. I think this has been demonstrated over and over again in New South Wales and Victoria (the two States I am most familiar with) in relation to the proteetion of natural areas. The big parks are delivered by political eampaigns and the masses of smaller important gains that can never be made the effective subjeet of campaigns are best delivered by an administrative process.

How well has the Aet lived up to the original hopes?

Twenty-three years after the eoncept of the Flora and Fauna Guarantee was first framed, how well has the Aet lived up to these hopes?

First, some general comments. The Act has:

- survived governments, both Labor and Liberal, that variously have been indifferent, fearful or hostile towards flora and fauna conservation – with the basic administration still operating;
- encouraged a much more strategic and holistic approach to flora and fauna conservation in Victoria;
- helped to dramatically widen the range of taxa that are covered by conservation efforts – especially important is the consideration now given to invertebrate animals and non-vascular plants;
- brought in the concept of identifying and protecting ecological communities (i.e. distinctive suites of flora and fauna);
- helped to lift the profile of flora and fauna conservation in the State from a very low base; and
- provided the model for all the recent wildlife legislation in Australia at National and State levels – so that this legislation now has a strategic emphasis on 'prevention' through ecological community protection and threat identification, management and avoidance[5].

The procedural sections of the Act that have required the government to take certain actions have operated reasonably effectively. Examples are the listing process for identifying threatened taxa, threatened ecological communities and threatening processes, the process for producing action statements and the requirement to produce an overall Flora and Fauna Guarantee strategy.

The situation in relation to the application of the protected flora controls has been mixed. The protected flora controls are potentially very powerful due to a last minute amendment proposed by the Liberals when the proposed Act reached Parliament. The taking (killing, injuring or collecting, harvesting) of any protected flora on public land requires an authorisation. This authorisation must be withheld if the taking would threaten the conservation status of the taxon or ecological community that the protected flora is a part of.[6]

Authorisations can be given via case-by-case permits or by comprehensive Governor-in-Council Orders. Orders of this sort have been used to build in more effective consideration of flora and fauna conservation into the 'taking' of protected flora as a result of logging or mining.

Case-by-case permits are required (somewhat spasmodically) for other ways of taking protected flora on public land. The flora controls have been applied more rigorously to the commercial harvesting of certain species on private land, introducing for the first time a strongly ecological approach to decisions about tree-ferns, grass-trees and sphagnum moss[7]. But the flora controls have not applied at all to numerous cases of illegal taking by other public authorities (e.g. road and rail managers and local governments).

When it comes to the declarations of critical habitat and the use of interim conservation orders (ICOs) fear and inaction have been the order of the day. No ICOs have ever been made – in 15 years. This seems to reflect a lack of government commitment to flora and fauna protection rather than the existence of a state of Nirvana in Victoria. A critical habitat determination has been made in relation to only one taxon, the Golden Moth Orchid. And this was then revoked shortly afterwards on a technicality, with the destruction of the habitat following soon after that!

While the Act has been written in a way that requires no major trade-offs in the treatment of native flora and fauna, the actual management is still dominated by the notion of trade-offs.

Implementation has suffered under corrosive administration

It will be interesting to see whether the administration of the FFG Act and the conduct of native species and ecological communities conservation policy under the new Minister for Sustainability and the Environment will break with tradition, but under past Ministers the approach has left a great deal to be desired.

There appears to have been a de facto policy not to use (and perhaps therefore demonstrate?) the powers of the FFG Act where other Acts can be used.

For example, not long after the passage of the Act a marine ecological community was listed. A marina was planned on an area that was critical habitat of the ecological community. Construction of the marina would have resulted in the taking[8] (in this case killing and injuring) of protected flora and Section 48(4) of the Act prohibited the authorisation of such taking. The government could have dealt with the issue straightforwardly by refusing to grant a permit for the taking of this protected flora. Instead it chose to stop the development using the procedures of the Planning and Environment Act.

Also, it has taken many years to extend the application of the FFG Act to control a significant proportion of the activities of public authorities that take protected flora on public land. Apart from management of the taking of tree-ferns, grass-trees and sphagnum moss, direct regulation[9] under the Act is rare. The application of the Act's flora controls to taking of protected flora on rail and roadsides has been practically non-existent. Public Authority Management Agreements have been applied to a few cemeteries and some roadsides. Where the Flora and Fauna Guarantee controls are applied widely, it is largely by proxy though controls under the Forests Act, the Mineral Resources Development Act and the Planning and Environment Act that have been deemed, using the Governor-in-Council Order, to be authorisations under the FFG Act. There is a lot of sense to this indirect approach, but it has the side-effect of minimising the extent to which agencies and developers are aware of the need to comply with the FFG. It also places the detailed, day-to-day regulation of flora and fauna impacts in the hands of people who are not employed specifically to work on flora and fauna conservation. A real risk is that these people are not aware that they are legally required to address and positively advance the achievement of the FFG objectives through the authorisations they are giving or refusing under the other Acts. Reflecting their organisation's culture and core business, the people administering authorisations under other Acts often see their job as finding a balance between multiple objectives (i.e. a compromise or trade-off) or they see flora and fauna conservation as in conflict with their main objectives.

The flora and fauna conservation budget has been wound back steadily and substantially (in real terms) since its peak in 1989-90.

Many people judge the adequacy of an Act by the actions they see on the ground. What often is not realised is that you can have the strongest Act imaginable, but action can still be grossly inadequate if the budget is not there to apply or act on the provisions of the Act.

At the time of writing (July 2003) another major cut to the State Government budget for flora and fauna conservation was delivered, with serious impacts on research, policy and regional functions being inevitable.

There has been a continuing failure to fix the enforcement provisions of the Act.

Shortly after the enactment of the Flora and Fauna Guarantee, the enforcement staff of the then Department of Conservation, Forests and Lands discovered weaknesses in the enforcement provisions – weaknesses that make it hard to mount successful prosecutions. Even though successive governments have known of this, the enforcement deficiencies remain 15 years later.

Enforcement staffing has declined dramatically over these years due to budget cuts and restructures. For example, the removal of the Fisheries branch from the Flora and Fauna division resulted in 'Fisheries and Wildlife' officers being directed away from 'wildlife' (i.e. flora and fauna) enforcement work.

Governments have taken advantage of areas of discretion and technical loopholes in the legal limits on Government discretion to avoid the intent of the Act, and at times they have simply violated the provisions of the Act where the Act's requirements were inconvenient.

Section 9 of the Act provides that the Minister can be advised on any aspect of the administration of the Act by the Conservation Advisory Committee set up under the Conservation Forests and Lands Act. This committee was representative, largely, of the views of the environment movement. However, it was abolished over 10 years ago and has not been reinstated by subsequent governments, despite its statutory role in the operations of the Act.

The head of the Department administering the FFG Act is required by Section 17 of the Act to 'prepare a Flora and Fauna Guarantee Strategy as soon as possible after this section comes into operation setting out how the flora and fauna conservation and management objectives are to be achieved'. Despite this explicit requirement that indicated, one would have thought, a sense of urgency, a draft Flora and Fauna Guarantee Strategy was released only in 1992 and the final Strategy was released in 1997 – nine years after the passage of the Act. And after the long wait the Strategy was almost a commitment-free zone.

A number of Ministers have taken advantage of tiny holes in the legally required procedure for listing, to slow the process down. One Minister discovered that, although a decision on listing had to be made within 30 days of considering the recommendation of the Scientific Advisory Committee, the whole listing process could be disabled by simply choosing not to consider the recommendation. Fortunately, this loophole in the Act has been closed. Another Minister brought the whole process to a halt by failing for some considerable time to appoint new members to the Scientific Advisory Committee after the period of office of all the old members had lapsed. At another time, a Minister appointed as Convenor of the Scientific Advisory Committee a person who failed to meet the qualifications required by Section 8(4) of the Act. And another Minister failed to make a recommendation to list the Grey-headed Flying-fox *Pteropus poliocephalus* as threatened (despite the fact that Section 10(7) requires that only conservation matters are taken into account) using the rationale that the issue was currently being considered by the Federal Government under its legislation. The procedural issue of what the Federal Government was or was not doing has no relevance to the conservation status of the Grey-headed Flying-fox in Victoria.

Despite the fact that the Act's protected flora powers on private land depend on the determination of critical habitat, the head of the Department administering the Act has only ever made one critical habitat determination (for the Small Golden Moth Orchid *Diuris sp. aff. lanceolata*). This failure to act appears to be a breach of Section 7(1) of the Act which requires the Secretary to administer the FFG Act in such a way as to promote the flora and fauna conservation and management objectives of the Act. In the case of the critical habitat of the Golden Moth Orchid, the Secretary revoked the Critical Habitat determination shortly after it was made, arguing that it had been incorrectly created. No attempt was ever made to remake the Critical Habitat determination in a way that was procedurally correct. The Minister claimed that other approaches to protecting the habitat of the orchid were more appropriate. Probably behind the unwillingness to determine the critical habitat was fear that once this was done the community would demand that an interim conservation order be made to protect the critical habitat and that this would then open the government up to the need to pay compensation.

Not long after the revocation, the Department allowed a large percentage of the land that was the subject of the initial Critical Habitat determination to be destroyed, most likely causing the extinction of the orchid in the wild. It is hard to see how the Secretary's actions in this case could have been legally permissible.

Another area where the requirements of the Act are ignored is in the application of offsets (for example, under the vegetation retention provisions of the planning system) where the destruction of the habitat of protected flora is permitted in one place with an accompanying action somewhere else to provide for a 'net gain' in the extent and quality of native vegetation. Section 48(4)[10] of the Act limits the extent to which this kind of trade-off can be allowed, but there is no transparent assessment process to make sure that offsets do not violate this requirement. In one case, a permit was given to destroy an area of Flora and Fauna Guarantee-listed grassland on a rail reserve, despite objections by scientific staff. Senior bureaucrats made the decision to allow the destruction to go ahead with the offset being $25,000 in compensation to be used to translocate species and manage other remnants of the community. It was argued that the offsetting actions meant that Section 48(4) was not compromised. However, it is doubtful this was a scientifically justified claim.

How could the act be improved?

There's no doubt the Act can be improved. The Act is weak in three critical areas. The first is that it treats private land differently from public land when it comes to conservation. This stems from an ancient British tradition that the moving animals belonged to the Monarch and the immobile plants belonged to the landowner. This distinction is meaningless from a conservation point of view. but changing the status quo is not a trivial political task.

The Act also is weak because, although its procedures point the government firmly in the direction of protecting the State's native flora and fauna, and although the Act provides the government with some powerful legal tools, if the government is determined not to conserve there is not a lot the public legally can do about it.

The third major area of weakness is in the enforcement provisions.

The first deficiency can be solved only with a two-pronged approach. Fixing the legal distinction between public and private land is a trivial thing technically, since all it requires is the removal of a few words that limit powers on private land. The real issue is the political one of gaining support for the change from both rural and urban communities. I think this support can be obtained if we recognise that nature conservation requires two actions. One is to stop damaging activities and the other is to provide proactive conservation management. In the final analysis, active management can be provided reliably only if it is recognised as work that needs to be done and it is paid for by the community. This work could be carried out by public conservation agencies, landholders or private contractors, but it has to be paid for. If significant funds were provided for this conservation work it would become a major rural employer, and for some private landholders it could be a significant source of income. If this approach were adopted, nature conservation would no longer be seen as an economic threat to rural communities.

In the meantime, an anomaly in the protective powers on private land needs to be fixed. Currently, protected flora in their own critical habitat can be protected, but protected flora in the critical habitat of another species or an ecological community cannot be protected. The Act needs to be changed so that any protected flora in the critical habitat of any taxon or ecological community can be protected.

The community's power to 'make' the government conserve has to spring from two sources. One is the process of politics. If conservationists cannot make conservation a compelling political issue, then we will not get the action we want – with or without good legislation. The other complementary way to make a government perform is to have some activities under the Act enforceable by any member of the public through the courts. But I do not think that the answer is to make *the whole Act* enforceable through third party action in the courts. Governments will set limits to what they can be forced to undertake. They do not want to write blank cheques any more than you or I. So, if the whole Act is third-party-enforceable the Act will be written so that it has very few powers and hence few circumstances in which actions can be enforced. The conservation of flora and fauna, however, needs an Act with very wide powers and lots of tools and mechanisms.

I think the solution to these competing needs is to create a mechanism whereby the Government can enter into third-party-enforceable 'undertakings' in relation to defined commitments. It is like a contract with the community – or an enforceable promise.

If the conservation movement feels that certain actions need to be taken by the government, then it is up to the movement to create the political 'opportunity-space' for the government to take that action – then the action can be entrenched in an enforceable undertaking.

In relation to the enforcement provisions, four changes are needed. Enforcement officers need to have the power to seize flora or fauna that they think has been taken, traded, moved, kept or processed in contravention of the Act. The courts need to have the power to order the forfeiture of flora or fauna that has been illegally taken, traded, moved, kept or processed. This enables law enforcement officers to take possession of the evidence of law-breaking and it enables the courts to recover the flora and fauna when an illegal act has been committed. Penalties for breaches of the Act need to be increased significantly for serious offences. Enforcement officers find that the cost of prosecution is so high that it is not worth the expense of taking people to court for minor offences. Instead the Act could provide for on-the-spot fines. The Environment Protection Act provides a useful model of what is needed.

Finally, there needs to be an increase in the number of enforcement officers and legal staff. This requires an increase in the flora and fauna budget.

There are a number of other useful improvements that could be made:

- To speed up the protection of species, departmental threatened species lists should be listed *en bloc* under the Act and then, if the departmental categorisation is considered to be wrong for any particular item, the formal delisting procedure could be set in motion;
- It should be mandatory for Action Statements to include an identification of what is desirable to be done to ensure effective action in relation to the listed item – currently it is optional;
- Action Statements need to cover what any party will do – not just the department administering the FFG Act;
- Because it is a scientific question, Critical Habitats should be determined by the Scientific Advisory Committee and the Committee should be able to carry out these determinations at its own discretion;
- Because it is a scientific question, the Scientific Advisory Committee should be required to assess whether proposed permits would satisfy Section 48(4) of the Act;
- All the procedures under the Act that limit government discretion or require governments to act should be reviewed to see how they could be circumvented and then loopholes should be closed;
- A body that is independent of the Government (the Auditor-General seems to be an appropriate option) should be required to conduct an 'effectiveness review' of the administration of the Act - at least once in the life of each government[11];
- The Wildlife Act should be incorporated into the FFG Act, as was the original intention. This is important under the current administrative regime where the Wildlife Act controls are applied only to deliberate and direct taking (killing, possession or control) of animals – not to damage to their habitat which can result in an even greater impact[12];
- A significant contingency fund for the payment of compensation under interim conservation orders should be established so that the administrators of the Act do not need to panic if it looks as though an interim conservation order is needed; and
- The protected flora powers need to be widely advertised so that it is clear to everyone, including all public authorities, that they must comply with them. For example public authorities, including local governments, would need to apply for licences for standard maintenance works and they should build Flora and Fauna Guarantee considerations and requirements into their standard procedures. Compliance with licence requirements needs to be regularly audited by an external monitor.

It also would be desirable to look closely at the wildlife[13] legislation of other States/Territories and the Commonwealth to see how they might have improved on the original Flora and Fauna Guarantee model.

What's the real problem?

For all its faults, the FFG Act is actually a powerful piece of legislation. A government that was committed to sustaining the State's flora and fauna could do a great deal using this tool – far more than we've ever seen or perhaps even dreamed of in Victoria. So what's the real problem?

Basically, the governments we have had over the last 15 years:

- have not understood that biodiversity conservation is an integral and essential element of environmental or ecological sustainability;
- have not felt that good flora and fauna conservation efforts are one key measure of competent and successful government;
- have been fearful that taking action to protect flora and fauna would anger

powerful vested interests and would also undermine the economy; and
- have not felt compelled to act decisively because the pressure from the conservation movement has not been strong enough.

What should we do?

The Act has fallen into disrepute because it has not been used to the extent that it logically could have. Few people in the Victorian State public sector, other than those directly involved in the administration of the Act, give any thought to the obligations the Act might place on them in relation to their area of work because it is thought to be of peripheral relevance, and, given the level of government support for the Act, few consequences flow if it is ignored. We need a publicity campaign to fire up awareness of the Act and a stated government determination to fully administer and enforce it (something stronger than a minor campaign promise).

But what will make the government start to administer the Act effectively? It has to feel that:
- it will not be punished politically for taking action;
- an effective nature conservation program will not cripple the economy; and
- it will be meeting a significant community demand by taking action.

A stronger environment movement is needed – to push governments to pay country people for active conservation work, thus taking away the major reason for rural opposition, to push for new economic strategies[14] that are compatible with nature conservation, and to engage the community in demanding effective flora and fauna conservation.

To kick-start this movement building process, I think it would be useful for a few people who feel excited about tackling the big picture to get together to develop and then implement a community-based strategy 'to guarantee that all of Victoria's native flora and fauna can survive, flourish and retain their potential for evolutionary development in the wild'[15].

New opportunity?

The current Victorian government, headed by Premier Steve Bracks and Deputy Premier and Environment Minister John Thwaites, offers the first opportunity since 1992 to get flora and fauna conservation back on the agenda as a serious issue. With a solid majority in the governing Lower House of Parliament and control of the Upper House the Government is now able to get improvements to the FFG Act through Parliament. It also faces strong political competition from the Greens Party which is within reach of taking seats from the Government at the next election.

Whether anything comes of this opportunity, however, will be up to us.

References

The Act can be found online at: http://www.austlii.edu.au/au/legis/vic/consol act/fa/fga1988205.

[2] The peak community environment group for the State.

Yaffee, SL (1982) *Prohibitive policy: Implementing the Federal Endangered Species Act.* (MIT Press: Cambridge, MA)

[4] Wilenski, P. (1986). *Public power and public administration.* (Hale and Iremonger: Sydney)

This model differs from the 'cure' emphasis of the US Endangered Species Act.

[6] e.g. "The Secretary must not issue a licence or permit for and the Governor in Council must not authorise the taking, trading, keeping, moving or processing of protected flora if in the opinion of the Secretary or the Governor in Council (as the case may be) to do so would threaten the conservation of the taxon or community of which the flora is a member or part."

[7] The commercial harvesting of sphagnum moss from private land is now not permitted at all.

[8] Meaning kill, injure, collect or harvest.

[9] Indirect regulation under the Flora and Fauna Guarantee Act is achieved where Governor-in-Council Orders allow approvals or prohibitions under other Acts to be counted as approvals or prohibitions for the purposes of the Flora and Fauna Guarantee Act.

[10] See footnote 6 on page 218

[11] Public submissions and public hearings should be provided for. This sort of review is undertaken in the US by the Government Accounting Office.

[12] Although it is virtually never used, the Wildlife Regulations do include a control over the damaging of wildlife habitat, providing the destruction isn't already authorised by another mechanism; e.g. via a planning permit.

[13] In other States and overseas, 'wildlife' usually means both fauna and flora.

[14] See: http://www.green-innovations.asn.au/ for many papers on how to tackle the economic restructuring.

[15] Since this paper was presented, a Biodiversity Alliance of environment groups has formed in Victoria to push to get biodiversity back on the government and community agenda. There is a link to the Biodiversity Alliance on the VNPA website at http://www.vnpa.org.au/. Green Innovations has also begun work on the formation of a transformative financing organisation to mobilise funds to support strategic actions to promote biodiversity conservation. See: http://www.green-innovations.asn.au/btf.htm.

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The Victorian Flora And Fauna Guarantee Act – A Toothless Tiger Quoll?

Andrew Walker*

Abstract

This paper provides a short summary of the FFG Act and sets out the key problems with the Act and its implementation to date. Then LFF's recommendations for reform of the FFG Act are summarised. This paper is not, and is not intended to constitute, legal advice. Comments are of a general nature only. Readers of this paper should not act or refrain from acting on the basis of this paper without first obtaining specific legal advice. (*The Victorian Naturalist* **120** (6) 2003, 224-237)

Introduction

Lawyers for Forests

Lawyers for Forests (LFF) is a non-politically aligned association of legal professionals working to promote the conservation and better management of Victoria's native forests. LFF believes there should be no logging of, or other activities that detrimentally affect, old growth and high conservation value forests.

Whilst such logging and other activities continue to occur, LFF's main focus is on the legal mechanisms in place to conserve and manage Victoria's native forests and the taxa of flora and fauna that live in those forests. However, LFF is also interested in the protection of biodiversity in general and is concerned by the alarming reduction in all forms of natural habitat and the consequent impact on Victoria's native taxa.

Loss of biodiversity

Loss of biodiversity is one of Australia's most pressing environmental issues.[1] In Victoria, we have lost 19 of the 91 taxa of non-marine mammals known to have inhabited the State since European settlement. More than 900 taxa of Victorian plants are rare or threatened and this number is growing. Satellite maps graphically illustrate the loss of some ecological communities, with 30% of the State's broad vegetation types having been reduced by 80%.[2]

While extinction can occur naturally, the vast majority of extinction of taxa in modern times is caused by human activities. These activities are varied and include habitat destruction and degradation (e.g. logging of old growth forests), incompatible land use and development, resource exploitation and toxic pollution. Of these, the single greatest human threat to threatened taxa is habitat loss.

LFF's Review of the Flora and Fauna Guarantee Act, 1988, Victoria, (the FFG Act)

The FFG Act is the principal legislation in Victoria aimed at protecting biodiversity. In its time, it was regarded as landmark and farsighted legislation. This was partly because the FFG Act focuses not only on single taxon conservation but also on threatening processes and protection of communities of taxa and their critical habitat.

In November 2002, and fourteen years after its enactment, LFF undertook a review of the FFG Act to examine its operation and implementation (the 2002 LFF review). LFF focused on whether the FFG Act was effective in achieving its objectives and, in particular, whether it has been effective in achieving what are its primary objectives – to conserve listed threatened taxa, and to ensure that genetic diversity of flora and fauna is maintained. In examining this question, LFF focused on a major and critical source of biodiversity – Victoria's native forests.

The following paper is an updated and shortened version of the 2002 LFF review.[3]

Summary of the FFG Act

Introduction

The FFG Act was passed by the Victorian Parliament on 6 May 1988. The objectives of the FFG Act are to:

- guarantee that all taxa of Victoria's flora and fauna can survive, flourish and retain their potential for evolutionary development in the wild;
- conserve Victoria's communities of flora and fauna;

*Solicitor, Accredited Planning and Environmental Law Specialist, c/- Lawyers for Forests, PO Box 550 Collins St West, Melbourne, 3007
Email llf@lawyersforforests.asn.au

- manage potentially threatening processes;
- ensure that any use of flora or fauna by humans is sustainable;
- ensure that the genetic diversity of flora and fauna is maintained;
- provide programs of community education, encourage co-operative management of flora and fauna and assist and give incentives to enable flora and fauna to be conserved; and
- encourage the conserving of flora and fauna through co-operative community endeavours.

The FFG Act outlines five main statutory processes which can be utilised to help achieve these objectives:[4]

- listing of threatened taxa, communities of flora or fauna, and potentially threatening processes;
- creation of Action Statements for all listed taxa, communities of flora or fauna and processes;[5]
- adoption of Management Plans for any taxon, community of flora or fauna, or potentially threatening process; [6]
- declaration of a Critical Habitat (Critical Habitat) if the habitat is critical for the survival of a taxon or a community of flora or fauna;[7] and
- if listed as Critical Habitat, the Minister for Environment (the Minister) may then make an Interim Conservation Order, (ICO) to conserve the Critical Habitat.[8]

These processes are described in greater detail below.

Listing of taxa and threatening processes[9]

Nominations for listing are considered by the Scientific Advisory Committee, (SAC) which was established under Section 8 of the FFG Act. While anyone can nominate a taxon, in practice considerable scientific knowledge is required to do so.

Part 3 of the FFG Act sets out the eligibility criteria for listing, and the process for the SAC to follow once a nomination has been made.

The Minister must consider (but is not bound to follow) the recommendations of the SAC and any comments of the Victorian Catchment Management Council.[10]

Action Statements[11]

An Action Statement must be prepared 'as soon as possible' after a taxon or community or process has been listed. The Action Statement must set out what has been done to conserve and manage the listed taxon/community/process. It may also include what is intended to be done.

The SAC and the Victorian Catchment Management Council have an advisory role in the preparation of an Action Statement.[12] The Minister must consider any advice given by these bodies, as well as any other relevant nature conservation, social and economic matters when making an Action Statement.

Management Plans[13]

The FFG Act allows the Secretary, (the Secretary) to the Department of Sustainability and Environment (DSE) to prepare plans for the management of any taxon or community or potentially threatening process. The Management Plan must include details of the taxon or community or potentially threatening process to which it applies and then detail the management objectives in relation to that subject, together with information on the implementation and evaluation of those objectives. As well as considering nature conservation matters, social and economic consequences must be considered and a date must be set for review of the Management Plan.

The FFG Act sets out a consultative process with landholders or water managers who may, in the Secretary's opinion, be directly and materially affected by the Management Plan. Notice of the preparation of a draft Management Plan must be published in relevant newspapers.

The FFG Act also allows the Secretary to enter into a public authority management plan with one or more public authorities for the management of any taxon or community or threatening process.

Critical Habitat[14]

The Secretary may determine that the whole or a part of any of the habitat of any taxon or community of flora or fauna is critical to the survival of that taxon or community.

The term 'Critical Habitat' is not defined in the FFG Act. Although there is a notification process, the determination of a Critical Habitat does not have any immediate consequences without an ICO.

Interim Conservation Orders[15]

The Minister may make an ICO to conserve the Critical Habitat of a listed (or nominated for listing) taxon or community on Crown land or in water under Crown control or a listed (or nominated for listing) taxon, but not community, on private land or water under private control.

Before making an ICO the Minister must consult with any other Minister whose area of responsibility is likely to be affected by the ICO. In making the ICO, the Minister must consider nature conservation, social, economic and any other relevant matters.

The ICO may deal with a range of matters associated with the management of the Critical Habitat, the subject of the ICO.[16]

After the making of the initial ICO, there is a public consultation period, and the opportunity for the Minister to confirm or revoke the ICO. When making a decision relating to confirmation, the Minister must consider nature conservation matters, social and economic consequences, the advice of the Secretary on consultation, submissions and any other relevant matters.

The Minister may suspend any licences, permits or authorities issued under other Acts if they contravene the terms of the ICO.[17] The ICO also prevails over the provisions of any planning scheme.

A landowner or water manager is entitled to compensation for financial loss suffered as a 'natural direct and reasonable consequence' of the making of the ICO, including the costs of complying with the ICO, or loss associated with the suspension of any licences, permits or authorities by the Secretary.[18]

Further, the Secretary is required to assist any person who is required to carry out works under the ICO, if the Secretary believes the person could otherwise claim compensation under the FFG Act.

A person has a right to appeal to the Victorian Civil and Administrative Tribunal (VCAT) in relation to a range of matters arising from the making of the ICO, for example, any requirement or prohibition placed on a person by a confirmed ICO.[19]

ICOs apply for a period of only 2 years from the date of the confirmation of the ICO, or an earlier date specified by the Minister or in the ICO. Before the ICO expires, the Minister and the Secretary must take all reasonable steps for the purpose of ensuring the long-term conservation of the taxon, community or Critical Habitat in respect of which the order was made.

Offences and Penalties under the FFG Act

The FFG Act creates the following offences:

- Non-compliance with an ICO is punishable by a maximum penalty of $10,000.[20]
- Taking, trading in, keeping, moving or processing protected flora without a licence or permit.[21] A maximum penalty of $5,000 applies.
- Taking, trading in, keeping, moving or processing protected flora in contravention of an Order of the Governor-in-Council. A maximum penalty of $4,000 applies.

Key Deficiencies in the FFG Act and its Implementation

This section of the paper considers some of the key deficiencies that LFF has identified in the FFG Act. It starts with issues regarding implementation (or lack thereof) and then looks at some intrinsic problems with certain provisions of the FFG Act.

Delays in implementation

The FFG Act provides for a variety of instruments and documents to be prepared by DSE. However, none of the provisions in the FFG Act sets definite time-frames for completion. Instead, in a number of cases, the FFG Act provides that documents are to be completed 'as soon as possible'. LFF has observed long delays in the completion of relevant documentation and instruments, in particular the preparation of Action Statements. For example:

- Section 17 of the FFG Act required the Secretary to prepare a Flora and Fauna Guarantee Strategy 'as soon as possible' after the section came into operation, which was 1988. However the Strategy was not produced until 1997.
- As at November 2003, 465 taxa and 35 ecological communities were on the list of threatened taxa and communities under the FFG Act and 32 processes were on the list of potentially threatening processes.[22] However, only 197 approved Action Statements have been completed, covering around 240 taxa, communities and threatening processes. In other

words, Action Statements have not been prepared for approximately half of the listed taxa, communities and threatening processes.

Lack of utilisation of key conservation powers

Aside from the instances where Action Statements or Management Plans have not been prepared, some sections of the FFG Act are not utilised at all. This is a critical issue. Whilst there are defects in the FFG Act itself, the Victorian Government also appears to lack the will to fully implement it, and provide the necessary resources to DSE. For example:

- Since the commencement of the FFG Act, only one Critical Habitat determination has been made.[23]
- While ICOs are an important legal power (and roughly one third of the FFG Act is dedicated to them), they remain an unused and untested mechanism. No ICOs have been made in the 15 year history of the Act.

Content of Action Statements and Management Plans[24]

It is arguable that the system for preparation of Action Statements and Management Plans, as it currently stands, is failing in many cases to address the decline of listed threatened taxa. Reform of the process is required in order for these documents to be relevant, powerful tools for conservation.

It is essential that any Action Statement or Management Plan prepared be effective in achieving the goals of the FFG Act, namely the conservation of threatened flora and fauna. Action Statements and Management Plans should be made in consultation with recognised experts in the area, in order to be scientifically sound.

They should indicate all key actions that are required, not just those DSE or other agencies have committed to.

Review and Implementation of Action Statements and Management Plans

All Action Statements (and Management Plans, when this tool is utilised) should be revised on a 'regular' basis so that they reflect scientific developments in the area.[25] They should also be implemented in government decision making, particularly with respect to forestry operations in Victoria's forests. Forest Management tools[26] should fully implement Action Statements and Management Plans. They should also be updated as new Action Statements or Management Plans are approved or updated. It is unclear why this is not the case at present, given the time and resources invested in researching and creating Action Statements and Management Plans.[27]

There are also problems of delay in implementing 'actions' specified in Action Statements. Typically, Action Statements specify numerous actions that need to be completed and implemented. Although LFF found it very difficult to obtain information on the status of the 'actions' in Action Statements, LFF is aware that many 'actions' have been awaiting implementation for considerable periods of time, and at the date of this paper still await implementation.[28]

Protection of flora severely limited

Part 5, Division 2 of the FFG Act sets out a range of offences relating to 'protected' flora (which includes all listed flora and any flora declared to be protected flora by the Governor-in-Council). Section 47(1) makes it an offence to 'take' (kill, disturb, injure or collect), trade in, keep, move or process protected flora, unless authorised by a licence or permit, or pursuant to an Order by the Governor-in-Council.

There is a notable limit on the ability to give such an authorisation by licence, permit or pursuant to an Order by the Governor-in-Council. Section 48(4) prohibits the Secretary issuing a licence or permit, and prohibits the Governor-in-Council giving authorisation, to take, trade in, keep, move or process protected flora if in the opinion of the Secretary or the Governor-in-Council (as the case may be) to do so would threaten the conservation of the taxon or community of which the flora is a member or part.

However, in practice the protection afforded to protected flora under these provisions is severely limited, because:

(a) the FFG Act excludes from its operation vast areas of land which form some of the most important habitats of listed flora, namely private land;

(b) logging activities in State Forest are given blanket authorisation under a poorly enforced Governor-in-Council Order; and
(c) the FFG Act fails to include powers to seize protected flora when an offence is detected, and for the magistrate to order that the flora be forfeited.
The first two of these issues are explained further below.

Lack of protection for flora on private land

The defences in Section 47(2) of the FFG Act permit the owner or lessee of private land to kill and disturb protected flora, provided that the flora is not taken for the purposes of sale and that the flora is not taken from a Critical Habitat.

As there are no Critical Habitat determinations, this exemption effectively means that, under the FFG Act, protected flora receives no protection on private land.

LFF believes that this exemption is inconsistent with the objectives of the FFG Act set out in Section 4, including the objective of guaranteeing that all taxa of Victoria's flora can survive and flourish. It also highlights the need to determine Critical Habitats for all species (especially flora) and communities that rely on private land, so that Section 47 is triggered when 'taking' is proposed or occurring.

Authorisation of logging activities

Of critical concern to LFF is the existence of the Forest Produce Harvesting Order, which effectively excludes logging and timber operations from the application of the FFG Act controls. The Forest Produce Harvesting Order authorises the taking of protected flora in State Forest and Crown land other than Critical Habitat, where that taking is a result of or incidental to harvesting operations or associated road works authorised under the Forests Act 1958 (Vic) and provided the taking complies with certain conditions.[29] As a result, individual protected flora permits are no longer required.

So, in addition to LFF's belief that the FFG Act and its implementation is ineffective, a significant proportion of Victoria's forests (and therefore a significant portion of Victoria's flora and fauna habitat) is effectively exempt from the operation of the FFG Act controls.

The argument is often made that logging in Regional Forest Agreement (RFA) areas has already been the subject of Environmental Impact Assessment (EIA) following the RFA process. Under the RFA process, the government undertook a 'Comprehensive Regional Assessment' (CRA) of Victoria's forests. Following the CRA, the Commonwealth and Victorian governments executed RFA agreements. Under the RFA agreements, Victoria's forests can be divided into two categories:

- 'Comprehensive Adequate and Representative' (CAR) Reserve forest (basically, forest identified as worthy of protection); and
- Other forest (State Forest) (basically forest identified as suitable for logging).

Under the RFA agreements, the Commonwealth also:

- Accredited the Victorian forest management system with its regulatory instruments, such as regional level Forest Management Plans (FMPs) and the Code of Forest Practices (the Code).
- Effectively withdrew from involvement in logging operations in Victoria.

However:

- Leaving aside the adequacy of the criteria for ascertaining the CAR Reserve Forests, there were flaws in the CRA analysis so that it could not be said to constitute adequate EIA.
- The Victorian forest management system assumes that the preparation of the FMPs and operation of the Code ensures adequate EIA of the effects of logging on State Forests.[30] However, LFF believes the FMPs and the Code do not adequately assess or minimise the impact of logging on Victoria's threatened flora and fauna.[31]

The lack of proper pre-logging EIA in Victoria's State forests leads to a failure to protect the biodiversity of those forests. The effective exemption of logging activities from the operation of the FFG Act exacerbates the problem.

No offence of taking listed fauna

Despite containing offences relating to protected flora (Part 5, Division 2) and listed fish (Part 5, Division 3), the FFG Act does not contain similar provisions in relation to other listed fauna. The operations of the FFG Act, in this respect, need to be considered in conjunction with the Wildlife Act. The Wildlife Act establishes a range of offences for the unauthorised handling of notable wildlife, including hunting, taking or destroying endangered wildlife.

It is likely that the FFG Act does not create an offence of taking listed fauna because of the existence of the offences in the Wildlife Act. However, the prohibitions applicable to fauna in the Wildlife Act provide less protection to taxa in their natural habitat than the prohibitions in the FFG Act. The FFG Act expressly prohibits disturbance and injury and, based on the decision in the Chaelundi case,[32] may also prohibit indirect as well as direct interference with essential social and biological patterns of a taxon.

General lack of enforceability

Currently, Section 4(2) requires public authorities to be administered with regard to the flora and fauna conservation and management objectives set out in Section 4(1). However, there is no specific statutory obligation on decision makers to implement or give consideration to the impacts on listed taxa, threatened communities or critical habitat in government decision making, except when deciding whether to grant a permit under Section 40(2) of the FFG Act. Similarly, other than under Section 40(2), there is no statutory requirement to ensure that Action Statements and the Flora and Fauna Guarantee Strategy are taken into consideration by authorities when making decisions under the FFG Act or any other Victorian legislation.[33]

Essentially, the FFG Act is good at setting out procedures, but lacks enforcement mechanisms for ensuring that those procedures are carried out. In particular:

(a) Action Statements

The FFG Act contains no enforcement mechanisms that could be used to ensure that Action Statements are prepared in a timely manner.

Perhaps more importantly, once an Action Statement is prepared, no enforceable obligations ensue. Action Statements do not bind the government, or anyone else, to take any actions at all. As a result, the existence of an Action Statement does not necessarily protect listed threatened taxa, or the habitat of those taxa. They are not, for example, fully implemented in FMPs.[34] Another issue of concern is that there are no penalties imposed on a person for breaching any provision of an Action Statement.

DSE's limited resources may also mean that the contents of Action Statements that are prepared are inadequate.

(b) No third party standing

Aside from suffering from an overall lack of enforceable provisions, one of the most significant omissions from the FFG Act is the lack of third party standing to uphold the provisions that can be enforced.

At present, DSE is the only body able to take action for offences committed against the FFG Act. While being an appropriate body to oversee the FFG Act, DSE is obviously constrained by its budget. This fact has the potential to impact on the extent of monitoring that can be conducted, and subsequently the number of breaches that can be penalised.

(c) Limited avenues for review

As previously mentioned, the FFG Act has a lack of time-frames for making decisions and implementing the FFG Act. In some instances, there is no statutory duty on DSE to take particular actions. For example, there is no duty on DSE to identify threatened taxa to be listed under the FFG Act or to declare Critical Habitat. Furthermore, there is no provision in the FFG Act requiring the decision makers to provide reasons for their decisions.[35] These factors make it difficult for an interested party to review a decision, or failure to make a decision, under the FFG Act.

Lack of information available to the public

It is difficult to obtain adequate information. For example, in LFF's experience, information about the steps taken to implement Action Statements has not been easy to obtain. Furthermore, the information on the DSE website is often out of date. For example, in November 2003, 197 Action Statements had been prepared, however, only 123 were available on the website.[36]

Impact assessment — no requirement for FFG Act to be taken into account in decision making

As indicated above, the FFG Act does not require any comprehensive assessment of projects which may impact threatened taxa or their habitat. The main legislation dealing with EIA in Victoria is the Environment Effects Act 1978, (the EE Act). This Act is administered by the Department of Infrastructure and typically applies only to large scale projects. The Planning and Environment Act 1987, (the P&E Act) also provides that the environmental effects of certain developments be considered in decision making. The State Planning Policy Framework of all Victorian Planning Schemes (apart from the Scheme for the Port of Melbourne) make the objectives of the FFG Act and any Action Statements relevant considerations in decision making under Victorian Planning Schemes. However, the Planning Schemes do not require Responsible Authorities to refuse to issue planning permits which contravene the requirements of Action Statements. Further, there is no requirement to consider the listing of taxa, or any other implementation of the FFG Act, when making decisions under the P&E Act or EE Act.

A review of EIA procedures under the EE Act and the P&E Act is currently being undertaken by the Department of Infrastructure. LFF made a submission to the Advisory Committee appointed to advise the relevant Minister and made a number of recommendations, which are discussed below.

Recommendations for Reform

Greater resourcing

The primary reason for non-implementation or delays in implementation of the mechanisms in the FFG Act to protect flora and fauna taxa appears to be insufficient resources and funding dedicated to this purpose at DSE and previously NRE.

LFF strongly advocates the provision of substantially greater resources to DSE to allow it to undertake the following tasks:

- prepare outstanding Action Statements for listed taxa, ecological communities and key threatening processes;
- review existing Action Statements and update where required;
- employ staff to monitor the implementation of the Action Statements 'on-the ground';
- require the Code, FMPs, WUPs and FCPs to adequately assess impacts on listed taxa and ecological communities, and avoid key threatening processes in State Forests;
- require the Code, FMPs, WUPs and FCPs to fully implement Action Statements, and update the Code, FMPs, WUPs and FCPs as required;
- educate other statutory authorities with land management functions about the requirements of the FFG Act; and
- conduct an education campaign in schools and local communities about the requirements of the Act and the rights of the community to nominate taxa and communities for listing.

Government commitment to implementing the FFG Act and greater government transparency

Whilst the Government may agree to amend the FFG Act to strengthen its operation, a strengthened FFG Act is of no effect if the Government lacks the will to implement it. An apparent lack of will seems to exist now, as sections of the FFG Act are not utilised.

Motherhood statements are insufficient evidence of such commitment. In the interests of open and accountable government, public reporting mechanisms should be put in place, and up-to-date information should be easily accessible to the public. LFF believes DSE and the Department of Primary Industries (DPI) should be subject to scrutiny in ascertaining whether the Departments have complied with the FFG Act, and should be required to report on their achievements in fulfilling the objectives of and meeting its requirements under the FFG Act.[38]

The performance of other agencies that have (or should have) committed to biodiversity conservation should also be reported. For example, Water Authorities, Parks Victoria and Local Government play important roles and should also be required to report.

Integration with other legislation[39]

The FFG Act should be integrated with other legislation. Currently it is not. It should be mandatory for the principles and mechanisms under the FFG Act to be taken into account in decision making, in particular in EIA, and when EIA is not required, in planning decisions made under the P&E Act.

In its submission to the Advisory Committee appointed to advise the Minister for Planning in the Environment Assessment Review, LFF made a number of recommendations regarding integration of the FFG Act with other legislation, including the following:

(a) Environmental impact assessment legislation

LFF recommends that whilst old growth and high conservation value forest continues to be logged, Victorian environment impact assessment legislation should be linked to the FFG Act so that:

- a mandatory trigger for EIA is introduced for highly hazardous activities, and activities which may have a significant effect on a threatened taxon, including logging in old growth or high conservation value forests in State Forests; and
- the provisions of and the objectives of the FFG Act should be required to be taken into account in the decision whether or not to approve an action subject to EIA.

(b) Planning legislation

LFF is also of the view that there should be greater integration between the FFG Act and the planning scheme processes. For example, either the P&E Act or the FFG Act could be amended to insert a requirement to identify any impact on listed taxa or communities and to address those impacts in planning permit applications and planning scheme amendments.

Furthermore, there should be a legislative requirement that the FFG Act be a mandatory consideration in decisions made under the P&E Act.

(c) Wildlife Act

As mentioned previously, the FFG Act imposes controls and prohibitions on protected flora and listed fish but not on listed fauna. The Wildlife Act then plays a role in relation to other native taxa.

LFF recommends that a review of the effectiveness of the implementation of the Wildlife Act and Regulations in achieving the objectives of the FFG Act and Flora and Fauna Guarantee Strategy be carried out.

LFF also recommends that the introduction of a prohibition on taking all listed flora and fauna be included in either the FFG Act or the Wildlife Act. This is discussed further below.

The FFG Act's limit on discretion in decisions to authorise activities that could threaten flora in Section 48(4) should be included in the Wildlife Act in relation to wildlife, and extended to listed fish in the FFG Act itself.

Furthermore, there should be some limitations on the ability to obtain a licence under the Wildlife Act to take threatened taxa that are listed under the FFG Act.

(d) Forestry legislation

Legislation should require the Code, FMPs, WUPs and FCPs to fully implement Action Statements and Management Plans. The Code and FMPs should be regularly reviewed to ensure they comply with Action Statements and Management Plans.

(e) General

The FFG Act should contain an obligation on decision makers to take, at a minimum, the following into consideration, when making decisions under the P&E Act and other legislation applicable to land use or development:

- the listing of a taxon, community or threatening process;
- the provisions of any Action Statement or Management Plan;
- the listing of any Critical Habitat, or making of an ICO; and
- the Victorian Flora and Fauna Guarantee Strategy.

This would go some way to avoiding planning permits being issued in areas of Critical Habitat and avoiding habitat destroying events.

Expansion of offences and controls

(a) Offence to take any listed taxon

Currently the Act creates offences relating to the handling of flora (Part 5, Division 2) and fish (Part 5, Division 3). These provisions state that a person must not, without a licence, 'take, trade in or keep' any listed fish (Section 52) or 'take, trade in, keep, move or process' protected flora (Section 45). It does not make sense to confine the offences in the FFG Act to flora and fish. The FFG Act should be amended so that the offences apply across the board to all listed taxa.

The defence available to private landowners and lessees in Section 47(2) of the FFG Act should be removed.

(b) Offence to damage habitat
As habitat destruction is the biggest single cause of taxa extinction, the FFG Act should prohibit the harmful alteration, disruption or destruction of habitat of listed taxa and communities. Or at the very least, the FFG Act should prohibit the destruction of the 'residence' of a listed taxon (e.g. the hollow, nest, or other dwelling place), as does the recent Canadian legislation, the *Species At Risk Act 2002*.

(c) No blanket authorisation for logging
Logging operations conducted in accordance with the Forest Produce Harvesting Order do not require individual permits under the FFG Act. This authorisation should be removed, and the FFG Act taken into account in approving and decision making under the Code, FMPs, WUPs and FCPs.

(d) Include essential enforcement provisions
Powers for an authorised officer to seize flora that is the subject of an offence, and for a magistrate to order the offender to forfeit the flora, are required before the protected flora controls can be fully implemented.

Increase penalties
In addition to broadening the ambit of the offences, the penalties, which are clearly inadequate to provide sufficient protection, should be markedly increased. For instance, currently the taking of a listed fish or protected flora will result in a $5000 fine, while the sale of that fish or flora or use of it in other ways may reap a far greater reward for the offender.

LFF submits that the penalties in the FFG Act should at least equate to those in the Commonwealth environment protection legislation, the Environment Protection Biodiversity Conservation Act, 1999 (EPBC Act). Generally, maximum penalties in this Act for offences similar to those in the FFG Act are $110,000 and/or two years' imprisonment.

Third party rights
Under the FFG Act the public has some rights to be consulted and to nominate items for listing. In particular, any member of the public can nominate a taxon or potentially threatening process for listing or 'de-listing'.[40] After the SAC has made a preliminary recommendation for listing there is provision for public consultation,[41] and the public has the opportunity to make submissions regarding ICOs.[42]

However, to ensure adequate community participation in the enforcement of the FFG Act, more accountable government decision making and to enable action to be taken in situations where DSE does not take enforcement action, the FFG Act should be amended to give third parties the following rights:

(a) Rights to appeal
Third parties should have the right to appeal the following decisions made under the FFG Act:

- the decision of the Minister to list or not to list threatened taxa, communities of flora or fauna and threatening processes;
- the decision of the Secretary to approve or determine not to approve an Action Statement or Management Plan;
- the decision of the Secretary to prepare or decide not to prepare Management Plans;
- the decision of the Secretary to declare or decide not to declare Critical Habitat (subject to the proviso that a definition of Critical Habitat should also be inserted in the FFG Act);
- the decision of the Minister to make or determine not to make an ICO;
- the decision of the Minister to approve or determine not to approve an Action Statement or Management Plan;
- the decision of the Governor-in-Council to make an Order authorising the taking of protected flora or listed fish; and
- the decision of the Secretary to issue a permit or licence authorising the taking of protected flora or listed fish.

(b) Rights to make nominations
Given the lack of resources provided to DSE, participation of NGO groups and other community groups in the processes of threatened taxa conservation and recovery is essential.

As previously mentioned, the FFG Act does give certain rights of nomination to the public. These rights should be expanded to allow third parties to nominate (and have considered):

- a threatened taxon or community or a potentially threatening process as meriting the preparation of a Management Plan; and
- areas for consideration as Critical Habitat; and
- threatened Critical Habitat as meriting the approval of an ICO.

(c) Enforcement action

LFF believes an appropriate model for enforcement action is that used in the Victorian planning process under the P&E Act. This model allows 'any person' to apply to VCAT for an enforcement order to enforce the provisions of the P&E Act and planning schemes made under it.

Accordingly, LFF believes third parties should have the right to take enforcement action prior to or after a breach of the FFG Act, Action Statements, Management Plans, protected flora permits and Orders, listed fish licences and ICOs made under the FFG Act.

The use of an enforcement order or interim enforcement order should not be tied to 'Critical Habitat' areas in the same way as ICOs are.

Extending enforcement rights to the general community would not only broaden the resource base for taking action, but would also empower people and allow those interested to take an active role in the protection of Victoria's most threatened taxa. Further, it would relieve the pressure currently placed on DSE to fulfil its duties in this area, in addition to its other duties under the FFG Act to prepare Action Statements and determine Critical Habitat. So, third party enforcement rights would be beneficial on a number of levels.

Two issues arise from introducing third party enforcement rights: the appropriate forum for enforcement action, and the extent of the right of third parties to bring enforcement action (third party standing).[43] LFF believes:

- VCAT (rather than, for example the Magistrates' Court) is the appropriate forum for third party enforcement action.
- To allay concerns that third party standing is too wide, a provision similar to that in the P&E Act, whereby people who bring a vexatious or frivolous matter before VCAT face having costs awarded against them. If this measure is considered an insufficient deterrent, the standing test could be slightly narrower, and mirror that found in Sections 475-480 of the EPBC Act.[44]

Expansion of the role of Critical Habitat declarations

The declaration of Critical Habitat is a crucial part of the FFG Act. However, no definition is included in the FFG Act. A broad definition should be included which concentrates on preservation of habitat critical to the ongoing evolution and development of the taxa in the wild rather than concentrating upon habitat critical to the maintenance of a minimum viable population.

Criteria for Critical Habitat should be set out in the FFG Act.The Act should also contain a requirement that the Secretary make a Critical Habitat declaration (or alternatively, consider making a Critical Habitat declaration) if habitat meets the Critical Habitat criteria. Furthermore, there should be an obligation on the Minister to either make, or at least consider making, an ICO if Critical Habitat is threatened.

Finally, the Critical Habitat declaration process should be overseen by the SAC, in much the same way as the listing process currently is.

Expansion of the role of ICOs

(a) Right to compensation

The right to compensation for financial loss suffered as a natural, direct and reasonable consequence of making an ICO, contained in Section 43 of the FFG Act, should be amended. LFF considers that the starting position should be that landowners have a responsibility to ensure the protection of listed flora and fauna on their properties, and should not be compensated for fulfilling that responsibility.[45]

However, LFF accepts that compensation may be necessary if, prior to the making of an ICO, the relevant landowner had existing use rights, generally as defined under the P&E Act, or the right to develop land in accordance with an existing planning permit. In such circumstances, if the ICO restricts the landowner's existing use rights, or where a landowner is required by the ICO to undertake positive action (such as revegetation), reasonable compensation should be payable to the landowner by DSE.[46]

(b) No time limit

LFF considers that ICOs should not be automatically limited to a maximum of 2 years, as often the importance of the habitat will not have diminished upon the expiry of 2 years. It would be more appropriate to leave ICOs in existence until they are revoked and to rename the orders 'Conservation Orders'.

In other words, ICOs should not necessarily be an 'interim' measure.

(c) Other matters

LFF believes the right to appeal to VCAT on matters relating to the making or application of an ICO should be retained.

The exemption of communities on private land from ICO controls should be repealed. All listed species and communities should have the protection of an ICO, regardless of land tenure.

Preparation and implementation of Action Statements

Currently, Action Statements *must* set out what has been done to conserve and manage that taxon or community or process and what is intended to be done and *may* include information on what needs to be done. It should be mandatory, rather than discretionary, to include information on what needs to be done to protect and conserve the taxa or community, or to halt the threatening process. Furthermore, the Regulations should set out in more detail the matters that should be included in Action Statements.

LFF has previously discussed the delay that is occurring in preparation of Action Statements. To address this problem, the FFG Act should specify a mandatory timeframe for completion of Action Statements.

One of the fundamental flaws in the current system is that there is no obligation to monitor the taxa, community or threatening process after Action Statements are completed. A mandatory obligation to implement Action Statements and review their effectiveness should be included in the FFG Act. In this regard, an obligation should be introduced to provide annual reports to Parliament on the progress of implementation of the FFG Act.

LFF submits that a legislative program of regular public and independent review of the status of Action Statements, and the effectiveness of Action Statements in protecting listed taxa and communities and in managing threatening processes should be introduced.

Other changes

(a) ESD Principles enshrined in the FFG Act

LFF submits that the FFG Act should incorporate the principles of ecological sustainable development (ESD). LFF notes that other environmental legislation – the EPBC Act, and the Environment Protection Act, 1970 (Victoria) – incorporate ESD principles.[17] These provide appropriate models.

Adoption of ESD principles into the FFG Act (and consideration of the FFG Act) may lead to the better protection of taxa in Action Statements and FMPs, WUPs and FCPs. ESD principles should be taken into account in decision making (and approving FMPs, WUPs and FCPs).

(b) Reasons for decisions

Decision makers should be required to state their reasons for the decisions they make under the FFG Act, and where appropriate, to demonstrate that the decision does not threaten listed taxa or communities, and otherwise complies with the FFG Act.

Conclusion

LFF's analysis shows that the existing regulatory and policy framework for the protection of threatened taxa in Victoria is in need of a major overhaul. Fifteen years after its enactment, it is evident that while the FFG Act contains a number of useful procedures and instruments, it lacks substance and mandatory obligations, strict monitoring and reporting requirements and sufficiently punitive penalties. Judged against what are arguably its primary objectives – to conserve listed threatened taxa, and to ensure that genetic diversity of flora and fauna is maintained – the FFG Act has not been a success. Action statements have only been prepared for approximately one half of the listed taxa, communities and threatening processes. Furthermore, there is no evidence that any taxa or communities have been removed from the list due to an improvement in their conservation status.

One of the greatest failings of the FFG Act has been the failure to implement it.

LFF believes there are a number of reasons for this, including the following:

- DSE is, and its predecessor was, under-resourced;
- there appears to be a lack of government will to fully implement the FFG Act;
- there is a lack of government transparency and accountability in its decision making under and implementation of the FFG Act;
- the FFG Act is unenforceable; and
- the FFG Act (and actions taken under it) are not required to be taken into account in government decision making under the FFG Act, or generally.

Consequently, LFF submits that DSE should receive appropriate funding to fully implement the FFG Act, and the government commit to DSE fulfilling its obligations under the FFG Act.

However, this of itself is not sufficient. The FFG Act should be enforceable, and DSE should be accountable in its efforts to fulfil its obligations under the FFG Act.

To seek to achieve this, the FFG Act should be amended as outlined in this paper. These amendments include the following:

- third party enforcement, participation and review rights expanded;
- specific time-frames inserted in the FFG Act for DSE and other decision makers to take certain actions, or make decisions;
- DSE, DPI and other bodies required to report annually on its progress in implementing the FFG Act; and
- Clear criteria for decision making set out in the FFG Act, and decision makers required to provide and publish reasons for their decisions.

Finally, the FFG Act should be taken into account in government decision making, and integrated with the EE Act, and P&E Act. Unless a comprehensive EIA has been undertaken, exemptions from the application of the FFG Act (such as that which occurs by reason of the Forest Produce Harvesting Order) should be removed.

Acknowledgements

A number of LFF contributed to and reviewed this paper and the 2002 LFF review, including Susan Mohar and Michelle Barasic.

References

[1] See for example, State of Environment Report, 2001.

[2] Victoria's Biodiversity – Sustaining Our Living Wealth, Department of Natural Resources and Environment, (NRE), 1997.

[3] The complete 2002 LFF review can be downloaded at LFF's website, at: http://www.lawyersforforests.asn.au/lawpolicy.html. LFF can be contacted at lff@lawyersforforests.asn.au.

[4] Another key element of the FFG Act is the Flora and Fauna Guarantee Strategy (refer FFG Act, Sections 17 & 18). Detailed consideration of this document is outside the scope of this paper.

[5] FFG Act, Part 3, Sections 10–16.

[6] FFG Act, Part 3; Sections 21–24 (Management Plans).

[7] FFG Act, Section 20.

[8] FFG Act, Sections 26-44.

[9] FFG Act Sections 10–16.

[10] Established under the Catchment and Land Protection Act 1994. Section 16 of the FFG Act also requires consideration of any comments of the Conservation Advisory Committee. The Conservation Advisory Committee was formally established under the Conservation Forests and Lands Act 1987 during the late 1980s. However, LFF has been advised by DSE that the committee no longer exists and has not existed for many years.

[11] FFG Act Section 19.

[12] FFG Act, Section 19 states that the Secretary must also consider advice given by the Conservation Advisory Committee. However, as noted in footnote 11, this committee is no longer functioning.

[13] FFG Act Sections 21–24.

[14] FFG Act Section 20.

[15] FFG Act Sections 26–44.

[16] For the full list of matters, refer FFG Act, Section 27.

[17] FFG Act, Section 38.

[18] FFG Act, Section 43.

[19] FFG Act, Section 41(1)(a). For the full list of decisions against which a right of appeal is available, refer FFG Act, Section 41(1).

[20] In addition, a continuing penalty of $1000 per day will apply where a person has been convicted of non-compliance with the ICO and continues to fail to comply.

[21] Exceptions apply – for example: (1) logging in State Forests in accordance with an Order of the Governor-in-Council published in the Government Gazette, and (2) on private land, generally provided the flora is not offered for sale.

[22] The figures for listings and Action Statements were obtained directly from DSE in November 2003. The DSE website does have lists of the listed taxa, communities and threatening processes. However, these lists are somewhat out of date.

[23] The sole determination was made on 4 May 1996 over a 9 hectare site in Altona. The area was declared in an effort to protect the environment of the Small Golden Moth Orchid, which was threatened by the subdivision of remnant Western Basalt Plains Grasslands. Following a media release by the Department stating that an independent study had failed to find the orchid, the Secretary revoked the critical habitat declaration in May 1997.

[24] LFF understands that there are currently no Management Plans that have been prepared under the FFG Act.

[25] The DSE is currently developing a computerised information system called the 'Priority Actions Information System'. The system is designed to facilitate the preparation, implementation and review of Action Statements, the assigning of priorities to actions, the communication of actions and priorities to land managers and other authorities, and the monitoring of progress towards implementation. It is hoped that this system will be fully utilised to address some of the past difficulties and delays in implementing and reviewing Action Statements.

[26] In particular, the Code, FMPs WUPs and FCPs. refer to the text in footnote 30.

[27] The 2002 LFF review lists a number of examples, at pp 17-19, 49-70, One of these is the Otways Forest Management Plan. It was prepared before the Powerful Owl Action Statement was prepared. It has not been updated to implement the Powerful Owl Management Area system outlined in the Action Statement.

[28] LFF's enquiries related to the Action Statements for the Powerfnl Owl and Leadbeater's Possum.

[29] LFF believes the conditions are inadequate. For further information, refer to the 2002 LFF review, pp 20-21. It should also be noted that the exemption does not apply if the flora is taken from a Critical Habitat. However, as noted above, no Critical Habitat determinations have been declared.

[30] Refer to the 2002 LFF review Schedule 2, (pp 46-49) for an overview of the Victorian forest management system. In summary, the regional level FMPs generally identify which areas of State Forest are to be fully or partially protected (in the form of Special Protection Zones and Special Management Zones respectively), and wbich areas should be logged (identified as General Management Zones in the FMPs). Wood Utilisation Plans, (WUPs) are then prepared by DSE and show which areas within a Forest Management Area, (FMA) are to be logged in a particular year. These should be prepared in accordance with the Code and the FMP for the area, and allocate coupes for logging, within forest identified in the FMP as suitable for logging. Under the Code, Forest Coupe Plans (FCPs), are then prepared and approved before logging commences. The Code states that the FCP should respond to and show stream buffers and other protected areas. So the WUPs and FCPs are the local level and therefore site-specific documents, as opposed to the regional level FMPs. However, based on the assumption that tbe RFA process, FMPs, and the Code provide adequate EIA, the preparation and approval of WUPs and FCPs does not involve any further meaningful EIA.

[31] Although prepared in the context of reviewing sustainable yield rates, and therefore not addressing biodiversity as such, the Report of the Expert Data Reference Group (Professor Jerome Vanclay and Dr Brian Turner, 31 October 2001), stated that the NRE was not in a position to make long-term resource commitments, given uncertainties in the data. LFF has no reason to believe that biodiversity data and information is any more accurate.

Corkill v Forestry Commission of New South Wales (1991) 73 LGRA 126

[33] Although Action Statements are relevant considerations for planning authorities to consider when considering applications for planning permits, there is no legislative provision that prevents Responsible Authorities from issuing planning permits which are inconsistent with any Action Statements.

[34] See paragraph 3.3 of the 2002 LFF review.

[35] In practice, the SAC does document its reasons within the recommendation reports.

[36] Another example is FMPs. A number are out of print and not fully available on DSE's website.

[37] Provided appropriate funding is given, LFF believes the Commissioner for Ecologically Sustainable Development could play a role in monitoring DSE's and DPI's performance. The Commissioner could prepare annual reports evaluating their performance. Such reports should be tabled before Parliament. In particular, the report sbould review the status of Action Statements and Management Plans, and their effectiveness in the protection of taxa and management of threatening processes.

[38] Note – references to taking the FFG Act into account also include taking into account Action Statements, Management Plans, ICOs and Critical Habitat determinations and other actions taken and documents prepared under the FFG Act.

[39] FFG Act, Section 12(1).

[40] FFG Act, Section 14(3).

[41] FFG Act, Section 29(1).

[42] For further explanation of the reasons why LFF believes VCAT is the appropriate forum and the restrictions on standing that could be introduced to allay concerns that tbe 'floodgates could be opened' refer to the 2002 LFF review at pp 33-34.

[43] Tbe EPBC Act restricts standing to 'an interested person', where an 'interested person' is a person who has been involved in activities for the protection and conservation of, or research into, the environment in the 2 years preceding the proposed conduct.

[44] This is similar to the owner of a heritage building. An owner's development rights are limited once it is listed under the Heritage Act 1995 (Victoria) or under a planning scheme.

[45] LFF notes this is more generous than the compensation provided to the owner of a heritage building.

[46] EPA Act, Section 1B – 1E and EPBC Act Section 3A.

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Glossary of terms used

2002 LFF review	LFF, November 2002. Review of the FFG Act.
Action Statement	Action Statement made pursuant to FFG Act
the Code	Code of Forest Practices
CRA	Comprehensive Regional Assessment undertaken under the RFA Process
CAR Reserve	Comprehensive, Adequate and Representative Reserves
Critical Habitat	Critical Habitat declared pursuant to FFG Act
EE Act	Environment Effects Act 1978 (Vic)
EIA	Environment Impact Assessment
EPA	Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Cwlth)
ESD	Ecologically Sustainable Development
FCP	Forest Coupe Plan
FFG Act	Flora and Fauna Guarantee Act 1988 (Vic)
FMA	Forest Management Area (for which a FMP is prepared)
FMZ	Forest Management Zone
FMP	Forest Management Plan (for a particular FMA)

Glossary of terms used cont'd

Forests Act	Forests Act 1958 (Vic)
the Forest Produce Harvesting Order	Flora and Fauna Guarantee Act (Forest Produce Harvesting) Order 1988
GMZ	General Management Zone – term used in FMPs – see Schedule 2.
ICO	Interim Conservation Order, made pursuant to the FFG Act
LFF	Lawyers for Forests, Inc.
Management Plan	Management Plan made pursuant to FFG Act
the Minister	the Minister for Environment
NGO	Non-government Organisation
NRE	Department of Natural Resources and Environment
P&E Act	Planning and Environment Act 1987 (Vic)
RFA	Regional Forest Agreement
RFA Process	Regional Forest Agreement Process
SAC	Scientific Advisory Committee established under the FFG Act
Secretary	Secretary to NRE (now DSE).
State Forest	Forest outside the CAR Reserve Forest and therefore available for logging
VCAT	Victorian Civil and Administrative Tribunal
the Wildlife Act	Wildlife Act 1975 (Vic)
WUP	Wood Utilisation Plan

Implementation of the Threatened Species Conservation Act in NSW

Graham Wilson[1]

Abstract

The *Threatened Species Conservation Act 1995* (TSC Act) came into effect, in NSW, on 1 January 1996. The TSC Act provides broad protection to threatened plants and animals, including invertebrates, but not fish, which are protected under the *Fisheries Management Act 1984* (FM Act). The Act also allows for the listing of endangered ecological communities and endangered populations of species which are not otherwise endangered, and provides legal protection to threatened species either from direct harm to individuals or from damage to their habitat. An independent scientific committee is established to determine the lists of threatened species and threatening processes. The Act also provides for the preparation of Recovery Plans and Threat Abatement Plans within specified timeframes, integrates threatened species assessment into the assessment provisions of the *Environmental Planning and Assessment Act 1979* (EP&A Act), and includes other conservation measures. This paper explains major provisions of the TSC Act and provides summary information in regard to its implementation. Amendments to the TSC Act in 2002 on the basis of a review by a Joint Select Committee of the NSW Parliament in 1997 are briefly discussed. As many of the protective measures within the TSC Act are given effect through provisions within the *National Parks and Wildlife Act 1974* (NPW Act) these provisions are also considered. (*The Victorian Naturalist* **120** (6), 2003, 237-248).

Introduction

The *Threatened Species Conservation Act 1995* (TSC Act) was passed by the NSW Parliament at the end of 1995 and came into effect from 1 January 1996, replacing the *Endangered Fauna (Interim Protection) Act 1991*, which expired at this time. The new Act met a government commitment to provide comprehensive threatened species protection legislation by giving broad protection to threatened plants and animals, including invertebrates but not fish or marine vegetation, which are protected under parallel provisions of the *Fisheries Management Act 1984* (FM Act). In addition to the measures specifically directed towards threatened species management, the TSC Act provides a broader framework for biodiversity conservation through a requirement to establish a biodiversity advisory council and prepare a biodiversity strategy for NSW.

[1]Biodiversity Research and Management Division, NSW National Parks and Wildlife Service (now part of Department of Environment and Conservation NSW), PO Box 1967, Hurstville, NSW 2220.
Email Graham.Wilson@npws.nsw.gov.au

As well as providing for the listing and protection of threatened species (being a taxon or recognisable variant), it allows for the listing of endangered ecological communities (assemblages of species in a specified area) and endangered populations of species which are not otherwise endangered. Threatened species are provided legal protection either from direct harm to individuals or to damage of their habitat. The TSC Act establishes an independent Scientific Committee, not subject to Ministerial approval of its decisions, which determines the lists of threatened species and threatening processes. It also provides for the preparation of Recovery Plans and Threat Abatement Plans within specified time-frames, which mirror Commonwealth legislative requirements. The TSC Act integrates threatened species assessment into the assessment provisions of *the Environmental Planning and Assessment Act 1979* (EP&A Act), both in relation to the development approval process and through the making of environmental planning instruments. It also provides many opportunities for public participation in threatened species conservation measures. These include public exhibition of decisions of the Scientific Committee, recovery plans, threat abatement plans and critical habitat, a requirement to consider and minimise social and economic impacts in many plans and decisions, and third party standing for enforcement of its provisions in the Land and Environment Court.

This paper explains the provisions of the TSC Act and provides summary information in regard to its implementation. Amendments to the TSC Act in 2002, on the basis of a review by a Joint Select Committee of the NSW Parliament in 1997, are briefly discussed. As many of the protective measures within the TSC Act are given effect through provisions within the *National Parks and Wildlife Act 1974* (NPW Act) these provisions are also briefly considered.

Protection under the National Parks and Wildlife Act

The NPW Act gives protection to all fauna (includes native birds, animals, reptiles and amphibians but not fish) in NSW, unless otherwise specified (e.g. locally unprotected or in lawful custody). As a result all non-threatened native fauna are protected species in NSW (unless declared unprotected) and many provisions that apply to protected species under the NPW Act also apply to threatened species, though offences harming threatened species attract significantly higher penalties.

Plants, however, are generally treated as the property of the landowner on whose land they grow, with only a limited subset, those recognised as in commercial use, being listed as protected on the schedules of the NPW Act. Picking or selling of such protected native plants requires a licence under this Act. Provision is also made for management plans to be prepared for protected native plants to specify the basis of their use.

The NPW Act specifies it as an offence to harm protected fauna (maximum 100 penalty units plus 10 units per additional animal). It is also an offence to harm a threatened species or damage its habitat, and in this case the penalty is for up to 500 penalty units for a vulnerable species and up to 2000 penalty units for an endangered species, or its habitat.

Where an action, such as a development or proposal, will have a significant effect on the environment (includes native plants and animals) the *Environmental Planning and Assessment Act 1979* (EP&A Act) requires the preparation of an Environmental Impact Statement (EIS) and adherence to any specified protective conditions within any approval given in relation to it.

Protection under the Threatened Species Conservation Act

In order to understand how the TSC Act operates, its contents and major provisions are outlined.

Contents of TSC Act

Part 1 – objects & definitions

Actions taken to manage threatened species in NSW are required to be consistent with the objects of the TSC Act. These objects are:

- to conserve biological diversity and promote ecologically sustainable development;
- to prevent the extinction and promote the recovery of threatened species, populations and ecological communities;

- to protect the critical habitat of those threatened species, populations and ecological communities that are endangered;
- to eliminate or manage certain processes that threaten the survival or evolutionary development of threatened species, populations and ecological communities;
- to ensure that the impact of any action affecting threatened species, populations and ecological communities is properly assessed; and
- to encourage the conservation of threatened species, populations and ecological communities by the adoption of measures involving cooperative management.

Part 2 – listing processes

The listing of threatened species and threatening processes, based on the decision of an independent committee of expert scientists, 'the Scientific Committee' are provided for in this part, and the scientific grounds for such decisions are specified.

Listing categories are:

Schedule 1: endangered species, populations and ecological communities

- Part 1: Endangered species
- Part 2: Endangered populations
- Part 3: Endangered ecological communities
- Part 4: Species presumed extinct in NSW

Schedule 2: vulnerable species

Schedule 3: key threatening processes – this allows listing of key threatening processes which threaten biodiversity.

Any person can make a nomination to list (or remove from the list) a threatened species or threatening process. The Scientific Committee is then required to determine whether, in its opinion, the nomination meets specified criteria for each listing category. First a preliminary determination is made and advertised, calling for public submissions. If, following consideration of submissions and other relevant information, the Committee is satisfied that the criteria are met, it then makes a final determination, also advertised, which has legal effect.

For a species, population or ecological community to be removed from these schedules the Scientific Committee needs to be satisfied that it no longer meets listing criteria in the TSC Act.

Current listings on Schedules 1-3 are on the NPWS website (www.npws.nsw.gov.au). Over 850 species, endangered populations and endangered ecological communities, and 18 key threatening processes are currently listed.

Part 3 – critical habitat identification

This part provides for the identification of habitat critical to the survival of threatened species. It applies only to species and communities in endangered categories (not vulnerable species) and can apply to the whole, or any part of the habitat of an endangered species, population or ecological community. The Minister identifies critical habitat following an extensive public consultation process, which includes anyone with an interest in the land. Currently areas of critical habitat have been identified at Stotts Island Nature Reserve for Mitchells Rainforest Snail *Thersites mitchellae*, near Nowra for the Bombadery Zieria *Zieria baeuerlenii* and at Manly for its Little Penguin *Eudyptula minor* population. In addition, critical habitat for the Grey Nurse Shark *Carcharias arenarius* has been declared under the FM Act. Once critical habitat is identified it is shown on environmental planning instruments, and any action which affects it requires detailed environmental assessment. Where complex management issues need to be dealt with in relation to critical habitat, regulations are made under the relevant legislation to specify how this occurs.

Part 4 – recovery plans

This requires the preparation of a recovery plan within 5 years for endangered species and 10 years for vulnerable species which were listed when the TSC Act came into force at the start of 1996. For listings since this time the requirement is to prepare a recovery plan within 3 years for those on schedule 1 and 5 years for those on schedule 2. The TSC Act specifies the broad content and process of preparation of recovery plans. It also specifies that priority is to be given to preparation of recovery plans for nationally listed species, keystone species, indicator species, species at highest risk of extinction and those where recovery is feasible.

Part 5 – threat abatement plans

This requires the preparation of a threat abatement plan within 3 years for a listed key threatening process. While threat abatement plans are separate from recovery plans it should be noted that actions for some threats listed may overlap with actions in recovery plans. For example fox predation is a listed key threatening process for which a threat abatement plan has been prepared. This plan requires fox control to protect priority threatened species sensitive to fox predation. In many cases this action is also specified in recovery plans for these listed threatened species.

Part 6 – licensing

This part requires the issue of a licence or the approval of a property management plan for any action which harms a threatened species, population or ecological community or damages its habitat. It also provides specified exemptions from this requirement, particularly for actions approved through the planning process. Licensing normally occurs only when a planning approval is not required under the *Environmental Planning and Assessment Act 1979* (EP&A Act). This part also specifies requirements for the preparation of species impact statements, to undertake detailed environmental impact assessment, where a significant impact on threatened species is likely to occur.

Part 7 – stop-work orders, joint management agreement

Stop-work orders provide an emergency power to direct cessation of operations while urgent negotiations on protection of the species, population, ecological community or its habitat take place. There are major limitations on their use, particularly where planning approvals exist.

Joint management agreements provide a mechanism for land management agreements between NPWS and other public authorities where important threatened species habitat is identified.

Part 8 – Scientific Committee

This provides the legislative basis for the operation of the Scientific Committee, and specifies the process for appointment of members, their functions and their independent status.

Part 9 – Biological Diversity Strategy

This provides for the preparation of a Biodiversity Strategy and the establishment of a Biodiversity Advisory Council, which is responsible for the strategy and the provision of broad biodiversity conservation advice to the Minister. Broad measures for the conservation of threatened species and ecosystems, coordinated across NSW, are specified within this Strategy.

Schedules 1 – 3, Lists of threatened species, populations, or ecological communities and threatening processes

Schedule 4 – Amendments to National Parks and Wildlife Act (NPW Act)

This includes additional licensing provisions and penalties for harming threatened and protected species.

Schedule 5 – Amendments to Environmental Planning and Assessment Act

These provisions integrate threatened species assessment with planning approvals under the *Environmental Planning and Assessment Act 1979* (EP&A Act) and are essential for the protection of threatened species habitat both through the development assessment process and through identification of threatened species habitat in environmental planning instruments.

Major mechanisms within the TSC Act

As indicated in the previous section there are several major mechanisms within the TSC Act which operate together to provide a framework for protection of threatened species. These are:

- Listing of threatened species, populations, ecological communities and threatening processes on schedules – this provides the legal basis for identifying particular threats and particular species or communities as threatened, and triggers (in respect of those listed) all the other protective measures which apply to them.
- Management Plans – Recovery Plans, Joint Management Agreements and Property Management Plans – the operation of these plans at a range of scales provides the mechanism for developing an agreed management framework for a threatened species. The recovery plan operates at a statewide scale to identify

actions required for species conservation, whereas the other two management planning processes operate at a land ownership level to provide agreed protection. Joint Management Agreements are limited to Public Authorities and require an expert review by the Scientific Committee, whereas property management plans operate at an individual landholder level and could therefore be used as a protective mechanism for specific land parcels with important habitat on private land. Property management plans also provide an exemption from other threatened species licensing requirements.

- Protection against species harm/habitat damage – it is a legal offence to harm a threatened species or damage its habitat, with a penalty of up to 2000 penalty units for endangered species and 500 penalty units for a vulnerable species (currently $110/unit).
- Approval processes under EP&A, TSC and NPW Acts for actions which harm a species or damage its habitat. These are subject to assessment requirements and other constraints which are further detailed in the next section. Where a significant impact on the species is deemed likely, through the initial assessment provisions (or if critical habitat is affected), then preparation of a detailed assessment of impacts (a Species Impact Statement) is required, and there is a formal NPWS approval or concurrence role (or a Ministerial consultation role) before the action can proceed.
- Habitat identification provisions

Part 3 of the EP&A Act provides for identification of threatened species habitat and threatened species requirements in amended Local Environmental Plans, Regional Environmental Plans and State Environmental Planning Policies. This allows NPWS to request local government or other state government agencies to identify threatened species habitat in Part 3 studies and Environmental Planning Instruments. For example it could allow the identification of shorebird habitat (e.g. feeding habitat and roosting habitat) around water margins in coastal Local or Regional Environmental Plans, or fauna habitat in native vegetation areas. Similar provisions exist in other equivalent planning instruments (e.g. Regional Vegetation Management Plans under the NVC Act). Through these mechanisms the potential exists for such habitat to be protected through appropriate land management zoning.

Part 3 of the TSC Act makes provision for identification of critical habitat. However, this operates only for endangered categories of threatened species.

More detailed information on some of the above mechanisms and the provisions through which they operate is set out below.

Approval process for actions which affect threatened species

The TSC Act specifies an approvals process which is required for those actions likely to

- harm or pick a threatened species, population or ecological community
- damage habitat of a threatened species, population or ecological community (includes critical habitat).

Where such an action occurs without the relevant approval, this constitutes a breach of the legislation and the penalty provisions relating to such breaches are specified in the NPW Act.

Definitions

Harm

The TSC Act defines 'harm' in relation to fauna (including an animal of a threatened species, population or ecological community) as having the same meaning as in the NPW Act:

> hunt, shoot poison, net, snare, spear, pursue, capture, trap, injure or kill, but does not include harm by changing the habitat of an animal.

Pick

The TSC Act has introduced an assessment provision for native flora (including a plant of a threatened species, population or ecological community). The TSC Act defines 'pick' as having the same meaning as in the NPW Act:

> gather, pluck, cut, pull up, destroy, poison, take, dig up, remove or injure the plant or any part of the plant.

Legislative approval process for actions which affect threatened species

In summary the legislative approval

process for approval of the above actions which affect threatened species is :

- determine if consent is required under Part 4 of EP&A Act. If so, approval occurs here and no further approval or licence is required
- if no EP&A Part 4 consent is required, then the issue is whether approval is required for the activity under Part 5 of the EP&A Act (granted by some public authority). If so, approval occurs here and no further approval or licence is required
- if no part 4 consent or part 5 approval applies, a licence is required under the TSC Act unless specifically exempt.

Specified TSC Act licence exemptions

A licence issued under the TSC Act is not required for:

- actions authorised by a licence granted under the NPW Act;
- developments carried out in accordance with development consent under the EP&A Act;
- activities approved under Part 5 of the EP&A Act;
- actions authorised by Rural Fires Act 1997 or the *State Emergency and Rescue Management Act 1989*;
- the carrying out of a routine agricultural activity;
- actions carried out in accordance with an approved property management plan; and
- actions that are not likely to have a significant affect on threatened species, populations or ecological communities, or their habitats, as determined by the Director-General of NPWS.

Significant impact on threatened species (commonly known as 8 part test)

Where an approval is required to harm threatened species the initial requirement is to determine whether there will be a significant effect on threatened species on the basis of specific provisions within the TSC Act and EP&A Act as follows. (Extract from s94 of TSC Act)

Significant effect on threatened species, populations or ecological communities, or their habitats

(1) ...., the Director-General must determine whether the action proposed is likely to significantly affect threatened species, populations or ecological communities, or their habitats.

(2) For that purpose, the Director-General must take into account the following:

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction,

(b) in the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised,

(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed,

(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas of habitat for a threatened species, population or ecological community,

(e) whether critical habitat will be affected,

(f) whether a threatened species, population or ecological community, or their habitats, are adequately represented in conservation reserves (or other similar protected areas) in the region,

(g) whether the action proposed is of a class of action that is recognised as a threatening process,

(h) whether any threatened species or ecological community is at the limit of its known distribution.

If a significant impact is likely then the preparation of a Species Impact Statement (SIS) is required. Prior to undertaking preparation of an SIS the proponent must seek from the Director-General of NPWS (or delegated officers) the specific requirements for preparation of the SIS. Once the SIS has been prepared the concurrence of the Director-General of the NPWS must be obtained, where a significant impact is still deemed likely, and any specified conditions in this concurrence decision must be followed. Where the action is to be undertaken by another Minister then the requirement following preparation of an SIS becomes consultation with the Minister for the Environment. Further information on these processes is available from Threatened Species Management Information Circulars Nos 1, 2 and 4 available from the NPWS Website (www.nationalparks.nsw.gov.au)

Recovery and threat abatement planning

The TSC Act has a statutory requirement to undertake recovery and threat abatement planning for listed species and threats. The process for their preparation is shown in Fig. 1.

Recovery Planning is the development of a 'strategic' program involving both planning and implementation of actions aimed at 'recovering' species, populations and ecological communities threatened with extinction. A recovery plan is a document which identifies the actions to be taken to promote the recovery of a species, population or ecological community.

A Threat Abatement Plan is a document which identifies the actions to be taken to abate, ameliorate or eliminate the adverse effects of threatening processes on threatened species, populations or ecological communities.

Both recovery and threat abatement plans must consider the social and economic aspects, as well as conservation benefits, for undertaking proposed recovery actions. They must seek to minimise adverse social and economic impacts of any actions to the maximum extent possible, consistent with meeting conservation objectives.

Recovery Plans for problematic species frequently involve formation of a recovery team. Such a team typically comprises a group of stakeholders and scientific experts. They may either directly formulate the recovery strategies for the species, or alternatively, the team can act as a reference group to assist in consultation where strategies and actions are developed by specific people.

Progress in implementing the TSC Act

The TSC Act was initially funded by a specific funding allocation from NSW Treasury of $4 million annually for NPWS to carry out its major requirements, and this funding has continued on a recurrent basis. At first this was principally directed at fulfilling the environmental assessment obligations under the Act. The principal focus of this role has been to assist consent and determining authorities, which must determine when significant impact on threatened species occurs, to minimise and mitigate this impact to acceptable levels which can be deemed as non-significant.

From the commencement of the TSC Act to 30 June 2002 there have been many thousands of decisions by consent and determining authorities in relation to significance of impact on threatened species. In a large number of such cases NPWS officers have had input prior to the formal decision stage on significance to seek to reduce impacts. During this same period there were 212 requests for Director-General's requirements to prepare an SIS, and 45 SIS's were lodged with NPWS with requests for concurrence. Of these, 40 concurrences were granted (with conditions) and 5 concurrences were refused. Of the refusals a further 3 were subsequently granted following modification of impacts. NPWS has also had input into a large number of proposed Environmental Planning Instruments, and other equivalent documents (e.g. Regional Vegetation Management Plans) to seek to have important threatened species habitat identified and zoned for long-term conservation.

As can be seen from these figures there have been many cases where threatened species assessment has been required in relation to developments and activities being considered under NSW Planning legislation. In a large number of such cases substantial modifications have been made to initial proposals which reduced impacts and allowed revised proposals to proceed without the need for formal NPWS consideration. For those proposals where formal NPWS input has been triggered through SIS preparation, the overwhelming majority of proposals have had their threatened species impacts ameliorated to an acceptable level and proceeded on this basis.

It is considered that these threatened species assessment requirements have, over the time in which the TSC Act has operated, led to a substantial change of attitude of many of those undertaking environmental assessment. Initially many considered such requirements a major obstacle, whereas the gradually increasing view

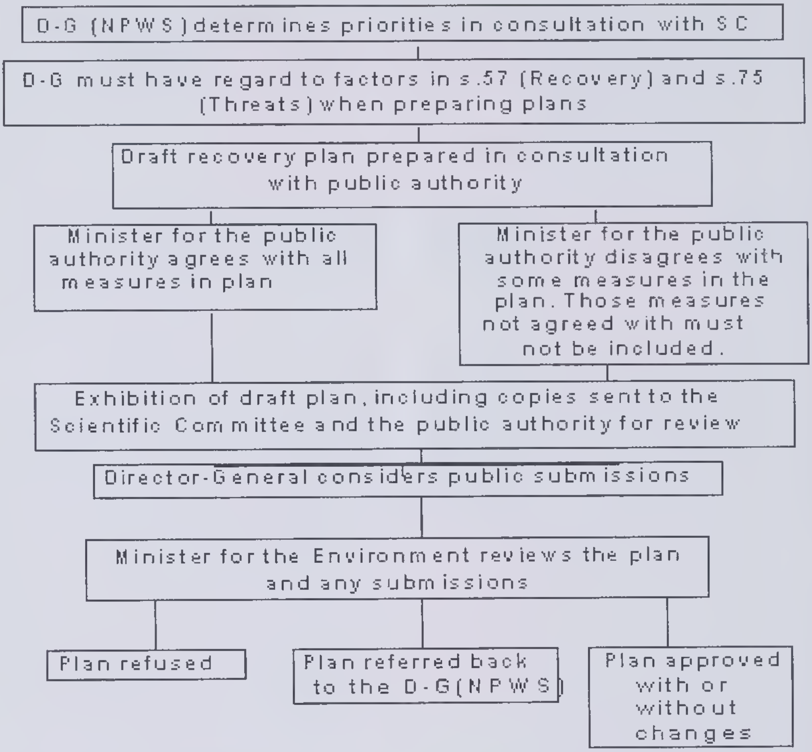

Fig. 1. Process to prepare Recovery and Threat Abatement Plans. DG = Director-General of NPWS, SC = Scientific Committee under TSC Act.

seems to be that this provides an opportunity to identify adverse consequences early in the planning process and thus accommodate them into final plans to improve overall conservation outcomes.

In the review of the TSC Act by a Joint Select Committee of NSW Parliament in 1997, it was recommended that additional resources be provided for the preparation of recovery plans and threat abatement plans. As a result a three year funding enhancement of an additional $6.5 million was given for this purpose. A large amount of effort has now gone into the preparation of recovery plans and threat abatement plans. A summary of the progress in this regard is listed in Table 1. Copies of all draft and approved recovery plans are available from the NPWS website.

A summary of progress with implementing recovery and threat abatement plan actions was published in 2003 (NPWS 2003), providing additional information and a range of case studies. It demonstrates a steady increase in the number of recovery plans prepared, which has escalated significantly since 2000. The rate of recovery plan preparation was slow because a substantial amount of policy development was required in parallel with the preparation of initial plans, along with production of guidelines on format and content of such plans. A considerable lead-time is required for the preparation of these plans. This includes assembling data on the species and threats, investigation of the range of actions which may be undertaken, determining priorities for different actions and seeking agreement from a wide range of parties to carry out specific actions.

In cases where biological information on particular threatened species is very limited, it may also be necessary to carry out preliminary research on issues such as distribution and ecology before it is realistic to formulate recovery actions.

Simple information on many species was prepared as a profile, which met the legislative requirements of s110 of the TSC Act. These provided information on species biology and distribution, major threats, and recommended management actions. Their purpose was to bridge the period before full recovery plans were available and also to ensure that accurate information on species was available in a simple form to meet a range of needs (such as landholder identification, preliminary environmental assessment, local government planning, and best practice environmental management).

These profiles are available on the NPWS website, and many of these species profiles have also been published as landholder guides for specific regions of NSW, such as the 'Threatened Species of the Lower North Coast of NSW' (NPWS 2000).

Amendments to the TSC Act

The TSC Act provides, in section 157, for it's review after 18 months of operation, to determine both whether its objects remain valid and whether changes to its detailed provisions are required. This review was conducted from July to December 1997 by a Joint Select Committee of the NSW Parliament, with the report of its findings tabled in Parliament in December 1997.

Its 30 recommendations supported the continued operation of the Act, but recommended a series of changes requiring a combination of policy and legislative amendments. As a result of this the Threatened Species Act Amendment Bill passed Parliament and received assent in October 2002. This bill represents the government's legislative response to this review. In addition, NPWS has implemented many recommendations requiring policy action. Its is expected that these legislative amendments will come into effect progressively in 2003 as they are proclaimed.

Three of the most important amendments relate to the test of significance for threatened species impact (commonly called the 8 part test), revision to threatened species licensing and the criteria for listing endangered populations of threatened species. These changes and their basis are briefly outlined. The full bill is available at www.legislation.nsw.gov.au.

Recommendation 2 of the Joint Select Committee suggested that the set of factors used to determine significant impact on threatened species should be reviewed. As the same set of factors are in the FM Act, the TSC Act and the EP&A Act, consideration of changes to all these Acts was required by government. Following public consultation a revised set of factors has now been placed in the legislation, and there is also a requirement for consideration of assessment guidelines which have the agreement of the Minister for Planning. The revised section is as follows:

Significant effect on threatened species, populations or ecological communities, or their habitats

For that purpose, the Director-General must take into account the following:

(a) each of the factors listed in subsection (3),

(b) any assessment guidelines issued and in force under section 94A.(3) The following factors must be taken into account in making a determination under this section:

(a) in the case of a threatened species, whether the action proposed is likely to have an adverse effect on the life cycle of the species such that a viable local population of the species is likely to be placed at risk of extinction,

(b) in the case of an endangered population, whether the action proposed is likely to have an adverse effect on the life cycle of the species that constitutes the endangered population such that a viable local population of the species is likely to be placed at risk of extinction

(c) in the case of an endangered ecological community, whether the action proposed:

i) is likely to have an adverse effect on the extent of the ecological community such that its local occurrence is likely to be placed at risk of extinction, or

(ii) is likely to substantially and adversely modify the composition of the ecological community such that its local occurrence is likely to be placed at risk of extinction,

d) in relation to the habitat of a threatened species, population or ecological community:

(i) the extent to which habitat is likely to be removed or modified as a result of the action proposed, and

(ii) whether an area of habitat is likely to become fragmented or isolated from other areas of habitat as a result of the proposed action, and

(iii) the importance of the habitat to be removed, modified, fragmented or isolated to the long-term survival of the species, population or ecological community in the locality.

(e) whether the action proposed is likely to have an adverse effect on critical habitat (either directly or indirectly).

(f) whether the action proposed is consistent with the objectives or actions of a recovery plan or threat abatement plan

(g) whether the action proposed constitutes or is part of a key threatening process or is likely to result in the operation of, or increase the impact of, a key threatening process.

The revised factors make it clear that this initial stage of threatened species assessment is clearly focused at the local level, as it is at this level that the gradual loss of populations occurs, fragmenting the distribution of a species and pushing it towards extinction. Therefore, for threatened species the likely loss of a further local population is considered to be a matter which requires careful environmental assessment, and may therefore be deemed to be significant.

There is now a factor, specifically to assess the impact on endangered ecological communities, which considers impacts on extent of occurrence as well as species composition. Habitat consideration has been modified to specify more clearly the likely components of habitat change, being extent, importance and fragmentation or isolation, and this is now considered in the context of the habitat being impacted rather than regional habitat.

Other changes include the consideration of recovery plans, threat abatement plans and intensification of threatening processes. Two previous factors, which require regional consideration, have also been moved to the detailed environmental impact assessment stage of an SIS; these are limits of distribution and representation in reserves.

In relation to licensing under the TSC and NPW Acts, the existing provisions require separate licences for research and conservation and also separate licensing of protected fauna, plants, animals and invertebrates. This is considered both inefficient and onerous for applicants who are frequently undertaking beneficial conservation or research actions. Accordingly a single licence category has been created for all threatened and protected plants and animals and endangered ecological communities, which allows licensing for scientific, conservation and educational purposes. This licence category allows NPWS to set conditions appropriate to the nature of the activity, and to licence both individuals and groups.

In relation to endangered populations listed under the TSC Act, the current criteria allow the listing of any endangered population which is disjunct and is of significant conservation value. Concern has arisen about potential for listing of a large number of populations of species not otherwise threatened which could divert conservation effort away from the most threatened taxa. The amended criteria for an endangered population require demonstration of its conservation significance at a regional level.

Discussion

The TSC Act represents a major legislative commitment by government to protect threatened species in NSW. It is significant in that its initial passage received bipartisan support and that the report of the Parliamentary Committee, which reviewed it, also received a broad level of political and community agreement.

However, as with much legislation, while it provides a good framework for operation the real challenge lies in developing and implementing the specific measures which the legislation requires (such as recovery and threat abatement plans). While this legislation has now been in place for almost seven years it is still relatively early in its implementation phase, as many of the recovery plans are still being finalised and work on preparing threat abatement plans for many threats has only just begun.

Many species losses and threats have occurred for over two centuries. It is not realistic to expect an immediate or rapid reversal of declining trends. In many cases the threats pushing species into decline result from broader natural resource management issues which need to be addressed at a landscape level. Such action must include consideration of social and economic drivers before significant progress is made; therefore, implementation of the provisions of this legislation must occur in the context of cooperative management and action across the whole community, with development groups and rural communities having a particularly vital role.

The TSC Act introduces into NSW ecological communities as a focus of conservation effort, which parallels national requirements under the *Environment Protection and Biodiversity Conservation Act 1999*. The concept of ecological communities, while soundly based on ecology, introduces a new level of complexity for conservation planning from a species based approach, because it requires development of a management regime for a suite of species which may have different and competing management needs, and different priorities for action. Early NSW attempts at developing conservation plans for such entities (e.g. Cumberland Plain Woodland), which have now been in progress for several years, demonstrate that this is a task which requires significant time and resources to achieve. This level and duration of commitment becomes vital when one considers the very large numbers of stakeholders with interest or management responsibilities for these ecological communities, who need to be involved in both the planning and implementation phases of such a recovery plan, if it is to succeed.

The integration of the TSC Act provisions with planning legislation is a very important component of gaining effective protection for threatened species in NSW. While the operation of this system poses significant challenges for land managers and developers in NSW it has resulted in a major commitment to build threatened species protection into development planning at the earliest stages. This is expected to lead to long term gains for conservation by initial appropriate design which mitigates impacts, rather than by leaving consideration to the end point of decision making where options for change are greatly reduced.

Identification and conservation planning for threatening processes has become an important feature of conservation planning legislation in several Australian jurisdictions including NSW. The value to conservation planning of dealing strategically with a threat to biodiversity to reduce its impact across a wide range of threatened species is demonstrated by the NSW fox threat abatement plan (NPWS 2001). In this plan 81 priority sites have been selected, managed and monitored in a standardised way for 34 priority species most sensitive to fox predation in order to maximise resource use and ensure consistency of approach, thereby increasing the likelihood of effectively reducing fox impact. Such an approach is also likely to prove effective for a range of other listed threats. However, such threat abatement plans require a high up-front commitment of resources for their preparation, as well as ongoing commitment of coordination resources, to ensure that their implementation remains effective in the longer term.

Management of a large number of threatened species and threatening processes, where many actions are required at many different locations for many different species, by a wide variety of participating organisations and individuals, presents a complex challenge. The development of advanced computerised databases to assist in this management function is likely to be an essential tool for this to occur effectively, hence NSW has developed a recovery planning database, which tracks actions and costs across species and organisations. NSW also seeks to collaborate in further development of such systems with other jurisdictions.

Conclusion

The TSC Act in NSW provides a framework for effective threatened species and biodiversity conservation in NSW, and its operations have been enhanced by recent legislative amendments. It provides a comprehensive range of tools to achieve its aims. However, as with all legislation, it is essentially a blunt instrument. Its success will be measured by progress in the conservation of the wide range of plants, animals and ecosystems at which it is directed.

This legislation is not just the responsibility of the NSW National Parks and Wildlife Service, which is the organisation given legislative responsibility for its operation. It is the responsibility of the whole NSW community to value and conserve biodiversity. The TSC Act is destined to fail if it does not receive a very broad level of community support. Its actions must be well directed to achieve required results with limited resources. Development of systems of data management, which effectively monitor this progress, will be an important component of evaluation of its effectiveness.

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The Victorian *Flora and Fauna Guarantee Act* and the Conservation of Lesser Known Groups of Biota

Tom May[1], Tim New[2], Neville Walsh[1] and Alan Yen[3]

Abstract

The Victorian *Flora and Fauna Guarantee Act* was designed to protect plants and animals through listing of individual threatened taxa as well as listing of communities and potentially threatening processes. This paper is a review of what the *Act* has achieved for non-vascular plants, fungi and invertebrates and also includes an assessment of the value of community listing as a surrogate for individual taxon listing in these highly diverse groups. It is suggested that listing all threatened taxa in these groups, which include numerous undescribed taxa, may not be the most practical strategy for ensuring their conservation. These lesser known groups may be better served by first listing a smaller number of better known threatened taxa, with emphasis on selected focal groups, while at the same time putting more resources into listing communities. The linkage between Department of Sustainability and Environment threat lists and the *Flora and Fauna Guarantee* list are discussed, as is a proposal for a comprehensive inventory of Victorian biota. Suggestions on where the *Act* could be directed in the future are outlined. (*The Victorian Naturalist* **120** (6), 2003, 248-260)

Introduction

Victoria's *Flora and Fauna Guarantee Act 1988* (hereafter FFG or the 'Act') is pioneering in its intent and complexity, and a model for much other conservation legislation in Australia. It allows for listing of species of any taxa other than those which 'constitute a risk to human welfare' for conservation priority. It also allows listing of wider entities such as threatened communities and potentially threatening processes. Yet the current taxon listings under FFG (Table 1) show a massive bias toward the vascular plants and more conspicuous vertebrate animals, with only trivial representation of the most diverse components of Victoria's biodiversity: the invertebrates, non-vascular plants, fungi and microorganisms, with the last two not represented at all. That few invertebrates are listed, along with even fewer bryophytes and lichens, may convey the message that these groups do not need or merit conservation – an impression far from reality. In this paper we explore the reasons for this dramatic under-representation in FFG listings, and discuss some ways in which it may be redressed so that

[1]Royal Botanic Gardens Melbourne, Private Bag 2000, South Yarra, Victoria 3141.
[2]Zoology Department, La Trobe University, Bundoora, Victoria 3086.
[3]52-54 Brushy Park Road, Wonga Park, Victoria 3115.

FFG becomes more truly representative for the whole of Victoria's conservation priorities and needs. In particular, we consider the ways in which the formidable impediments imposed by poor taxonomic and biological knowledge of these organisms may be partially overcome, so that their conservation needs can be incorporated realistically under the banner of FFG.

The organisms we discuss, despite their biological variety, are united by being extremely diverse, poorly documented, taxonomically intricate (with numerous species undescribed and undiagnosed), and of little interest and appeal to most people. The collective outcome of scientific inadequacy and image problems is that these organisms are largely disregarded, despite their ecological importance in sustaining the ecosystems on which all depend. People can 'relate' to a mammal, bird, orchid or wattle, but not as easily to a slime mould, moss or nematode worm. There are exceptions that have taken a firm place on conservation agendas within Australia. For example, butterflies (the most potent terrestrial invertebrate flagships for promoting conservation interest) have hobbyist interest and several are listed under FFG.

Hurdles to listing invertebrates, non-vascular plants and fungi as individual taxa

The listing process for individual threatened taxa works well for the better known vascular plants and vertebrates for which there is a solid information base. Most of these species are described, there are few taxonomic problems (at the species level), and these groups are accepted readily by people as 'worthy.'

Most biodiversity, in terms of species numbers, involves non-vascular plants, fungi and invertebrates. Credible listing of many taxa in these groups involves different levels of knowledge from that commonly available for the better known vascular plants and vertebrates. Some hurdles associated with listing of these groups are:

1. ***The taxonomic impediment*** Numerous species are undescribed, and many await collection and are not represented in institutional collections. An estimated 66% of Australian terrestrial invertebrates lack specific names. For many invertebrate groups, even the estimated numbers of species are highly speculative. For macrofungi, recent taxonomic treatments in south-eastern Australia for genera such as *Amanita*, *Galerina*, *Gymnopilus*, *Hygrocybe* and *Mycena* have revealed that at least 50% of taxa were previously undescribed, and most are Australian endemics. For microfungi, particularly leaf-inhabiting fungi of native plants, many thousands of species are expected to occur, but very few have been described.
2. ***Difficulty of identification*** Most invertebrates, fungi and non-vascular plants are difficult and time-consuming to identify, and for many groups impossibly so for the non-specialist. Many groups lack usable field guides, and identification often requires examination of microscopic features. Identification is further complicated by the need to take into account the high likelihood of encountering unnamed taxa. Modern taxonomic tools such as DNA sequencing can assist with identification (and taxonomy) but are obviously not of assistance with routine identification by non-specialists.
3. ***Life-history issues*** This is particularly a problem with invertebrates, where the immature stages often bear no resemblance to the adult stages. As taxonomic descriptions have been largely based upon mature adults, this can be a major obstacle to inventory when it is common for the immature stages to occur more frequently than adult stages in collections.
4. ***Uneven knowledge across groups*** Among poorly known taxa, some are more poorly known than others. For non-marine invertebrates, there is a great diversity at the higher levels as well as large numbers of species within each higher taxon. Because aquatic invertebrates are known to be good indicators of water quality, significant resources have been allocated to enable the necessary systematic field surveys and subsequent taxonomic research into these organisms, primarily insects of rivers and streams. In many cases, research has focused on the immature stages because these are often the stages

Table 1. Number of taxa, communities and potentially threatening processes listed or currently recommended for listing under the *Flora and Fauna Guarantee Act*.

	Listed	Recommended for listing
Taxa		
Vascular plants	213	11
Mosses	4	
Liverworts	4	
Lichen	2	
Algae	0	
Fungi	0	
Mammals	33	2
Reptiles	26	
Amphibians	9	1
Fish	23	
Birds	63	10
Worms	1	
Crustacea	13	
Echinoderms	1	
Insects	21	
Molluscs	6	
Communities		
Communities (plant)	31	
Communities (animal)	4	
Potentially threatening processes	30	

that are totally dependent upon the aquatic habitat. Unfortunately the same progress has not been made for invertebrates of terrestrial environments.

5. ***Lack of information on distribution*** The difficulty of identification, the smaller sizes of non-vascular plants, fungi and invertebrates, and the cryptic nature of many species makes routine recording of distribution more difficult. For most groups, distributional information has been accumulated serendipitously rather than from systematic surveys. Most groups attract few knowledgeable devotees.
6. ***Lack of information on biology and ecology*** Very little information is available, except in the most general terms, for most groups.
7. ***Peculiarities of biology*** Fungi have quite different sexuality, life cycles and biology from other biota. These make assessment of conservation status complicated. Fruit bodies (such as mushrooms, coral fungi, puffballs and bracket fungi) are the reproductive (spore-producing) structures. The vegetative portion of a fungus, the mycelium, is often perennial, but is hidden in the soil or other substrates. The mycelium is made up of very fine threads (hyphae) and is not visible. In some species of fungi individuals may be very large (up to several hectares), whereas in other species numerous individuals can occupy minute spaces. A large mycelium (genet) may be very long-lived and over time becomes fragmented into smaller portions. Fruit bodies may appear in only a part of the individual mycelium, may appear only in certain years, or not at all.
8. ***Lack of information on decline or threats*** Except for several groups of aquatic macro-invertebrates, there is a paucity of information on threats to many groups of non-vascular plants, fungi and invertebrates; let alone responses of these groups to the threats. Threats may be specified in very general terms with quantitative information on impacts unavailable.

Data sources for poorly known groups

These hurdles in selecting taxa for nomination can be illustrated by examining the relative paucity of data for fungi in comparison to that for vascular plants. With specific data on threats lacking, the relative number of collections (or sight records) is a starting point for identification of taxa suitable for nomination. With a sufficiently large random sample, rare species would be expected to predominate among those with low numbers of collections (or sight records). This is exemplified by the holdings of the National Herbarium of Victoria (MEL) for the predominant tree genus *Eucalyptus* (May and Avram 1997). The mean number of collections for the 93 Victorian *Eucalyptus* species among the MEL holdings was 63.6. The Victorian *Eucalyptus* considered rare or threatened on state or federal listings tended to have fewer collections: 24 of the 27 rare or threatened taxa were represented by less than 50 collections (mean 27.2). Among the *Eucalyptus* not considered rare or threatened, the mean number of collections per species was 78.5, with as many as 266 collections held for particular species. A few species not considered threatened had small numbers of collections because their distribution is restricted in Victoria, but common to the north of the State. The raw number of herbarium collections is thus a random enough sample to act as a starting point for identification of rare vascular plant species, especially when the distribution pattern is also taken into account.

For fungi there is, however, both a paucity of collections and a lack of information on distribution (May and Avram 1997). For the 724 species of Victorian macrofungi represented at MEL, the mean number of collections per species was 4.2. Most species (80%) were represented by five or less collections, and more than a third (39%) of species were represented by a single collection. There were also few records per species when the literature (vouchered or not) was analysed. For a sample of 32 species of the genera *Cortinarius* and *Dermocybe*, the mean number of MEL collections was 1.4, and the mean number of localities from the literature was 1.6 (May and Avram 1997). Members of these genera are large and often brightly coloured, so for many macrofungal genera there will be even less information in the literature. Numerous species described from Victoria are not held at MEL.

For macrofungi the only data set of sufficient size to allow for estimation of rarity is that for the Fungimap target species (Fungimap database held at Royal Botanic Gardens Melbourne). There are about 10,000 records of the 100 target species, and since the target species appear to be equally obvious, those species for which there are few records seem definitely rare. An example is *Hypocreopsis* sp.'Nyora', for which there are very few records from only three sites, in comparison to more than 100 records for most of the other target species. The Fungimap target species have been chosen so as to be readily recognisable by non-experts. Further species could be added to the list of target species, but because many macrofungi are quite difficult to identify, there is a need to examine microscopic characters, so there will always be a significant number of species for which mapping schemes such as Fungimap will not be appropriate.

The situation for butterflies, in assessing distributions from Museum collections, is an interesting contrast to that for the macrofungi. Butterflies are the best documented group among the terrestrial insects. The taxonomy of this group in Australia is well advanced and most species have been described. However, in contrast to the fungi, the use of Museum or other institutional records to map distributions and assess rarity is not so straightforward because our knowledge base on butterflies has historically been compiled by dedicated, generally amateur, collectors. There has been a tendency to concentrate on rarer species, and common species were often not collected or even recorded. For example, the introduced Cabbage White Butterfly *Pieris rapae* could be classified as relatively rare on the basis of museum collection records alone, but it is one of the most widespread species in Australia. Butterfly collectors sometimes have their favourite collecting sites, thereby introducing still more biases into the collections. There are, in the case of butterflies, some sites that are more speciose because they are used by butterflies for 'hill-topping' rather than harbouring residential populations.

It is worth noting the important role of taxonomists in accumulating information of value in assessing conservation status. Taxonomists accumulate collections. They also become familiar with the groups upon which they work, and are often aware of peculiarities of biology which may influence evaluation of conservation status. Their input is important, because there are so few ecologists working on poorly known groups such as invertebrates and fungi. For others involved in collecting poorly known groups, the importance of noting habitat and associated species when making collections or observations should be emphasised, so as to maximise the ability to make conservation assessments.

Nominations in poorly known groups

The regulations already in place under FFG do make some allowances for the hurdles faced in nominating taxa in poorly known groups. Taxa can be nominated if they are accepted as a valid Victorian taxon by the National Herbarium of Victoria for flora or by Museum Victoria for fauna. This relies upon maintenance of adequate expertise at both these institutions. Undescribed species can be nominated and listed if a voucher specimen is lodged in the appropriate institutions and a manuscript standard description exists. Of the two such terrestrial invertebrates listed under the *Act*, only the ant *Peronomyrmex* sp. has been formally described (as *P. bartoni*) since FFG listing, while the bullant *Myrmecia* sp.17 still remains as a description in an unpublished PhD thesis, with voucher specimens lodged in the CSIRO Australian National Insect Collection.

When considering nominations, the FFG Scientific Advisory Committee takes into account whether someone has studied the taxon. If a taxon recorded from only one locality is nominated for listing, it is unlikely to be listed unless there has been some attempt to ascertain its broader distributional range. This helps to overcome the problem of 'rarity' in status assessment; numerous species are rare but not under any apparent threat.

Even for 'better known' groups, the depth of knowledge about populations and threats varies widely. One extreme is the Helmeted Honeyeater *Lichenostomus melanops cassidix*, for which there is precise knowledge of the number of individuals and their nest sites, genealogies for captive populations, and genetic structure of wild populations. For some plants simply the observation of low numbers (based on reasonable surveys) would be sufficient for nomination.

Many invertebrate listings are based on (1) rarity and supposed vulnerability to future threat, or (2) evidence of distributional range decline (dependent upon historical records, often compiled by naturalists). If we apply the precautionary principle more readily, then many more invertebrate taxa could be considered for listing, and it is pragmatic to consider their wide ecological roles. Invertebrates may be essential, for example, to the survival of plant species. Currently the FFG has more orchids listed than any other family, plant or animal. Many orchid species depend on specific wasp pollinators, yet no wasp species and only one species of native bee are listed under the *Act*. Without these receiving protection, it is possible that a number of the listed orchid species would not be able to be naturally pollinated.

Poorly known taxa listed under the *FFG Act*

For non-marine invertebrates, as at August 2002, the FFG has listed 40 taxa. These 40 taxa result from 47 nominations, of which five were rejected and two were initially listed but later delisted on the basis of information obtained subsequent to their listing (Table 2). Action Statements have been published for 10 of the listed taxa, three Action Statements are awaiting publication, seven have been drafted and four are in preparation. Some of the Action Statements in draft form or in preparation cover several closely related taxa. However, they include six taxa that have not been nominated for listing under FFG. Overall, 24 of the 40 listed invertebrate taxa have had Action Statements prepared or are in preparation. However, eight of the 10 published Action Statements have already passed their review dates without being reviewed.

Although more than half of the listed invertebrate taxa have reached 'the Action Statement phase', very few of the listed taxa have had sufficient resources allocated to their recovery. Two taxa, the Otway Stonefly *Eusthenia nothofagi* and the Spathula Alpine Flatworm *Spathula tryssa* were surveyed after listing and delisted on the basis of this later information. It is interesting to note that although *Spathula* Alpine Flatworm was delisted, other species of *Spathula* were found and deemed to require nomination for listing, although to date this has not been done (St Clair *et al.* 1999). The taxa which have had more resources allotted to them are the Giant Gippsland Earthworm *Megascolides australis*, the Eltham Copper Butterfly *Paralucia pyrodiscus lucida*, the Golden Sun Moth *Synemon plana*, and the Hemiphlebia Damselfly *Hemiphlebia mirabilis*. Relative to the better known vertebrates, the resources allocated to these taxa have still been inadequate. However, the taxon range does include a spectrum of habitats and life histories that reflect changes to the Victorian environment and associated threats: a subterranean species on agricultural land (Giant Gippsland Earthworm), a species closely associated with the decline of temperate grasslands (Golden Sun Moth), aquatic species

(Hemiphlebia Damselfly) and a species whose life history relies on a complex interaction of fire, host food plant and an attendant species of ant (Eltham Copper Butterfly). Some of the more high profile species have local conservation significance (Yen and Van Praagh 1997).

Several groups of invertebrates with similar ecological needs have been listed (the burrowing crayfish, the alpine stoneflies) and here there is the opportunity to look at their conservation needs and perhaps to formulate recovery plans on a group level.

Currently, 10 species of non-vascular plant (eight bryophytes and two lichens) are listed under the *Act* (Table 1). No nominations for non-vascular plants have been rejected. These groups are understood reasonably well taxonomically, and collections in institutions (although meagre) are usually complete enough to allow sensible assignations of threat categories. The low level of representation then, is a reflection of the generally low level of interest in these groups in the community. No Action Statements have been prepared for these organisms, perhaps indicating a similarly low level of interest, if not expertise, within the Department of Sustainability and Environment (DSE) for the preparation of these statements.

For groups where there are no or very few listed species, listing of even some species under FFG will hopefully stimulate research in biology, ecology and management, and contribute knowledge that would assist in understanding these aspects for a much wider range of species than just those listed.

Inventory of Victorian biota

For Victoria's biota there is no comprehensive list of known species, although lists are maintained for some groups, such as vascular plants (Ross 2000). Available checklists and censuses vary in how comprehensive and up-to-date they are, and in whether or not they are based on voucher specimens. Lists of rare and threatened taxa, such as Gullan *et al.* (1990) and that produced by the Department of Natural Resources and Environment (2001), have as a taxonomic underpinning such checklists and censuses. It would be beneficial for a number of reasons to have a total inventory of Victoria's biota, which would summarise the natural assets of the state, and act as a framework for preparation of lists of rare and threatened taxa.

Formal, regular inventory should be instigated, listing the number of taxa known for each group, the number expected, and the proportion of known species where threat assessment has been carried out. This last figure is important since the lack of listing for many groups is simply due to a lack of assessment, and not because there are no taxa worthy of nomination to FFG. The early precedent by Taylor (1983), in which he also surveyed the proportion of each order of insects 'not yet collected,' has very wide relevance. Such systematic inventory allows for setting and tracking of targets, such as trying to describe all species in reasonably well known groups ('catch-up groups' of New 1999a) within a certain time. A biotic inventory is a species-level analogue to the Victorian National Parks Association Nature Conservation Reviews, which have been carried out at the community level for plants at regular intervals, the most recent being by Traill and Porter (2001).

Lists of rare and threatened taxa and the FFG list

In addition to listing under FFG, there are also state-based lists of rare and threatened species for some groups. In addition to the FFG listed taxa, Victoria currently has separate lists of threatened taxa for fauna and for flora. Rare and threatened plants are marked in the annual *Victorian Flora Species Index* (e.g. Department of Natural Resources and Environment 2001) and for animals there is the *Threatened Fauna List*. Neither of the latter lists has provisions to list communities. Both lists use the World Conservation Union (IUCN) categories as criteria. In the case of invertebrates, there has not been a revised Threatened Fauna List since 1995.

The value of having comprehensive censuses with risk coding for all taxa is demonstrated by the vascular plants, the group for which there has been a list for the longest time. Of the approximately 650 vascular plant taxa recognised as being threatened in Victoria (Department of Natural Resources and Environment 2001), 221 (35%) are currently listed under the *FFG Act*.

Table 2. Number of invertebrate taxa listed under the *Flora and Fauna Guarantee Act*, as at August 2002, and associated Action Statements. The numbers do not include the invertebrate community (Butterfly Community No. 1). The draft and in preparation Action Statements include two Statements that cover several closely related species, and also include six taxa that have not been nominated for listing.

Taxa nominated for listing	47
Taxa listed	42
Taxa rejected	5
Taxa delisted after listing	2
Current listed taxa	40
Action Statements published	10
Action Statements to be published	3
Draft Action Statements	7
Action Statements in preparation	4
Listed taxa in Action Statements	24

Serious consideration needs to be given to an appropriate strategy for maintaining lists of rare and threatened taxa, across all groups of the biota. Should these lists be extended to cover all taxa, and should this be the responsibility of DSE? It would be possible to link DSE lists to FFG lists. One scenario is that once threat status assessment was carried out for a particular group, then the extinct, endangered and vulnerable ('XEV') species could be automatically listed under FFG. This process would require modification to the *Act*. This would be a more efficient system, as long as initial assessments were reasonably accurate, and there were resources made available. However, it would lack the independent appraisal possible for FFG nominations. Due to the very few taxonomists and members of community groups with sufficient interest and knowledge of poorly known groups, without some automatic listing process it is unlikely that there will be much listing of these under FFG.

For some groups, initial threat assessment would yield few 'secure' taxa, and numerous taxa for which there was insufficient data upon which to base threat assessment, along with a few E or V taxa. Such a situation could then stimulate input from field naturalists and others to improve knowledge of threat status, especially identifying common species among the data deficient (DD) taxa, and successive versions of the list would have fewer DD taxa. It would be expected that most of the DD species would in fact not be threatened (in contrast to 'K' listing for vascular plants). In time though, the list of DD species would be gradually whittled down to allow a focus on genuinely rare/threatened species. This process of refinement has been carried out for plants, and it is worth noting that the Rare Or Threatened Australian Plants (ROTAP) listing has changed considerably from the 1st to the 4th edition (Hartley and Leigh 1979; Briggs and Leigh 1996).

Listing communities of invertebrates, fungi and non-vascular plants

Nominations of communities focus on groups of organisms that are susceptible to common threats. There is an inherent attraction to the notion of listing and ultimately conserving biological communities in that suites of organisms are protected, and threatening processes that have potential landscape-scale effects are (in theory at least) ameliorated. Listing of communities of poorly known groups may be a way of covering more species with less effort. However, there are difficulties in community definition affecting both well- and poorly known groups that need to be resolved.

The FFG currently lists in excess of 30 communities, most of which are plant communities, but with an increasing number of animal communities. The preponderance of plant communities reflects a long tradition of vegetation science in Victoria. The notion of animal communities is relatively novel and the process of determining these is more controversial due to the lack of an established methodology for defining communities.

An example of a faunal community listed under FFG is the Woodland Bird Community. Here, some species in the community are not yet listed individually, but there is a trend where many species in the community are perceived likely to be threatened, and there is a likelihood that others (not threatened at present) may become so. Listing of such a community focuses on all species in the community, rather than waiting until each species becomes threatened, by which time remedial action may be much less effective.

Listing of communities can also create efficiency in the preparation of action/recovery plans. There can be an ability to see patterns of threat within a group of taxa. This can also be achieved through joint action plans (such as across species of orchids), although there will always be species-specific issues.

The definition of 'community' in the current FFG is 'a type of assemblage which is wholly or substantially made up of taxa of flora or fauna existing together in the wild.' This definition is so loose that almost anything goes, and allows tenuously associated organisms to be regarded as a community, which means that it may have little credibility amongst the scientific community. There is a need for a formal process for accepting communities as valid (as is the case for taxa). Perhaps DSE could create a formal inventory of vascular plant (and perhaps in time non-vascular plant, fungal and faunal) communities from which those communities that may be threatened may be nominated for listing. A variety of different analyses can be used to define communities; it is possible to use two way tables, or to apply multivariate analyses (ordination, classification). There is very little published information on how communities used by management agencies in Victoria are defined.

For flora, emphasis is currently being placed by management agencies on Ecological Vegetation Classes (EVC). These are not communities, however, and were explicitly conceived as not being such. Nonetheless nominations are received for EVCs because there is more information in the literature about them, even though there is little published scientific confirmation or explicit definition of them. Even if problems of community definition could be overcome, there still exists a discrimination between publicly appealing plant communities (e.g. rainforests and alpine bogs) and communities that are perceived as being drab or may remain undetected in vegetation surveys through the State (e.g. many semi-arid communities, saltbush plains, halophytic shrublands, and moss-mat communities). This situation parallels that of the individual taxon approach where some organisms have been traditionally neglected while the FFG list is replete with orchids and high-profile vertebrates. Another issue relating to vascular plant communities is that their delineation is not uniform across the State.

There are also problems in defining communities of the poorly known groups. For fungi it is possible to characterise a community (Packham *et al.* 2002) but this requires multiple visits over several seasons and years. Nevertheless there are major problems with the identification of taxa, since many are undescribed. For fungi there may be a succession after fire or other disturbances, and there can be strong differences between suites of fungi producing fruit bodies at different stages of succession at sites of otherwise similar vegetation (McMullan-Fisher *et al.* 2002). One fungal community has been listed for New South Wales (Hygrocybeae community at Lane Cove Regional Park). However, this appears to be a 'hot-spot' of high diversity of the particular group of fungi (*Hygrocybe* and relatives), rather than defined by comparison of a suite of species across a number of sites.

For fauna, a range of factors, such as mobility and seasonal and inter-generational changes in composition, make delineation of a community more difficult, and application of the concept of 'community' is more successful when applied to less mobile invertebrates such as benthic species. There has been a tendency to confuse true communities and local aggregations of taxa at a particular site because the FFG does not allow listing of particular sites if they form only part of a taxon's range unless there is a case of special need.

Two invertebrate communities have been listed under the FFG *Act*: the San Remo marine community, which in hindsight should have been named 'Marine invertebrate community No. 1' because it may occur in locations other than San Remo, and Butterfly Community No. 1 (which is currently known only from Mt. Piper). The latter is an interesting example of an attempt to define an invertebrate community. Butterfly Community No. 1 was listed on the basis of the presence of at least 20 species of butterflies including five rare species. It was suggested that Butterfly Community No. 1 may also occur at The Paps. Surveys of butterflies at these locations have recorded 41 species at Mt Piper, including the five rare species, and 27 species, with only two of the rare species at The Paps. On this basis, the two locations are not considered to represent the same community (Wainer and Yen 2000), although the extent of compositional difference or similarity for such decisions has not been formalized.

An attempt should be made to define 'community' more clearly in the *Act*. A possible definition is: 'a set of organisms that have a strong tendency to co-occur across a series of sites'. For such a definition to be applied, it would be necessary to study suites of species across a wide range of sites, and to allow for single occurrences of sites with unique geology and thus a unique plant community. There is need for further debate in the scientific community about what constitutes an ecological community, and to determine the practicality of applying definitions of communities under the FFG *Act*. There should certainly be more explicit indication of the basis on which communities are defined, both when nominated, and when used as a management tool.

A weakness of the FFG is that areas of particular biological significance cannot be nominated simply because of such significance. In contrast, the New South Wales Threatened Species Act enables nomination of areas such as 'hot-spots' of very high diversity, or significantly disjunct occurrences of communities or species. Disjunct occurrences may be particularly important to conserve since there are examples where what were thought to be significantly disjunct populations have turned out to be genuinely distinct taxa.

Using vascular plant communities as umbrellas for invertebrates, fungi and non-vascular plants

At present, conservation of most of the State's species-level biodiversity (most invertebrates and non-vascular plants and all fungi) rests on the hope that the species are adequately represented in existing conservation reserves. Even if not explicit, there is an assumption that vascular plant communities are a surrogate for poorly known groups. Put another way, the poorly known groups are conserved under the 'umbrella' of protection of vascular plant communities. Thus, if a certain proportion of a particular vegetation type is conserved, then we expect to implicitly conserve by association the invertebrates or fungi that are found in that vegetation type. As yet, this approach is untested for macrofungi or microfungi. It may be that fungi are not evenly dispersed throughout each vegetation type, and sites which appear to have the same vegetation have in fact different fungal communities.

For invertebrates, there is considerable evidence of the lack of congruency between invertebrates and plant community classifications (Yen 1987; MacNally *et al.* 2002). There is an urgent need for research to test the congruence of surrogate communities with communities of poorly known flora and fauna. When assessing how well plant communities act as an umbrella for poorly known groups, there are also problems of scale in defining plant communities. Broad Vegetation Types (BVTs) are used to ascertain how much vegetation is reserved, such as in comparison to pre-1770 vegetation cover. BVTs are very broad categories, and, for example, a well-defined community such as Cool Temperate Rainforest is not treated separately in *Victoria's Biodiversity Directions in Management* (Department of Natural Resources and Environment 1997), but combined with other, quite different, communities. The *State of the Parks 2000* report (Parks Victoria 2000) provides information for each Park in Victoria, and for example at Wilsons Promontory very different vegetation communities (Lilly Pilly rainforest and the Myrtle Beech rainforest) are not separately identified. Thus the BVT approach appears to be at rather a coarse scale. Studies of congruence may need to be carried out at a much finer scale. The use of vegetation as an umbrella also needs to take into account habitats that are not defined on the basis of flora (such as aquatic habitats or caves), and that threatened taxa may survive in the absence of native vegetation, as is the case for the Giant Gippsland Earthworm.

Using potentially threatening processes to cover invertebrates, fungi and non-vascular plants

There is a great lack of information regarding the effects of threatening processes on lesser known taxa. The most significant threatening process for poorly known groups is likely to be habitat destruction (Scott *et al.* 1997), but there will also be threats specific to particular groups.

For macrofungi there are already some species for which specific threats are known that would make them suitable as candidates for listing (May and Avram 1997). Examples are: (1) the crust fungus *Hypocreopsis* sp. 'Nyora'. This species grows on another fungus, in long-unburnt stands of tea tree in three small reserves subject to disturbance. Inappropriate fire regimes are a threat, although little is known of the life cycle and population biology. (2) The toadstool *Nyctalis mirabilis* grows on another fungus, only in Cool Temperate Rainforest (CTR), but does not occur throughout areas of CTR in Victoria, only in a few sites in the Central Highlands, some of which are small pockets. Fire could destroy such sites. (3) The morel *Morchella esculenta* is edible, with a common relative (*M. elata*) widely collected for sale in markets and restaurants. *Morchella esculenta* is known from only a few near-coastal sites, and would be susceptible to disturbance from collecting activities. Thus there are some threats to fungi, and no doubt investigation of the biology of other species will reveal more threats.

There is a lack of empirical data on the effects of threatening processes on terrestrial invertebrates. Thus, although pollination is considered an essential ecoservice, and many threatened plant taxa have been listed, there is inadequate information to nominate even one taxon of pollinators. However, the listing of the introduction of the Bumble-bee *Bombus terrestris* as a threatening process is an example of how listing a potentially threatening process may benefit native pollinators.

Discussion

It is pertinent to consider a possible future scenario. If it ever becomes possible to evaluate the more diverse groups of poorly known taxa sufficiently to be able to appraise their worth as FFG candidates, hundreds or even thousands of nominations may result for individual taxa, each of them soundly based and convincing. Most of these will be the result of the diligence of individual nominators who, in many cases, will be the only people with relevant first-hand field experience with the taxa; independent peer-review will be difficult, even impossible for many species.

Long lists of species nominated or adopted for inclusion on protected species schedules are a very mixed blessing. On the one hand they are a potent demonstration of the extent of conservation need, and the number of species that are threatened; on the other hand they foster impotence because they far outstrip the limited resources that can be devoted to conservation activity. As Bean (1996) emphasised, the problem then simply moves down a level to select which of the numerous deserving species gains support, under some unwanted but necessary triage system. The problems posed by long lists of protected species were summarised by New (1999a,b). At present, FFG capacity is already exceeded; many documents are long overdue for revision, and their number increases every year.

The practicality of indiscriminately adding numerous taxa, even deserving ones, to the FFG list needs careful consideration. As far as raising the profile of poorly known groups among the public and politicians, there are divergent views. Strong advocacy for increased profile is provided by Yen and Butcher (1997) for invertebrates and Scott *et al.* (1997) for non-vascular plants. There is no doubt that listing of members of such highly diverse groups has considerable potential to increase public and political awareness of their roles and importance. Thus, three of the first invertebrates listed under FFG (Eltham Copper Butterfly, Hemiphlebia Damselfly and Giant Gippsland Earthworm) collectively served to increase awareness of invertebrate functional diversity within the state (Yen *et al.* 1990), as a flagship suite of very different life forms.

It is perhaps useful to distinguish 'reasonably well known groups' from 'extremely poorly known.' Reasonably well known are exemplified by bryophytes, macrolichens, macrofungi, 'seaweeds', freshwater algae, butterflies and dragonflies (most of these groups have a relatively recent checklist, at least some herbarium/museum specimens, and often field guides, and are of popular interest to field naturalists). Extremely poorly known groups ('black hole groups'; New 1999a) are exemplified by bacteria, nematodes, microfungi, and protozoa. Most of these are microscopic, and knowledge of them will always be restricted largely to specialists.

In the face of limited resources, it seems desirable to focus on the 'reasonably well known groups' and bring them more under the umbrella of the *Act*. A good start would be an integrated and co-ordinated taxonomic census for each such group, regularly updated, and prepared with credibility. The Royal Botanic Gardens or Museum Victoria would be the appropriate institutions to cover most groups, but collaborative approaches with DSE should be explored. Once a census has been prepared, threat category assessment should be carried out for the group. It would be desirable to use IUCN categories, but due to stringency of these categories, and the lack of population knowledge, there may need to be appropriate local modification, such as occurs for ROTAP lists. Using a few well-selected 'reasonably well known groups' as a test for such a procedure would be advisable, before embarking on listing and undertaking threat status for all such groups.

If threat lists for selected poorly known groups are long, this may reflect reality and indicate that more needs to be done to protect these groups. Listing of numerous taxa among poorly known groups imposes a formal duty of care that cannot be ignored if credibility in the workings of FFG is to be maintained. However, the current system (in terms of resources and knowledgeable staff, especially as far as management of species is concerned) could not cope with a vast increase in the number of listed species. It would certainly be useful in all poorly known groups to have a small number of species listed under FFG to highlight the existence of the groups, and to stimulate research on the conservation needs of different groups. The problem is with extending listing beyond a small number of species.

Another means of coping with large lists of threatened taxa is to prioritise their recovery actions. This is difficult at present because taxa and communities are listed as 'threatened' or 'extinct' under FFG without any distinction about the degree of threat. The NSW and Commonwealth Acts employ the IUCN criteria (extinct, critically endangered, endangered, vulnerable) as justification to list taxa. This system does allow direction of resources towards those taxa that are closer to the brink of extinction (although the triage argument can be raised that it would be more cost-effective and possibly more ecologically valuable to conserve the less endangered taxa). If taxa are prioritised for action, this should not be restricted to poorly known groups. In addition to prioritising taxa based on the degree of threat, other approaches that acknowledge the limited resources in the face of numerous listed poorly known taxa are to direct resources to (1) selected threatened taxa that have flagship status; or (2) particular groups of taxonomically or ecologically related taxa that can act as models or surrogates for other groups.

In Europe, Haslett (1998) suggested augmenting the invertebrate suite listed under the Bern Convention with taxa that depend on habitats or communities that are themselves under-represented in conservation legislation, so acting as both flagships and umbrellas for these wider considerations. A related consideration, ideally complementary to species-level listing, is to seek greater umbrella or 'inclusive benefits' (Carroll *et al.* 1996) through seeking listing of key members of communities or mutualistic associations. For example, FFG lists a number of orchid species for protection, but nothing is known of the vulnerability and conservation needs of their obligate specific insect pollinators, without which basic habitat management may be futile.

There is no doubt that the *Flora and Fauna Guarantee Act* is a pioneering piece of legislation for conservation in Australia. It has provided an opportunity for lesser-known biota such as fungi, bryophytes, mosses, algae and invertebrates to be considered for protection if threatened. No piece of Government legislation can remain static; legislation needs to evolve to be more effective in achieving its original objectives. The major issues confronting us in applying the FFG to successfully conserve a range of lesser known biota. In summary, the main issues that should be addressed are:

1. Understanding the **implications of listing a large number of threatened taxa** in poorly known groups such as fungi, algae, bryophytes, lichens and invertebrates.
2. **Identifying species for listing** that represent selected focal groups, to act as representatives of very diverse poorly known groups.
3. Recognising that some '**poorly known**' groups are in fact '**reasonably well known**' and progress could be made in producing checklists and threat lists for such groups, given adequate resources.
4. Acknowledging the value of an **overall inventory of Victoria's biota**, for tracking knowledge about the biota, and highlighting gaps. An allied issue is deciding what sorts of censuses/checklists of Victorian biota should be maintained and by whom. As far as threat lists based on these are concerned, deciding if it is desirable to maintain two separate lists: FFG listed taxa and the DSE lists for threatened flora and fauna.
5. Deciding whether there should be some attempt to make **threat assessment uniform** ('threatened' is used under FFG but the IUCN categories are used in nearly all other lists). If so, should FFG adopt the IUCN categories, and automatically include species listed as extinct, vulnerable or endangered in other lists?
6. Refining the **definition of communities** under FFG to provide a better framework to enable listing of floral and faunal communities.
7. Emphasising the importance of research on the role of **vegetation communities as a surrogate** for conservation of poorly known groups.

Whatever changes are considered necessary to improve the FFG, they do not hide one major problem – the lack of resources required to improve our knowledge of these lesser-known groups of plants and animals. Resources are required for survey, taxonomy, collection development and maintenance, ecological studies, and threat assessments. It may never be possible to obtain resources for each taxon of non-vascular plant or invertebrate equivalent to those provided for each taxon of vascular plant or vertebrate, but imaginative approaches may help to overcome this problem. Co-ordinated statewide surveys for selected focal groups (and the taxonomy required for these groups), more detailed research on the effectiveness of surrogacy, and more research on the landscape spatial scale appropriate for these groups would go a long way to improve our knowledge base. It is time to recognise that for some overlooked groups the main impediment is no longer lack of knowledge, but lack of resources applied to their management.

The need for dedicated staff in the relevant conservation agencies is still a matter of high priority. One of the main recommendations in the national overview on the conservation of non-marine invertebrates (Yen and Butcher 1997), was the appointment of an invertebrate policy person in the then NRE to co-ordinate invertebrate work. There would also be benefit in the creation of such a position to cover fungi and non-vascular plants.

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Vale

John Hilary Seebeck
28 September1939 – 8 September 2003

With the passing of John Seebeck in the Austin Hospital on 8 September 2003, Victoria lost a true champion of nature conservation. John spent his entire working career influencing the development of flora and fauna conservation in this State. He joined the fledgling Wildlife Research Section of the Fisheries and Game Department in 1960 as a technical assistant, and worked assiduously with Keith Dempster, Robert Warneke and others to build this group into a springboard for better conservation in Victoria.

Since 1960 there has been a revolution in public and governmental attitudes to wildlife conservation and a vast improvement in our knowledge base. John's career spanned this exciting time and he was a key player in the development of wildlife conservation in Victoria. Recently, whilst reading a 1960 assessment of the conservation status of Australian mammals (Calaby 1960), we were reminded of how much our knowledge of Australia's mammal fauna has grown over the last few decades. Coincidently, we had been alerted to the existence of this article when perusing John's typically comprehensive and valuable bibliography of Leadbeater's Possum (Seebeck 1987). The list is replete with old and unfamiliar nomenclature. It points out that almost nothing is known about the mammal fauna of the northern half of the continent; the Mountain Pygmy Possum is yet to be found as a living animal (having been described from a fossil); Leadbeater's Possum is yet to be rediscovered; the Thylacine is not yet considered to be extinct; so little is known about the taxonomy of our native rodents that they are discussed mostly at genus level, consequently there is no mention of the New Holland Mouse, Smoky Mouse or Heath Mouse; the Western Barred Bandicoot is listed for Victoria but not the Eastern Barred Bandicoot, and so on.

John Seebeck played a significant role in overcoming this critical lack of knowledge, working diligently over 43 years to document essential natural history information about Victoria's mammals and helping others to contribute. His pioneering studies of the Eastern Barred Bandicoot, Long-nosed Potoroo, New Holland Mouse, Smoky Mouse, Broad-toothed Rat, and the recognition and scientific description of the Long-footed Potoroo (Seebeck and Johnson 1980), stand as testament to his contribution.

John was also at the forefront of the development of threatened species recovery in Victoria through his pivotal roles in recovery teams for the Eastern Barred Bandicoot, New Holland Mouse, Long-footed Potoroo, Brush-tailed Rock Wallaby and Leadbeater's Possum. In particular, John's humble and caring approach to his work allowed numerous valuable collaborations to flourish, paving the way for effective management of habitats and threats across jurisdictional and disciplinary boundaries. Perhaps the best example of this is John's close collaboration with Tim Clark and Robert Lacy – North American experts in policy development for threatened species recovery, and in the management of small populations. This collaboration helped to revitalise the ailing recovery program for the Eastern Barred Bandicoot. It also resulted in a highly-successful conference held in September 1989 and in the publication of the proceedings in 1990 (Clark and Seebeck 1990).

John Seebeck in the field in the early 1960s. Photo: Department of Sustainability and Environment.

Apart from his distinguished contribution to the scientific study of Victoria's native fauna, John is remembered for mentoring and guiding several generations of Australian post-graduate students, wildlife researchers and field naturalists. These people remember John as a friendly and insightful scientist and conservationist, who willingly imparted his experience, knowledge and that elusive virtue, wisdom, to many a debate, project and emerging career.

Importantly, John's contribution extended to more mundane, but equally essential tasks – nobody edited drafts as diligently, nobody contributed records so assiduously to the Atlas of Victorian Wildlife, and few knew the wildlife literature like John did. He also brought an insightful sense of history to his writing and editing. Indeed, the history of mammal conservation in Victoria was a particular interest and the subject of his MSc, granted by The University of Melbourne in 1988 (Seebeck 1988).

John also undertook official roles for scientific and natural history societies. He served on the Council of the Australian Mammal Society, as Secretary from 1976-1979, and as Assistant Secretary for a few months prior to his death. He was made an Inaugural Fellow of the Society in 2002; in the same year he received its highest award – the Ellis Troughton Memorial Award – in honour of his sustained contribution to Australian mammalogy. He was also Newsletter Editor for the Australasian Wildlife Management Society for six years (1994-97 and 1998-99).

In addition, John served on the Award Committee of the Australian Natural History Medallion several times.

John was an Honorary Member of the Field Naturalist's Club of Victoria, in which he was active over many years, bringing his scientific and conservation expertise directly to the community as a teacher and role model. He was a member of FNCV Council from 1997 to 2000 and a Vice President from 1998 to 2000. He contributed to the high status and integrity of *The Victorian Naturalist* through editing, refereeing and proofreading. Yet he also made the time to imbue many a junior field naturalist with an appreciation of our faunal heritage. John's active participation in the Mammal Survey Group of the FNCV and his enthusiastic pursuit of knowledge about mammals during the mid to late 1960s provided another avenue through which a number of budding field naturalists and biologists gained inspiration. John's encouragement and facilitation of research projects by school students at that time was generous and far-sighted.

Despite a long series of medical setbacks, John continued to perform these roles until the very end. He will be sadly missed by the entire wildlife conservation community. Our flora and fauna have lost a true champion.

John Seebeck after being awarded Honorary Life Membership to the Australian Mammal Society, Alice Springs, April 2000. Photo: Australian Mammal Society.

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Peter Menkhorst,
Ian Mansergh and Ian Temby
colleagues from the Department of Sustainability and Environment.

Ian Robert McCann

4 July 1914 – 30 July 2003

Ian McCann, the eldest of the two sons of Robert Edward McCann and Annie Minnetta (née Hocking), was born in Stawell. He grew up on the family property 'Moray', and was educated first at Stawell Primary School and then at Stawell High School where he obtained his Leaving Certificate.

His first job was as Assistant Town Clerk for the Borough of Stawell (1929-34). Following this he moved to Melbourne where he worked as a cost accountant for G.J.Coles, studying accountancy at night school and by correspondence.

In 1940 he enlisted in the AIF, serving first in the Middle East and from 1942-45 in New Guinea.

Ian's interest in natural history began during the war when he became friendly with some amateur entomologists in his unit.

This led to studies of the plants and birds in the environment, and eventually, when he was able to get a camera, to photography.

In 1946 he married René Harradine. They moved to Stawell and established a poultry farm while Ian studied poultry farming by correspondence. During this time their children Philip, Andrew and Deborah, were born. René died in 1983.

In 1968 Ian retired from farming to become Tourist Promotion Officer for the town of Stawell, a position he held for 11 years. One of his projects at this time was to act as naturalist guide for Kingston's Bus Company. A portion of the proceeds from some of these tours was donated towards the publication by Portland Field Naturalists' Club of Cliff Beauglehole's series of plant surveys, *The Distribution and Conservation of Vascular Plants in Victoria.*

Ian was a dedicated and knowledgeable naturalist and a delightful and stimulating companion in the bush. He joined the Field Naturalists' Club of Victoria in 1953, becoming an honorary member in 1993. He was a foundation member of the Stawell Field Naturalists' Club and of the Western Victorian Field Naturalists' Clubs Association. He was influential in the establishment of several reserves in his district including the Three Jacks and Jack Kingston Nature Reserves near Stawell and the Little Desert National Park and Kiata Malleefowl Reserve near Nhill. He was also a member of the advisory committee during the establishment of the Grampians National Park and a member of the Victorian National Parks Association.

During the 1960s, together with fellow naturalists Aldo Massola, Ellis Tucker and Lionel Elmore, he discovered almost 70 rock art sites in the Grampians and Black Range.

Over the years he lent his support to most of the conservation issues of the period, most recently to the so far successful campaign opposing the open cut mining of Big Hill in Stawell, which would have been almost at his front door.

Ian served his community in many capacities. At various times he was a member of the Stawell Primary School Committee, the Australian Primary Producers Union and the Victorian Egg Board and was its delegate to the Australian Egg Board. He was a member of the National (formerly Country) Party and a candidate in State elections during the 1950s. He was a member of the Stawell Town Council for 15 years.

His conservation work is commemorated in the naming of the Ian McCann Bushland Reserve on the outskirts of Stawell and the McCann Dam in the Deep Lead Flora and Fauna Reserve. A tiny fungus, *Banksiamyces maccannii*, apparently specific to the cones of *Banksia saxicola*, is named in his honour.

Ian was widely known for his photographic skills and was responsible for the publication of nine small natural history field books:

Grampians Birds 1982
Little Desert Wildlife 1983
Grampians Wildflowers 1984
The Alps in Flower 1987
The Mallee in Flower 1989
The Grampians in Flower 1992
The Coast and Hinterland in Flower 1994
Australian Fungi Illustrated 2003

During the later years of his life Ian was lovingly supported and helped in his work by his partner Thelma Argall who survives him, together with his sons Philip and Andrew, daughter Deborah and seven grandchildren.

Margaret Corrick
7 Glenluss Street,
Balwyn, 3103

One hundred years ago, "under cover of shooting foxes and other vermin unscrupulous persons" were "destroying the ducks, &c" (*The Victorian Naturalist,* XX No. 5, page 60) at Lake Moodemere, which was a reserve for "wild fowl". Mr. A.J. Campbell moved "that the attention of the Minister of Public Works and the Rutherglen Shire Council be directed to the destruction of game on Lake Moodemere". Mr. G. Coghill, in seconding the motion, stated that some years ago the attention of a former Minister had been successfully directed to the matter."

Perhaps there is a little more hope today. We have the attention, not only of former Ministers but, also, current Ministers. We even have the support of some! However, let's become evangelical and convert the lot.

Australian Natural History Medallion 2003

Clive Minton

Dr Clive Minton AM is the recipient of the 2003 Australian Natural History Medallion, awarded for his long-term studies of migratory waders and his influence on the practice of bird studies in Australia and internationally.

Clive first became interested in studying, trapping and banding birds while still at school in the UK, and during the completion of a degree in Natural Sciences and a PhD in metallurgy at Cambridge University (1953-1960), he spent his spare time studying migratory waders in the Wash, becoming the founding chairman of The Wash Wader Ringing Group which is still active today. Together with Dr Eric Ennion in the early 1950s Clive pioneered banding of waders in the UK initially using clap nets, then mist nets, followed by 'rocket nets' (originally borrowed from Peter Scott) and, from 1967, explosive powered 'cannon-nets'. This final technique enables large numbers of individual birds to be caught, usually at their high tide roosts, then, while in the hand, detailed studies of morphometrics, weight and plumage can be made prior to their release. Subsequent retrapping and sightings of banded and leg-flagged birds allow life history, migration routes and individual site significance to be established.

Prior to leaving the UK for Australia Clive undertook detailed studies on waders, Mute Swans, Canada Geese, Swallows, Sand Martins, thrushes and finches, and the Grey Heron. He commenced the Mute Swan study in 1960 and ran it until his departure in 1978. It is still running and now is one of the longest single species studies known.

When Clive came to Australia as Managing Director of Imperial Metal Industries Australia, he catalysed the activities of the three-year-old Victorian Wader Banding Project with his energy, enthusiasm, ornithological knowledge and expertise in the use of cannon-nets. In June 1979 the project was transformed to the

Clive Minton, the 2003 Australian Natural History Medallion recipient with his wife Margaret. Photo Joan Broadberry.

Victorian Wader Study Group with Clive as Co-convenor. He became Convenor in 1982, a position he still holds today, and the group is now the most active wader banding group in the world, handling on average over 7,000 birds in Victoria each year. In 2002 the total was 12,500.

Interest in the cannon-netting techniques being used in Victoria resulted in an invitation to demonstrate their use in other States. This led to a meeting of representatives from all States and New Zealand in 1980 and the Australasian Wader Studies Group (AWSG) was born, with Clive Minton as founding Chair.

A Royal Australasian Ornitholgists Union (RAOU) project searching for Australia's rarest birds discovered thousands of migratory waders at Broome, Western Australia. Under the auspices of the AWSG, Clive led a major reconnaissance in 1981 which established the region as being amongst the six most important in the world for waders. Since then extensive expeditions have been held nearly every year and over 1,000 people from 24 different countries have participated and been trained in the techniques which they have taken back to their home locations, particularly in the countries of the East Asian-Australasian Flyway which stretches from Siberia and Alaska southwards through east and southeast Asia to Australia and New Zealand. Clive was instrumental in the establishment of the Broome Bird Observatory by the RAOU in 1988.

Recognition of the major migratory route that includes Broome has led to many international advances, including the establishment of the Asian Wetland Bureau, the Japan-Australia Migratory Birds Agreement (JAMBA) and the China-Australia Migratory Birds Agreement (CAMBA). Clive Minton has represented Australia on various occasions associated with JAMBA and cooperative studies in Russia. He has been invited to join international expeditions to Russia, China, North and South America and within Australia.

If asked, Clive would probably list his work on Roseate Terns and Banded Stilts as two of the highlights of a long bird oriented life. Clive has provided the cannon netting expertise and impetus to a major Queensland National Parks and Wildlife Service study on Swain Reefs at the southern end of the Great Barrier Reef. It was discovered that two thirds of the large numbers of Roseate Terns at the site were birds from breeding areas in Japan and Taiwan. It had never been suspected that the northern hemisphere population ventured south of the equator in their non-breeding phase. He was one of the first to locate breeding sites of the nomadic Banded Stilt at Lake Torrens in 1989 and to take colour photographs of an active colony. A breeding event at Lake Ballard in 1995 resulted in an ABC documentary, and in 2000 Clive's observations of the depredation of young by Silver Gulls, together with his recommendations, led to intervention by the South Australian Parks and Wildlife Service. Removal of the gulls allowed the Stilts to breed successfully on their third attempt.

Dr Clive Minton was on the Research Committee of RAOU from 1980 to 1988 and was Vice-President from 1989 to 1995. He was elected RAOU Fellow in 1988 and won the RAOU John Hobbs Memorial Medal in 2000. In 1973 he had been awarded the British Trust for Ornithology Tucker Medal. Both the John Hobbs and the Tucker Medals are presented for contributions to ornithology by an amateur. Clive was awarded an AM in the 2001 Australia Day Honours 'for services to ornithology, particularly in the study of migratory wading birds in Australia'. Clive has held Officer roles in the RAOU, Victorian Wader Study Group, Australasian Wader Studies Group, British Trust for Ornithology, Royal Society for the Protection of Birds, International Wader Study Group, Wash Wader Ringing Group and Worldwide Fund for Nature Australia. For ten years he was a member of the Science and Industry Forum of the Australian Academy of Science.

Clive retired from business at the early age of 58 to pursue his interest in waders and to write up more fully his lifetime knowledge of ornithology, particularly waders. He has major publications in *Ardea*, *Bird Study*, *Emu*, *Wildfowl* and *British Birds* and over 100 articles published in the Stilt and VWSG Bulletin. He is a willing, stimulating and passionate speaker who has the ability to engage people at all levels, from international treaty negotiations representing Australia, to enthusing and assisting children to learn about the wonders and importance of shorebirds. In the UK Clive had a weekly session on radio and he has been involved in many Australian radio and television broadcasts and documentaries both as technical advisor and participant. Clive is an accomplished photographer of wading birds with many of his photographs enhancing guide books and other publications.

Andrew Whittaker recognised the friendship and guidance given to him in his formative years by naming the Cryptic Forest-falcon, a bird from the Amazon jungle, *Micrastur mintoni* in Clive's honour.

This worthy recipient of the Medallion was nominated by the Victorian Ornithological Research Group.

Ian Endersby
56 Looker Rd
Montmorency 3094

A Field Guide to the Mammals of Australia

by Peter Menkhorst and Frank Knight

Publisher: *Oxford University Press, Melbourne 2001. 275 pages.*
ISBN 0-19-550870. RRP $39.95

The publication of this field guide is welcomed by all those who have an interest in Australian mammals. It is the first true mammal field guide for Australia and the authors are to be congratulated on this attractive work—being knowledgeable about 379 species is no mean feat!

The guide is directed at a broad market (tourists, amateurs, professional scientists). It is easy to use and scientific jargon is avoided as much as possible. Adequate identification of some groups (e.g. insectivorous bats, rodents, dasyurids, pygmy-possums) to species level will, however, require more specialist information and comparison with reference collections. I would not suggest that students, survey biologists and professional mammalogists rely solely on the Guide to identify accurately the small mammals listed above. Collecting voucher specimens and having them identified by qualified museum personnel will be necessary for such purposes. There are a number of spelling errors, which suggests that there was a last minute rush to produce the Guide. For example, several names of people are spelled incorrectly in acknowledgments and references, and some of the scientific names in the body of the Guide are wrong (e.g. *Macrotis leucrura* should be *leucura*, *Pseudomys hermannsbergensis* should be *hermannsburgensis*, *Pseudomys laborifax* should be *laborifex*). There are also several examples of mistakenly dropping the second '*i*' from the end of the scientific name (e.g. *Mesoplodon layardii*, *Notomys mitchellii*).

The book begins with an informative introduction that explains many of the things necessary for using the Guide (classification, field characters, distribution maps, etc.) as well as some of the techniques used to study mammals. In future editions the authors might consider adding a section on the risks associated with handling Australian mammals. I would suggest that more accurate diagrams are provided to illustrate features and how to measure different parts of the body, since these are critical to distinguishing between many small mammal species. For example, the diagram of the head of *Burramys* on page 27 shows no anterior teeth and the untrained user would find this misleading. Encouraging observers to submit records is an excellent idea but these should be accompanied by detailed descriptions and photos, if at all possible.

The up-to-date checklist is good, although there appears to be at least one species missing (*Myotis macropus*) and *Australophocoena dioptrica* should be *Phocoena dioptrica*. However, I realise that it is difficult to please all taxonomists! A suggestion for a future edition is that the conservation status be added to the checklist. Common names are always a topic of hot debate and I will not dwell on them here except to say that it is not a good idea to change a recognised name unless there is a very good reason. For example, the two bottlenose dolphin species are known internationally as Common Bottlenose Dolphin (*Tursiops truncatus*) and Indo-Pacific or Indian Ocean Bottlenose Dolphin (*Tursiops aduncus*). The length of the beak is not consistent for *T. aduncus*, so calling it the Long-beaked Bottlenose is incorrect.

Keys are difficult to write, especially for small mammals, and I applaud the authors' efforts here. The keys are easy to follow but not always correct and sometimes use vague statements such as 'hindfoot long and narrow', and 'tail covered in short, dense fur' which applies to most rodents. The diagram of the upper incisor of *Mus* is not good enough to distinguish this from rodents without a notch. It would be helpful to have arrows pointing to the features described because they might not be all that obvious to the untrained person. The cetacean key and its introduction are excellent, although with some amusing statements as in 7b 'Mouth opens anteriorly'. I wonder what a mouth opening posteriorly would be like! Also in 7b, Shepherd's Beaked Whale is the exception in having many teeth in the jaws.

The majority of the book is dedicated to the species accounts, distribution maps and plates. These are well laid out and easy to use. The plates are attractive and the species are depicted in uniform poses to simplify comparisons. The basis for including some of the diagrams of particular features in the margin is not always obvious. It may be that there was not sufficient communication between publisher, illustrator and author. Similarly, the illustrations of some species could be improved in terms of accuracy. For example, the flippers of most of the cetaceans do not represent their true form, the shape of the dorsal fin of the Spectacled Porpoise is incorrect and the head shape of some of the dolphins is not accurate. The plates will be much more useful for identifying the medium- and large-sized species of terrestrial mammals—it is notoriously difficult to illustrate the differences between small mammals because these are often subtle. It is not explained why the number of teats (2 = 4) is noted for so many of the *Pseudomys*, *Notomys* and others, when *Rattus* and *Mus* are the only rodent genera with more than eight teats. The distribution maps are, on the whole, the best available for Australian mammals, and it is obvious that a good deal of effort went into compiling these. There are some minor errors in the cetacean maps, e.g. the Spectacled Porpoise has stranded in Tasmania and the Short-finned Pilot Whale has been recorded several times off South Australia.

The authors have asked for feedback on how the guide could be improved. I will be contributing to this and hope other Australian mammalogists will be too. We are all eagerly looking forward to the next edition!

Catherine Kemper
South Australian Museum,
North Terrace, Adelaide, SA, 5000

Spiders and Scorpions Commonly Found in Victoria

by Ken L Walker, Alan L Yen and Graham A Milledge

Publisher: *The Royal Society of Victoria, 2003. xiii + 144 pages, 177 figures. ISBN 1 876677 05 8. RRP $19.50*

Field guides to taxa that are widely disliked, such as spiders and scorpions, would be challenging to write, since they must be capable of popularising the unpopular, whilst providing new and practical information for those already interested in the subject. However, *Spiders and Scorpions Commonly Found in Victoria* achieves this balance through its erudite text, and the infectious enthusiasm of its authors.

This book is a revised and expanded version of *Spiders Commonly Found in Melbourne and Surrounds* (1992; published by The Royal Society of Victoria). The most notable changes are the inclusion of a section on Victorian scorpions, and the addition of much new information to the spider biology section, as well as many more photographs and illustrations. I think that anybody who owns the older *Spiders Commonly Found in Melbourne and Surrounds* will find that the purchase of this updated version is more than justified by the expanded content.

The new book is divided into two main sections: one on spiders, and one on scorpions. Each section contains general biology information that includes definition, classification, evolution, ecology, cultural information, and medical notes on the group in question. This general information is followed in each section by a series of identification pages that cover commonly encountered species (29 spiders, and all nine described Victorian scorpions). The book is rounded off with short sections on spider and scorpion conservation, studying spiders and scorpions, society contacts, and a bibliography (oddly, however, there is no glossary).

The general biology sections for both spiders and scorpions are innovatively set out as a series of questions and answers. This format is particularly successful because the authors have worked as museum scientists, and are well acquainted with frequently asked questions. There are some captivating answers to questions such as 'why don't spiders get caught in their own webs?' and 'can scorpions glow in the dark?' The explanations are also well supported by illustrative diagrams, photographs, and scanning electron micrographs. One minor criticism, however, is that some of the answers to questions on spider classification and evolution are far too complex. The classification information particularly, requires greater use of diagrams, and more background information about taxonomic concepts. Unfortunately, this heavy section is near the beginning of the book, and may cause some readers to put the book aside before they reach the more accessible text that follows.

The identification sections have been practically designed. There is a useful colour-code at the top right-hand corner of these pages, so that the relevant section can be quickly located. Each species covered takes up a double page spread, and includes illustrations on one side, and written information on the other. A standard grid system with an overlaid silhouette of the species in question is employed throughout the book, so that species size can be easily assessed. There are also black and white drawings for all species, and at least one colour photograph for most. Information on identification features, habitat, biology, and bite effects is included for spiders, whilst identification features, habitat, biology, distribution and nomenclature (where necessary) is covered for scorpions. Specific distribution maps (rather than the more general distributions given for scorpions) would have been a useful inclusion, and could have provided the opportunity for readers to expand them by sending for professional identification any specimens seen outside these ranges.

Overall, anybody who is involved in invertebrate identification work, or who is curious about their local invertebrate fauna, will know the value, and rarity, of an identification guide that is clear and region-specific. This book should certainly appeal to the specialist and non-specialist alike, as well as the child in all of us.

Melanie Archer
The Victorian Institute of Forensic Medicine
57-83 Kavanagh St, Southbank, Victoria 3006

One hundred years ago, the Field Naturalists' Club of Victoria was fighting the same battles, protection of our flora and fauna!

At the ordinary monthly meeting of the Club, held in the Royal Society's Hall on a Monday evening, 10th August, a letter was read from the National Forests Protection League (*The Victorian Naturalist* XX No. 5.page 61). In it, the Club was thanked for the support given by members and urged to give "unrelaxed attention" to the reservaton of timber country. At an earlier meeting, 13th July, Mr. T.S. Hall, M.A. "brought under the notice of the meeting the destruction of our forests, and called attention to the recent founding of the National Forests Protection League, having for its objects the protection of our forestrs, the encouragement of tree planting, &c. He pointed out the results likely to ensue from the indiscriminate cutting up and throwing open of our forest reserves, and thought that this ought to be rendered impossible, except by a special Act of Parliament, and said that, as this Club is specially concerned in the preservation of the indigenous fauna and flora, members should individually give all the practical assistance in their power in forwarding the objects of the League." (*The Victorian Naturalist* XX No. 5 page 45). A motion to this affect was carried unanimously.

We have progressed! There is the Flora and Fauna Guarantee Act, but we have a long way to go. We must still give our 'unrelaxed attention' to the protection of our flora and fauna.

Flora and Fauna Guarantee Act 1988

The Flora and Fauna Guarantee Scientific Advisory Committee has made a number of final recommendations in relation to nominations for listing under the provisions of the ***Flora and Fauna Guarantee Act* 1988**. The Committee's recommendations are currently awaiting the Minister's decision. A short Recommendation Report has been prepared for each recommendation. These are available from Martin O'Brien, Executive Scientific Officer, Scientific Advisory Committee, Department of Sustainability and Environment, 4/250 Victoria Pde, East Melbourne, 3002, ph: 9412 4567, email: Martin.O'Brien@dse.vic.gov.au (also major country offices of the Department of Sustainability and Environment). For information on specific items please contact flora and fauna staff at DSE offices. The **Flora and Fauna Guarantee Act 1988** and the Flora and Fauna Guarantee Regulations 2001 can be viewed at these offices.

Final Recommendations

Items supported for listing

		Criteria satisfied
651 *Abutilon oxycarpum* var. *malvaefolium*	Mallow-leaf Lantern-flower	1.2.1
666 *Abutilon oxycarpum* var. *subsagittatum*	Flannel Weed	1.2.1, 1.2.2
667 *Acacia binervia*	Coast Myall	1.2.1, 1.2.2
687 *Acacia caerulescens*	Limestone Blue Wattle	1.2.1, 1.2.2, 1.2.3
691 *Accipiter novaehollandiae*	Grey Goshawk	1.2.1, 1.2.2
668 *Alectryon subcinereus*	Native Quince	1.2.1, 1.2.2
684 *Anseranas semipalmata*	Magpie Goose	1.1, 1.2, 1.2.1, 1.2.2
670 *Aristida jerichoensis*	Jericho Wire-grass	1.2.1
671 *Aristida obscura*	Rough-seed Wire-grass	1.2.1
672 *Aristida personata*	Purple Wire-grass	1.2, 1.2.1
673 *Asperula ambleia*	Stiff Woodruff	1.1.1
652 *Botrychium australe*	Austral Moonwort	1.1, 1.2, 1.2.1
674 *Callistemon kenmorrisonii*	Betka Bottlebrush	1.2.1, 1.2.2
675 *Cardamine franklinensis*	Franklin Bitter-cress	1.2.1, 1.2.2
676 *Cardamine gunnii*	Tuberous Bitter-cress	1.2, 1.2.1
665 *Craspedia canens*	Grey Billy-buttons	1.2.1
654 *Cyperus rigidellus*	Dwarf Flat-sedge	1.2.1
677 *Daviesa laevis*	Grampians Bitter-pea	1.2.1
655 *Deyeuxia affinis*	Allied Bent-grass	1.2.1
683 *Egernia guthega*	Alpine Egernia	1.2, 1.2.1
678 *Epilobium brunnescens* ssp. *beaugleholei*	Bog Willow-herb	1.2.1, 1.2.2
679 *Eucalyptus alligatrix* ssp. *limaensis*	Lima Stringybark	1.1.2, 1.2.1, 1.2.2
680 *Eucalyptus molyneuxii*	Little Desert Peppermint	1.2.1
685 *Grevillea infecunda*	Anglesea Grevillea	1.2, 1.2.1, 1.2.3
681 *Hakea macraeana*	Willow Needlewood	1.2.1
658 *Hesperilla flavescens flavescens*	Yellow Sedge-skipper Butterfly	1.1, 1.2, 1.2.1
660 *Hypochrysops ignitus ignitus*	Fiery Jewel Butterfly	1.1, 1.2, 1.2.1
692 *Hypocreopsis* sp. 'Nyora'	Clasping Hypocreopsis	1.2.1, 1.2.2
662 *Jalmenus icilius*	Amethyst Hairstreak Butterfly	1.1, 1.2, 1.2.1
656 *Juncus antarcticus*	Cushion Rush	1.2, 1.2.1
690 *Muehlenbeckia gracillima*	Slender Lignum	1.2.1, 1.2.2
661 *Ogyris genoveva araxes*	Purple Azure Butterfly	1.1, 1.2, 1.2.1
657 *Sclerolaena ventricosa*	Salt Copperburr	1.2.1
682 *Sminthopsis leucopus*	White-footed Dunnart	1.2, 1.2.1
609 *Swainsona sericea*	Silky Swainson-pea	1.2.1
659 *Trapezites luteus luteus*	Yellow Ochre Butterfly	1.2, 1.2.1
688 *Westringia lucida*	Shining Westringia	1.2.1, 1.2.2
650 Wetland loss and degradation as a result of change in water regime, dredging, draining, filling and grazing (potentially threatening process).		5.1, 5.1.1
664 Inappropriate fire regimes causing disruption to sustainable ecosystem processes and resultant loss of biodiversity (potentially threatening process).		5.1, 5.1.1, 5.1.2
689 Infection of Amphibians with Chytrid Fungus, resulting in Chytridiomycosis (potentially threatening process).		5.1.1, 5.2.1

Item not supported for listing

653 *Callitriche umbonata*	Winged Water-starwort	rejected

663 Camphor Laurel trees as a threatening process in Victoria (potentially threatening process).

Guidelines for Authors – The Victorian Naturalist

Submission of all Manuscripts

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.

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.

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.

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 for Windows v2 to ensure compatibility with the typesetting software Quark Xpress. Other PC formats may be accepted (e.g. RTF or later versions of MS Word), but additional type-setting time is required with the subsequent delay of publication.

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, 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. Computer-generated figures should be submitted as high-quality TIFF or encapsulated postscript (EPS) files of at least 600 dpi, either separately on disc or embedded into a MS Word document. Low-resolution JPG files will not be accepted.

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.

Journal Style

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 of 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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In which is incorporated the Microscopical Society of Victoria

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Proteaceae of New South Wales

edited by Gwen J Harden, David W Hardin and Dianne C Goddin

Publisher: *University of New South Wales Press. 2000. 204pp. 16 colour plates. ISBN 0 86840 302 4. RRP $39.95*

The *Proteaceae of New South Wales* is a wonderful, user-friendly book, encouraging to even the most raw of beginners in their endeavours to understand the family and, indeed, the study of Botany in general. Beginners in the use of floras and botanical keys often throw up their hands in horror when they are introduced to the unique and almost incomprehensible language of Botany. This book, however, provides a gentle introduction to this strange tongue. Terminology is kept to a minimum, although the novice might find this hard to believe when using the keys and reading the plant descriptions, especially when coming across words such as conflorescences, dichlamydeous, polygamodioecious and mucronulate. But there is an excellent glossary with well-chosen diagrams to help the reader understand these more unusual terms.

The first part of the book deals with the collection, preservation, naming and conservation of plants, and highlights the importanee of taking care when collecting plants and of having the appropriate permits. This section is written in a simple, flowing, easily understood style, explaining some of the fundamentals behind plant systematics.

Part B introduces the family: where the family occurs, how and where it evolved, the variation that oceurs within it, how it is related to other families, its classification, ecology and pollination. This is accompanied by excellent diagrams illustrating the variations of leaf forms within the family, flower arrangements, pollen presenters, ovule types, fruits and seeds. The family is shown to be a strange one. Many well known genera such as *Grevillea*, *Hakea* and *Persoonia* occur in diverse habitats from alpine and sub-alpine regions to semi-arid zones, while other genera such as *Dryandra* and *Stirlingia* are confined to Western Australia. Still other genera are confined to tropical rainforest in north-eastern Queensland. Many grow in areas particularly poor in nutrients and are able to produce specialised roots, called proteoid roots, which are physiologically different from the other roots and facilitate the increased uptake of phosphorus.

There are also segments of special interest such as how to grow species, what common pests and diseases affect them, and aboriginal usage.

Part C provides keys and descriptions of genera and species. These are simple to use. The larger genera are first divided into smaller, more workable groups from which the individual species are easily keyed out. The description of each species is brief but informative and includes comments on distribution, flowering times and extent of hybridisation with close associates.

Even people with no interest in the Proteaceae at all would soon become enthusiastic converts once they had delved through the pages of this fascinating book. The price is extremely reasonable and I would strongly urge any student or would-be student of botany to purchase a copy. I am sure it would rapidly become dog-eared by repetitive use. It probably would be wise to buy two copies, as once borrowed by a friend, it is unlikely ever to return!

Maria Gibson
School of Biological and Chemical Sciences,
Deakin University, Burwood, Victoria 3125

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Cover: Eastern Snake-necked Turtle *Chelodina longicollis*. From *Prodromus of the Zoology of Victoria* by Frederick McCoy, Volume 1, Plate 93 (detail).

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Habitat and dietary preferences of freshwater turtles in ephemeral billabongs on the Ovens River, north-east Victoria

Catherine E Meathrel[1], Phillip J Suter[1] and Sharon Reid[1]

Abstract

An investigation of the habitat and dietary preferences of freshwater turtles inhabiting ephemeral billabongs on the Ovens River State Forest floodplain at Killawarra, Victoria, was conducted over the summer of 1997/1998. Two species of turtle, *Chelodina longicollis* and *Emydura macquarii*, were captured. Analysis of turtle stomach contents provided confirmation of their diets with other published literature, with the exception of *Chelodina longicollis* which consumed large amounts of plant matter although it has been classified as an obligate carnivore. Field observations revealed that turtles preferred more complex macrophyte habitats, when available, over less complex snag and clear water areas. When macrophyte habitats were less available (due to drought), no habitat or prey preference was observed in any of the turtle species investigated. (*The Victorian Naturalist* **121** (1), 2004, 4-14)

Introduction

Individual billabongs may vary significantly within the same floodplain. This variability is influenced by a variety of factors including hydrological influences. The duration and frequency of the connection to the parent river, as well as the time of year the connection takes place, can influence sedimentation levels and species composition (Hillman 1986). The hydrological regime of billabongs also leads to variability in their water chemistry. Periods of inundation, resulting in dilution and then gradual concentration as a result of evaporation, cause a constantly changing physicochemical environment for organisms dwelling within a particular billabong. This continual ranging of conditions, along with their propensity to dry out, make billabongs a harsh environment in comparison with their parent river.

Another distinction between billabongs and their associated parent river is their relative wealth of nutrients (Boon *et al.* 1990). The river is subject to continual movement of nutrients and sediment downstream, whereas billabongs are, for the most part, closed systems. Hence, any primary production and decomposition within a billabong results in nutrient reserves that are not immediately washed away. The high levels of productivity of lower-order organisms provide a plentiful food supply for higher-order consumers (Carpenter *et al.* 1985). Turtles occupy a complex trophic role, feeding on a large variety of plants, animals and microbes and can enter temporary water bodies via overland migrations that are otherwise inaccessible to other aquatic vertebrates (e.g. fish) (Chessman 1978; Cogger 1996).

The Ovens River of south-eastern Australia provides an ideal environment for freshwater turtles. To date, this river remains unregulated and its floodplain is relatively pristine. Three species from the Family Chelidae have a distribution encompassing this floodplain, the Eastern Snake-necked Turtle *Chelodina longicollis* (Shaw), the Broad-shelled River Turtle *Chelodina expansa* (Gray) and the Murray Turtle *Emydura macquarii* (Gray). Comparisons of the habits and size of these three species are given by Meathrel *et al.* (2002).

In a study of turtles in the Murray Valley, Chessman (1988) found that *C. longicollis* utilised more ephemeral (i.e. less permanent) water bodies, such as billabongs, to a greater extent than the other two species. Chessman (1988) also observed a negative correlation between *C. longicollis* abundance and water depth, transparency, persistence and flow. The preference of this species for less persistent water bodies has been attributed to the advantage that can be gained by the colonisation of such highly productive ephemeral waters compared to more permanent water bodies which are likely to contain many more competitors (Kennett and Georges 1990). In years of

[1] Department of Environmental Management and Ecology, La Trobe University, Wodonga, Victoria 3690
Email: c.meathrel@aw.latrobe.edu.au

drought, Kennett and Georges (1990) observed that *C. longicollis* migrated to permanent water bodies as ephemeral ones dried up.

The Murray Turtle *Emydura macquarii* appears to have contrasting habitat preferences to *C. longicollis*. It was found more commonly in deep, transparent, permanent, flowing waters and its abundance in billabongs was negatively correlated with distance from the main river channel (Chessman 1988).

Chelodina expansa appears to occupy an intermediate position, but its habitat preference is more closely correlated to that of *E. macquarii* than to *C. longicollis*. A positive correlation between *C. expansa* abundance and water depth, along with a negative correlation between abundance and distance from the parent river has been recorded (Chessman 1988). The relative permanence of the water body does not appear to affect the distribution of this species.

Previous research related to the ecology of *C. longicollis, C. expansa* and *E. macquarii* has contrasted their distribution between rivers and billabongs (Chessman 1988; Kennett and Georges 1990). However, there remains a paucity of research detailing the turtles' ecology within particular rivers and billabongs.

A recent study investigated the freshwater turtle population of a large, permanent billabong associated with the Murray River, Lake Moodemere (Meathrel *et al.* 2002). This study looked at species distributions within the billabong, assessed habitat preference on a smaller scale and related turtle distribution to habitat complexity and potential interspecific competition. During this study, Lake Moodemere was connected to the River Murray for part of the study due to a spring flood. Results of the study concluded habitat and dietary overlaps existed between all three species suggesting strong competition for resources in large, permanent billabongs (Meathrel *et al.* 2002).

As yet, no assessment has been made of habitat and dietary preferences of freshwater turtles in small, ephemeral billabongs. This study was designed to address this lack of knowledge within the small, ephemeral billabongs of the Ovens River. It was hypothesised that there would be no difference in microhabitat or dietary preferences between the turtle species.

The floodplain of the Ovens River (a major tributary of the River Murray) at Killawarra was chosen as the study site because large numbers of freshwater turtles are known to occur in the billabongs and this site is potentially under threat of human development. Currently, the Ovens River is a largely unregulated river under continued threat of regulation. Being unregulated, the flood plain is subject to natural flooding regimes. In late 1997, the Victorian State Government considered plans to dam the river for agricultural purposes. To date, no progress has been made on the dam proposal and the river's lower reaches have now been Heritage Listed. Hence, a unique research opportunity existed to collect baseline data on turtle ecology in a relatively pristine environment before a possible perturbation occurred.

Methods

Study sites

The billabongs chosen for this study site are located within the Ovens River floodplain at the Killawarra State Forest, 13 km north-west of Wangaratta, Victoria (146°14'44"E, 36°14'05"S). Four anabranch billabongs were chosen because of their similar size (all <0.05 km^2) and distance from the parent river (all <1 km). All contained the three habitat types (macrophytes, snags and clear water areas) used by Meathrel *et al.* (2002, Table 2 therein).

The dominant vegetation of the floodplain was open forest comprising River Red Gum *Eucalyptus camaldulensis* and Black Wattle *Acacia mearnsii*. Few understorey plants were present because of grazing by beef cattle. Those present were mainly grasses and sedges along with some small herbaceous plants. The overstorey of *E. camaldulensis* contributed large amounts of organic debris to the billabongs as well as creating the snag habitats investigated. The billabongs themselves contained two aquatic macrophytes, Floating Pond Weed *Potamogeton tricarinatus* and milfoil *Myriophyllum* spp. (Sainty and Jacobs 1981).

Habitat types were chosen initially because their respective habitat covering was at least 20 m^2 (with ≥60% cover). The macrophyte areas chosen contained dense

Myriophyllum spp. beds and less than 5% cover of other macrophytes or debris. These beds were located along the perimeter of the billabongs in water less than 70 cm deep. Snag areas were selected where large logs and other woody debris, generally *Eucalyptus camaldulensis*, had fallen into the water. Depth was quite variable but always less than 1 m. Initially these areas contained no macrophytes. A maximum of 5% macrophyte or woody debris cover was found in the clear water areas at the time of selection. These were the deepest of all the habitat types, having depths of greater than 1 m on the initial trip.

Seven sampling trips were carried out between October 1997 and February 1998 during the turtles' active, summer period. Each trip lasted three days, with the first two days spent sampling turtles and the third finalising invertebrate sampling (see below). As the physical environment of billabongs was known to be changing continually, water depth and temperature (top and bottom) were measured in each habitat, in each billabong, during each trip. Measurements were taken on the last day of each trip when nets were pulled, to minimise disturbance within billabongs.

Over the study period the habitat types were subject to seasonal change. One major alteration was the emergence of the macrophyte *Potamogeton tricarinatus* that appeared in all of the habitat types in varying quantities. In some snag habitats it grew to have approximately 80% cover and thus changed the nature of the area being sampled.

Collection and processing of turtles

Sampling of turtles was carried out under Department of Natural Resources and Environment permit RP-97-170 and La Trobe University Faculty of Science, Engineering and Technology Animal Experimentation Ethics Committee permit LSB96/24/V2. Turtles were caught using unbaited fyke nets, as this was thought to not bias the capture. Within each billabong, two nets were set randomly in each of the three habitat types to determine the habitat preferences of the three species of turtle. Sampling commenced at 1000 hr and the nets were removed from the billabongs at 2030 hr. Whilst in the billabongs, nets were checked and cleared of turtles every four hours.

Once captured, the turtles were handled as detailed in Meathrel *et al.* (2002). Any turtle with a maximal carapace length greater than 15 cm had its stomach contents sampled using water off-loading (Legler 1977) as quickly as possible. All turtles were returned to the area from which they were caught in less than 30 minutes. Stomach contents were stored in 70% ethanol. Turtles that yielded no digesta were omitted from the study.

Stomach contents were examined in the laboratory. Fish were often unidentifiable due to partial digestion and were clumped into one group for analysis. Another grouping, vegetable debris, consisted of all vegetable matter found in the stomachs. This was mostly sticks and bark with a few grass seeds and some algae. Bones and insect exoskeletal parts were found, but these were omitted from analysis due to lack of positive identification and their likelihood to bias results due to differential digestibility rates.

Assessment of prey in the habitat types

Invertebrates and small fish were sampled from each habitat type within each billabong on every trip. These samples were used to represent the prey populations in each habitat type that were available to the turtles.

The invertebrates in macrophytes were sampled using a modified Hess sampler (Southwood 1971). A 20 cm diameter, metal cylinder was placed over the macrophytes and a 200 µm mesh net was swept within the cylinder to collect trapped invertebrates and fish. To sample the snag habitat, a 200 µm mesh dip net was placed alongside a submerged snag and the snag's surface was scrubbed using a brush so that dislodged invertebrates were collected by the net. The open water was sampled by sweeping the 200 µm mesh dip net towards the bank in an uplifting motion thus sampling the benthic invertebrates. Two sideways sweeps parallel with the bank followed, to net any invertebrates that had been dislodged from the sediments but not entrapped in the net. All samples collected were stored in 70% ethanol until they were identified at a later date.

Identification of prey items was performed using Hawking and Smith (1997). Most specimens were identified to family level with the exception of nematodes,

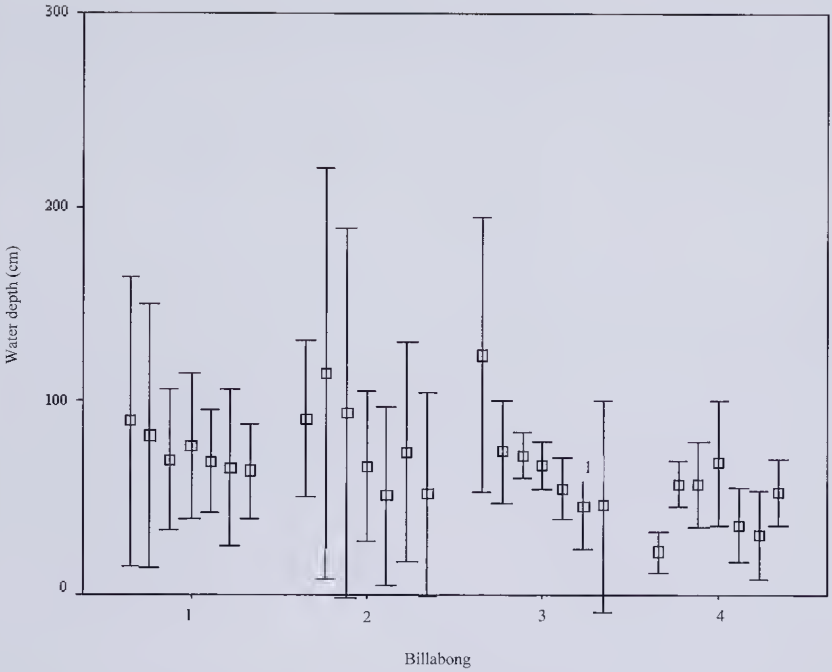

Fig. 1. Mean (±1 SE) water depth in each billabong, separately by trip, at Killawarra, Victoria, during the summer of 1997/98.

snails and mites which were identified to Phylum Nematoda, Class Gastropoda and Order Arachnida, respectively. Once identified, prey items were counted to estimate relative abundances. The index of relative importance (IRI; Pinkas 1971) was calculated following Meathrel *et al.* (2002) to assess the dietary value of each prey group.

Multivariate analysis using PATN was performed to test for grouping of turtles and habitat types using dietary and reference collection data (Belbin 1992). Abundance and presence/absence data were used to generate a Bray-Curtis dissimilarity matrix and clustered by flexible unweighted pair-group arithmetic means (UPGMA). Resultant groups were confirmed by examining their position in ordination space using Semi-strong hybrid multidimensional scalings (SSH). Analysis of similarity (ANOSIM) tests were conducted to determine the significance of differences between groups.

Data were analysed following Sokal and Rohlf (1995) with the statistical packages SPSS for Windows v. 7 (SPSS Incorporated 1996) and PATN v. 3.5 (Belbin 1992). All means are presented ±1 standard error unless otherwise stated.

Results

The depths of billabongs decreased over the summer (linear regression, $R^2 = 0.08$, $F_{6,82} = 7.41$, $p < 0.05$: Fig. 1). On any particular trip, water depth was not significantly different between the billabongs ($F_{3,80} = 2.68$, $p > 0.05$). The greatest overall depths were recorded at the beginning of summer (trip one) and water levels dropped on each subsequent trip. From trip five onward, the clear water habitat in billabong four and the macrophyte habitats in billabongs two and three were unable to be sampled due to water either completely drying up or being too shallow. The macrophyte habitat in billabong one was also very shallow after trip five and sampling may have been affected by this.

A comparison of the depths in the different habitat types revealed no differences in depth between the snag and clear water areas but the macrophyte areas were sig-

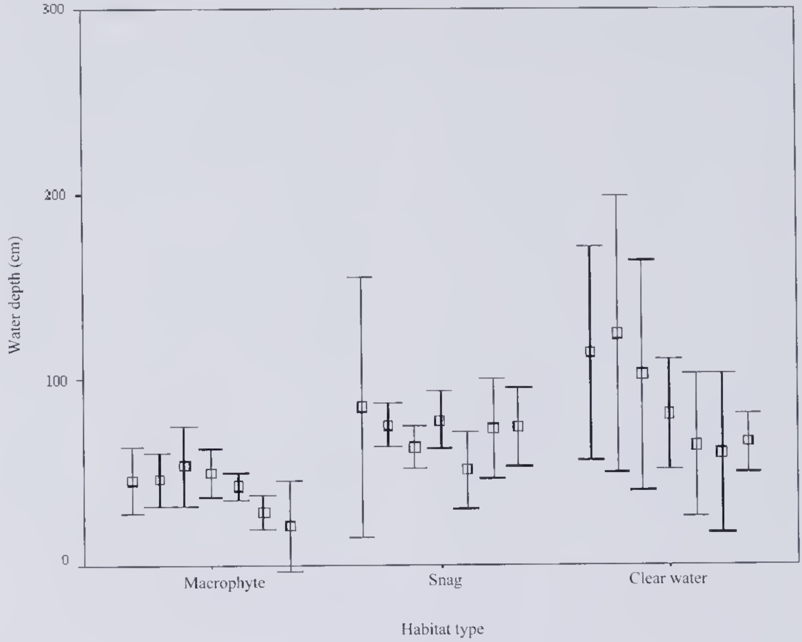

Fig. 2. Mean (±1 SE) water depth for each trip, separately by habitat, for billabongs at Killawarra, Victoria, during the summer of 1997/98.

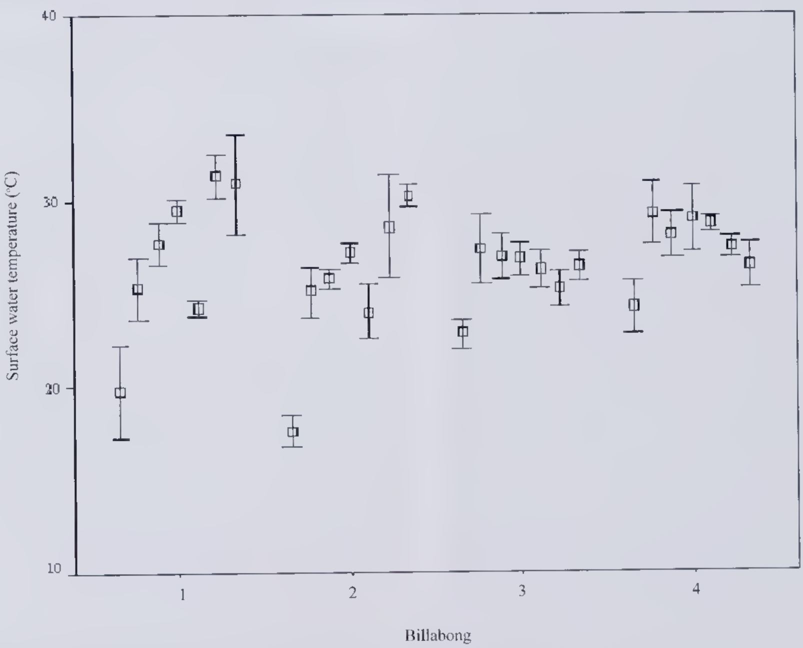

Fig. 3. Mean (±1 SE) water temperature at the surface of each billabong, separately by trip, at Killawarra, Victoria, during the summer of 1997/98.

Table 1. The number of *Chelodina longicollis* and *Emydura macquarii* caught in particular billabongs at Killawarra, Victoria, during the summer of 1997/98.

Billabong number	Number captured *C. longicollis*	*E. macquarii*
1	10	3
2	9	0
3	13	2
4	4	2

Table 2. The number of *Chelodina longicollis* and *Emydura macquarii* caught in the different habitat types of the Killawarra billabongs, Victoria, during the summer of 1997/98.

Habitat type	Number captured *C. longicollis*	*E. macquarii*
Macrophyte	18	3
Snag	7	4
Clear water	11	0

nificantly shallower ($F_{3,80} = 12.49$, $p < 0.001$; Fig. 2).

Water temperature increased markedly over the sampling period at both the surface and bottom of the billabongs (linear regression, $R^2 = 0.28$ and 0.28, $F_{6,80} = 31.34$ and 30.86, respectively, both $p < 0.005$; Fig. 3). There was a significant difference between surface and bottom temperatures over all trips with the surface measurements being 4°C warmer than those taken at the bottom (Student's $t_{81} = 12.01$, $p < 0.001$).

Habitat preference of turtles

In total, 36 *Chelodina longicollis*, no *C. expansa* and seven *Emydura macquarii* were captured (Table 1). Species combined, the number of turtles captured was independent of billabong ($\chi^2_3 = 4.53$, $p > 0.20$). Hence, capture data were pooled across billabongs to examine the habitat preferences of turtles.

Species combined, the turtles did not favour any one particular habitat during the course of the study ($\chi^2_2 = 4.65$, $p = 0.10$; Table 2). It did appear, however, that twice as many were captured in the macrophyte habitat (n = 21) than in either the snag or open water habitats (both n = 11). *C. longicollis* were caught in all habitat types. It appeared that more *C. longicollis* were caught in macrophyte areas than in snag or clear water areas, but this was not significant ($\chi^2_1 = 5.17$, $p > 0.07$). No *E. macquarii* were caught in clear water areas.

Prey preference of turtles

Of the 26 turtles whose stomach contents were analysed (i.e. 26 had carapace lengths of >15 cm), all but one were *C. longicollis* making the majority of the conclusions relevant to this species only. The remaining turtle was an *E. macquarii*.

The dendogram grouping turtles and habitats over time, by the abundance of invertebrate species, resulted in 10 groups at the 1.00 level of dissimilarity (Fig. 4). The first group contained 24 invertebrate samples, mainly from snag and clear water habitats from billabongs three and four and all trips. Group two contained 13 samples comprising 11 invertebrate samples from snags and two turtles. Group three contained 34 samples, comprising 32 invertebrate samples from macrophytes and open water (from billabongs one to three) and two turtles. Group four contained only three samples, two open water samples from billabong one and a turtle. Group five contained nine samples comprising four macrophyte samples and five turtles. Group six comprised three turtles and one macrophyte sample. Group seven contained two snag samples only. Groups eight to 10 were made up almost entirely of turtles. Therefore, the grouping of invertebrates from the reference collection and turtle diets did not appear to be influenced by either trip or habitat type. Turtles did, however, appear to group more closely to each other than to any particular habitat type or trip. ANOSIM analysis confirmed groups were significantly different from one another (Best B/W 1.097, Real B/W 1.282). These groups are represented in two dimensions further on an ordination plot (stress level of 0.216) showing axes one and three of a three-dimensional configuration (Fig. 5).

The calculated index of relative importance (IRI) values for prey items identified from the guts of turtles are given in Table 3. The item that had the highest IRI was vegetable debris. Fish had the next highest value followed by corixids and naucorids. Excluding vegetable matter and those items

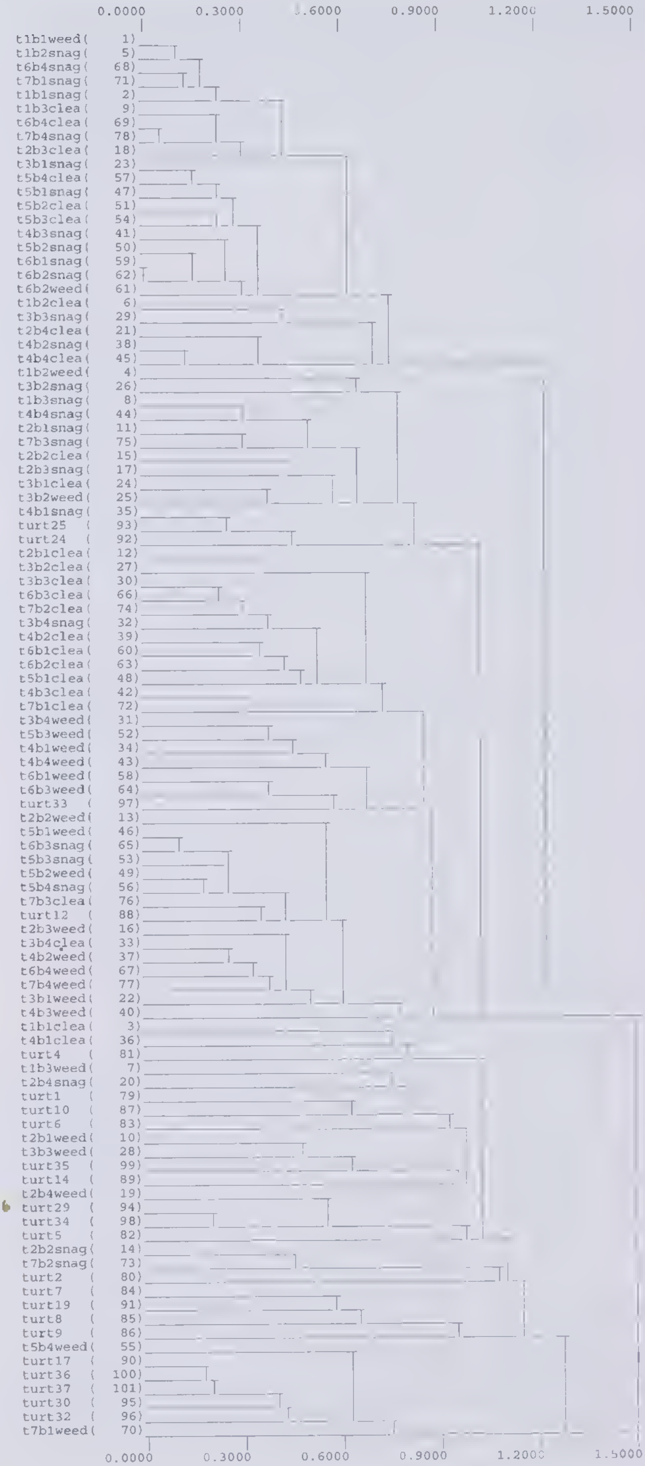

Fig. 4. (left) Dendogram based on abundance of prey items from turtle stomach contents and the habitat types from a Bray-Curtis association. t = trip; b = billabong; weed = macrophyte habitat; snag = snag habitat; clea = clear water habitat; turt = turtle.

with an IRI less than five, fish became the predominant food item (Fig. 6).

Discussion

Over the 1997/98 summer, the billabongs at Killawarra were subject to a local drought. Of the three habitat types examined, the macrophyte areas were most affected since these vegetation beds were situated along the periphery of the billabongs. As water levels receded, the temperature of the billabongs increased. Macrophyte beds became increasingly exposed and eventually perished due to desiccation. Only then were turtles forced into deeper snag and clear water areas.

Chelodina longicollis was the most abundant species captured in the billabongs. This confirmed previous habitat preference research where *C. longicollis* was shown to be the dominant species in more ephemeral water bodies (Chessman 1978, 1984). Within the billabongs, *C. longicollis* were found most commonly in macrophyte and clear water areas. Similar numbers of *C. longicollis and Emydura macquarii* were caught in the snag areas. *E. macquarii* is an

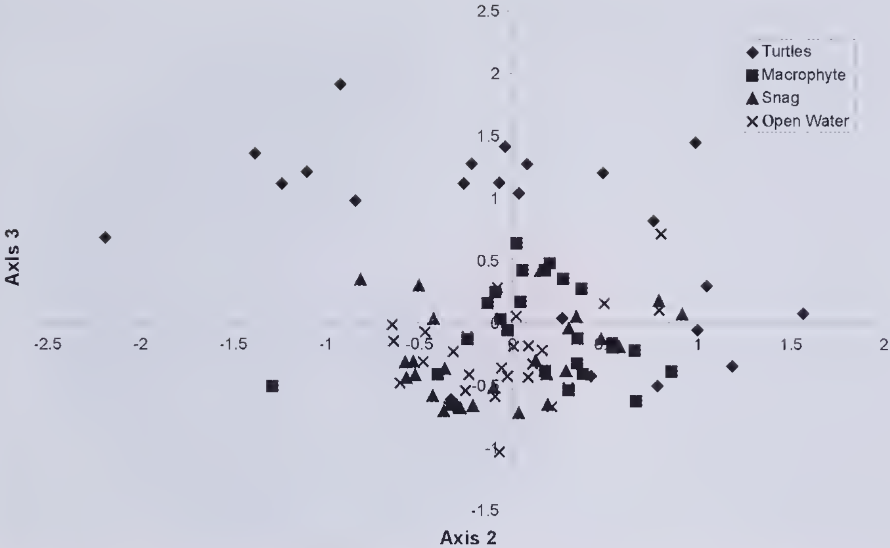

Fig. 5. SSH ordination plot in two-dimensions based on abundance of prey items from turtle stomach contents and the habitat types from a Bray-Curtis association.

aggressive turtle that has been recorded to exclude *C. longicollis* from areas where it occurs (Chessman 1984). The apparent preference by *E. macquarii* for the snag areas may be related to their propensity for basking on emergent woody debris (Chessman 1978). The low capture rates in this study prevent any conclusive comment on the competitive exclusion of *C. longicollis* by *E. macquarii* in the billabongs at Killawarra.

Billabongs are dynamic systems, constantly changing and cycling (Hillman 1986). It was therefore expected that the habitat types within the billabongs would not be static. The snag areas within the four billabongs were all clear of any macrophytes at the beginning of summer and under at least 40% *Potamogeton tricarinaris* by the summer's end. The selection of habitats by turtles may also be a continually changing process. As the habitat itself changes, the turtles may be continuously assessing the conditions and relocating in order to access the most favourable environment at any one time.

One factor thought to influence the habitat preferences of freshwater turtles is habitat complexity (Sheldon and Walker 1998; Meathrel *et al.* 2002). In this study, habitat complexity was defined by the surface area of snags/macrophytes to water volume ratio. Of the three habitat types sampled, macrophyte areas were the most complex. Snag areas were intermediate in complexity and clear water areas the least complex. Habitat complexity offered only a partial explanation for our results. Although the turtles showed a preference for the most complex habitat type, once these areas became less accessible (due to desiccation) turtles showed no preference between the snag and clear areas despite differences in the complexity of these habitat types.

The cyclic nature of billabongs may induce changes to invertebrate assemblages (Hillman 1986). As a general rule, the more complex the habitat type, the greater its species richness (Boulton and Lloyd 1991; Pusey *et al.* 1993). Therefore, turtles may spend time in more complex habitats in order to access prey organisms dwelling there. The reference collection of invertebrates and small fish from the Killawarra billabongs suggested considerable overlap between the invertebrate communities of the chosen habitats irrespective of complexity although snags and clear water (groups one and two) seemed to separate from the more complex macrophyte habitat (group three). The clear water habitat was common

Table 3. The index of relative importance for each prey type consumed by turtles captured at the Killawara billabongs during the summer of 1997/98.

Prey item	IRI
Chironomid larvae	30.8
Shrimp	7.9
Anisopteran larvae	1.8
Zygopteran larvae	0.7
Zygopteran adult	0.7
Naucorid	105.6
Hydrophilid larvae	11.1
Hydroptilid larvae	0.6
Corixid	106.6
Curculonid	61.5
Hydrophilid adult	0.7
Sminthurid collembolla	5.7
Spider	4.2
Terrestrial coleopteran	8.8
Leptocerid larvae	59.8
Lepidopteran larvae	2.1
Metal fragment	8.5
Snail	1.9
Hymenopteran	7.7
Cherax	5.1
Nematode	1.4
Baetid mayfly larvae	0.4
Dipteran	1.4
Unidentified fish	244.0
Vegetable debris	1256.3

in groups one (billabongs 3 and 4) and three (billabongs 1 to 3). Another, more robust, investigation using species level identification has revealed quite different faunas in habitats of differing complexities (Sheldon and Walker 1998). The overlap between the invertebrate faunas of different habitat types in this study could be due to the taxonomic resolution used or to the sampling effort. This study found turtles did not feed preferentially in any particular habitat type. The turtles may use more complex habitats as refugia for themselves, both to hide from predators, and to remain invisible as they sit and wait to ambush prey.

The major component of all the turtles' diets was vegetable debris. This was also observed by Meathrel *et al.* (2002). Bark and small sticks, probably originating from *Eucalyptus camaldulensis*, made up the majority of the debris, with additional items such as grass seeds and small amounts of algae. Most turtles in the analysis were *C. longicollis* which have been classified as obligate carnivores (Chessman 1978; Georges *et al.* 1986; Cogger 1996). The high proportion of plant debris suggested either a contradiction of carnivory or that its ingestion was accidental during the consumption of more highly-digestible animal prey.

A large proportion of the Killawarra turtles had consumed fish flesh, some of which could represent carrion. Previous dietary analyses have revealed *C. longicollis* feeds readily on carrion (Chessman 1978, 1984; Georges *et al.* 1986). In the current study, much of the fish was partially digested, and therefores unidentifiable. Chessman (1984) identified fish carrion from the stomachs of *C. longicollis* as European Carp *Cyprinus carpio* which he occasionally observed dead within the study area. The flesh found in the current study was that of small fish that could have been juvenile carp, but was more likely to have originated from either Mosquito Fish *Gambusia affinis*, or from Western Carp Gudgeons *Hypseleotris klunzingeri*, as these were the most abundant species in the billabongs sampled (D McNeil, La Trobe University, pers. comm.).

Other dominant prey items included insects from the Corixidae, Naucoridae, Leptoceridae, Chironomidae and Curculionidae. These items were the primary diet of *C. longicollis* sampled in north-eastern New South Wales (Parmenter 1976). Other studies have found that <11% of stomach contents contained these items (Chessman 1978, 1984). Chessman (1978) found items common in turtle diets were also common in the surrounding environment. The reference collection from Killawarra revealed that the commonly consumed organisms were abundant within the billabongs. Therefore, their presence within the stomachs may merely represent their availability and accessibility rather than any specific preference the turtles may have for them. Intraspecific differences in feeding habits related to local factors such as prey availability have been observed between different populations of freshwater turtles (Vogt and Guzman 1988). Therefore, variation in diets between different populations of *C. longicollis* could also be expected.

Kennett and Georges (1990) observed turtles migrating in periods of drought to larger, more permanent water bodies to escape desiccation. Even though the Ovens

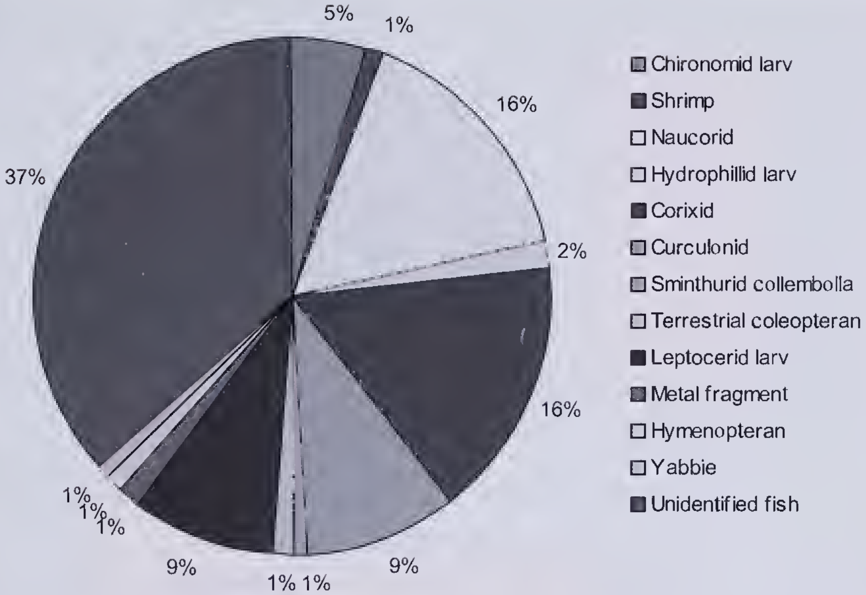

Fig. 6. Percentage composition of IRI values for prey identified from water off-loading turtles caught in the billabongs at Killawarra, Victoria, during the summer of 1997/98 (vegetable debris and IRI values <5 excluded).

floodplain became very dry, only on two occasions were turtles observed to move to smaller and shallower billabongs. As such, it is unlikely desiccation was the motivating force behind the moves.

In conclusion, it appeared from this study that freshwater turtles, particularly *Chelodina longicollis*, used ephemeral billabongs opportunistically to feed as water levels dropped. When water levels were high, and hence more favourable, turtles preferred more complex habitats (Sheldon and Walker 1998; Meathrel *et al.* 2002). However, when billabongs dried, turtles fed at random within snag and clear water habitats. As ins many field studies, highly variable environmental factors may alter the behaviour of organisms. In the future, a controlled laboratory study of food preference in freshwater turtles is required.

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Solution pipes or petrified forests? Drifting sands and drifting opinions!

Ken G Grimes[1]

Abstract

Two alternative interpretations exist for the pipes and other features of the so-called 'Petrified Forest' at Cape Duquesne, west of Bridgewater Bay, Victoria. The early tree-mould hypothesis of Boutakoff (1963), which is still advocated by the new interpretation signs at the site, is rejected in favour of more recent suggestions that interpret the features as solution pipes formed by focused vertical water flow through the porous calcareous sands (aeolianites). The focusing of the flow may be spontaneous and associated with patchy cementation of the hardpan of the soil, or it may be guided by other factors such as concentrated stem-flow beneath trees, or along taproots, or the pooling of water in hollows in exposed hardpans. (*The Victorian Naturalist* **121** (1), 2004, 14-22)

Introduction

The 'Petrified Forest' at Cape Duquesne, in the Bridgewater Bay area 20 km west of Portland, is a particularly good example of the many exposures of vertical pipes in calcareous dune sands which are seen in coastal areas of western Victoria, South Australia and Western Australia (Fig. 1). Similar features also occur in other parts of the world (e.g. southern Africa, the Caribbean and Bermuda – see reference list) where the host sand is known as calcarenite or aeolianite.

Typically the pipes in the Gambier-Portland region are 0.2 to 0.5 m wide, but can exceed 1.0 m. The exposed part is usually 1-3 m high (with the top removed by erosion and the base hidden below the soil surface). In a few places we see them up to 20 m deep. They can occur as isolated individuals, widely-spaced sets (e.g. 5-10 m spacing) or in dense fields (as at the 'Petrified Forest') with spacings closer than 1 m (Fig. 2; Appendix 1). They form smooth vertical cylinders which may narrow downward towards a rounded base ('cigar shaped' is a common description) or terminate abruptly in a hemisphere (Fig. 3). They commonly have a calcareous cemented rim around them that is a few centimetres thick. These rims may have concentric layers, and some have traces of thin calcareous root structures (rhizomorphs) and calcareous veins embedded

[1] PO Box 362, Hamilton, Victoria 3300
Email: ken-grimes@h140.aone.net.au

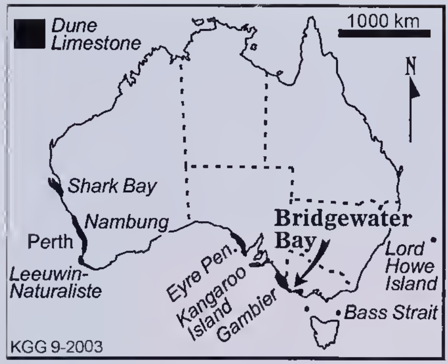

Fig. 1. Dune limestone areas in Australia.

in them (as does the surrounding sand). The exposed pipes tend to be empty, or are filled with a red or pale brown soil (silty sand). Occasionally the fill contains concentric calcareous laminae. The pipes are commonly associated with an old soil horizon, either descending from it (Fig. 4), or cutting through a calcified band that could be a subsoil hardpan. Occasionally, as noted by Boutakoff (1963), the pipes may bottom in a palaeosoil.

Solution pipes are subsoil karst features comprising vertical cylindrical pipes attributed to solution by downward percolating water. They can occur in hard crystalline limestones, where they generally follow vertical joints, but are a distinctive feature of soft limestones; e.g. the chalk of Europe or the Australian aeolian calcarenites (Jennings 1985). Some authors distinguish 'soil pipes' from 'solution pipes' by restricting the former term to soil-filled pipes and the latter to empty pipes. Here I will use the term 'solution pipe' for both types.

Associated with the pipes are *rhizomorphs*, which are hard calcified root structures. They are common in the calcareous dunes of the region and have an obvious branching root structure. These form from carbonate that has been precipitated around the root, which may be identifiable as a thin hollow core if it has not been infilled by younger cement. Thus they are much thicker than the original root; examples occur up to 100 mm thick but are generally less than 20mm.

A petrified forest?

In 1963, Boutakoff interpreted the pipes in the Portland region as having formed where an advancing dune had engulfed a forest of trees (Boutakoff 1963). Boutakoff argued that after the sand had been cemented into a soft rock, and the trunks had rotted away, the pipes were left as open holes which were locally filled by younger soil that developed on the surface of the engulfing dune. He rejected the alternative hypothesis that these were solution pipes (which had been argued by Woods (1862) and others); but he did allow that occasional deeper solution pipes occurred as solutional modifications of the tree moulds. Calcified traces of what are recognisably old roots (rhizomorphs) occur together with the pipes and were cited in support of his hypothesis. Boutakoff claimed to have seen 'unmistakable rooted tree stumps' and bark, logs and other 'woody structures'. He illustrated his argument with an imaginative diagram (his figure 17, which is reproduced here as Fig. 5) that unfortunately shows large roots spreading out from the base of the 'trunks' which do not appear in the real outcrop!

Boutakoff has overstated his case: these features are either capable of alternative interpretations or cannot now be found in the area.

Boutakoff's interpretation is attractive at first sight, and his diagram is deceptively beguiling. It has been referred to on numerous occasions in the local literature (e.g. Bird 1993) and appears, unchallenged, on interpretative signs recently erected in the area by Parks Victoria. However, his 1963 interpretation was rapidly challenged. Blackburn *et al.* (1965), described numerous areas of pipes just across the border, in South Australia, and referred to Boutakoff's site (and others) as having 'indisputable solution pipes'. Jennings (1968) favoured solution as the main process, and commented that 'secretion round the roots of vegetation growing down into the sand' seemed more likely than burial of a forest. Coetzee (1975) also argued against Boutakoff's concept from a study of similar features in southern Africa. There was initially some support from workers in Bermuda (cited by Boutakoff), where the pipes were regarded as moulds of palmetto stumps; but recent work has discredited this (Herwitz 1993). Palm trunks do have a

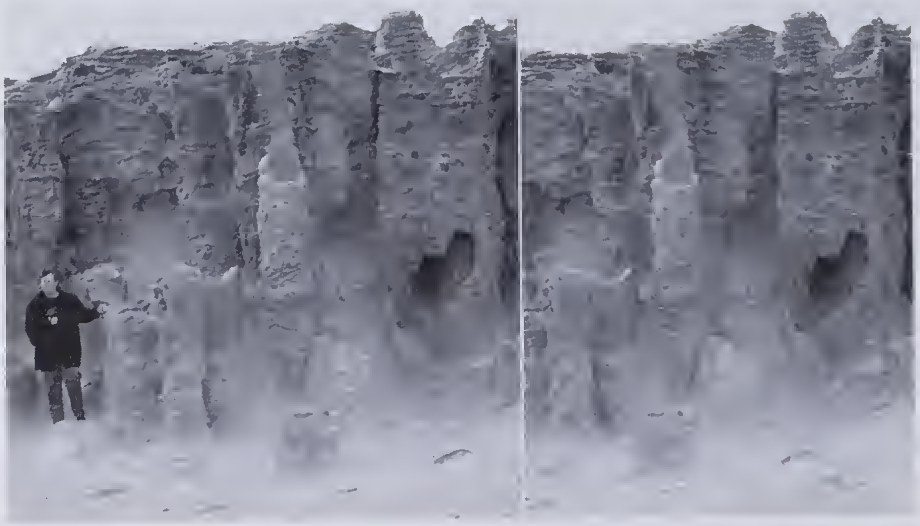

Fig. 2. Stereopair of the main cluster of pipes at the 'Petrified Forest', Victoria.

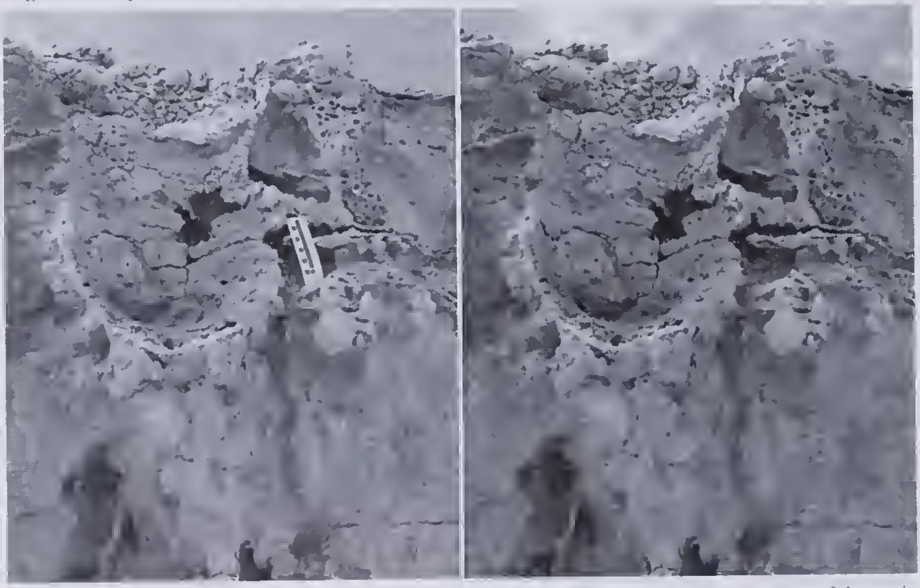

Fig. 3. Stereopair of a pipe with rounded base at the 'Petrified Forest', about 30 m west of the main group shown in Fig. 2. Scale bar is 10 cm.

rounded basal form more akin to the shape of the pipes than other trees, but no native palms are found in the Portland region.

Boutakoff (1963) quoted an extract from Darwin (1845) which describes calcified 'roots and branches' (but not trunks) at King George Sound in Western Australia. Fairbridge (1954:68-69) discussed that and other early reports on the Coastal Limestone of Western Australia, and agreed that the smaller branching bodies are formed from roots (i.e. they are rhizomorphs), but he then went on to say 'The most important correction that must be made concerns the larger "cylindrical bodies". These are now recognised as karst solution pipes or sink holes'. A more detailed discussion of the alternative solutional origin of the Western Australian pipes appears in Fairbridge (1950).

Fig. 4. Red palaeosoil and soil-filled pipes beneath a younger sand dune exposed in a cliff at Canunda National Park, South Australia.

The 'tree mould' hypothesis has a number of problems, which I will expand on below:

- The spacing of the pipes (less than 0.5 m in places) seems too dense for a typical forest with trunks the size of these pipes.
- Where seen, the base of the pipes is a rounded hemisphere – nowhere are there thick-rooted tree structures such as those shown in Boutakoff's figure (Fig. 5).
- Boutakoff (1963) claimed his pipes were based ('rooted') in a palaeosoil layer and extended upward from it. This is unusual; usually the pipes are seen descending to varying depths below an old soil or unconformity.
- The cross-bedding of the dune sand shows no disruption where it passes the 'trunks'.
- Some pipes are up to 20 m deep (or high!), and are all unbranched vertical cylinders.
- The pipes are not restricted to dunes, they also occur in beach and marine calcarenites.

Size and spacing

At the 'Petrified Forest' site, and elsewhere, the spacing of the pipes (locally less than 0.5 m: Appendix 1) seems too close for a typical forest with trunks the size of these pipes, whose inside diameters are typically 0.2 to 0.5 m (Appendix 1). In a comparable area in Puerto Rico, Lundberg and Taggart (1995) report cases of overlapping pipes, where younger pipes intersect older ones – though there are no good examples of this in our area. McNamara (1995) argued that the pinnacles at Namhung, WA, are remnant cemented areas left between coalescing solution pipes.

The close spacing seen in the 'Petrified Forest' could only occur with dense stands of small-diameter trees such as paperbarks or tea-trees. The Parks Victoria interpretative sign suggests Moonah *Melaleuca lanceolata*, but that species usually has a mallee-like habit of multiple diverging stems which is unlike the individual vertical pipes. Boutakoff recognised this problem of size, and argued for the development of a series of calcareous layerings around smaller trunks which makes them seem bigger. Nonetheless, the observed rims average only 5 cm thick, and the hollow centre within the cemented rim (Appendix 1) seems still larger than is compatible with the density of the 'trunks'. Also, if one accepts Boutakoff's suggestion of massive 'thickening' of the original trunk size by cement rims, then one must consider also Jennings' (1968) suggestion that calcification around taproots growing down into the sediment is a more likely explanation of the pipes than burial of a forest – though Jennings favoured solution as the primary process.

Lack of solid basal roots

The bases of the pipes are seldom seen at the 'Petrified Forest', but where we do see them (there and elsewhere) they end in a rounded hemisphere (Figs 3 and 7).

Nowhere have we found thick-rooted tree structures such as those shown in Boutakoff's figure 17 (Fig 5). His photographs (plates XIV-3 and 6) of a supposed stump with roots show small rhizomorphs running away from a pipe, but even without allowing for the exaggerated thickness of such calcareous overgrowths, these seem too small to support a trunk of that size. Small calcified roots (rhizomorphs) do occur, but are at all depths, not just at the base of the pipe.

Downward or upward development?

Boutakoff claimed his pipes were based ('rooted') in a palaeosoil layer and extended upward from it. When observing the surface outcrops, as distinct from the cliff cross-sections, one gets the impression that the pipes are ending just below the surface. This is because of the concave layered filling of partly cemented red soil, and is therefore misleading. Where seen in a good cross-section (cliff or quarry) the pipes descend to variable depths, but have a uniform upper termination at the present surface or at an old unconformity surface which may have an associated palaeosoil (Fig. 4). Where pipes are seen to bottom uniformly in a basal soil (as in some parts of the 'Petrified Forest'), that could be explained by reduced permeability and solubility of the soil material, inhibiting further downward solution.

Lack of disruption to the dune bedding

The cross-bedding of the dune sand shows no disruption where it passes the 'trunks' – there are no eddies or hollows on the lee side. This is not a strong argument, as Boutakoff argued that his calcareous growth layers extended out into the dune bedding and so would have destroyed any such distortions.

Some very deep pipes occur

The pipes at the 'Petrified Forest' are only short (1-3 m), but similar pipes elsewhere in the region can be up to 20 m deep (e.g. in Brown Snake Cave, described below). These deep pipes are simple vertical unbranched cylinders, not tree-like. Boutakoff regarded these isolated long pipes as 'secondary' solution pipes formed by modification of his tree moulds.

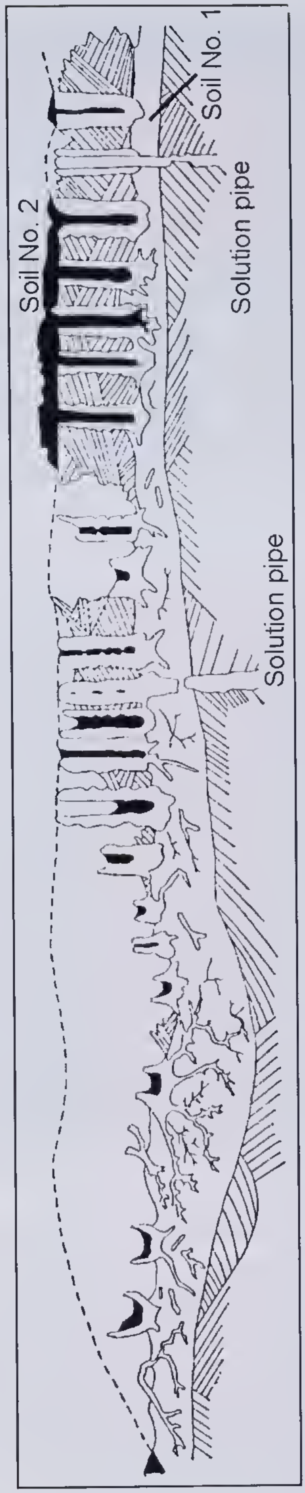

Fig. 5. Boutakoff's figure 17 shows many features of the 'Petrified Forest' correctly but grossly exaggerates the thickness and extent of root development at the base of the pipes. Black = soil fillings (after Boutakoff 1963).

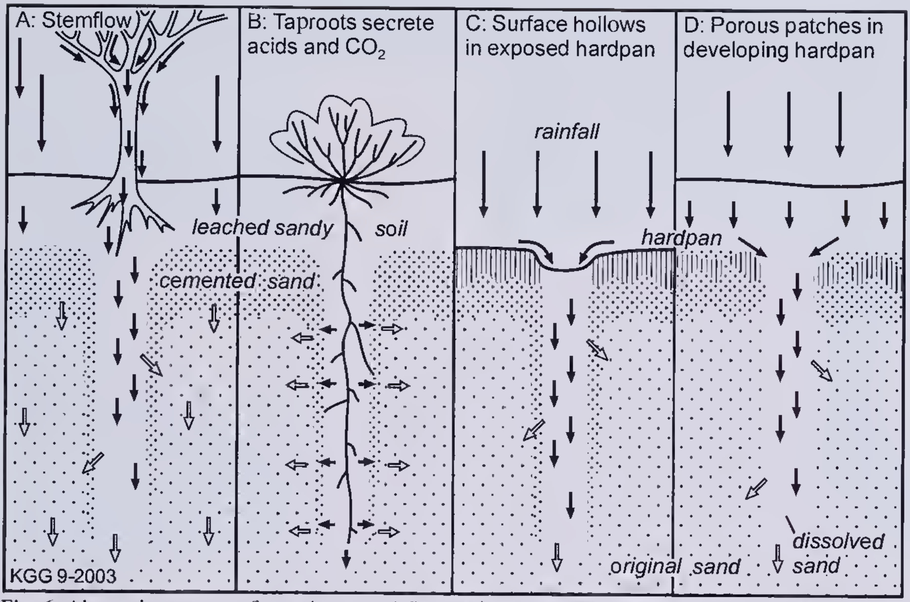

Fig. 6. Alternative ways to focus downward flow and generate solution pipes. Note: the alternatives are not mutually exclusive; they could all contribute in different settings. See Fig. 7 for symbols key.

Host sands are not all dunes

The pipes are a characteristic feature of dune limestones, but are not restricted to dunes. Similar pipes occur in beach sands associated with the dunes, and in the mid Tertiary marine Gambier Limestone, though the latter does not occur in the dense fields described by Boutakoff and so one cannot be sure that the genesis is identical. An example of solution pipes in marine limestone is seen in Brown Snake Cave (5U-14) at Naracoorte. This cave is in soft, sandy, Tertiary marine limestone with a thin capping of dune limestone. It is entered via a 15 m deep solution pipe that opens into the ceiling of a large chamber. This vertical pipe is perfectly cylindrical and about 0.6 m wide (apart from a constriction where it passes through a better-cemented band just above the ceiling of the chamber). Within the cave chamber there are 10 other blocked pipes in an area about 60 m long, each with a conical soil cone below it indicating a connection with the surface. For a map of this cave see figure 13 in Grimes *et al.* (1995).

Or solution pipes?

A recent review of solution pipes is given by Lundberg and Taggart (1995), who advocate 'dissolution pipe' as being a more correct term. They note that dissolution by focused downward vertical flow of under-saturated rain or soil water through the porous sediment can explain all the features of the pipes: the uniform, vertical cylindrical form, the dense clustering in places, and the cemented rims (where dissolved material is re-precipitated at the edges of the pipe). The associated rhizomorphs are simply formed around roots that have penetrated the sands from above, possibly following the soil-filled pipes by preference and radiating out from them. As the pipes are developing downward from the surface or from a soil cover, the infilling material will progressively fill them as they deepen.

But why is the downward water flow focused into the pipes rather than travelling evenly throughout the uniformly porous sand? In hard limestone, pipes usually form where flow is concentrated along the intersections of joints or steeply dipping bedding planes. But in soft sandy limestone there are no vertical joints, and the initial inter-granular porosity is uniform apart from occasional horizontal hard-bands – the dune cross-bedding seems to have little effect on flow directions. Three methods of concentrating the flow have been suggested by Lundberg

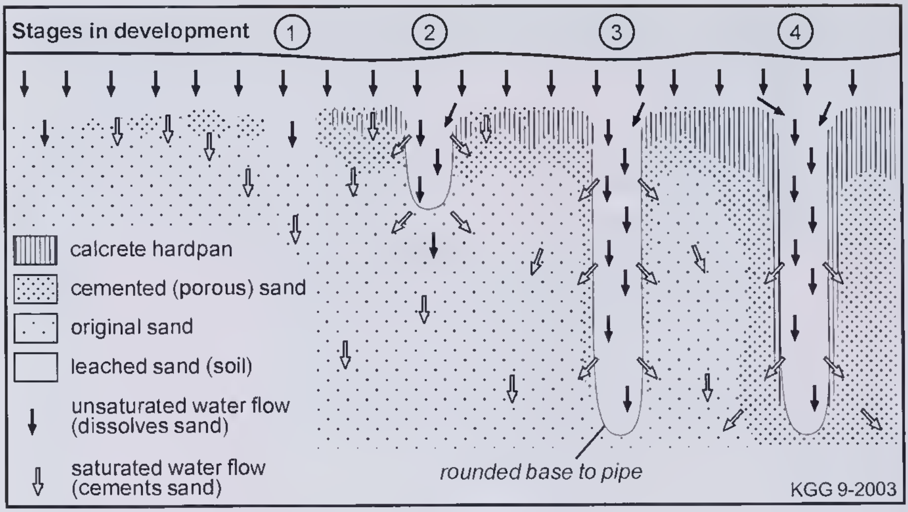

Fig. 7. How a solution pipe deepens and develops a rim.

and Taggart (1995), drawing on other authors: surface hollows, roots and stem-flow; to those I will add a fourth: patches of higher porosity in the developing soil hardpan (Fig. 6).

In passing, it is worth noting that similar vertical pipes occur in the giant podsols that develop on the quartz sand dunes of the Queensland coast (Thompson and Bowman 1984). These have a deep leached A2 horizon over a humic-rich B horizon, with pipes of the leached A2 from a few centimetres to nearly half a metre wide penetrating several metres down into the enriched B horizon. I have also seen analogous, soil-filled, pipes formed in ferruginous duricrusts associated with deep-weathering profiles in tropical Australia. In both cases, focusing of downward water flow seems to be involved.

Stem-flow is the process whereby the leaves of a tree intersect rain, and direct it down the branches so that it is concentrated at the base of the trunk. The concentrated inflow would cause localised solution and pipe development (Fig. 6a). Herwitz (1993) measured stem-flow under a variety of trees in Bermuda and showed that it could generate significant concentrations of water with increased acidity and noted that multiple generations of trees could produce the dense spacing of pipes which is observed in places.

The influence of **tree roots** was suggested by Jennings (1968) and later by Bird (1970). Roots generate organic acids and raised CO_2 levels that enhance solution in their vicinity (Fig. 6b). A vertical taproot could therefore form an initial thin pipe which would enhance water flow and enlarge with time. This is a self-perpetuating process as a pipe, with soil fill, would be a preferred place for continuing root growth and organic activity.

Surface hollows were suggested by Coetzee (1975) and others (Fig. 6c). If hollows exist (on a partly indurated surface, or on the top of the soil hardpan) then water will accumulate in these and the base of the hollows will be lowered by solution at a faster rate than the surrounding higher areas – the process becomes self-perpetuating.

A possible fourth process involves **uneven cementation of the hardpan**. Rain dissolves carbonate grains as it penetrates the sandy soil, and some of this is re-precipitated lower down to form a hardpan or calcrete band near the base of the soil. In the initial stages this band would not develop evenly (Fig. 6d). The early-cemented areas would tend to deflect flow laterally to places which retained more of their original porosity and concentrated inflow would occur there, inhibiting further cementation, and allowing solution pipes to form below.

In all four cases, once the inflow is concentrated at a point, solution will progressively deepen a vertical pipe beneath the focal point. Lateral movement of saturated water out of the pipe would form the cemented rim (Fig. 7).

Discussion

Boutakoff himself admitted that some of the pipes were solutional in origin, but argued that most were tree moulds. I argue the opposite: most are solutional and while it is possible that a forest could be buried and rot away to leave moulds resembling the pipes, this would probably be a rare event and there is no unambiguous evidence for it at the 'Petrified Forest'.

The focused solution process seems a better hypothesis for general interpretation of both isolated pipes, and the dense fields of pipes which are a distinctive feature of dune limestones throughout the world. Note that the four alternative modes of focusing water flow discussed above are not presented as mutually exclusive hypotheses – all could act, either together or separately, according to the local situation in any area.

Rhizomorphs are common in dune sands and form around small roots growing through the sand. Such roots would preferentially follow the organic-rich soils that fill the solution pipes and branch out from them. Thus, rhizomorphs could be called petrified roots, but the pipes are not petrified trunks.

So, while 'Petrified Forest' provides a picturesque name for the features at Cape Duquesne, the name should be kept in quotes, and not confused with the real process by which these features were formed. The recently erected interpretative signs are incorrect.

Acknowledgements

My colleague, Susan White, has contributed to many discussions on the nature of these and other features of the calcareous dunes. I also thank my wife, Janeen Samuel, for assistance in the field. Andy Spate and two anonymous referees helped by pulling me up on some excessive statements and by providing copies of additional reports discussing the local geology.

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Appendix 1: Morphometric analysis of solution pipes

The Petrified Forest, this study

A 5 × 5 m quadrat was set up near the track to the 'Petrified Forest', just before the first good three-dimensional exposure. This contained 53 pipes, giving a density of 2.12 pipes/m^2. For each pipe within the quadrat, or crossing the north and east boundary, the following were measured: inside diameter, outside diameter, thickness of cemented rim, distance to nearest neighbour (centre to centre), direction to nearest neighbour. Where the pipes were noticeably elongate both the length and width were measured; there were three of these, with elongation ratios between 1.6 and 2.6. Three composite pipes occurred, two pairs and one triplet. For one pair, the rim of the larger pipe was slightly superimposed on the smaller, suggesting that it formed later. For the other two, the members shared a common rim and were connected by open necks. For these composite units, the widths etc. of the individual members were measured rather than the unit as a whole.

The mean inside diameter of the pipes was 270 mm, with a standard deviation of 92 mm, but the total size range was from 60 to 460 mm. The rim thickness varied within individual pipes as well as between pipes and was difficult to estimate accurately, but averaged 48 mm.

A nearest neighbour analysis was based on the method described in Swan and Sandilands (1995). Mean distance to nearest neighbours was 458 mm, with a standard deviation of 12.8 mm. This gives a nearest-neighbour statistic (R) of 1.35 (slightly uniform), however the Z statistic of 0.52 indicated that the result was not significantly different from random. A plot of the direction to nearest neighbour shows a slight peak in the NNW-SSE direction (Fig. 8), the mean bearing was 153° magnetic.

Other morphometric studies

Webster (1996) also measured pipes at the 'Petrified Forest'. He reported results from ten 3 × 3m sites as follows: The mean density of pipes at all sites was 1.80 pipes/m^2, ranging from 1.22 to 2.78 pipes/m^2. The average diameter (presumably the inside diameter) ranged from 275 to 540 mm at the different sites, with an overall mean of 401 mm.

Herwitz (1993) measured pipes at four sites in Bermuda and reported that the mean diameter ranged from 200 to 370 mm. He reported densities of between 0.33 and 0.60 pipes/m^2 in his table (much less than at the 'Petrified Forest') , but mentioned in his text that densities in other, smaller, plots exceeded 1.2 pipes/m^2. For comparison he measured a Palmetto stand which had mean trunk widths of 320 mm, but a density of only 0.06 trunks/m^2 – much less than that of the pipes. Coetzee (1975) reported from southern Africa an average pipe density of 1 pipes/m^2 with exceptional cases up to 3 pipes/m^2. His diameters were between 300 and 400 mm.

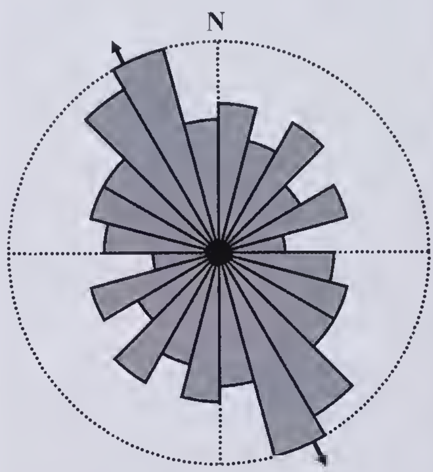

Fig. 8. Rose diagram of directional frequency of nearest neighbouring pipe, using magnetic bearings. N = 53. Plotted by area of sector.

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Hybridisation between radiate and erechthitoid species of *Senecio* L. on Mount Macedon, Victoria

Daniel Caspar Thomas[1]

Abstract

Several plants resembling the radiate *Senecio linearifolius* A.Rich., but with atypically small ligules not conforming to the circumscription of *S. linearifolius*, were observed on Mt Macedon, Victoria. Their small ligules and an unusual composition of florets in their capitula suggested that these plants were of hybrid origin, prompting a morphometric study to investigate this hypothesis. The multivariate morphometric study, using vegetative, floral and fruit characters, was based on 25 specimen samples collected on Mt Macedon and included specimens of the putative hybrid and representative specimens of sympatric *Senecio* species (*Senecio biserratus* Belcher, typical *S. linearifolius*, *S. minimus* Poir., and *S. pinnatifolius* A. Rich.). Numerical methods used include cluster analysis (flexible UPGMA), principal components analysis (PCA) and semi-strong-hybrid multidimensional scaling (SSH). The morphometric analyses supported the hypothesis of a hybrid origin of the shortly-liguled plants from Mt Macedon, and identified the two likely parent species: the radiate *S. linearifolius* and the erechthitoid *S. minimus*. (*The Victorian Naturalist* **121** (1), 2004, 23-31).

Introduction

Several species of *Senecio* L. can be found in the tall open forests on the western side of Camels Hump, a rocky outcrop on Mt Macedon, Victoria. The radiate (ray-flowered) Fireweed Groundsel *S. linearifolius* A.Rich. and Variable Groundsel *S. pinnatifolius* A.Rich., and the erechthitoid Jagged Fireweed *Senecio biserratus* Belcher and Shrubby Fireweed *S. minimus* Poir. are common in this area and often form sympatric populations. The term erechthitoid is used *sensu* Belcher 1956, for species of *Senecio* which have inconspicuous capitula composed of central bisexual tubular florets and marginal pistillate tubular florets which lack ligules. Besides the aforementioned species, plants were observed which show, prima facie, a strong similarity of vegetative characters with *S. linearifolius*, but differ distinctly from it in capitular morphology. The ligules of their ligulate florets are very short, clearly outside the range of *S. linearifolius*. In contrast to the radiate capitula of *S. linearifolius*, which show a clear differentiation into bisexual tubular florets and pistillate ligulate florets, the capitula of the shortly ligulate plants are composed of three types of florets: central bisexual tubular florets, few marginal filiform pistillate florets and marginal pistillate ligulate florets. These morphological characteristics are very unusual for *Senecio*. However, similar conditions have been described in former studies of hybrids between radiate and discoid senecios (Hilliard and Burtt 1976; Burtt 1977), and the occurrence of shortly ligulate hybrids between radiate and erechthitoid species of *Senecio* is known in the Australian flora. One example is *Senecio* × *orarius* J.M. Black which was shown to be the sterile hybrid of the erechthitoid *S. biserratus* and the radiate *S. pinnatifolius* (Lawrence 1980; see also Jessop and Toelken 1986). A close examination of herbarium specimens of *S. linearifolius* revealed that there are several areas in Victoria and Tasmania where plants with a ligule morphology matching that of the plants at Mt Macedon occur (I Thompson 2002, pers. comm.). In all these areas, the shortly-liguled plants occur sympatrically with typical *S. linearifolius* and several other species of *Senecio*. The small ligules and the floret composition of the plants observed on Mt Macedon and in the herbarium material suggest that they are of hybrid origin. The aims of this morphometric study are to test this hypothesis and to identify the likely parent species.

Methods

Nomenclature throughout this report follows Ross (2000).

Collection regime

For the purpose of the morphometric analyses, samples of 25 specimens (five specimens of each of *Senecio biserratus*, *S.*

[1]Westendallee 72, 14052 Berlin, Germany. E-mail: d.c.thomas@gmx.de

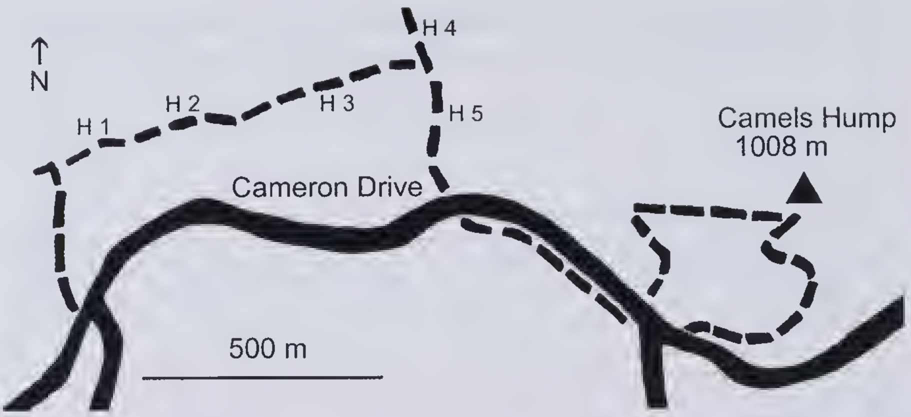

Fig. 1. Map of collection site. Latitude: 37° 22′ south, longitude: 144° 36′ east, altitude: c. 920 m. H 1-5: collections of putative hybrid specimens.

linearifolius, *S. minimus*, *S. pinnatifolius* and the putative hybrid) were collected along a trail north of Cameron Drive to the west of Camels Hump (latitude: 37°22′ south, longitude: 144°36′ east, altitude: c. 920 m) at Mt Macedon, Victoria (Fig. 1). The relative rarity of the putative hybrid restricted the sampling size to five specimens. Specimens of *Senecio biserratus*, *S. linearifolius*, *S. minimus* and *S. pinnatifolius* were collected from populations nearest to the collected putative hybrids.

Measured characters

Ten quantitative characters were measured on mature leaves, capitula, florets and cypselae of each sampled specimen. A mean value was calculated from five measurements of each character (except for length of the longest leaf).

Leaf characters scored included: length of leaves (LML), length of the longest leaf (LLL), maximum width of leaves (WML) and frequency of callus-points at leaf margins (FCP). Leaves were measured in the middle part of the stem. Capitular characters scored were: length of involucral bracts (LIB), number of involucral bracts (NIB), length of calycular bracteoles (LCB) and number of calycular bracteoles (NCB). One floral character, length of the corolla of the central tubular florets (LTF), and one fruit character, length of the pappus of mature cypselae derived from the central tubular florets (LPA), were scored. Only mature organs were measured in order to minimise the effect of ontogenetic variation. All measurements were taken from dried and pressed material.

Several floral characters were either difficult to score or methodologically difficult to incorporate in the multivariate analysis, and were therefore not included in the morphometric study. Characters such as floret morphology, length of the ligulate florets and floret composition, showed wide variation in addition to transitional stages in the putative hybrid (a detailed description of the floret morphology and composition is given with the results). It was therefore difficult to compare them quantitatively with the distinctly differentiated morphological conditions of the other *Senecio* species included.

Morphometric evaluation

For all analyses, individual plants functioned as operational taxonomic units. The morphometric analyses were performed in the following sequence:

1) A cluster analysis (flexible UPGMA) (Sokal and Michener 1958) was carried out in order to determine the taxa most closely related to the putative hybrid. Prior to the application of the Canberra metric as the association measure, the data was range-standardised. The Canberra metric was employed on the basis of its relatively robust performance in comparison to several other association measures (Cao *et al.* 1997).

2) A principal components analysis (PCA) (Sneath and Sokal 1973; Krzanowski 1990) was performed in order to enable a visualisation of the information

from the multivariate data set in a reduced dimensional space. (The information was condensed to two new attributes, which define the two dimensions of the visualisation). The data matrix were range-standardised prior to the calculation of the correlation coefficient.

3) As an alternative and more robust ordination method, semi-strong-hybrid multidimensional scaling (SSH) (Faith *et al.* 1987; Belbin 1991), was applied. This analysis was performed in order to test if similar patterns in the visualisation of relationships among the operational taxonomic units were obtained from the application of alternative ordination algorithms and association measures. For the SSH, the data set was range-standardised and the squared Euclidean distance was estimated as the association measure.

All analyses were performed with *PATN: Pattern Analysis Package* (Belbin 1995), using procedures ASO, DEND, FUSE, PCA, PCC and SSH.

Seed trial

A seed trial was carried out in order to test fertility of the putative hybrid. Ten cypselae from each putative hybrid specimen were sown in individual pots of 10 cm diameter containing compost. Illumination of the greenhouse was provided by natural daylight supplemented by mercury vapour lights to give a photoperiod of 16 h. Temperature was maintained at 22 °C ± 2 °C.

Results

Floret morphology and composition

The putative hybrid specimens consistently show ligulate florets with distinct but conspicuously short ligules, ranging from 0.4 to 2.8 mm in length. This is clearly outside the range of *S. linearifolius*, whose ligule length is between 3.5 and 6 mm (Walsh and Entwisle 1999) (Fig. 2).

The capitula of the putative hybrid specimens are often composed of three types of florets: central bisexual tubular florets; marginal pistillate filiform florets, of which some show rudimentary staminal development; and pistillate ligulate florets. Sometimes specimens possess a whole range of morphologically different pistillate florets, including regularly lobed filiform florets, irregularly lobed florets, bilabiate (or irregularly bidentate) florets and

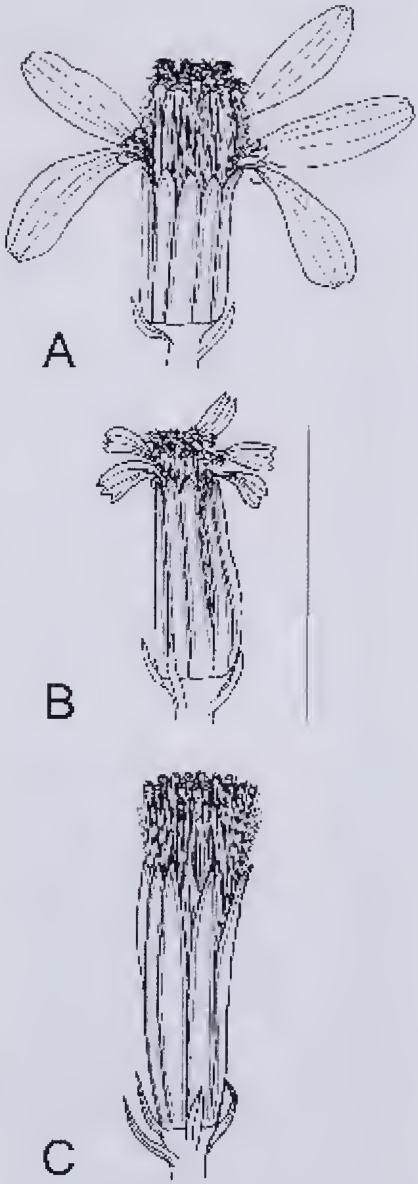

Fig. 2. Capitula. A: *Senecio linearifolius*. B: Putative hybrid. Scale bar = 7 mm. C: *S. minimus*. Drawings by D. C. Thomas.

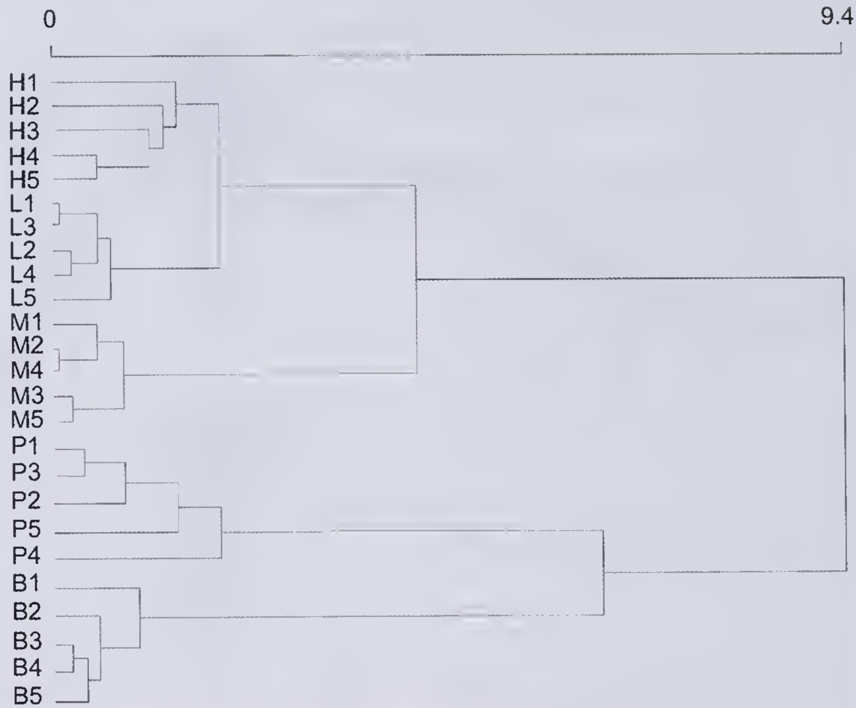

Fig. 3. Cluster analysis (flexible UPGMA) of the putative hybrid (H 1-5), *Senecio linearifolius* (L 1-5), *S. minimus* (M 1-5), *S. pinnatifolius* (P 1-5) and *S. biserratus* (B 1-5). The scale above the diagram denotes dissimilarity.

very shortly ligulate florets. This represents a transition from the regular pistillate filiform florets to the very shortly ligulate florets, similar to conditions which have been observed in a few erechthitoid *Senecio* species (Belcher 1956).

The ratio of florets in the putative hybrids (central bisexual tubular florets: marginal pistillate filiform florets: ligulate florets) ranges from 8:0:5, a floret composition similar to *S. linearifolius*, to 10:5:5.

Morphometric analyses

The results of the morphometric analyses as explained in the methods section were as follows:

1) Cluster analysis (flexible UPGMA): On the dendrogram resulting from the flexible UPGMA, all sampled taxa, *Senecio biserratus*, *S. linearifolius*, *S. minimus*, *S. pinnatifolius* and the putative hybrid, formed distinct clusters (Fig. 3). Two main groups can be differentiated. The first group incorporates *S. pinnatifolius* (P 1-5) clustered with *S. biserratus* (B 1-5). The second group contains three clusters: the putative hybrid (H 1-5), the *S. linearifolius* cluster (L 1-5) and the *S. minimus* cluster (M 1-5). The putative hybrid is most closely clustered with *S. linearifolius* specimens, indicating the strongest phenetic similarity between these two taxa.

2) Principal components analysis (PCA): The ordination diagram derived from the PCA separated the specimens in two dimensions (Fig. 4). The first component axis (PC 1, x-axis) accounts for 58% of variation, the second component axis (PC 2, y-axis), for 25%. The information loss was 17%. Principal components analysis, like semi-strong-hybrid multidimensional scaling and other ordination methods, condenses the information on the individuals in order to enable a visualisation of the information from a multivariate data set in a reduced dimensional space: 'There is a

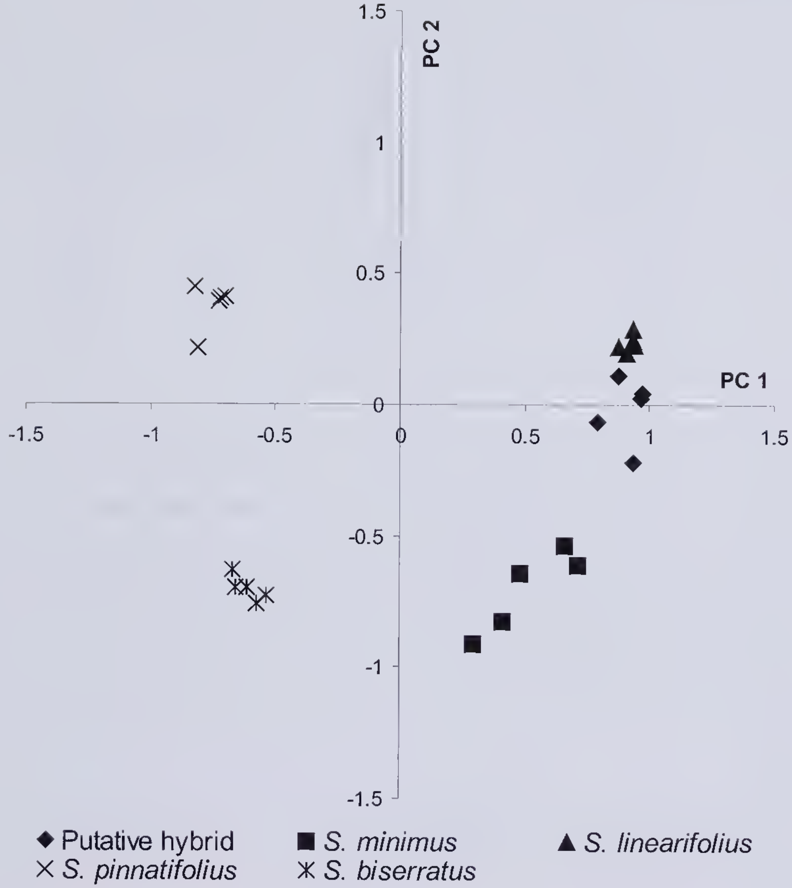

Fig. 4. Principal components analysis (PCA).

trade off between loss of information and the simplification of data in order to detect pattern' (Beals 1984).

The distinct grouping of the flexible UPGMA is also recognisable in the ordination diagram derived from the PCA. The *S. biserratus* group and the *S. pinnatifolius* group have positions divided from each other along the second component axis and distinctly isolated from all other groups along the more informative first component axis. The putative hybrid group shows the closest position to the *Senecio linearifolius* group, only slightly divided along the second component axis. It has an intermediate position between *S. linearifolius* and *S. minimus*. *S. minimus* is, however, slightly divided from the hybrid and the *S. linearifolius* group along PC 1, and variation expressed in PC 2 results in a clear division along this axis.

Capitulum characters NIB (number of involucral bracts) and NCB (number of calycular bracteoles) were highly correlated with the first principal component axis, which indicates their importance for the division of *S. pinnatifolius* and *S. biserratus* from the *S. linearifolius*/putative hybrid/*S. minimus* group. WML (width of midstem leaves) and FCP (frequency of callus-points at the leaf margins) have a high correlation with the second component axis, and strongly contribute to the division within the *S. linearifolius*/putative hybrid/*S. minimus* group.

3) Semi-strong-hybrid multidimensional scaling (SSH): The stress (a measure of information loss) of the SSH was c. 0.1.

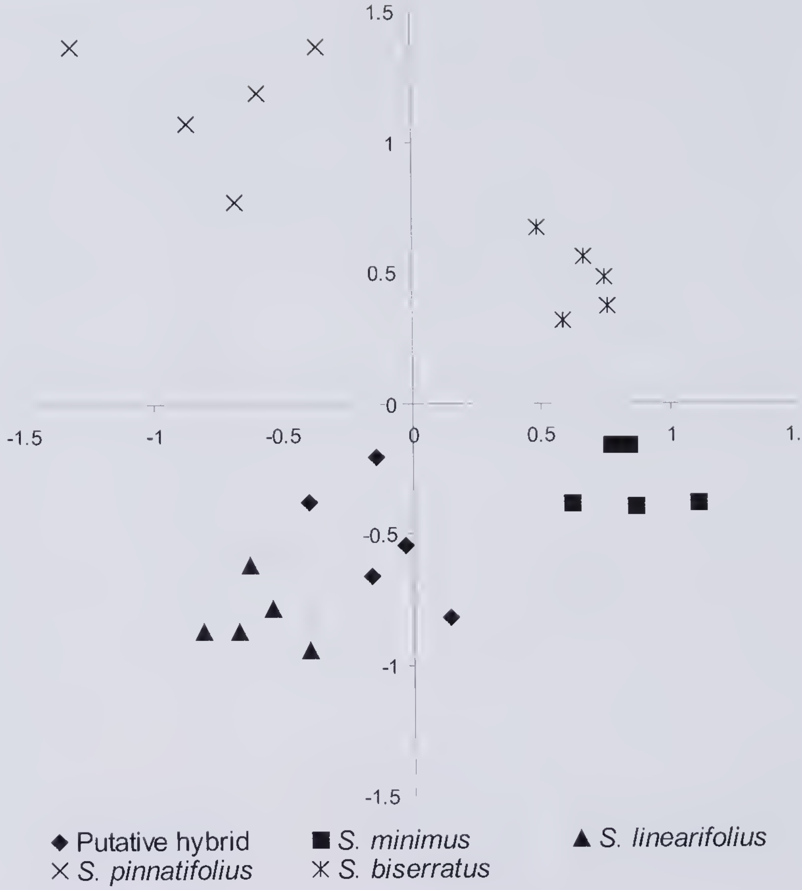

Fig. 5. Semi-strong-hybrid multidimensional scaling (SSH).

After Kruskal (1962, 1964) this can be estimated as at the border between satisfactory and fair, i.e. the analysis gives a meaningful representation of the data and most of the relevant data is retained.

The groupings of the PCA are also apparent in the ordination diagram resulting from the application of the SSH technique (Fig. 5). *Senecio pinnatifolius* is isolated in the 2-dimensional space. The putative hybrid specimens have a position between the *Senecio linearifolius* group, the *S. minimus* group and the *S. biserratus* group, showing the closest proximity to the *S. linearifolius* specimens.

Seed Trial

All putative hybrids produced viable seeds and vital offspring. The germination rate was between 30 and 60%. Six cypselae of putative hybrid specimen one (H 1), four cypselae of each of putative hybrid specimens three and four (H 3 and H 4), and three cypselae of each of putative hybrid specimens two and five (H 2 and H 5) germinated.

Discussion

The hypothesis of hybrid origin of the shortly ligulate plants from Mt Macedon, which was based on observations of an unusual capitular morphology that can be interpreted as intermediate between a radiate and an erechthitoid capitulum, was supported by the morphometric analysis of vegetative, floral and fruit characters. The results showed clearly that specimens classified as putative hybrids form a distinct group, intermediate in position between the radiate *S. linearifolius* and the erechthi-

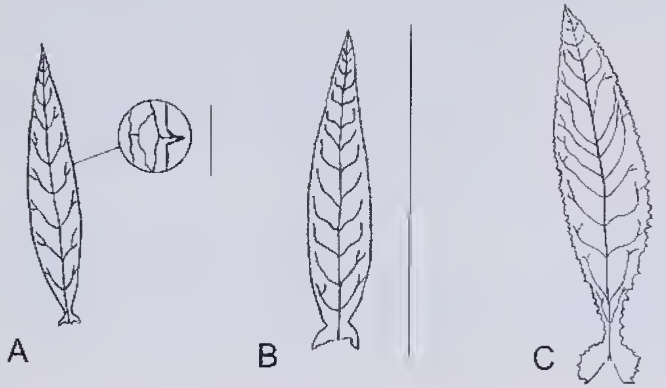

Fig. 6. Leaves. A: *Senecio linearifolius*. Detail of leaf margin with callus-point. Scale bar = 1 mm. B: putative hybrid. Scale bar = 15 cm. C: *Senecio minimus*. Drawings by D. C. Thomas.

toid *S. minimus*, and considerably further separated from *S. pinnatifolius* and *S. biserratus*. One example of this intermediacy is the leaf morphology of the putative hybrid, which distinguishes it from both the *S. linearifolius* specimens and the *S. minimus* specimens. The width of the leaves and the frequency of callus-points at the leaf margins of the putative hybrid specimens are clearly intermediate between the *S. minimus* specimens, which have broader leaves and more frequent callus-points, and the *S. linearifolius* specimens (Fig. 6).

Two further points indirectly substantiate the hypothesis that *S. linearifolius* and *S. minimus* are the likely parent species of the putative hybrid. First, while most radiate senecios in Australia have chromosome numbers based on n = 20, erechthitoid senecios show a wide spectrum of base chromosome numbers (Lawrence 1980). Hybridisation between radiate and erechthitoid senecios often results in sterile hybrids, because their chromosome sets are not compatible. One example is *Senecio* × *orarius* (chromosome number 2n = 70), which is the sterile hybrid of the erechthitoid *S. biserratus* (2n = 100) and the radiate *S. pinnatifolius* (2n = 40) (Lawrence 1980; see also Jessop and Toelken 1986). However, the radiate *Senecio linearifolius* is a major exception in terms of chromosome number because it has a base chromosome number of n = 30, just like the erechthitoid *S. minimus* (Lawrence 1980). Thus it is likely that hybrids between these two taxa are fertile, as was the putative hybrid examined in this study. Second, a close examination of herbarium specimens showed the existence of plants with a ligule morphology matching that of the putative hybrids at Mt Macedon. The existence of these herbarium specimens, which have either been assigned to *S. linearifolius* or *S. minimus*, suggests that these two species hybridise at other locations in Victoria and Tasmania (I Thompson 2002, pers. comm.).

An interesting result was the apparent greater similarity of the putative hybrids to *S. linearifolius*. Potential causes for this stronger phenetic resemblance are breeding mechanisms, which promote a higher rate of backcrossing between the putative hybrid and *S. linearifolius*. The erechthitoid Australian species of *Senecio* are all self-compatible, whereas radiate taxa are self-incompatible (Lawrence 1980). Although the erechthitoid *S. minimus* shows mechanisms to promote outcrossing, such as the functionally proterogynous capitula (the outer pistillate filiform florets open first due to the centripetal anthesis of the florets in the capitula) and the protandrous central bisexual florets, inbreeding can still occur in the many-headed inflorescences and might be an important factor in the pollination biology of this species. Inbreeding does not occur in the self-incompatible *S. linearifolius*, therefore the chance of backcrossing with a hybrid might be higher. Other potential reasons for more frequent backcrossing of the putative hybrid with *S. linearifolius* are greater abundance of *S. linearifolius* in comparison to *S. minimus* at the collection site, higher congruence of pollinators between the ligulate taxa, and greater congruence of flowering time. These considerations of ecological factors, however, have not yet been tested.

Another cause may be a sampling artefact, i.e. the data set may be biased towards *S. linearifolius* because of the limited number of characters scored or the small sample size of the putative hybrid population due to the relative rarity of the putative hybrid. Assuming that backcrossing occurred among the sympatric populations of the fertile putative hybrid, *S. linearifolius*, and *S. minimus*, the samples might, by chance, have contained only specimens genetically and phenetically closer to *S. linearifolius*. Furthermore, it is possible that specimens phenetically closer to *S. linearifolius* were collected because these hybrids are more conspicuous. More detailed analyses of the putative hybrid should not only analyse a greater number of characters, but should also include a larger sample size, or else monitor all specimens within a certain range of putative hybrid specimens.

The morphometric evidence clearly indicates that the shortly ligulate plants collected at Mt Macedon are the result of hybridisation between the radiate *S. linearifolius* and the erechthitoid *S. minimus*. Further morphometric studies, however, and congruence with other data sets, e.g. chromosome numbers and karyotypes, chemical characters, allozymes or presence of parental markers in the DNA of the putative hybrid, are needed to test the findings of this study, and to provide a more detailed morphological evaluation of the putative hybrid.

Acknowledgements

I am deeply indebted to Dr Ian Thompson, who drew my attention to the presence of putative hybrids on Mt Macedon. Despite working on the formidable task of writing the *Senecio* treatise for *The Flora of Australia*, he always found time for cooperation in the field, as well as most helpful discussions and critical comments on all aspects of this paper. I wish to thank Professor Pauline Ladiges for making me feel welcome at the School of Botany of the University of Melbourne, and for her advice. My work was supported by an exchange scholarship (University of Melbourne and Freie Universität Berlin) which I gratefully acknowledge.

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Appendix 1
Character scores. H: putative Hybrid. L: *Senecio linearifolius*. M: *S. minimus*. P: *S. pinnatifolius*. B: *S. biserratus*. For explanation of abbreviations of characters see methods section.

	LML (cm)	LLL (cm)	WML (cm)	FCP (#/5cm)	LIB (mm)	NIB	LCB (mm)	NCB	LTF (mm)	LPA (mm)
H 1	19.3	20.5	1.9	14.2	4.7	10.4	1.8	4.0	5.2	5.1
H 2	13.4	13.8	1.8	12.6	4.0	10.4	1.6	4.0	4.4	4.4
H 3	12.2	13.4	1.5	14.8	4.7	8.2	1.5	3.8	4.6	4.9
H 4	14.9	16.2	1.9	13.2	4.5	9.6	1.6	3.0	4.8	4.5
H 5	14.5	15.6	1.9	14.2	4.5	8.2	1.6	3.2	4.7	5.0
M 1	15.9	17.2	2.2	32.0	5.2	8.0	1.4	4.4	4.7	5.7
M 2	15.4	16.7	3.4	32.2	5.6	8.4	1.5	3.2	5.1	5.9
M 3	21.2	22.5	3.6	25.0	5.2	8.0	1.5	4.6	5.1	5.6
M 4	15.9	17.5	3.2	29.0	5.7	7.8	1.4	3.6	5.1	5.7
M 5	18.3	20.0	3.3	25.2	5.5	8.6	1.6	4.2	5.0	5.6
L 1	14.8	15.0	1.7	8.2	3.8	9.2	2.0	3.4	4.8	4.3
L 2	15.7	16.8	1.8	7.0	3.5	10.6	1.5	3.2	4.7	4.4
L 3	14.9	15.6	1.3	8.2	3.5	9.2	1.8	3.0	4.9	4.3
L 4	15.3	16.1	1.5	8.2	3.7	9.8	1.7	3.2	4.8	4.5
L 5	15.4	16.7	1.4	7.8	3.7	9.4	2.0	2.4	4.9	4.6
P 1	9.5	9.7	2.3	14.2	6.0	13.0	3.2	9.0	5.8	5.3
P 2	11.2	11.4	1.9	16.4	5.9	13.0	2.6	9.0	5.8	5.0
P 3	7.9	9.2	3.1	13.0	5.9	13.0	2.6	9.0	6.1	4.9
P 4	7.7	8.3	0.6	14.0	6.3	13.0	3.0	7.0	6.0	4.9
P 5	9.3	9.9	1.5	18.8	6.2	13.0	3.0	9.0	6.1	5.4
B 1	9.8	10.4	3.0	35.2	6.9	7.8	1.5	4.6	6.5	6.1
B 2	12.1	12.8	4.0	33.2	7.2	8.0	1.4	3.8	6.5	6.2
B 3	11.4	11.6	3.7	34.4	7.2	8.4	1.4	4.6	6.5	6.2
B 4	10.7	11.7	4.0	34.4	6.7	8.0	1.3	3.4	6.2	6.0
B 5	11.5	12.9	3.5	27.4	6.8	8.2	1.4	3.8	6.2	6.0

A Note on the welfare of small mammals captured during pitfall trapping

During a reptile and amphibian survey of the Wonthaggi Heathland and Coastal Reserve in 2001 and 2002 (*The Victorian Naturalist*, 2003, **120**, 147-152), in which pitfall trapping was the principal survey method, thirty-one White-footed Dunnarts *Sminthopsis leucopus*, three Swamp Antechinus *Antechinus minimus*, two juvenile Bush Rats *Rattus fuscipes* and twenty-four House Mice *Mus musculus* also were captured.

To provide shelter for all captured vertebrates, each pitfall bucket had a thick layer of vegetation in the bottom to a depth of approximately 12 cm. As additional protection for any captured mammals, a 245 ml polystyrene take-away coffee cup was placed on its side, under the vegetation. If inclement weather was forecast during the trapping session, the cup was placed on its side in a secure position on top of the vegetation.

Captured White-footed Dunnarts used the polystyrene cups on nearly every occasion, with only two specimens found outside the cup when pitfall lines were checked at dawn. The other twenty-nine Dunnarts were found curled up inside each cup. On one occasion a White-footed Dunnart and a House Mouse were found sharing the same cup, with the Dunnart in the warmest position behind the House Mouse.

Two Swamp Antechinus were caught during daylight hours and were found outside the cup when buckets were checked at noon. However, the one Antechinus captured overnight was found curled up inside the cup. The two Bush Rats were found outside the cups during dawn checking. Captured House Mice tended to use the cups; however, many chewed out the bottom of the cup.

Despite heavy rain during one trapping session and cold nights during others, no trap-deaths occurred during the survey. This may be attributable to the high insulation properties of the polystyrene cups. The use of shelter in pitfall buckets, however, does not preclude the need to use external bucket covers at appropriate times. This information may be useful to other workers carrying out pitfall trapping in areas where small mammals are likely to be caught.

Peter Homan
409 Cardigan Street
Carlton 3053

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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Postal Address: FNCV, Locked Bag 3, PO Blackburn, Victoria 3130, Australia.
Phone/Fax (03) 9877 9860; International Phone/Fax 61 3 9877 9860.

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Australian Fungi Illustrated

by I R McCann

Publisher: *Macdown Publications, Vermont, Victoria, 2003. 128 pages. ISBN 0 975078003. RRP $29.95.*

It is always exciting when a book of larger Australian fungi is published, especially if it is illustrated. Ian McCann's book has over 400 coloured photographs of fungi, some of which have never been illustrated, while others are found only in obscure publications.

The book covers all the major groups of fungi with their weird and wonderful forms and colours, from Mushrooms and Boletes to Puffballs (within the Basidiomycetes) and some Ascomycetes and Slime Moulds. The groups and pages are listed at the start under 'Groupings of Illustrations'.

Each page contains three or four illustrations, and each species is accompanied by a caption which includes (where possible) the common name, a binomial and the family name. In cases where McCann has lodged a collection of the species with the National Herbarium in Melbourne, the letters MEL appear after the family name. Also mentioned is the substrate (if other than the ground), habitat such as 'in forest' or 'in woodland' and the month in which each specimen was photographed. Photographs show the upper and lower surface of specimens, which is useful for recognition in the field. The fact that many of the species are named only to genus level emphasises the lack of taxonomic research on Australian fungi.

McCann has provided common names for many of the fungi. This is a controversial subject, but common names are now being applied in many areas, Alan Andersen recently gave common names to Australian ants, and in Britain the British Mycological Society has created a list of common names for fungi. Ideally common names should indicate some field characteristics, for example the Gilled Bolete (page 65), the common name for *Phylloporus* sp., seems particularly apt as DNA research shows this genus is more closely aligned with the pored boletes than with gilled fungi.

I found it useful to see several photographs of the same genus, for example, the Banksiamyces (pages 111–112). Comparison of several species is made so much simpler and visually indicates differences between them. Similarly with the series of Boletes (pages 60–65) and the Mushrooms (pages 6–7). It was amazing to see the enormous range of colours in the *Cortinarius* (pages 14–21) and *Entoloma* (pages 28–30) species and the oddities of Slime Moulds (pages 122–123). Extensive illustrations of several species within a genus not only visually give a better indication of the characteristics of these fungi, but also emphasise the care needed to distinguish them in the field, for example, the Boletes on page 60. Could any of these be mistaken for the Fungimap target species *Boletellus obscurecoccineus*?

As in all books with such a large number of illustrations, there are a few spelling and typographical mistakes and page number errors. Perhaps the Genus Index could have been expanded to include the actual species, and all the common names could have been listed in the Common Names Index.

It is satisfying to see a species in the field and be able to put a name to it, or at least to identify the genus. McCann's book, illustrating as it does over 400 of the Australian larger fungi, is a great help to the non-expert.

This is an excellent book both for beginners and the more experienced, and the extensive range of fungi covered in *Australian Fungi Illustrated* is to be applauded.

Pat Grey
8 Woona Crt
Yallambie, Victoria 3085

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Cover: Wombats in the snow. See story on page 69. Photo: Ken Green.

Web address: http://www.vicnet.net.au/~fncv/vicnat.htm
Email fncv@vicnet.net.au

Blue-gums *Eucalyptus globulus* in north-west Tasmania: an important food resource for the endangered Swift Parrot *Lathamus discolor*

Stephen Mallick[1], David James[1], Raymond Brereton[2] and Simon Plowright[3]

Abstract

Over the past 100 years, the natural range of Tasmanian Blue-gum (east and south-east Tasmania) has been extended through artificial plantings to include the state's north-west. We assessed the importance of north-west Blue-gum to the endangered Swift Parrot *Lathamus discolor*. Blue-gum flowering in the south-east is variable from year to year. In heavy-flowering years in the south-east, approximately 10% of the Swift Parrot population (total *ca.* 2000 birds) is located in the north-west. In poor-flowering years in the south-east, up to 50% of the Swift Parrot population may occur in the north-west. North-west Blue-gums include both small-scale plantings (ornamentals, shelter belts) and commercial plantations. We estimate there are between 6000 - 14 000 large (> 40 cm DBHOB) non-plantation Blue-gums in north-west Tasmania. The number of potentially-flowering edge-trees in commercial Blue-gum plantations is estimated to be in the order of 1000 trees. Non-plantation Blue-gums in the north-west represent < 3% of the estimated number of Blue-gums in the south-east. However, these north-west trees appear to flower more consistently than trees in the south-east, and may provide an important food resource for the Swift Parrot population during years of poor Blue-gum flowering in the south-east. (*The Victorian Naturalist* **121** (2), 2004, 36-46)

Introduction

The Swift Parrot *Lathamus discolor* (White) is an endangered species which breeds in Tasmania and over-winters on the south-eastern Australian mainland. Data from breeding-season surveys indicate that numbers are at best stable at an estimated 1000 breeding pairs, although numbers may be continuing to decline because of continued habitat loss (Swift Parrot Recovery Team 2001).

The Swift Parrot is a largely nectarivorous species which feeds on flowering eucalypts or on sugar-rich resources such as lerp and honeydew (Kennedy and Overs 2001). During the breeding season in Tasmania (September – January), Swift Parrots feed primarily on flowering Blue-gum (*Eucalyptus globulus*), with over 80% of feeding records during the breeding season occurring on Blue-gum flowers (Brown 1989). Blue-gum flowering tends to be highly variable from year to year, with a tendency for poor-flowering seasons to be followed by heavy-flowering seasons, and vice versa.

The majority of breeding Swift Parrots utilises Blue-gum trees in open grassy *E. globulus* forest in Tasmania's south-east. The natural range of grassy *E. globulus* forest is restricted to a near-coastal band along the east and south-east coasts of Tasmania (Brereton 1997) (Fig. 1). Since European settlement, it is estimated that land clearing and forestry operations have reduced the original 28 000 ha of grassy *E. globulus* forests by more than 50% (Swift Parrot Recovery Team 2001).

In contrast to the clearing of natural stands of Blue-gum forest in Tasmania's south-east, the last 100 years has seen high numbers of Blue-gums planted in north-west Tasmania (Fig. 1). These north-west Blue-gums represent an extension to the natural range of *E. globulus* in Tasmania. Resident populations of Swift Parrots occur in several parts of the north-west each year (Brown 1989), and breeding has been reported for these north-west birds in some seasons (Brereton 1996). However, the significance of the new, anthropogenic Blue-gum resource in Tasmania's north-west to the total Swift Parrot population is not known.

The present study aimed to assess the potential importance of the north-west Blue-gum resource to Swift Parrots. We employed honey-production figures from a major Blue-gum honey producer in the state's south-east (H. L. and H. M.

[1]Department of Primary Industries, Water and Environment
134 Macquarie Street, Hobart, Tasmania 7001
[2]Hydro Tasmania, GPO Box 355, Hobart, Tasmania 7001
[3]Wildspot Trust, PO Box 73, Smithton, Tasmania 7330

Fig. 1. Map showing the areas and localities referred to in the paper

Hoskinson, Woodbridge) to provide an index of Blue-gum flowering in the 1985/86 to 2001/02 seasons. We utilised available databases to document the number of birds and foraging patterns of Swift Parrots in north-west Tasmania in the three seasons for which substantial data were available: 1987/88 (moderate Blue-gum flowering season), 1994/95 (poor Blue-gum flowering season), and 1995/96 (heavy Blue-gum flowering season). We also systematically surveyed for Swift Parrots in the north-west in one breeding season (1997/98; poor Blue-gum flowering) to obtain an estimate of the number of adult birds present and the number of juveniles produced. Lastly we attempted to estimate the extent (total number of trees) and patch-type (ornamental, farm, plantation) of Blue-gums over the entire north-west. The size structure (and likelihood of flowering) of north-west Blue-gums in each patch type was also considered.

For the purposes of the study, we designated the 'north-west' area as a zone of varying width which included the principal areas where Blue-gums and Swift Parrots are known to occur. The north-west zone commenced at Westbury and took in the townships of Deloraine and Sheffield. West of Sheffield the band narrowed to ca. 10 km from the coast running from Latrobe to Smithton (Fig. 1). The city of Launceston was excluded from the area, although low numbers of birds (< 20) have been recorded in the city in some years.

Methods

Swift Parrot records from north-west Tasmania

Since 1986, the Nature Conservation Branch, Tasmanian Department of Primary Industries, Water and Environment, has been collecting records of the Swift Parrot from around Tasmania. Record sheets include information on location, the number of birds observed, whether birds were foraging, and the forage species. We used this database to investigate the number of birds and foraging patterns of Swift Parrots in Tasmania's north-west. We considered in detail only the three seasons for which there were sufficient records to justify detailed analysis, namely 1987/88 (moderate Blue-gum flowering season), 1994/95 (poor Blue-gum flowering season), and 1995/96 (heavy Blue-gum flowering season).

Swift Parrot survey in the north-west: 1997/98 season

The area between Port Sorell in the central-north and Smithton in the far north-west was surveyed by SJP with the help of volunteers resident in the area during the 1997/98 season. The survey method was not systematic, but was intended to give a gross estimate of total number of Swift Parrots in the north-west area. All volunteers were experienced bird-watchers who were able to identify the Swift Parrot. Initial observations were obtained by assessing patches of *E. globulus* for the presence of flowering trees and foraging Swift Parrots. Heavily flowering sites where Swift Parrots were observed were visited at irregular intervals over the season to record any changes in the numbers of birds using the patch and for the presence of juveniles.

Extent of Blue-gums in north-west Tasmania

We attempted to obtain a gross estimate of the total number of *E. globulus* trees present in north-west Tasmania. We confined our estimate to larger trees with Diameter at Breast Height Over Bark (DBHOB) > 40 cm as it is these larger trees that contribute the majority of flowering (R. Brereton unpubl. data). Because Blue-gum trees in the north-west typically occur in widely scattered small patches or isolated aggregates of trees, we employed a variety of methods to obtain our estimate. We considered the north-west area to be composed of townships and farmland. Townships were defined as any populated site with a population of > 1000 and included small townships (population 1000 – 8000) and large townships (population > 8000). Populated sites with a population of < 1000 were included in the farmland category.

1.We attempted to estimate the total number of trees in and around the smaller north-west townships (population 1000 - 8000) where concentrations of Blue-gums are known to occur and where Swift Parrots are regularly sighted. Small townships within the north-west zone included Westbury, Deloraine, Latrobe, Ulverstone, Penguin, Wynyard and Smithton. All these townships except Smithton were surveyed over three days (10-11 October and 4 November, 2002) by driving throughout the towns and recording all patches of Blue-gum trees, the number of trees per patch, and the number of flowering trees. The number of Blue-gums for Smithton was estimated based on the mean number of trees recorded in the other small towns, and the fact that the distribution of Blue-gums around Smithton is generally similar to that of the other towns surveyed (D. James, pers. obs.).

2. The two larger towns within the designated area (Devonport and Burnie, population > 8000) were too large to survey all Blue-gums within the town precinct. We therefore counted only the number of Blue-gums in the larger patches within the town area. To estimate the contribution of smaller patches and single trees to the total count for each town, we surveyed approximately 10% of the town area and counted all Blue-gums (excluding those already surveyed in larger patches). We then extrapolated this subset to the entire town area.

3. A method of direct count was not feasible for open agricultural land where Blue-gums typically occur as widely spaced small patches over a very large area. Therefore, for the remaining (non-urban) parts of the north-west, we counted the number of Blue-gums 200 m either side of the road along 10 km roadside transects (transect area = 400 ha). We surveyed eight such transects along major (A category) roads and 12 transects along minor (B or C category) roads within the designated area. We ensured that a number of these 'rural' transects passed through small villages (towns with a population < 1000) to account for possible concentrations of Blue-gums in these small townships which were not dealt with by direct counts. We used two methods to extrapolate these transect data to the entire north-west area. For a lower estimate based on roadside habitat, we used 1:100 000 maps to obtain an approximate total distance of A and B/C roads within the north-west area and extrapolated the figure for mean

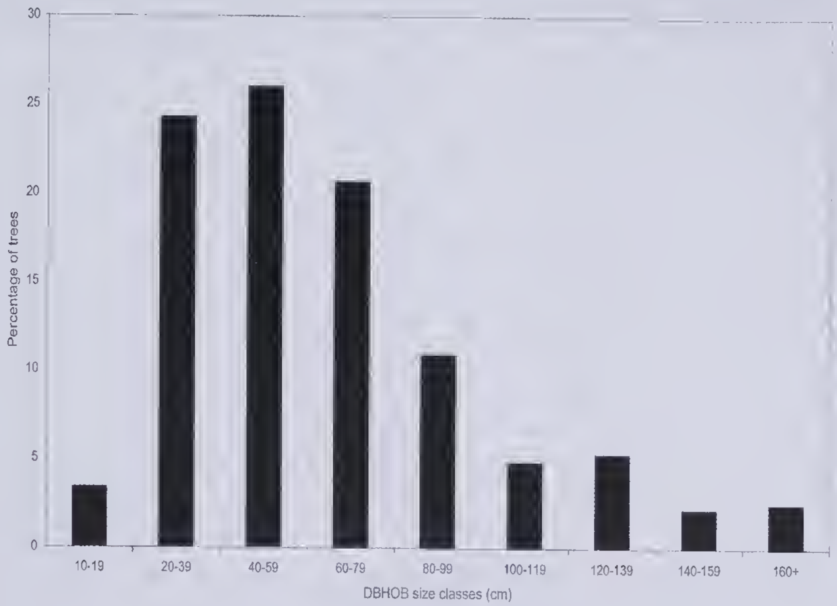

Fig. 2. Distribution of *Eucalyptus globulus* in tree-size-classes in north-west Tasmania

number of Blue-gums per km of transect to the entire north-west. This figure ignores the area of farmland more than 200 m from a roadside and is likely to be a significant underestimate. For an upper estimate, we used 1:100 000 maps to obtain a gross estimate of the total area of farmland (excluding large contiguous patches of forest and plantation) for the north-west area and extrapolated the figure for mean number of Blue-gums/400 ha transect to the entire north-west area. This figure assumes that Blue-gums are evenly distributed over the landscape. However, because Blue-gums tend to occur in populated rural areas and to be more common along roadsides (D. James, pers. obs.), this estimate is likely to be a significant overestimate.

4. In addition to township and farmland, Blue-gums also occur as timber-production trees in commercial plantations. We obtained figures for the approximate harvest DBHOB and area of Blue-gum plantation in state forest (Forestry Tasmania) and in private forests (Private Forests Tasmania) in north-west Tasmania.

Size structure of Blue-gums in different patch types in north-west Tasmania

A total of 50 patches of *E. globulus* which were known foraging sites for Swift Parrots were selected across Tasmania's north-west coast. Sites were allocated to one of two patch types: Ornamental (38 sites), including trees (single or group) planted within the boundary of a private residential address (garden), planted in parks and other areas intended for public recreational use (park), and planted in an urban environment, including nature-strip trees in fringe suburbia and trees within non-residential properties (urban); and Farm (12 sites, 182 trees total), including groups, singles and rows (shelter belts) of trees situated on rural property or on roadsides within a rural landscape.

The DBHOB was measured for a maximum number of 25 trees per site. DBHOB is the diameter of the tree's trunk at a standard height of 129.54 cm. DBHOB data were obtained using a metric tape measure. Fewer trees were measured at some sites where there were less than 25 trees present. Many trees were found to consist of multiple stems starting below breast

Table 1. Blue-gum honey production, number of hives employed, and honey production per hive for the 1985/86 to 2001/02 seasons. Figures are from H. L. and H. M. Hoskinson, Apiarists, Woodbridge.

Season	Blue-gum honey (kg)	No. hives	Honey/hive (kg)
1985/86	3180	300	10.6
1986/87	6195	250	24.8
1987/88	12194	250	48.8
1988/89	0	0	0
1989/90	16366	350	46.8
1990/91	6610	360	18.4
1991/92	5902	400	14.8
1992/93	2184	400	5.5
1993/94	12820	450	28.5
1994/95	0	0	0
1995/96	17512	550	31.8
1996/97	35336	530	66.7
1997/98	0	0	0
1998/99	0	0	0
1999/2000	43593	500	87.2
2000/01	0	0	0
2001/02	6825	350	19.5
2002/03	0	0	0

height. With such trees all stems were measured then recorded as individual trees. Trees were placed into the following size classes: 10-19 cm, 20-39 cm, 40-59 cm, 60-79 cm, 80-99 cm, 100-119 cm, 120-139 cm, 140-159 cm, and 160 + cm DBHOB.

All data are expressed as mean ± standard deviation.

Results

Extent of south-east Blue-gum flowering in the 1985/86 – 2001/2002 seasons: honey-production index

Based on Blue-gum honey production figures from the principal commercial apiarist in south-east Tasmania over the last 18 seasons, there are clearly wide fluctuations between years in the extent of Blue-gum flowering in south-eastern Tasmania (Table 1). Over this period there have been four seasons of very high production (> 40 kg/hive: 1987/88, 1989/1990, 1996/97 and 1999/2000) and seven seasons of low (< 10 kg/hive) or 'zero' production when no hives were put out (1988/89, 1992/93, 1994/95, 1997/98, 1998/99, 2000/01 and 2002/03). Two of these 'zero' seasons occurred in consecutive years (1997/98 and 1998/99; Table 1). Overall, there does not appear to have been a consistent trend for biennial flowering, although the last five years (1998-2002) have seen the emergence of what appears to be a biennial pattern of 'zero' followed by moderate to high honey-yield years and vice versa (Table 1).

Swift Parrot records from north-west Tasmania: Parks and Wildlife database

There were sufficient records for only three seasons (1987/88, 1994/95 and 1995/96) to allow detailed analysis of Swift Parrot foraging records in north-west Tasmania (Table 2). Two of these seasons (1987/88 and 1995/96) corresponded to survey years when the entire Swift Parrot population was surveyed throughout Tasmania (R. Brereton, unpubl. data).

We divided the foraging data into breeding (September to December) and non-breeding periods (all other months). In all three years, Swift Parrots were recorded foraging in the north-west during the breeding season (Table 2). For all three breeding seasons, the majority of foraging was recorded in Blue-gum, with the other foraging records distributed over other flowering native and introduced gums (Table 2). There were no records of Swift Parrots foraging in black gum *E. ovata* in the north-west during the breeding season (Table 2).

Swift Parrots were also recorded outside the breeding season in the north-west in all three years (Table 2). Only 13 birds, all foraging in *E. amygdalina*, were recorded

Table 2. Summary of records of Swift Parrots in north-west Tasmania during the breeding and non-breeding seasons of 1987/88, 1994/95 and 1995/96. Number of foraging records for each forage species given in brackets as a percentage of total foraging records. *E. glob* = *E. globulus*; *E. ob* = *E. obliqua*; *E. amy* = *E. amygdalina*; *E. vim* = *E. viminalis*; *E. ov*= *E. ovata*; *E. nit* = *E. nitida*; Other = *E. leucoxylon* and *Quercus robur*.

Season	Total birds	Non-foraging records	Foraging records	*E. glob*	*E. ob*	*E. amy*	*E. vim*	*E. ov*	*E. nit*	Other
Breeding (September – December)										
1987/88	115	12	103	80 (77.7)	10 (9.7)	13 (12.6)	-	-	-	-
1994/95	119	48	71	59 (83.0)	-	-	6 (8.5)	-	-	6 (8.5)
1995/96	154	137	17	9 (52.9)	3 (17.7)	-	5 (29.4)	-	-	-
Non-Breeding (pre-breeding: August + post-breeding: January onwards)										
1987/88	13	-	13 (100.0)	-	-	13 (100.0)	-	-	-	-
1994/95	102	102 (including 80 juv.)		-	-	-	-	-	-	-
1995/96	472	209	263	2 (0.8)	29 (11.0)	-	2 (7.6)	6 (2.3)	220 (83.7)	4 (15.2)

1995/96 (breeding season) 'non-foraging' records includes 15 adult birds feeding on artificial sugar at Forest Glen Tea Gardens, near Devonport
1995/96 (non-breeding season) 'non-foraging' records includes 100 adults and 25 juveniles feeding on artificial sugar at Forest Glen Tea Gardens, near Devonport.

in the north-west outside the breeding season in 1987/88. In 1994/95, 102 birds including 80 juveniles were recorded flying over after the completion of the breeding season (Table 2). The data for the 1995/96 season were more comprehensive, with 472 Swift Parrots observed outside the breeding season in the north-west including records of 263 foraging birds. The majority of these foraging birds was included in two large post-breeding flocks feeding on *E. nitida* (Table 2). There was a number of records of foraging in other native species of eucalypt, including two birds (0.8%) foraging on Blue-gum in late January (Table 2).

Swift Parrot records from north-west Tasmania: 1997/98 survey

During the 1997/98 season the north-west region was surveyed extensively for the presence of Swift Parrots. Although this was a poor flowering season for Blue-gum in the south-east (Table 1), the majority of north-west Blue-gums encountered during the survey was flowering profusely. The survey located approximately 1000 adult birds during the breeding season, and detected approximately 150 juvenile birds (Table 3). It appeared that groups of birds were using an area of heavily flowering Blue-gums for an extended period (up to four months), with numbers remaining relatively constant over time. The largest single record of Swift Parrots was approximately 500 birds in the vicinity of a large plantation of mature Blue-gums in the upper Burnie area (Table 3). This group of adults appeared to have produced 30-50 young.

Number of Blue-gums in north-west Tasmania

The mean number of large (> 40 cm DBHOB) Blue-gums per 10 km roadside transect was 30.7±11.4 (n=20). The mean number of Blue-gums per patch or grouping of trees for the 10 km

Table 3. Number of adult and juvenile Swift Parrots observed in north-west Tasmania between August - December 1997.

Location	No. of adult birds	No. of young
Smithton area	12	-
White Hills	26	-
Irishtown	5	-
Montagu	50	-
Stanley	10	-
Wynyard	30	-
Burnie area	500	30 - 50
Sulphur Creek	9	-
Penguin	200	10 - 20
Ulverstone	15	-
Devonport area	150	80 - 100
Total	1007	120 - 170

transects was 9.9±3.3 trees per patch. Using 1:100 000 maps, we estimated the length of major (A route) and minor (B and C route) roads in the north-west region to be 250 km and 1300 km, respectively. The majority of roads was in the Forth region. The total area of agricultural land (excluding large areas of contiguous forest) in this north-west region was estimated at 168 000 ha. Most of the agricultural land was located in the Tamar and Forth regions.

Based on the mean number of Blue-gums per 10 km transect and the estimates of road length and land area for the north-west region, the lower estimate (using road length as the multiplier) for the number of Blue-gums in agricultural land in the north-west is estimated at 4759 trees. The upper estimate (using area of land as the multiplier) for the number of Blue-gums in agricultural land in the north-west is estimated at 12 894 trees.

The number of large (DBHOB > 40 cm) Blue-gums in small towns (population 1000 – 8000) in the north-west region ranged from four (Latrobe) to 93 (Penguin) (Table 4). The estimate for the larger towns was considerably higher, with 166 Blue-gums for Devonport and 691 Blue-gums for Burnie (Table 4). The mean patch size for townships was 6.4±1.0 trees per patch. The total number of Blue-gum trees for north-west townships was 1180 trees (Table 4).

Our estimate for the total number of large Blue-gum trees in the north-west was therefore within the range of 5938 to 14 073 trees. The majority of these trees (80-90%) occurred in agricultural land, with the remainder aggregated around townships in the region, principally around the township of Burnie in the mid-north-west. The average patch size in both agricultural land and around townships was small (< 10 trees), with many patches made up of single trees.

Size structure of north-west Blue-gums

The number of Blue-gums measured at each site varied considerably, ranging from four sites with only one or two trees to five sites where the maximum of 25 was measured. In total, 589 Blue-gums were measured. The mean DBHOB of Blue-gums were similar for ornamental (67.2±1.7, n = 407) and farm patches (63.4±3.5, n = 185) (unpaired Student's t-test: t = 1.13, df = 590, P>0.2). The distribution of size classes for all the trees was heavily skewed to the lower size classes, with a mode in the 40-59 cm DBHOB size class (Fig. 2).

Blue-gum plantation

Blue-gum is frequently used as a plantation tree in north-west Tasmania, typically at elevations of < 300 m asl. Blue-gum plantations in the north-west include both state (Forestry Tasmania) and private forests.

For state forests, of the three principal Forestry Tasmania growing regimes (sawlog, veneer and pulp), the DBHOB for pulpwood when harvested at 15 years is *ca.* 21 cm, with a total of 2340 ha of pulpwood plantation in the north-west. The DBHOB of veneer timber when harvested at 20 years is *ca.* 33 cm, with a total of 330 ha of veneer forest in the north-west (Forestry Tasmania, unpubl. data). Because of their relatively small diameter and dense planting conditions, these pulp and veneer trees are considered unlikely to contribute substantially to flowering. The total area of state forest Blue-gum plantation dedicated to sawlogs for the north-west is 500 ha at a density of *ca.* 300 stems/ha, with the majority of plantation within 10 km of the coast (Forestry Tasmania, unpubl. data). The DBHOB for sawlog trees when harvested at 25 years is *ca.* 40 cm. Given their larger size at harvesting, these sawlog trees may contribute significantly to flowering, although consis-

Table 4. Number of large (DBHOB > 40 cm) Blue-gum trees and the number of trees in flower in townships in Tasmania's north-west. Nov/Dec. 2002.

Township	No. of trees	No. of trees flowering
Deloraine	20	0
Latrobe	4	1
Penguin	93	11
Smithton[1]	46	-
Ulverstone	81	24
Westbury	37	0
Wynyard	42	2
Burnie		
Large patches	271	-
10% town	42	-
Total	691	-
Devonport		
Large patches	86	-
10% town	8	-
Total	166	-
Totals	1180	38

[1] Number of trees predicted based on mean number of trees for other small townships.

tent flowering is likely to be confined primarily to edge trees which receive significantly more light than non-edge trees (S. Plowright, pers. obs.).

For private forests, there are approximately 900 ha of private Blue-gum plantation in north-west Tasmania, the majority of which occur within 10 km of the coast. Of these, *ca.* 800 ha are harvested for pulp at age 15 years with a density of 900 stems/ha and a DBHOB of < 35 cm (A. Warner, Private Forests Tasmania, unpubl. data). These pulp plantations are considered unlikely to contribute substantially to flowering. The remaining *ca.* 100 ha of private Blue-gum forest is dedicated to sawlog or veneer timber. These forests are harvested at age 25 years with a density of 250 stems/ha and a DBHOB of > 50 cm (A. Warner Private Forests Tasmania, unpubl. data). These sawlog trees may contribute to Blue-gum flowering, although consistent flowering is likely to be confined to edge trees for the same reasons as in State forests.

This gives a total of 600 ha of plantation Blue-gum forest in north-west Tasmania dedicated to sawlogs, of which only the edge trees are likely to flower consistently. However, only a portion of this total forest will be mature enough to include flowering trees in any one year, with the remainder of the plantations at a younger age. Assuming only 50% of sawlog plantations are old enough to include flowering trees, this leaves 300 ha of 'mature' sawlog plantation. Assuming for convenience that this 300 ha occupies a single circle with radius 978 m, this would represent a circumference of *ca.* 6000 m. At a density of 250 trees/ha, the inter-tree distance along this circumference would be *ca.* 6 m, giving a total of *ca.* 1000 potentially-flowering edge-trees.

Discussion

Extent of Blue-gum in the north-west

Tasmanian Blue-gum is endemic to the south-east of Tasmania, with the natural range of the species extending from St Helens southwards to Southport (Brereton 1997). The planting of Blue-gums in the north-west of Tasmania over the past 100 years therefore represents an artificial extension of the natural range of the species. Blue-gums have been introduced into the north-west for a variety of reasons. The species has been widely planted as an ornamental in parks, gardens and other urban and suburban situations, as well as for shelterbelt and land-stabilisation purposes in both urban and rural areas. More recently, Blue-gums have been used as a wood-production species in hardwood plantation forests in north-west Tasmania.

Our estimates place the number of large non-plantation Blue-gum trees in the north-west in the range 6000 - 14 000 trees. The number of Blue-gum trees in state and private plantations in the north-west is substantial (up to 600 ha of plantation forest at a density of 250-300 trees/ha dedicated to sawlogs), although the number of potentially flowering edge-trees within this plantation forest is estimated to be in the order of only 1000 trees. Further work is required to assess the flowering capacity of plantation Blue-gums, and whether the Swift Parrot will utilise the resource if and when the trees flower.

In order to place the north-west Bluegum in context, we attempted to estimate the number of (naturally occurring) large Blue-gum trees in south-east Tasmania. The majority of Blue-gum in the south-east occurs in grassy *E. globulus* forest, of which 8700 ha is extant within the breeding range of the Swift Parrot. We used unpublished data (R. Brereton, unpubl. data) on the number of > 40 cm DBHOB Blue-gum trees in 0.1 ha quadrats within grassy *E. globulus* forest to obtain an estimate of the density of Blue-gum in this forest type (density = 4.84±0.45 trees/0.1 ha). This gives an estimate of around 420 000 trees in grassy *E. globulus* forest in the south-east. However, the number of Blue-gums in south-east Tasmania would be higher than this figure and include planted trees (similar to those in the north-west) scattered throughout agricultural and urban areas of the south-east. Assuming a conservative estimate of 420 000 large Blue-gums in the south east, the estimated 6000 – 14 000 non-plantation Blue-gums in the north-west represent < 3% of the south-east Blue-gum resource in Tasmania.

Characteristics of Blue-gum in the north-west

Blue-gums in the north-west appear to be generally larger in size than comparable trees in the south-east. The mean DBHOB of Blue-gums in the north-west (ornamental and farm trees combined; 66.0±1.6 cm, n = 592) was slightly larger than the mean DBHOB of Blue-gums in the south-east (61.9±1.8 cm) (R. Brereton, unpubl. data). This difference was close to significant (unpaired Student's t-test: t = 1.96, df = 974, 0.05< P<0.1). The size-class distribution of Blue-gums in the north-west resembled the distribution of south-west trees in being skewed to the smaller size classes. However, the mode for trees in the north-west was in the larger 40-59 cm DBHOB size class (Fig. 2) compared to a mode in the 20-39 cm DBHOB size class for south-west Blue-gums (R. Brereton, unpubl. data).

There is some evidence that the year-to-year variation in flowering in north-west Blue-gum is less extreme than in the south-east. Brereton (1996) notes that in the 1994/95 season there was very little flowering in the south-east and the Blue-gum flowering that did occur in Tasmania was located along the north-west coast. Similarly, during the 1997/98 season when most Blue-gums failed to flower in the south-east, the majority of Blue-gums surveyed between August and December, during a survey of Swift Parrots, was flowering profusely (S. Plowright, pers. obs.). While obtaining our estimate of the number of Blue-gums in the north-west in the 2002 season, we also noted the number of trees in the townships that were flowering (Table 4). In this season, there was almost no flowering in the south-east, while 16.2% of Blue-gums located in townships in the north-west were in flower (Table 4).

The coastal region of north-west Tasmania is characterised by high rainfall (mean annual rainfall for Burnie = 978 mm) and deep fertile soils of basaltic origin, while much of the south-east is relatively dry (mean annual rainfall for Hobart Airport = 507 mm) and supports relatively less fertile soils of doleritic and sedimentary origin. The prime growing conditions characteristic of the north-west apparently leads both to larger Blue-gum trees and less extreme fluctuations in flowering than occurs in the south-east. Even in 'failed' years in the south-east there may be a significant proportion of the north-west Blue-gums that flower strongly. Further, systematic monitoring of Blue-gum flowering state-wide is required to determine the relationships between flowering patterns in the east and north of the state.

Swift Parrots and north-west E. globulus

Anecdotal records of Swift Parrots indicate that in most years low numbers of Swift Parrots occur along Tasmania's north-west coast, west of the Tamar River, with most records coming from developed areas around townships (Brown 1989). Brereton (1996) suggested that approximately 10% of the total breeding population remain in the north of Tasmania, with small numbers of birds breeding in the north-west in some years.

This figure of 10% of the total population appears to refer specifically to years of heavy Blue-gum flowering in the south-east. For example, in the 1987/88 breeding season, a particularly heavy-flowering year in the south-east, 88% of the total Swift Parrot population was recorded along Tasmania's east and south-east coast, with the remaining 12% located in the north-west (Brown 1989). During the most recent census in the 1995/96 season (also a heavy-flowering year), 90% of the population was recorded in the east and south-east and 10% in the north-west (Brereton 1996).

In contrast, during poor flowering years in the south-east, the distribution of Swift Parrots in Tasmania appears to shift away from the south-east to the north-west of the state. For example, when the Blue-gum failed to flower in the south-east in the 1988/89 and 1994/95 seasons, Brereton (1996) noted that concentrations of Swift Parrots occurred in northern Tasmania. Similarly, a survey of Swift Parrots in the north-west during the 1997/98 season recorded up to half the total Swift Parrot population (*ca.* 1000 birds) in the north-west region associated with heavily-flowering Blue-gum (Table 3).

Although the total number of Blue-gum trees in the north-west is relatively small compared to Blue-gums in the south-east, the north-west trees tend to be relatively large in size, they occur in small patches , flower heavily, and are clearly used by Swift Parrots in most years. There is also some evidence that these north-west trees flower more consistently than trees in the south-east. We suggest that the prime growing conditions characteristic of much of the north-west (deep fertile soils and high rainfall) may lead to a large portion of the total north-west Blue-gum flowering in any one year. This contrasts with the situation in the south-east where during a very poor year < 1% of the total Blue-gum can be in flower. In this sense, the introduced north-west Blue-gum may provide a more predictable and reliable flowering resource than the naturally-occurring Blue-gum of the south-east.

The role played by the north-west Blue-gum may be two-fold depending on the level of flowering in the south-east. In heavy flowering years in the south-east, the north-west Blue-gum appears to provide a foraging resource for an overflow of around 10% of the total breeding population of Swift Parrots. Given the size of the flowering resource in the south-east, the relative contribution in terms of adult survival and recruitment of young of the north-west population is likely to be small in years of heavy flowering in the south-east. In contrast, during poor flowering years in the south-east, Swift Parrots remaining in the south-east have been shown to switch to *E. ovata* as a replacement food source (Brown 1989, R. Brereton, unpubl. data). In contrast, for the Swift Parrot population which remains in the north-west during these poor (south-east) Blue-gum years, the majority of foraging appears to be on Blue-gum rather than *E. ovata* (Table 3). In other words, the role played by *E. ovata* in the south-east appears to be performed in the north-west by the planted Blue-gum.

The north-west Blue-gum resource may be providing an important alternative food supply for Swift Parrots in years when the south-east Blue-gum fails to flower. Before European settlement, *E. ovata* was the only alternative, late-winter/spring-flowering resource in poor Blue-gum years, and presumably played a vital role in 'carrying' the Swift Parrot population over years when the Blue-gum failed (Brereton 1996). *Eucalyptus ovata* forests have been heavily cleared since European settlement, with < 5% (11 500 ha) of the original pre-European *E. ovata* forest remaining (North and Barker 2002).This loss of over 95% of the original alternative food resource has presumably increased the importance of the artificial north-west Blue-gum to Swift Parrots seeking an alternative food supply when the south-east Blue-gum fails to flower.

Despite the presence of a substantial number of large, consistently flowering Blue-gum trees in north-west Tasmania, the contribution of these Blue-gums to the total Swift Parrot breeding appears to be relatively minor. Although breeding has been documented in the north-west in some years, it appears to be relatively sporadic and to involve a relatively minor contribution to total recruitment compared to breeding in the south-east in good Blue-gum years (Brereton 1996). This may reflect the low number of north-west Blue-gums (in the order of 10 000 trees) relative to the number of Blue-gums in the south-east (estimated at over 300 000). The north-west Blue gum is also an extremely fragmented resource spread over a very large area, suggesting it may be energetically difficult for breeding birds to harvest sufficient nectar for both their own survival and to satisfy the requirements of rearing young. A lack of suitable nest hollows is considered unlikely to be a limiting factor for Swift Parrot breeding in the north-west, given the continued availability of substantial tracts of mature forest containing hollow-bearing trees inland from the north-west coast (R. Brereton, pers. obs.).

Management implications

The security of the current north-west Blue-gum food resource is likely to be poor in the medium to long term. Blue-gums in the north-west are planted, occur in small patches in a typically highly modified landscape, and are frequently at risk of removal for safety reasons when trees reach a large size. As a result, natural recruitment through establishment of seedlings tends to be minimal. Ensuring the long-term availability of Blue-gum in Tasmania's north-west will therefore require a commitment to the continued replacement of trees as trees are lost through natural or human-induced causes. Given the potential safety issues posed by mature Blue-gums in populated areas, future planting of Blue-gums should take place in properly designed habitats away from residential zones. Local municipalities should be encouraged to undertake a long-term planning approach to planting Blue-gums on public land, with the long-term aim of maintaining and expanding this important Swift Parrot resource in north-west Tasmania.

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Arthropod guilds associated with the Austral Grasstree *Xanthorrhoea australis* R.Br. in the Brisbane Ranges National Park, Victoria

Philip S Barton[1] and John G Aberton[1]

Abstract

Investigations into the composition and abundance of arthropods in dry sclerophyll forest of the Brisbane Ranges National Park, Victoria, were undertaken during the winter of 2000. A total of 4217 arthropods was collected using pitfall trapping and branchlet shaking methods in two vegetation types which were characterized by presence or absence of *Xanthorrhoea australis*. Arthropods were sorted and assigned to nine guilds based on their feeding modes. A higher abundance of scavenging and predator guilds were found in areas of vegetation characterised by *X. australis* absence. Two phytophagous guilds also showed a higher affinity with vegetation from areas of *X. australis* absence. Reasons for the differences in guild composition and abundance may include variability in plant species richness and abundance, leading to different food resources available to arthropods.
(*The Victorian Naturalist* **121** (2), 2004, 47-50)

Introduction

The dry sclerophyll open forest of the Brisbane Ranges National Park, Victoria, has an understorey dominated in places by the Austral Grasstree *Xanthorrhoea australis* (R.Br.). The entomology associated with *X. australis* is a subject that has had little attention, with only a few pest moth species known to have larvae that bore into fruit and seeds (Staff 1974). Any arthropods associated with healthy or diseased *X. australis* appear to be unknown in an ecological context, with only papers by Froggatt (1896) and Newell (1997) providing foundations for further study.

This study investigated arthropod associations with *X. australis* through the analysis of feeding guilds. This method of differentiating between arthropods was used as a means of simplifying the communities as well as providing an understanding of underlying ecological associations.

The objective of this study was to compare the composition and abundance of arthropods from open dry sclerophyll forest in areas characterised by the presence or absence of *X. australis*.

Methods

The study site was located at the northern end (37°47' S, 144°18' E) of the Brisbane Ranges National Park. Four plots were selected and matched for aspect, slope, overstorey vegetation and soil type. Plots one and two were selected for the presence of *X. australis* within the sites, and plots three and four were selected for the absence of *X. australis* within the sites. At each of the four plots a transect approximately 50 m long was created with four 6 m x 6 m quadrats constructed for arthropod and vegetation sampling, giving a total of 16 quadrats. Collection of arthropods was confined within each of the four quadrats and below two metres above ground level. Branches of all the shrubs or small trees within each quadrat were shaken over a white sheet for 10 seconds with resulting arthropods collected using an aspirator. Branchlet shaking was carried out once in July and August 2000. Four pitfall traps per quadrat were set for 72 hours once during June, July and August 2000. All specimens were preserved in 70% alcohol. Arthropods collected were classified to Order, and Family where this was possible, and were placed into their respective guild according to their feeding mode, found in relevant literature (CSIRO 1991; Naumann 1994). Guild definitions were adapted from Moran and Southwood (1982) and Stork (1987) (see Table 1). Comparisons of arthropod guild abundance between sites with *X. australis* present and absent were made using 1-Way ANOVA tests based on pooled data for each of the sampling methods. In an effort to explain potential differences between arthropod

[1] School of Ecology and Environment, Deakin University, Geelong, Victoria 3217.

Table 1. Summary of arthropod guilds, taxa assigned to each guild, and total numbers captured.

Arthropod Guild	Feeding Mode^	No	Taxonnmic Composition
Chewing Phytophages	Defoliator, leaf miner, gall former, or live wood eater	176	Coleoptera (Elateridae, Curculionidae, Chrysomelidae) Orthoptera (Acrididae) Lepidoptera (larvae)
Sucking Phytophages	Specialised feeding aparatus and sucks plant fluid	54	Hemiptera
Epiphyte Grazers	Graze on fungus, lichen or algae on plant surfaces	182	Psocoptera
Scavengers	Eat general decaying matter or fungus	1227	Diplopoda, Blattodea Coleoptera (Scarabaeidae) Dermaptera, Acari Collembola, Isopoda Thysanura (Lepismatidae)
Arthopod Predators	Prey entirely on live arthropods	1441	Araneae (Araneidae) Hemiptera (Reduviidae) Coleoptera (Melyridae, Coccinellidae) Neuroptera, Chilopoda
Other Predators	Prey entirely on live or dead organisms other than arthropods	20	Diptera (larvae) Coleoptera (Carabidae, Staphylinidae), Acari
Parasitoids	Parasite at some stage of its life cycle	35	Acari, Hymenoptera (Ichneumonidae, Braconidae)
Ants	Not applicable	276	Hymenoptera (Formicidae)
Transients	No direct or long-lasting association with surroundings	806	Hymenoptera (Vespidae) Diptera (Culicidae, Muscidae)

^ Adapted from Moran & Southwood (1982) and Stork (1987)

communities, the abundanees of 19 plant species reeorded across the 16 quadrats were subjected to multidimensional scaling (SPSS v11) to provide an objective classification of eaeh quadrat.

Results and Discussion

A total of 4217 arthropods from 17 major taxa (class/order) was taken from the four sample plots in the Brisbane Ranges National Park (Table 1). The major guild eontributing to pitfall-captured arthropods was the 'scavengers', with 'arthropod predators', 'ants' and 'transients' also contributing notably (Fig. 1). A significantly higher mean abundance of 'sucking phytophages' (F = 6.011, df = 1, p = 0.018), 'seavengers' (F = 6.511, df = 1, p = 0.014), and 'transients' (F = 8.553, df = 1, p = 0.005) were found for pitfall-captured arthropods. The major guild contributing to the branehlet-captured arthropods was'arthropod predators', with the 'transients', 'epiphyte grazers' and 'chewing phytophages' also contributing notably (Fig. 2). Minor guilds for both pitfall and branchlet-captured arthropods were 'parasitoids', 'sucking phytophages' and 'other predators'. No signifieant difference in mean guild abundance was found for branchlet-captured arthropods between the two vegetation types. Also of note was the absenee of 'epiphyte grazers' from pitfall captures, and the absenee of 'other predators' from branchlet captures in areas with *X. australis* absent.

The MDS ordination plot (Fig. 3) shows the quadrats characterised by *X. australis* absenee displayed less variation in the abundance of the 19 plant species recorded compared to quadrats characterised by *X. australis* presence. The variation in plant abundanees may partly explain differences in the abundance and composition of the arthropod guilds. Variation in plant species abundance may suppress high populations of individual arthropod species, but encourage a higher diversity of the overall arthropod population because of the higher diversity of possible niches available for exploitation (Vandermeer 1972). The presence or absence of *X. australis* as an understorey speeies in the sample areas may have enhanced or lessened the favourability of the associated habitat for

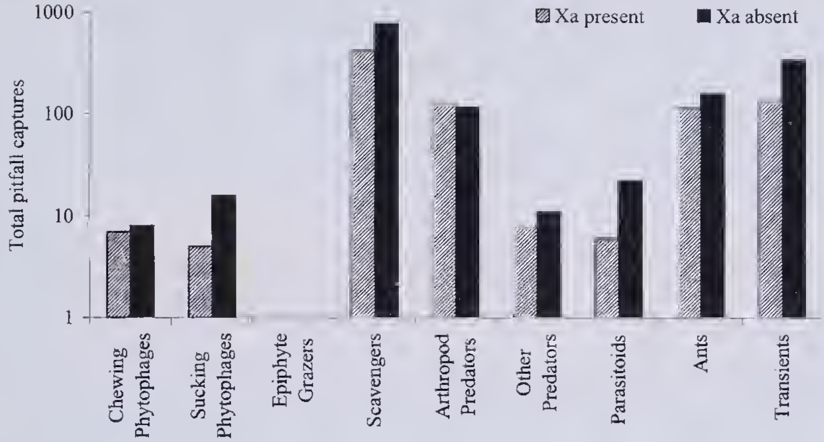

Fig. 1. Summary of total pitfall trap captures for sites with *X. australis* (Xa) present and absent.

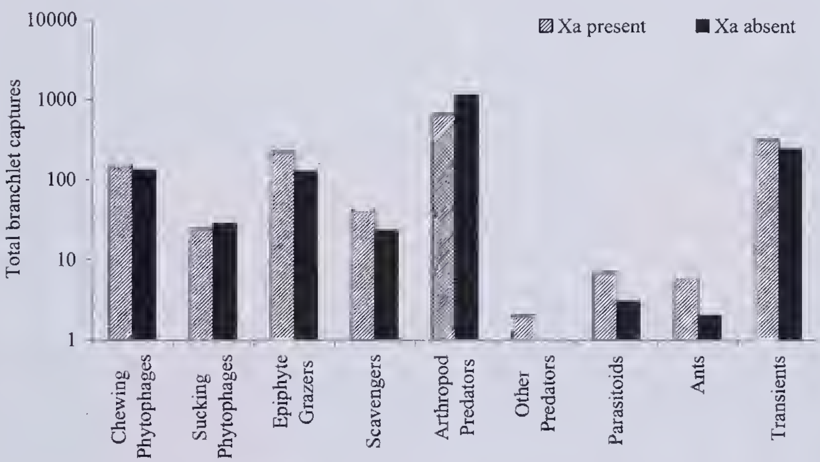

Fig. 2. Summary of total branchlet captures for sites with *X. australis* (Xa) present and absent.

particular arthropod guilds by creating differences in food availability or habitat characteristics (Nicholson 1958). Most of the arthropods represented in the pitfall captures are ground-active and *X. australis* is likely to affect the microclimate at ground level due to increased cover and protection (Newell 1997). The higher abundance of the guilds 'sucking phytophages', 'scavengers' and 'transients' in sites with *X. australis* absent suggests these guilds may prefer lower levels of protection or cover. The absence of *X. australis* would also be expected to increase variability in moisture and temperature at the ground surface level through exposure to sun and wind.

The present study clearly shows that differences in the abundances of particular arthropod guilds occur between sites characterised by the presence or absence of *X. australis*, especially at ground level. As arthropods were collected in winter only, it is recommended that further investigations

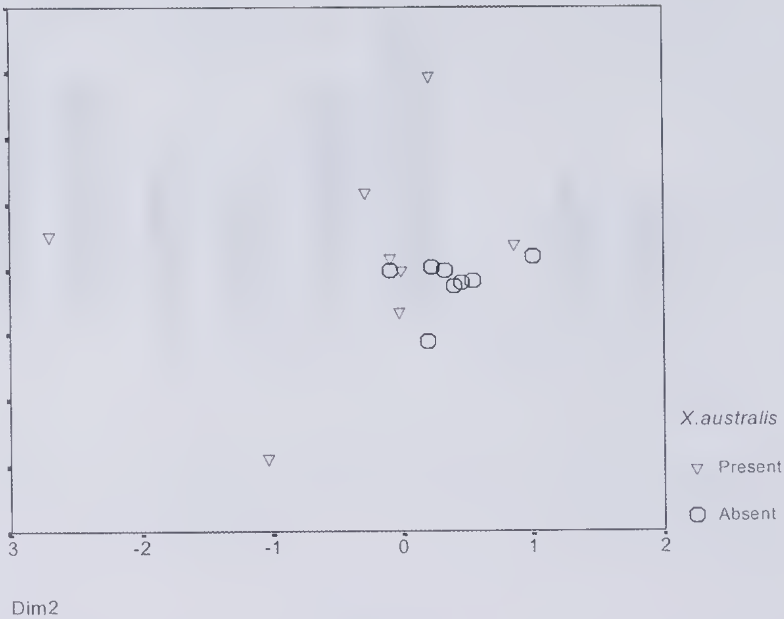

Fig. 3. MDS ordination of plant abundances based on quadrats with *X. australis* present or absent. (Stress = 0.1652, RSQ = 0.9280).

consider longer-term sampling of arthropods, as numbers are likely to change seasonally (Newell 1997).

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Prey preference and feeding behaviour of two Australian glossiphoniid leeches, and the avoidance response of their snail prey

Fredric R Govedich[1], Mohsen M Negm-Eldin[2], Bonnie A Bain[1] and Ronald W Davies[3]

Abstract
Two freshwater leech species *Helobdella papillornata* and *Alboglossiphonia australiensis*, when offered a variety of potential prey (snails, triclads, oligochaetes, corixid adults and chironomid larvae) fed almost exclusively on snails. Both leech species showed a significant preference for non-operculate snails (*Physa acuta*) compared to operculate ones (*Potamopyrgus antipodarum*), and in nearly all cases, consumed all of the soft tissues of each species. When attacked by a leech, operculate snails immediately close their aperture and non-operculate snails begin vigorous thrashing movements or detach from the substrate and float to the surface. Each of these responses resulted in some, but not all, snails escaping predation. *Lymnaea tomentosa* was observed to produce a repellent compound when attacked by a leech,which caused the leech to move away from the snail. (*The Victorian Naturalist* **121** (2), 2004, 51-55)

Introduction

Members of the family Glossiphoniidae are important predators in aquatic ecosystems, feeding by means of a protrusible proboscis on a variety of invertebrates (Davies *et al.* 1979, 1997; Sawyer 1986; Kutschera 1987, 1989, 1992; Kutschera and Wirtz 1986; Govedich 2001) and a few genera (e.g. *Placobdella*, *Placobdelloides*, *Theromyzon* and *Haementeria*) are facultative sanguivores on fish, reptiles, birds, amphibians and occasionally mammals (Davies and Wilkialis 1980; Sawyer *et al.* 1981; Sawyer 1986; Negm-Eldin 1992; Moser 1995). Glossiphoniids are cosmopolitan in distribution, occurring in both lentic and lotic ecosystems, attached to solid substrates such as rocks, driftwood or aquatic macrophytes, and often locally occur in large numbers (Sawyer 1986; Davies 1991; Davies and Govedich 2001).

Freshwater snails, one of the main prey items of glossiphoniids, are often used as intermediate hosts for trematode parasites (ie. *Fasciola*) which can be transmitted to domestic animals (sheep, cattle) and humans (Wright 1971; Loker 1986). In addition, glossiphoniids themselves have also been shown to be intermediate hosts for a range of other trematodes (Taft and Kordiyak 1973; Corkum 1975; Palmieri and James 1976; Spelling and Young 1986a, b) and they can also serve as vectors for the transmission of haematozoans to fish hosts (Negm-Eldin 1997, 1998a,b, 1999). Since these trematode species are not typically transmitted from leeches to humans and domestic animals, and since many glossiphoniids are voracious predators of freshwater snails (MacAnanally and Moore 1966; Abdallah and Tawfik 1972; Kutschera 1987, 1989, 1992; Kutschera and Wirtz 1986; Bronmark and Malmqvist 1986; Bronmark 1992; Govedich and Davies 1998), this suggests that the glossiphoniids which prefer snails as prey could successfully be used to control trematode-infested snail populations (Chernin *et al.* 1965; Berg 1972; Klemm 1975a,b; El-Shimy and Hamada 1990; El-Bahy 1992; Negm-Eldin 1996).

Several predacious species of freshwater leeches occur in Australia (Richardson 1967; Govedich and Davies 1998) but little is known about their prey preference or feeding behaviour. In this study prey preference and feeding behaviour are examined for two Australian glossiphoniid species *Helobdella papillornata* (Govedich and Davies 1998) and *Alboglossiphonia australiensis* (Goddard 1908) and the

[1] School of Biological Sciences, Monash University, Clayton, Victoria 3800
Email fredric.govedich@sci.monash.edu.au
[2] Benha University, Department of Parasitology, Faculty of Veterinary Medicine, Tukh Moushtohour, Egypt
[3] Central Queensland University, Rockhampton, Queensland, 4702

avoidance responses of their snail prey observed.

Study sites

Both species of leech were collected from the underside of stones and from aquatic vegetation; *Helobdella papillornata* from Aura Vale Lake, 40 km southeast of Melbourne, Victoria and from the Loddon River near Guildford, Victoria; and *Alboglossiphonia australiensis* from Cardinia Creek near its outflow from Cardinia Reservoir, 43 km southeast of Melbourne, Victoria. Prey species were collected from the same sites.

Materials and methods

Individual *H. papillornata* (n = 50) and *A. australiensis* (n = 50) were maintained in the laboratory (20°±2°C) in clear plastic containers containing 200 ml of Cardinia Reservoir water (pH 7.61±0.25, O_2 saturation = 78.8±6.3%, salinity = 65.8±26.2 ppm, electrical conductivity = 148.4±57.4 mS). Weekly behavioural observations were made for one year on the feeding behaviour of individuals of varying size and maturity following the introduction of prey. Snails, triclads, oligochaetes, corixid adults and chironomid larvae were placed individually into containers containing starved leeches (n = 10) to determine which prey are consumed by *H. papillornata* and *A. australiensis*.

Prey preference on snails by *H. papillornata* and by *A. australiensis* was determined for eight individuals of each species. Each individual was isolated in a container holding 200 ml of reservoir water. Each container was provided with three operculate snails, *Potamopyrgus antipodarum* (Gray 1843) (n = 48), and three non-operculate snails, *Physa acuta* (Draparnaud 1805) (n = 48). Leeches were allowed to feed for 24 hours and the number and species of snail consumed determined. R version 0.62.4 (Ihaka and Gentleman 1996) was used to perform an ANOVA test to determine if leeches consumed more operculate than non-operculate snails, at a probability of $p <= 0.05$.

Results

The snails *Physa acuta* and *Potamopyrgus antipodarum* were the only prey readily consumed by starved *Helobdella papillornata* and *Alboglossiphonia australiensis*. Freshwater triclads were sometimes examined by starved *H. papillornata*, but feeding never occurred and the triclads were quickly abandoned following the initial encounter. Freshwater oligochaetes, corixid adults, and chironomid larvae were rarely fed upon. Few of these were ever observed being consumed by either leech species and none was consumed when snails were made available. However, *Helobdella papillornata* would occasionally attach temporarily to the dorsal surface of a corixid, utilising it as a solid substrate.

Helobdella papillornata and *A. australiensis* consumed significantly ($F= 14.150$, $p=0.003$) more non-operculate *Physa acuta* than operculate *Potamopyrgus antipodarum*, indicating a strong preference for the non-operculate snails. Immature *Lymnaea tomentosa* were also consumed by both species of leech, but large adults of *L. tomentosa* were often killed but not consumed or were avoided by adult leeches of both species. One very large adult *H. papillornata* was observed to attack a large *L.tomentosa* and where the leech had pierced the snail with its proboscis, a milky blue substance poured out of the snail. When this blue cloud made contact with the leech, it quickly backed away and released the snail.

Over 24 hours, *H. papillornata* consumed on average 1.13 ± 0.06 SE snails per leech, of which 88% were *P. acuta* and only 11% *Potamopyrgus antipodarum*. *Alboglossiphonia australiensis* consumed on average 1.06 ± 0.04 SE snails per leech of which 80% were *P. acuta*, and 20% *Potamopyrgus antipodarum*.

During feeding, both *H. papillornata* and *A. australiensis* undergo a similar series of behavioural responses leading to the capture and ingestion of a snail. Initially the leeches have a random search pattern with the head sweeping back and forth until a snail is encountered. When the leech touches the snail, it moves its anterior sucker along the shell until the aperture is found. When attacked by a leech, the snail frequently begins to thrash back and forth, and if operculate, the aperture is closed. The thrashing is often very vigorous, particularly in *Physa acuta*, and some snails succeed in escaping from the leech. Snails will also detach from the substrate and float to the surface in an attempt to escape the predator. Both *H. papillornata* and *A. australiensis* often 'probe' several snails before successfully capturing one by attaching both anterior and posterior suckers to the snail.

Once captured, the snail is dislodged from the substrate and pulled towards the leech. The snail is penetrated through the shell aperture by the leech's proboscis and the soft tissues and fluids sucked into the oesophagus and crop until all the soft tissues are ingested, leaving an empty shell. Occasionally, *A. australiensis* will discard the anterior soft tissues ('head' region containing the tentacles and eyes) and ingest only the remaining soft tissues. The basic stages of capture and feeding by leeches are similar on both non-operculate and operculate snails. The leech bypasses the operculum of *Potamopyrgus antipodarum* by forcing its head and proboscis between the edge of the operculum and the shell. Fed to satiation, a leech detaches from the empty snail shell and moves to the substrate, where it remains inactive for 6 to 24 hours before feeding behaviour resumes. One adult leech can typically consume a maximum of 2-3 snails per day.

Discussion

Understanding prey preferences and the avoidance responses of predators and prey in aquatic systems is important in food web dynamics. Prey preference in leeches has been attributed to food quality, palatability, or the ease of detection of prey species (Davies and Everett 1975; Wrona *et al.* 1981). The avoidance response of prey species is also important and has direct consequences for the capture and consumption of prey species (Townsend and McCarthy 1980; Bronmark and Malmqvist 1986). Both *Helobdella* and *Alboglossiphonia* feed on gastropods (Klemm 1975a,b; Sawyer 1986; Govedich and Davies 1998), but the strong avoidance responses exhibited by some species of snails discourage and can often prevent leeches from initiating feeding.

By blocking the aperture of the shell, operculate snails initially make it more difficult for a leech to feed. Thus, when given a choice, non-operculate snail species are selected significantly more frequently than operculate species, and the presence of an operculum is an important factor in prey preference exhibited by both *H. papillornata* and *A. australiensis*. The violent thrashing and floating responses of some snails also inhibits feeding by *H. papillornata* and *A. australiensis* but does not determine prey preference.

The three snail species used in this study are not endemic to Australia. Two of them, *Physa acuta* and *Lymnaea tomentosa* are widespread invaders, originally from the northern hemisphere, whereas *Potamopyrgus antipodarum*, another widespread invader of freshwater habitats worldwide, originated in New Zealand. All three snail species are very common in lakes and streams throughout Victoria and can occur in very large numbers in some areas. In addition, *Physa acuta* and *Lymnaea tomentosa* are intermediate hosts for trematode parasites (i.e. *Fasciola*) which can be transmitted to domestic animals (sheep, cattle) and humans (Wright 1971; Loker 1986) and *Potamopyrgus antipodarum* is an intermediate host for a variety of trematode parasites that infect fish, birds, and mammals (Jokela and Lively 1995a,b; Winterbourn 1973). Since these snails can occur in very large densities, thereby increasing the possibility of transmission of parasites both to humans and domestic animals, several different means have been employed to control these snail populations. Application of chemicals is one commonly used method and, more recently, introduction of invertebrate predators has been successfully used as a biological control (Ferguson 1977; El-Bahy 1992; El-Shimy and Hamada 1990; Negm-Eldin 1996). In areas where non-endemic snails and their trematode parasites are a problem, it may be possible to use glossiphoniid leeches such as *Helobdella papillornata* and *Alboglossiphonia australiensis* to reduce snail densities, thereby reducing the incidence of snail-born diseases in domestic livestock and humans.

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An extended visit by a Leopard Seal to Phillip Island, Victoria

Leanne Renwick[1] and Roger Kirkwood[1]

Abstract

A 2.45 m long, female Leopard Seal *Hydrurga leptonyx* was recorded ashore 15 times on beaches around Phillip Island, Victoria, during a 52-day period, 20 December 2001 to 10 February 2002. Typically, it remained ashore for less than 24 hrs. Faecal analysis revealed that the seal was eating mainly Little Penguins *Eudyptula minor*. (*The Victorian Naturalist* **121** (2), 2004, 55-59)

Introduction

Leopard Seals *Hydrurga leptonyx* breed on the Antarctic pack-ice and have an estimated population of ~300 000 (Erickson and Hanson 1990). Their foraging range includes waters north of the Antarctic convergence, and individuals are sighted on beaches around Southern Africa, South America, New Zealand and Australia (Best 1971; Castello and Rumboll 1978; Crawley 1990; Rounsevell and Pemberton 1994; Shaughnessy 1999). Sightings in these regions are most frequent in winter and early spring (Rounsevell and Pemberton 1994; Warneke 1995).

In Victoria between 1960 and 2000, there were 129 reported sightings of Leopard Seals, i.e. about three per year (Atlas of Victorian Wildlife 2003). This compares with an average of five sightings per year in Tasmania (Rounsevell and Pemberton 1994). Typically, the records are of individuals that remained ashore for less than a day and were not sighted again at the same site or nearby. On occasions, however, recognisable individuals have been sighted several times at different locations over a period of weeks. Due to the undoubted resighting of some individuals at different localities, the number of seals that have visited the coast cannot be determined accurately.

To understand the visitation of Leopard Seals to the Victorian coast, it is important to document the residence time of recognisable individuals. Here we report on an extended visit by a Leopard Seal to beaches around Phillip Island, Victoria, during the 2001/02 summer. We also analysed the seal's faeces to assess its diet during the period.

Description of sightings

A Leopard Seal was first sighted on 20 December 2001 at McHaffies Beach on the north coast of Phillip Island (Table 1, Fig. 1). The same individual, recognisable by its size and distinctive scarring, was resighted on at least 14 occasions at several beaches, including Red Rocks, Shelly, Summerlands, Thorny, Surf and Cape Woolamai (Fig. 1). It was last sighted on

[1] Phillip Island Nature Park, P.O. Box 97, Cowes, Vic. 3922

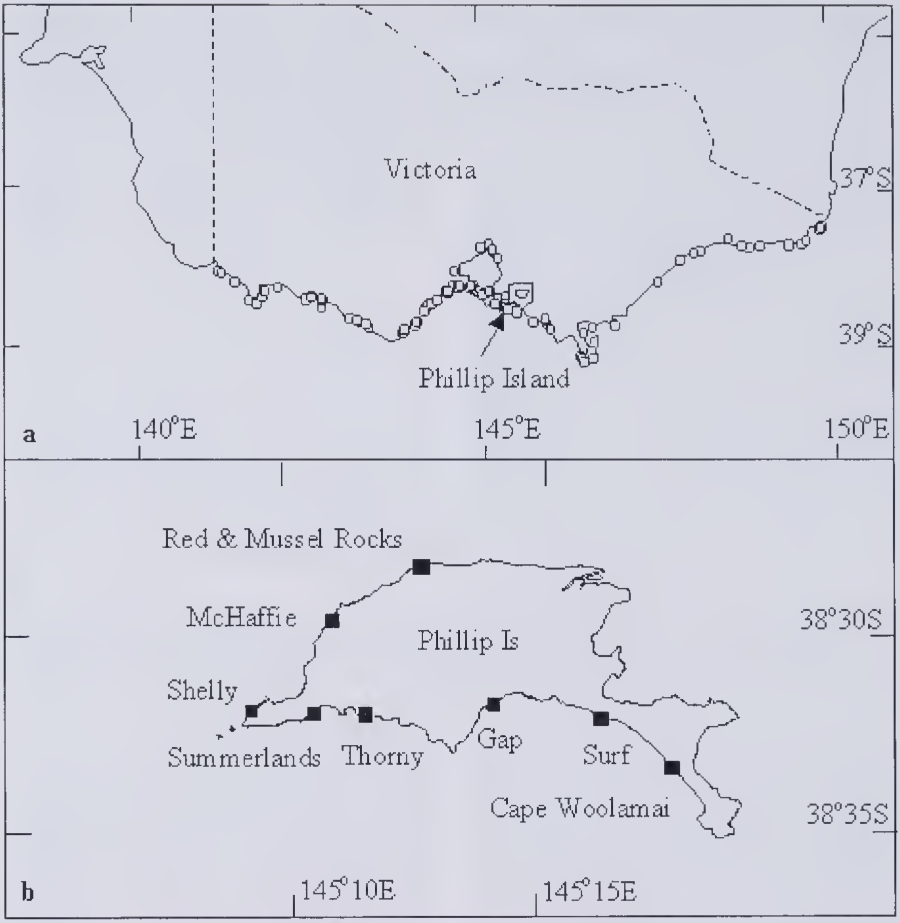

Fig. 1a. Locations of Phillip Island and previously reported sightings of Leopard Seals in Victoria (from the Atlas of Victorian Wildlife 2003).
Fig. 1b. Locations where a Leopard Seal was sighted on Phillip Island between 20 December 2001 and 10 February 2002.

10 February 2002 at Summerlands Beach, 52 days after it was initially reported.

The seal was identified as a young, female Leopard Seal, approximately 2.45 m in total length (nose to tip of hind-flippers). Its body condition was considered to be thin but improved over time. Based on our experience with otariid body masses, we estimated the seal to weigh 80-100 kg. On one occasion, 21 January 2002, a green substance was noted draining from its mouth and nostrils and its breathing appeared to be laboured, but on most occasions no evidence of ill-health was evident. On its last sighting it was thought to 'look a bit fatter' than when it was first seen (Ben Moore, pers. obs.).

The seal usually came ashore during the night or in the early morning. It remained near the water line, following this down as the tide receeded. It always departed from beaches within 24 hours of arrival and did so during a rising tide. On occasions, however, its departure was obviously an escape response to people walking near. The seal's most frequently reported haul-out site was at the western end of Summerlands Beach. This was adjacent to the 'Penguin Parade', where tourists visit nightly to view Little Penguins *Eudyptula*

Table 1. Dates and locations of reported sightings of a Leopard Seal on beaches around Phillip Island. (Asterisks indicate when faecal samples were collected.)

Date	Sighting
20.12.01	McHaffies Beach, am - left overnight.
22.12.01*	Red Rocks, am - left 12.30 pm, arrived Mussel Rocks in pm.
25.12.01.	Summerlands Beach, 8 pm - left overnight.
09.01.02	Surfies Point, Surf Beach, 10 am.
14.01.02	Beach at the end of Gap Rd, 10 am - gone in pm.
17.01.02	Shelly Beach rock platform, 11am - left 1 pm.
21.01.02	Summerlands, 10am - left 4 pm.
24.01.02*	Summerlands, am - left 5.30 pm.
25.01.02*	Summerlands, 3 am - left 5.30 am, back 9.15 am - left 1.30 pm, back 9 pm.
26.01.02*	Summerlands, 8.30 am, still there at 1 pm.
30.01.02*	Summerlands 9.30 am - left 5pm.
02.02.02	Thorny Beach, 3pm - left overnight.
06.02.02	Summerlands, 10am - left overnight.
07.02.02	Cape Woolamai, am.
10.02.02*	Summerlands, 10 am.

minor crossing a beach. A colony of approximately 60 000 Little Penguins lives on the Summerland Peninsula (P. Dann, pers. comm.; Fig. 1).

Faeces deposited on beaches by the Leopard Seal were collected on six occasions (Table 1). The faecal samples were rinsed through a 0.5 mm sieve and carefully sorted. Identifiable prey remains were removed; bird species were identified by their feathers, fish by their otoliths and cephalopods by their beaks, based on reference collections held at the research centre at the Phillip Island Nature Park, Victoria.

Results and Discussion

The seal's appearance on Phillip Island and its behaviour was not unusual for a Leopard Seal on beaches in southern Australia. Leopard Seals seen in southern Australia are usually described as being thin and mostly are juveniles, although adults also occur (King 1983; Rounsevell and Pemberton 1994). They are considered to be near the edge of their range (Rounsevell and Pemberton 1994) where feeding conditions could be sub-optimal. Moreover, most of the seals are juveniles that could have poorly developed hunting and navigational skills (Rounsevell and Pemberton 1994). Also, Leopard Seals are slim in appearance compared with other phocids, such as Elephant Seals *Mirounga leonina*, so this thin appearance does not necessarily imply ill-health. The Phillip Island seal was sufficiently healthy to survive for at least several months and was eating, as demonstrated by the regular deposition of faeces on the beaches.

Reviewing the Atlas of Victorian Wildlife database for the period 1960 to 2000, and assuming individuals could be recorded in the same area (within about 100 km) over periods of up to two months, we conclude that an average of two Leopard Seals come ashore on Victorian beaches each year (range 0 to 7). On most occasions, the reports suggest visits of short durations, but this is not always the case, and the extended visitation of 52 days to Phillip Island, was not unprecedented. In 1977, one or two Leopard Seals (individuals of both sexes were reported, R. Warneke pers. comm.) were frequently sighted on beaches along the central Victorian coast, including Phillip Island, between 31 July to 30 September, i.e. about 60 days. In 1990, there was a similar series of visits by a lone Leopard Seal (or perhaps a number; some descriptions of the seal conflicted, R. Warneke pers. comm.) to beaches west of Port Phillip Bay; the reported sightings occurred over a 72 day period, 17 August to 28 October.

Perhaps the most unusual feature of the seal's visit to Phillip Island was that it occurred during summer, whereas most Leopard Seal visits to South-Eastern Australia are in winter and spring (Rounsevell and Pemberton 1994; Warneke 1995). The peak visitation in winter and spring may be influenced by movements of the seals away from pack-ice regions, which achieve their maximum extent at that time of year (Rounsevell and Eberhard 1980; Bester and Roux 1986). In fact, near five-yearly peaks in relative abundance of Leopard Seals in temperate seas have been related to five-yearly fluctuations in the extent of the sea ice (Testa et al. 1991). The visits in summer may simply indicate that southern Australian waters are within the Leopard Seals foraging range year-round.

Faecal samples from the Phillip Island Leopard Seal consisted almost entirely of the remains of Little Penguins, a prey species that has been reported previously for this seal in South-Eastern Australia (Shulz and Menkhorst 1984; Warneke 1995). Seabirds are a common component in the diet of Leopard Seals elsewhere in their range (e.g. in Antarctica, Rogers and Bryden 1995; and the Sub-Antarctic, Walker et al. 1998). In South-Eastern Australia, Little Penguins, along with the abundant, migratory Short-tailed Shearwater *Puffinus tenuirostris* (see Warneke 1995), potentially represent an important food source for Leopard Seals. We also identified >50 beaks from Gould's squid *Nototodarus gouldi*. Based on a regression for lower rostral length to mantle length (ML = 38 x [LRL + 0.71], O'Sullivan and Cullen 1983) two of the beaks were from squid >20 cm long and the remainder were from individuals <12 cm long. Only the larger individuals are likely to have been prey of the Leopard Seal, the rest probably deriving from the stomach contents of the penguins (see Cullen *et al.* 1992). Several small, heavily-eroded otoliths from Red Bait *Emmelichthys nitidus* also probably derived from the ingested penguins. In addition, we recovered one passive induction transponder, an identification chip that had been implanted in a fledging penguin chick at the Penguin Parade 10 days earlier.

It is not surprising that penguin was the major dietary component of the Leopard Seal, considering the seal's preferred resting site (Summerlands Beach) is a main landing beach for Little Penguins. The seal's attendance coincided with young chicks fledging. Considering their unpractised swimming skills, these young would have been particularly vulnerable to the seal.

Concluding remarks

Leopard Seals are commonly seen on beaches in South-Eastern Australia and in most years individuals are reported along the Victorian coast. For example, prior to 2001, Leopard Seals had been reported on and around Phillip Island in 1963, 1974, 1977, 1978, 1992 and 2000 (Atlas of Victorian Wildlife 2003). More information on the frequency and duration of visits would improve our understanding of this species and its role in local marine ecosystems. We therefore encourage observers to report all sightings of Leopard Seals to local wildlife officers.

The value of sightings can be greatly improved by recording individual characteristics, such as sex. Male Leopard Seals can be recognised by the penile opening and often an associated wet patch on the lower belly, whereas the lower belly of females is smooth. Recognisable injuries, scaring or colouration patterns are also useful to record and a photograph can greatly aid individual identification. Other features to record include approximate length and weight.

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Notes on the birds of Lady Julia Percy Island, western Victoria

Peter Dann[1], Moragh Mackay[2], Roger Kirkwood[1] and Peter Menkhorst[3]

Abstract
A total of 27 species was observed during five visits to Lady Julia Percy Island in 2000-2003, including two species not previously reported there (Kelp Gull *Larus dominicanus* and Black-shouldered Kite *Elanus axillaris*). The discovery of breeding Kelp Gulls on the island makes this only the third breeding location recorded for this species in Victoria. Population estimates of breeding Little Penguin *Eudyptula minor*, Short-tailed Shearwater *Puffinus tenuirostris* and Kelp Gull were made in January 2000. Numbers of breeding penguins appear to have declined since a seabird census in 1978-79, while those of shearwaters have increased. The decline in penguin numbers on the island may have been associated with increasing numbers of Australian Fur Seals *Arctocephalus pusillus doriferus* or a widespread mortality of pilchards *Sardinops sagax*. (*The Victorian Naturalist* **121** (2) 2004 59-66)

Introduction

Lady Julia Percy Island (140 ha) is one of the larger Victorian off-shore islands but, unlike most, it is volcanic in origin (Jennings 1959). The island has a long history of human activity, first as a spiritual site for the Gunditjmara people and, after its European discovery (Grant 1803), as a place visited by sealers and guano collectors throughout the 19th century. Rabbits were introduced in 1868 and it was stocked with pigs and horses between 1879 and 1908 (Mahony 1937). Rabbits have increased to the extent that they have severely damaged the island's vegetation (Pescott 1968).

The island has been visited by naturalists on a number of occasions since the McCoy Society Expedition in 1936 made extensive observations of its natural history (Edmonds 1937; Mahony 1937; Patton 1937; Wood-Jones and Tubb 1937). The most detailed survey of avifauna in recent times was carried out in November 1978 and January 1979: this study was subsequently published together with an extensive review of previous ornithological visits (Norman *et al.* 1980).

[1] Phillip Island Nature Park, P.O. Box 97, Cowes, Phillip Island, Victoria 3922. Email: pdann@penguins.org.au
[2] "Riverbend", Bass Highway, Bass, Victoria, 3922, Australia
[3] 11 Haig Street, Heidelberg Heights, Victoria, 3081, Australia

Table 1. Maximum numbers of birds recorded or estimated on Lady Julia Percy Island on five visits between January 2000 and January 2003. + = present, no numbers available. Species recorded breeding marked in bold. Nomenclature follows Christidis and Boles (1994)

Species		4-10 Jan 2000	21-22 Jul 2001	6-7 Mar 2002	18-20 Jul 2002	6-10 Jan 2003
Black Swan	*Cygnus atratus*		+			
Little Penguin	*Eudyptula minor*	*c* 630	+	30 moulting	+	+
Common Diving-Petrel	*Pelecanoides urinatrix*	dead only			dead only	
Fairy Prion	*Pachyptila turtur*	*c.*500				+
Short-tailed Shearwater	*Puffinus tenuirostris*	*c.*162 000	+		+	
Black-faced Cormorant	*Phalacrocorax fuscescens*	5			2	1
White-faced Heron	*Egretta novae-hollandiae*	4				1
Black-shouldered Kite	*Elanus axillaris*					1
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	1	+			
Swamp Harrier	*Circus approximans*	9		+	1	3
Brown Falcon	*Falco berigora*		+			2
Peregrine Falcon	*Falco peregrinus*	4	+			2 adults and 2 juveniles
Nankeen Kestrel	*Falco cenchroides*	1	+	+		2 adults and 1 juvenile
Sooty Oystercatcher	*Haematopus fuliginosus*	10		2		2 adults and 1 chick
Masked Lapwing	*Vanellus miles*		+		+	
Pacific Gull	*Larus pacificus*			1		
Kelp Gull	*Larus dominicanus*	26 adults and 2 juveniles	4 adults	8 adults and 5 juveniles	16	29 adults, 8 juveniles & 2 immatures
Silver Gull	*Larus novae-hollandiae*	55 -100	+	+	13	70
Crested Tern	*Sterna bergii*					2
White-fronted Chat	*Epthianura albifrons*	*c.* 30	+		+	+
Skylark	*Alauda arvensis*	*c.* 20			+	+
Richard's Pipit	*Anthus novaeseelandiae*	*c.* 15				+
European Goldfinch	*Carduelis carduelis*		+			
House Sparrow	*Passer domesticus*					12
Welcome Swallow	*Hirundo neoxena*	6	+		+	+
Little Grassbird	*Megalurus gramineus*	*c.* 30	+	+		+
Common Starling	*Sturnus vulgaris*	*c.* 20	+			40

Parks Victoria, which manages the island as a wildlife reserve, embarked on a rabbit eradication program in 2000. It is the intention of this study to provide baseline data for monitoring the effects of this eradication on the island's seabird colonies, as suggested by Norman *et al.* (1980). We visited the island in January 2000, July 2001, March and July 2002 and January 2003. On the first occasion, we mapped seabird colonies and surveyed the island's avifauna thoroughly; during the other four visits we made incidental observations of birds as they were encountered during the course of studies on the ecology of Australian Fur seals *Arctocephalus pusillus doriferus.*

Methods

The island was visited for a total period of 19 days from 4-10 January 2000, 21-22 July 2001 (RK only), 6-7 March 2002 (RK only), 18-20 July 2002 (RK only) and 6-10 January 2003. All species were noted while making complete traverses of the

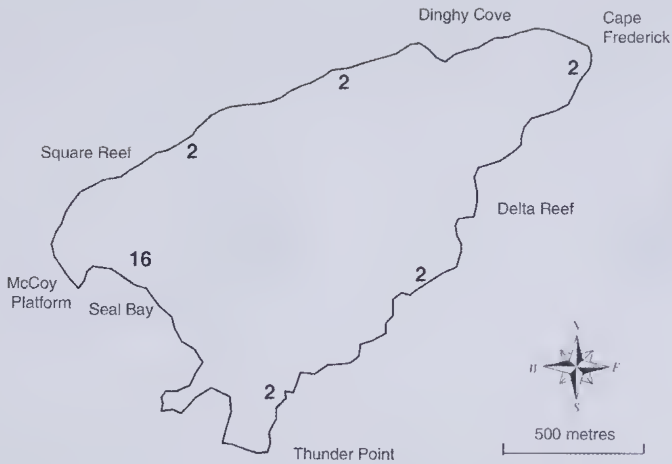

Fig. 1. Map of Lady Julia Percy Island showing place names mentioned in the text and the distribution of adult Kelp Gulls (number of birds shown) in January 2000.

island each day for five consecutive days in January 2000, two consecutive days in January 2003 and, incidentally, around seal colonies at other times. Birds flying out at sea have not been reported here. Seabird colonies were mapped in January 2000. All individual Little Penguin *Eudyptula minor* burrows were counted. Only occupied burrows or those showing signs of recent occupation (i.e. fresh digging or excreta) were included in the counts. For Short-tailed Shearwaters *Puffinus tenuirostris*, density estimates were made for the larger breeding areas and complete counts in the smaller areas. The number of burrows of breeding shearwaters in larger areas was estimated from the product of 25 randomly selected 5 x 4 m quadrats and the estimated colony area measured on the ground. Shearwater colony identification followed that of Norman *et al.* (1980). Occupied Fairy Prion *Pachyptila turtur* burrows were noted as they were encountered during the penguin and shearwater surveys. An aerial photo taken for Parks Victoria in April 2000 was used to map seabird colonies, and the scale was determined from a measurement on the ground between two features obvious on the photograph.

Results

Species

A total of 27 species was observed on Lady Julia Percy Island during the five visits, including two species (Kelp Gull *Larus dominicanus* and Black-shouldered Kite *Elanus axillaris*) not previously recorded for the island in the literature (Table 1). The former species was also recorded breeding at this location for the first time. All other species seen by us (Table 1) have previously been recorded on the island. A further 18 species have been recorded previously (Norman *et al.* 1980) but these were considered occasional visitors or vagrants.

Distribution and abundance of seabirds

Little Penguins

A total of 317 active burrows was counted on the island in January 2000. These burrows were concentrated in five areas: around landing sites at Dinghy Cove (105 burrows), at Seal Bay (29), above Seal Bay (60) at Delta Reef (1) and McCoy Platform (123 burrows; Figs. 1 and 2). At Dinghy Cove, all breeding sites were under substantial rocks and most were in the top half of the scree slope in areas of lesser seal activity. Several dead penguins, apparently squashed by seals, were found in the lower

Fig. 2. Distribution of Little Penguin burrows in 1978-79 (a) and 2000 (b) at Lady Julia Percy Island. Distribution in 1978-79 taken from Norman *et al.* (1980).

Fig. 3. Distribution of Short-tailed Shearwater burrows in 1978-79 (a) and 2000 (b) at Lady Julia Percy Island. Distribution in 1978-79 taken from Norman *et al.* (1980). The long narrow strip of burrows near the centre of the island was in a slightly different location in the two surveys [compare (a) and (b)] and is presumed to be a mapping error from 1978-79.

scree slopes but it is not known whether they had died from other causes before being squashed. Similarly, at Seal Bay, penguin breeding sites were sparsely distributed under rocks on the scree slope; eight dead penguins, which also appeared to have been squashed, were found there. The majority of penguin burrows (in soil) was distributed around the periphery of the main seal loafing area on the plateau above Seal Bay (Fig. 2). Fourteen penguins were found sheltering in the two caves during daylight at the western end of Seal Bay.

In January 2000, 246 (77.6% of the 317 examined) penguin burrows were unoccupied, 19 (6%) contained adults only, 23 (7.3%) held eggs with or without adults and 29 (9.2%) contained chicks with or without adults.

Short-tailed Shearwaters

Shearwater burrows were concentrated around the outer edge of the island (Fig. 3) and their distribution covered an estimated 36.03 ha (Table 2). The estimated total number of burrows was 80 874 (Table 2).

Table 2. Estimates of numbers of Short-tailed Shearwater burrows on Lady Julia Percy Island, January 2000. Colony identification follows Norman *et al.* (1980).

Colony	*Area (ha)*	*Burrow density/m²* *(mean ± s.e., no. of quadrats)*	*Estimated burrow total*
A	0.84		2436
B	2.05	0.29 ± 0.05, 6	5945
C	0.90		2610
D	5.84	0.34 ± 0.03, 8	19856
E	6.85		13015
F-J & M	4.52		8588
K	0.96	0.19 ± 0.03, 5	1824
L	3.61		6859
T	6.85	0.25 ± 0.07, 6	17810
Rest	3.61	All burrows counted	1931
Total	**36.03**		**80874**

Kelp Gulls

Twenty-six adult Kelp Gulls were recorded daily between 8-10 January 2000 as well as five young (two of which were almost flying). Three nests were found, two with one egg and one with two eggs. Five pairs were well dispersed around the island (Fig. 1), while another 16 adults congregated with the five young at the top of Seal Bay (Fig. 1) on the edge of a bare area where the seals loaf. It is not known if the gulls bred there or had moved there from other parts of the island. The seals appeared to provide the main source of food for Kelp Gulls on Lady Julia Percy Island. Extensive observations over three days in January 2000 revealed that, at that time, adult gulls rarely fed on anything other than squid remains regurgitated by seals.

In January 2003, 29 adults were seen on the island on two consecutive days, as well as eight fledged young and two birds in their second year. All, except a pair of adults and a newly fledged chick, were at the top of Seal Bay around the seal loafing area. There were two nests with two eggs and one with one egg and one brood of two chicks less than one week old in the area. There were also two empty nests in the same area.

Fairy Prions

In January 2000, downy young of Fairy Prions were found singly in burrows in large numbers at Seal Bay (*c.*450), above McCoy Platform (*c.*110) and in Dinghy Cove (*c.*37). A complete census of this species was not attempted.

Common Diving-Petrels

The remains of a number of Common Diving-Petrels *Pelecanoides urinatrix* were found around the periphery of the plateau during the two January visits.

Sooty Oystercatchers

A colour-banded Sooty Oystercatcher *Haematopus longirostris* (one of a pair) observed at Dinghy Cove on 6 January 2000 had been banded at Flinders, Victoria, in March 1998 as an adult (Victorian Wader Study Group, unpublished data).

Discussion

Distribution and abundance of seabirds

Little Penguins

The number of penguin burrows (317) found during this survey was considerably less than has been reported previously (McKean 1962; Reilly 1977; Norman *et al.* 1980). While McKean (1962) considered that the island was the largest nesting area in Victoria, with 5,000-10,000 burrows; Reilly (1977) estimated that there were 1,260 burrows in Dinghy Cove and Seal Bay and Norman *et al.* (1980) calculated, from counts and extrapolations of mean densities and areas, a total of about 2000 burrows. The breeding season was half way through at the time of the census in January 2000 and, consequently, evidence of earlier breeding may have been missed. However, the error associated with the timing of the census is unlikely to have accounted for such a dramatic discrepancy with earlier work.

There have been two phenomena during the past 20 years that may have contributed to declining numbers of penguins at Lady Julia Percy Island. The first has been the large increase in the number of Australian Fur Seals breeding on the island (Pescott 1968; Shaughnessy *et al.* 2002), and the second was the widespread breeding failure and mortality of penguins in Victoria following a pilchard *Sardinops sagax* mortality in 1995-96 (Dann *et al.* 2000) and again in 1998.

The number of seals on Lady Julia Percy Island increased at an annual rate of 1.7% between 1976 and 2000 (Shaughnessy *et al.* 2002) and their increased activity may have reduced the availability of nesting sites and the survival of penguins. The number of sites at which penguins can come ashore on the island is limited by the steep cliffs around most of the perimeter (Tarr 1954; Pescott 1976; Norman *et al.* 1980) and access to the majority of the island is from McCoy Platform or through the seal colony at Seal Bay. Seal activity now extends up to 500 m inland above Seal Bay and McCoy Platform. Most of the area is devoid of vegetation and the soil is compacted, rendering it unsuitable for breeding penguins. Norman *et al.* (1980) estimated that there were 1600 burrows in this area in 1978, yet we counted only 123 burrows. In addition, the unusually large number of dead, squashed penguins around Dinghy Cove and Seal Bay may suggest that accidental mortality caused by seals could be contributing to a decline. Crawford *et al.* (1995) identified two former penguin breeding sites in South Africa where current high densities of South African Fur Seals *A. p. pusillus* effectively exclude breeding of African Penguins *Spheniscus demersus.*

Shaughnessy *et al.* (2002) reported for the first time the breeding of New Zealand Fur Seals *A. forsteri* on the island in 2000. The increase of this species may also have some impact on the numbers of penguins on the island as this species is a known predator of penguins (S. Goldsworthy pers comm) unlike *A. pusillus* which is not known to feed on them (R. Kirkwood unpublished obs.).

Another possible cause of a reduction in breeding penguin numbers could have been the 1995-96 pilchard mortality. Its contribution to a decline in penguin numbers on the island is difficult to quantify; however, there was some evidence of increased mortality of penguins and reduced breeding success after 1995 at other sites in Victoria, including Port Campbell, some 90 km to the east (Dann *et al.* 2000).

Short-tailed Shearwaters

The area occupied by Short-tailed Shearwater burrows has expanded by c. 85% in the 22 years between 1978 and 2000. Most of the expansion has been in the north-east around Cape Frederick and along the eastern shore to Thunder Point and south of Seal Bay (Fig. 3). What were small colonies along the eastern shore in 1978-79 (Norman *et al.* 1980) had increased substantially by 2000 and some discrete colonies had expanded and merged. In addition there were several new areas of breeding shearwaters north of Thunder Point.

Estimates of burrow density were also considerably higher in January 2000 than in November 1979 (mean 0.27 burrows per m^2 in 2000 compared with 0.10 burrows per m^2 calculated from Norman *et al.* 1980: Table 2). Although methods of assessing burrow densities were (deliberately) similar in both studies, it is not known to what extent differences in the timing of sampling may have contributed to differences in the burrow density estimates. Lower burrow densities due to nest failure, rather than the greater ones recorded here, might be expected in January compared to November.

The larger area occupied by breeding shearwaters, coupled with the higher estimates of burrow densities in 2000, resulted in an estimated burrow total for the island 5.29 times that estimated in 1978 by Norman *et al.* (1980) and more like the 90 000 estimated by Wheeler (1965) in 1964. The increase in shearwater numbers is unlikely to have contributed to the decline in penguin numbers because the shearwaters have not moved into the areas where penguins were recorded previously by Norman *et al.* (1980).

Kelp Gulls

The presence of breeding Kelp Gulls makes this only the third breeding location reported for the species in Victoria. Robert Warneke first recorded this species breeding in Victoria at Seal Rocks (south-west of Phillip Island) in 1969 (Harris and Bode 1981). The second breeding location recorded in Victoria is on the western end of Phillip Island where a pair nested from 1996 to 1999 and raised several young (Dann, unpublished obs.). It is not known when the birds commenced breeding on Lady Julia Percy Island but they were not recorded by Norman *et al.* (1980) in 1978 or by previous ornithologists (Wood Jones and Tubb 1937; Tarr 1954; McKean 1962 in Norman *et al.* 1980; Wheeler 1965; Pescott 1968, 1976; Atlas of Victorian Wildlife 2003). Several birds were observed behaving territorially on the island in January 1995 (Farnes pers. comm.) and may have been breeding at that stage. It is likely that the actual breeding population during 2000-03 was close in number to the 26-29 adults that were counted on the island during our January visits, although not all were actually recorded breeding.

Potential effects of rabbit control on avian distribution and abundance on the island

The removal of rabbits is likely to have a substantial influence on the vegetation structure and floristics of the island (Norman 1970; Norman and Harris 1980) and correspondingly affects the numbers and distribution of some birds there. Burrowing seabirds, such as penguins and shearwaters, could benefit from increased vegetation cover through a reduced incidence of burrow collapse and better burrow insulation in vegetated areas. Breeding Short-tailed Shearwaters invaded previously eroded areas after they became vegetated following the removal of rabbits on Rabbit Island, Wilsons Promontory, Victoria (Norman and Harris 1980). Some resident land birds, such as Little Grassbirds *Megalurus gramineus*, may also benefit from any increased vegetation structure, cover and diversity following rabbit eradication. Swamp Harriers *Circus approximans* may experience a drop in numbers if they are unable to switch from rabbits to alternative prey, particularly as the island has no other small mammals.

Other species recorded previously but not published in Norman et al. (1980)

Additional species recorded by PM on a previous visit between 8-10 December 1973 were the Great Cormorant *Phalacrocorax carbo* and House Sparrow *Passer domesticus*. The Great Cormorant had not been recorded previously or subsequently.

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Some effects of the recent drought on the fauna of Rushworth Forest

Rushworth Forest is located in the Box-Ironbark region of central Victoria, immediately south of the township of Rushworth, on the inland slopes of the Great Dividing Range. Rushworth Forest is considered the largest remnant of Box-Ironbark forest in Victoria (Wilson and Bennett 1999). The forest is largely composed of Red Ironbark and Grey Box with stands of Yellow Gum, some Red Stringybark and Red Box amongst others. These trees flower at different times of the year, but over winter there are usually many trees in flower, providing an abundant source of nectar that attracts and nourishes a wide range of fauna, including invertebrates, birds and marsupials. Many blossom nomads and migratory nectivorous birds such as Swift Parrot, Musk, Little and Purple-crowned Lorikeets and a wide range of Honeyeaters including Fuscous, Yellow-faced, White-naped, Black-chinned and Noisy Friarbird descend on the forest at certain times of the year for this feast. This flowering is also a valuable source of carbohydrates for the arboreal marsupials of the forest, notably Yellow-footed Antechinus, Sugar Glider and Brush-tailed Phascogale. Over the last few years, the level of annual rainfall has been well below average and this has led to many obvious effects on the flora of the forest. Last winter (2002) most of the Ironbarks, Boxes and Yellow Gums failed to flower and, as a result, there were relatively few records of migratory and nomadic birds in the forest. Swift Parrots largely bypassed the region and either stayed closer to the coast or travelled much further north (Tzaros 2002; Tsaros pers. comm.). Fuscous Honeyeaters largely left the forest and were recorded in large numbers on the coast of NSW with some, unusually, being recorded in SA.

The effects of the drought on the sedentary, nocturnal mammals of the forest are more difficult to determine. The Fauna Survey Group of the FNCV has been monitoring numbers of Sugar Glider and Brush-tailed Phascogale using nestboxes that have entry holes designed to admit only small animals (Dashper and Myers 2003; Myers and Dashper 1999). A number of these nestboxes are located on what could best be described as marginal habitat, poor soils supporting mainly small diameter Red Ironbarks with few natural hollows. These nestboxes have a high occupancy rate by Sugar Gliders and Phascogales (Dashper and Myers 2003). Over the last four years the numbers of Phascogales recorded in these nestboxes over winter has declined from 10 in 2000 to zero animals recorded in 2003 (Fig. 1). This is the first time that no Phascogales have been found in winter in these boxes during the eight years that they have been monitored. Due to the low numbers of Phascogales detected, even in good years, the apparent decline could be a result of random change. however the numbers of Sugar Gliders in these nestboxes have also declined markedly during this period to an unprecedented low number (Fig. 1). The Phascogales usually present in winter in the nestboxes are females who are either pregnant or with young. These animals remain in a single nestbox for long periods, so it is likely that the single sampling of nest boxes is indicative of the population trend in this marginal habitat. Interestingly, because the Phascogale breeding season is already over, it will take until next season before Phascogale numbers can start to build up again, providing conditions are favourable. At a population level, this decrease in abundance of Phascogales in the more marginal habitats of Rushworth Forest probably will not affect the long term viability of this population. However, in smaller, more isolated patches of forest this drought could have led to the local extinction of some Phascogale populations. Although male Phascogales disperse over great distances, females disperse only a short distance (Soderquist and Lill 1995). It is, therefore, unlikely that recolonisation of isolated remnant forest patches would occur rapidly, if at all.

Stuart Dashper
13 Ryan St, Brunswick East
Victoria. 3057

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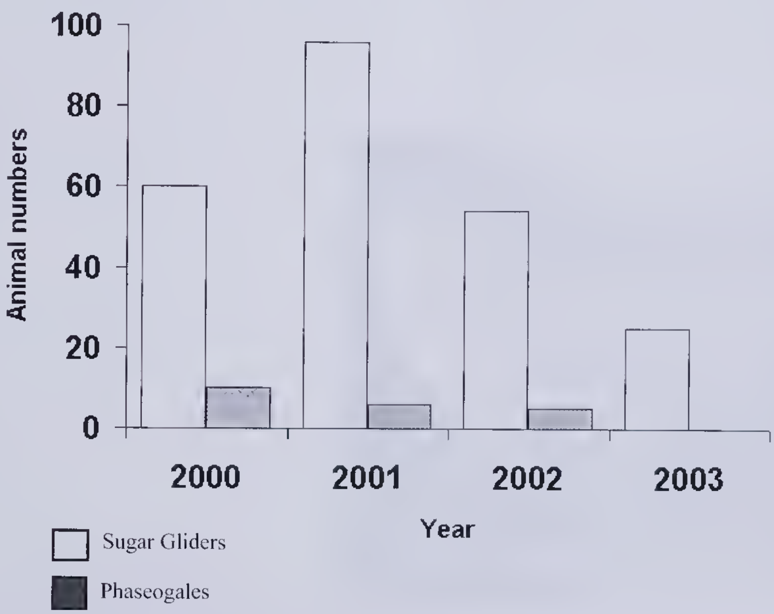

Fig. 1. Brush-tailed Phascogales and Sugar Gliders recorded from 44 nestboxes located in marginal habitat in Rushworth Forest during the winters of 2000 to 2003.

Life in the Urban Parklands - Foxes

I was walking in Bushy Park Wetlands one day, but instead of following the bike path along and over the hillside formed on top of the old tip site I went straight ahead towards Dandenong Creek, away from places where regular walkers and bike riders go. I was searching for possible fox dens and checking known hot spots against the GPS. I had been working on the fox project in Dandenong Creek Valley (*The Victorian Naturalist* 2002, **119**, 269-275) for about a year and I was yet to see an elusive red-furred and mainly nocturnal canine until today! My lucky day! March, early afternoon, I found footprints in the ground still soft after autumn rains. They looked fresh - possibly from the night before. The path disappeared into a thin track heavily overgrown by weedy herbage and grass and I caught a glimpse of something moving ahead - most likely rabbit or hare (or so I thought) - although I had never seen either in the Wetlands before. But no! Those foot prints were really fresh, about five minutes before me, and then a fox appeared, jumping through the ground cover and turning to give me a quick glance before loping away again. There was a large fallen tree ahead and the fox ran for this, leapt onto one of the branches and ran along it until he had a clear view of me. I stopped and we eyed each other. Then, as I moved, he turned and ran back along the branch, leapt off and disappeared into the Phragmites, honeysuckle and blackberry behind.

My second daytime fox sighting was only a week later in similar circumstances, still March, a fine and sunny afternoon and, again, I was checking den sites for GPS readings, this time in a natural remnant in Jells Park. I had visited this particular den site before. It was completely surrounded by natural trees and grass and built among the roots of Silver and Black Wattle not 20 m from Jells Road. In the previous November, it had been a very active den site and dead Common Ringtail Possum, Black Rat and various bird species remains were spread around.

I thought it would be easy to find in only a small remnant and 20 m from Jells Road, but no, I found I had walked straight past and uphill to the fence. I turned to retrace my steps and, suddenly, there was a fox! A fine specimen, head up and tail flying - we looked at each other. I remembered that this time I had the camera with me and tried to reach for it surreptitiously. No way! The fox was off across my path and heading downhill. I followed and sure enough found the den site (but not the fox).

The third fox sighting was not memorable. It was morning, late winter, at the Scoresby Freeway reservation and in the distance amongst rabbits and weeds, but the fourth fox sighting was the best of all, and the worst, as I didn't have the camera with me.

It was two years later and March again and the morning began wet and overcast. I made a late decision to risk the weather, but thought it wiser not to take the camera with the threat of rain. By the time I arrived at Bushy Park (the farmland side of the creek this time) the keen northerly had blown the rain away. As I wandered down the hill I saw a movement in the long grass ahead of me. Again I thought of a hare, but this was bigger and, as I watched, it moved again. A fox! Totally

Fox photographed at Keith Turnbull Research Institute (not in Dandenong Creek Valley) March 1998 oblivious to my presence, not 10 m away! It was attempting to pounce on something, a House Mouse or rat, either for its breakfast or a last morsel before retiring for the day. The fox's head was cocked, a whirl of a turn, a leap and all concentration on its prey and I regretted having no camera for five long minutes until I moved enough to attract its attention. The fox checked me out, then decided there was safety in discretion and it loped away into the nearby remnant.

There was no more rain again that day, and I vowed then never to venture out at that time of the year without the camera. And I give you fair warning that if you happen to encounter a mad woman with camera and zoom lens in any out of the way spots of urban parklands in March, then you are probably looking at me.

Anne Morton
10 Rupicola Crt
Rowville, Victoria 3178

Wombats in winter

Over the years I have wondered how wombats go about their life in a snow-covered landscape. The Common Wombat *Vombatus ursinus* does not fit the bill as an animal of deep snows, it has short legs, a fairly high ratio of weight to foot surface area and feeds primarily on grass (Triggs 1988). The species was certainly caught out in deep snow in the big winter of 1981 when numbers crashed. It seems only fairly recently that numbers have recovered and pushed up into some higher areas where I have no recollection of them in the 1970s or 1980s. The grid that has been live trapped to monitor Broad-toothed Rats *Mastacomys fuscus* since 1978 never had problems with wombats upsetting traps until recent years – then again, Swamp Wallabies *Wallabia bicolor* didn't occur there either until about the same time - that warmest decade of the century, the 1990s. In the 1980s, however, in the areas I was studying, there wasn't much opportunity to take an interest in wombats – they just weren't there.

The January-February 2003 fires brought the need to look at the mammals in the Snowy Mountains and how they were coping with their first winter post-fire, so I was forced to find the time to take that interest in wombats I'd always professed. There were other species that were just as time consuming though, but in different seasons. For small mammals, such as the Broad-toothed Rat, there was the annual live-trapping program in February and early April to catch, mark, weigh and check on the animal's condition before its release. For the Mountain Pygmy Possum *Burramys parvus*, this is done only in early December at the same time as the first post-winter monitoring of Broad-toothed Rats. For other animals, such as feral foxes, there has been regular monitoring of a scat transect and of tracks on the snow to check on numbers in relation to the control program conducted each winter.

The large areas where undergrowth did not regenerate after the fires allowed access by skis to areas that previously were often inaccessible in the variable (read shallow) Australian snow. As I moved around after the wombats, I found plentiful evidence of Common Ringtail Possums *Pseudocheirus peregrinus* in both unburnt and burnt areas (they seem to have a preferred tree under which, possibly while grooming, they deposit their droppings for the night). Swamp Wallabies seemed more visible too and I was able to watch an individual from about 20 m as it stretched its forepaws through a hole in the snow in a bank and pulled out pawfuls of vegetation to eat, sometimes 'one handed', sometimes less casually using both paws.

Of all the mammals that occur above the snowline, the one that seems easiest to follow is the wombat. It has a home range, burrows that it visits on its nightly rounds, it leaves tracks on the snow in profusion and has well-used routes. So the past winter saw me out after each snowfall for the ensuing two days, following five wombats on one day and a different four on another – until the tracks became too confused and I had to wait for the next snowfall. The aim of the study was to look at wombats in totally burnt areas and compare their home range and feeding with wombats that had access to both burnt and unburnt areas.

One thought I had was that although wombats may be good at surviving bushfires by using their burrow as a fire-proof bunker, they may have trouble with the ensuing winter. However, one advantage for the wombat in these conditions is its ability to live on almost nothing. It has a stomach that is a third larger for its weight than occurs in other herbivores, it uses fermentation as a second step in digestion and, overall, wombats are three times more efficient than kangaroos in the use of food. The results of this study, especially the analysis of their food from droppings, will take some time to put together, but the winter's work did reveal some interesting facts about wombats. How, I always wondered, does a wombat find its way in the snow? In a 'normal' wombat landscape there are well-worn paths, there are piles of dung deposited on high spots, and there may be other scent marks along their routes, but what happens when the tracks are covered and the scent marks are buried beneath the snow? The wombats were still able to find buried burrows – digging down through more than a metre and a half of snow to one burrow I examined and finding the entrance exactly. In another case, however, the wombat missed the mark by about a metre and had to dig a trench downhill to the entrance. Following a wombat's track I noticed small brown marks in the snow. At first I thought they were meltwater drops out of the trees, but there was one drop after every fourth footprint. The wombat was carefully marking its outward trail in deep fresh snow and, at the end of the night, the track came back and merged with itself for the run back to the burrow. Once I knew what I was looking for, I regularly found these drops on wombat trails in new snow.

Most of the time, I could follow the wombat's nightly trip, seeing where it had dug away the snow to reach grass, where it had gnawed bark off the base of a tree trunk, dug out roots, and met another wombat way up on the Kerries, where no right-minded wombat would be found in a 'normal' year (and follow its tracks where it was chased by the other wombat from over Finns River way), but one wombat was able to keep some of its nocturnal wanderings a secret. As James Woodford writes, "Wombats seem to suffer life above ground as a necessary evil." One wombat in an unburnt patch in the Whites River area took this to extremes. Its patch consisted of old thick Mountain Plum Pines *Podocarpus lawrencei* and other shrubs. These held the snow off the ground and provided a large subnivean space, which is normally only occupied by the small mammals – rodents and antechinuses. But this subnivean space was big enough for the wombat to forage beneath while I could ski over the top. This, by the way, seems to be the record for the world's largest subnivean inhabitant! It must have foraged there for nearly two full nights, seemingly only coming out from beneath the snow to cross a vehicle trail and then disappear back under the snow.

So how did they survive the fire? While one wombat, living and foraging in a burnt area on the walk into Rainbow Lake, went up to the edge of the unburnt habitat, it never foraged there. Another wombat, with two burrows in unburnt bush above the main road between Smiggin Holes and Perisher Valley, would regularly cross the road to the burnt area below the road. This had a number of advantages. Firstly, wombats are able to feed on the shortest blades of grass. This was obviously handy with all the fresh green pick that came back after the fire. Additionally, the fresh green grass was on a north-facing slope and, for most of the winter, was bare of snow, making the grazing easier. For this wombat, the biggest danger in the winter after surviving the fire was crossing the road!

Ken Green
National Parks and Wildlife Service,
PO Box 2228, Jindabyne, NSW 2627

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Ronald Calder Kershaw

1920-2003

The death of Ron Kershaw in Launceston, Tasmania in March 2003 not only brought to a close a life-time contribution to the knowledge of the Tasmanian mollusc fauna and support for the FNCV, but also brought to an end a membership of the Club by the Kershaw family, which stretched back four generations to the inaugural meeting of the Club in 1880. Ron Kershaw was made an Honorary member of the FNCV in 1986.

Ron was a born field naturalist. His great-grandfather, William Kershaw, was an original member of the Club, a keen entomologist and the taxidermist at the National Museum of Victoria. His grandfather, James Kershaw, was Director of the National Museum and a noted field naturalist, who served as President of the FNCV on a number of occasions. From an early age Ron was encouraged to take an interest in natural history and he quickly established his main interests, in geology and also in shells. He used to tell of meeting some of the leading specialists in these fields, both at his grandfather's home and at Club meetings and excursions – people such as Charles Gabriel who greatly influenced him in his later work on molluscs.

Like so many of his generation, Ron was called for active war service and spent time in the Western Desert and Middle East as well as Northern Australia and New Guinea. After the war he moved to Tasmania and was first a farmer and then a technical officer with the Department of Agriculture where his knowledge of geology assisted in his work on soil structure and testing. He published articles in the *The Victorian Naturalist* and elsewhere on the geology and geomorphology of Flinders Island and northern Tasmania, and on the marine and land mollusc fauna of both Tasmania and Victoria. At this time there was really no-one in Tasmania except Ron taking an active interest in documenting, collecting and describing the large, varied and, where non-marine fauna was concerned, the mainly endemic fauna of the state. For over 20 years, Ron single-handedly carried forward the study of this important part of the fauna, collecting from all round the state. He carried on an active correspondence with specialists both in Australia and around the world to get specimens identified and to buy or beg literature to further his studies. He was doing most of this from home, paying expenses out of his own pocket, while working at a busy family business and bringing up a young family.

Gradually he became more interested in the land mollusc fauna and published a number of descriptions of new genera and species, and co-authored two field guides and handbooks on this fauna to assist other field workers and amateur naturalists. His large and significant shell collection and his malacological library were donated to the Queen Victoria Museum and Art Gallery a few years before his death. Ron was very much in the grand tradition, in the field of natural history in Tasmania and Australia, of the highly gifted and dedicated non-professionals who made a significant contribution to their chosen field of interest and study. He stands well in the same company as Legrand, Petterd, Gatliff and Gabriel.

Brian J. Smith
Curator of Zoology
Queen Victoria Museum and Art Gallery
Launceston, Tasmania

Eric Allan

1909 – 2002

Eric Allan was elected to the FNCV in 1955. He served the Club in various ways over a 15-year period, as Assistant Librarian in 1957-58; Sales Officer 1959; Council member 1961-68; acting President 1967-68; President 1968-70 and Immediate Past President 1970-72. He became an Honorary Member in 1995. Eric contributed several papers to *The Victorian Naturalist* between 1961-1978 on many diverse topics including Spider Crabs and Sacred Kingfisher. He was a Trustee of the MA Ingram Trust during this time.

Eric, an accountant by profession, was involved in many other organisations, notably the Scouting movement. He was a Scout Leader for many years and spent much time with the Scouts at 10th Malvern Scout Group and in the training of Scout leaders at the Gilwell Park Scout Camp near Gembrook. Through Scouting, Eric was able to introduce large numbers of young people to the values of respect for nature and the Australian environment.

The family had a holiday home at McCrae and more recently at Blairgowrie. From there Eric became very involved with the Friends of Arthurs Seat Park and the Mornington Peninsula National Park (then known as the Nepean National Park). Many hours were spent working on walking tracks throughout the parks, including the Two Bays Walking Track. By the time the tracks were completed Eric was in his eighties. He later became active with the Friends of the Early Settlers Graves at Sorrento. In more recent years, Eric was also an active member of the Friends of Gardiner's Creek near his home in Ashburton.

Eric's interests in the natural world also extended to other organisations, including Friends of the Zoo, Victorian National Parks Association, the Yarra Valley Conservation League, the BP Guild of Old Scouts and member and office bearer of the Bird Observers Club. For over fifty years he was a trustee of the Ingram Trust, a philanthropic trust dedicated to supporting nature conservation projects.

Eric Allan died at his home in Ashburton on 4 September 2002, at the age of 93 years.

From information supplied by **David Allan, Tom Sault and Sheila Houghton**

Frederick Charles Wesley Barton

1909 – 2003

Fred Barton, who died in September 2003, was elected to the FNCV as an associate member in 1926, at the age of seventeen. In April 1935 he wrote to the Club, informing them of the resignation of himself and his sister, because the effect of the Depression on farming had meant that they could no longer afford the subscriptions. The Council, aware of Fred's active interest in natural history, was sympathetic and offered to send *The Victorian Naturalist* gratis, which Fred appreciated. Conditions improved and Fred was re-elected as a full country member in May 1937, so apart from this brief two-year break, he was a member for seventy-seven years, a record probably equalled only by Alexander Burns.

In 1980 he sent congratulations to the Club on its centenary, and in his letter he said he had been 'reading with considerable interest the articles with reference to the early history of the Club', and went on to say that many of the names brought back to him 'the very happy associations' he had, mentioning in particular the 'enjoyable bush rambles with TS Hart to whom I owed my early interest in and knowledge of the native flora', even before 1926. Others who had assisted him in his study of natural history included HB Williamson, Charles Barrett, AD Hardy, Edith Coleman and Hugh Stewart. Hardy was the Honorary Secretary and Barrett a member of the committee of management of the Lakes National Park in the 1930s, which would have brought Fred into contact with them.

The Bartons lived at Paynesville and Fred's particular interest was in birds. His articles published in *The Victorian Naturalist* between 1926 and 1959 deal almost exclusively with birds, and the early ones are extracts from his diary. In 1929 he was particularly pleased that a bird sanctuary had been established on Spermwhale Head, where the family owned a farm. This was sold in the 1950s to become part of the Lakes National Park. Rotomah Island was also farmed by the Barton family, until this was sold in 1976 to extend the Lakes National Park. The RAOU observatory was set up there in 1979, a development which must have given great satisfaction to a very keen naturalist and bird-lover.

Fred Barton was made an Honorary member of the FNCV in 1977.

Sheila Houghton
12 Scenic Crt, Gisborne
Victoria 3437

We also note with regret the deaths of Steven Marshall, Robert Croll, Alan Beasley and Victor Jacobs

Vincent Steven Marshall

Steve Marshall was elected to the FNCV in 1958 and became an Honorary Member in 1998. He was Secretary of the Botany Group in 1963-64. He died in 2003.

Robert Devereaux Croll

Robert Croll, a former member of the FNCV, was first elected in 1929 as an Associate Member, and contributed several articles to *The Victorian Naturalist* in the mid-1930s. He was re-elected as a joint member with his wife Greitje in 1988. His father, Robert Henderson Croll, a well-known anthropologist, was President in 1938-39 and was the designer of the first die for the Australian Natural History Medallion. The Medallion from this die, first awarded to Alec Chisholm, was presented from 1940 to 1980.

Alan Wakefield Beasley

Although not a regular member of the FNCV, Alan Beasley was a frequent contributor to *The Victorian Naturalist* over a 30-year period, with articles on topics ranging from olivine in volcanic bombs, uses of clay, and geology of popular places in the Western MacDonnell Ranges. He was Curator of Minerals at the National Museum of Victoria and died in October 2003.

Victor Jacobs

Victor Jacobs was elected to the FNCV in March 1952 as a Country member from Moonambel. After a brief lapse, he was re-elected in 1958 and became an Honorary member in 1998. He was a teacher at Doveton State School and later became Principal of Upwey Primary School. Between 1963 and 1973 he contributed nature observations to the series 'Readers' Notes and Queries' which featured in *The Victorian Naturalist* at this time. Longer articles dealt with trips to various National Parks, e.g. 'The Search for Rudd's Rocks' being an account of the visit of a party of Grade 6 children to Wyperfeld National Park in 1973.

His interests were fairly general and he was keen on a nature study approach to natural history, not surprising in his profession.

Compiled from information supplied
by **Sheila Houghton**
12 Scenic Crt, Gisborne
Victoria 3437

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

The Genus Mycena in South-Eastern Australia

by Cheryl A. Grgurinovic

Publisher: *Fungal Diversity Press and the Australian Biological Resources Study, 2002. 329 pp, hardback. RRP US$80.*

The genus *Mycena* is a diverse group of small white-spored gilled mushrooms, growing on wood and litter, distinguished by a slender stipe and the lack of velar remnants. This long-awaited book is a major step in the slow process of elucidating the agaricoid fungi of Australia, tackling a genus that forms a conspicuous part of the mycota of this continent. A measure of the difficulty of the task is that only 66 *Mycena* species are treated, a fraction of the species likely to be encountered out in the bush. The work is based upon the PhD dissertation that the author completed in 1997. Twenty species and one variety are proposed as new, together with three new sections.

The early part of the book is devoted to the taxonomic position of the genus and to its previous treatment by mycologists. The history of the classification of the genus *Mycena*, progressing from macromorphology to micromorphology, is essential, but the 17-page table comparing the subgeneric classification systems of four leading mycologists who have wrestled with the taxonomic issues surrounding this complex genus, whilst essential in a PhD thesis, is superfluous in a regional book about south east Australia. This reviewer would have liked to see these pages devoted to the inclusion of additional species beyond the 66 that were treated.

It is very satisfying for the field naturalist to be able to match a specimen to a description in a book and obtain a name for it. My partner Genevieve and I were able to identify our 'blister Mycena' as *Mycena albidofusca*, our dark brown 'sticky date' as *M. mulawaestris*, our 'bleach sulcate' as *M. carmeliana* and a small red species clearly different from *M. viscidocruenta* and *M. sanguinolenta* as *M. toyerlaricola*. However, there are many other common *Mycena* species in Tasmania and presumably other parts of southeastern Australia that are absent from this book. For example, our 'grey rubbery', 'liver gills', 'pink-yellow with iodine odour', several small white species differing from *M. albidocapillaris* and from each other in odour, stipe colour or degree of glutinosity, and many distinct grey-brown species, could not be matched with names in the book.

The microscopic drawings of spores, basidia, and cystidia are of a very high standard, and are to be welcomed by anyone trying to differentiate between closely related species on the basis of their microscopic features. The book is reasonably user-friendly to the field naturalist with an interest in fungi who has access to a good compound microscope. However, nothing beats a good photograph and the first thing we did was scrutinise the 30 colour plates in the front of the book, which include 20 superb ones by Bruce Fuhrer, taken in the field under natural conditions. What a pity there weren't more of these photos!

The keys to the 21 sections and to the species have been presented very professionally using a detailed combination of macroscopic characters such as colour, glutinosity, presence or absence of a gill margin, whether latex is exuded upon crushing, etc., and microscopic characters of the cap, gill and stipe. This may be heavy going for the field naturalist and perhaps an artificial key for use in the field based solely upon observable macrocharacters such as colour, odour, gill attachment and photos could be produced to supplement this book.

The author has drawn a few unsettling taxonomic conclusions, proposing that what has been regarded as *Mycena sanguinolenta*, *M. epipterygia* and *M. pura* in Australia are not the 'true' forms of those species as they are understood elsewhere, thereby requiring new names for their Australian counterparts. These decisions were based upon morphology, and no mention is made of mating compatibility studies or DNA work to support the erection of new species.

The book is well presented, with quality binding and paper, and is a must for the library of every serious mycologist. It augurs well for the future if the Fungal Diversity Press, based in Hong Kong, continues to support the publication of taxonomic studies in Australia either alone or in collaboration with another body, in this case the ABRS. There is still a long way to go, as the vast majority of Australia's mycota remains undescribed and unpublished. Although this book is a great start towards the process of documenting *Mycena* in Australia, it is not the 'definitive' work on that genus, but only the beginning. This is not a criticism of the author but reflects the enormity of the task and the lack of concerted taxonomic effort in the past and at the present time, not only on that genus but also on all species-rich genera of the Australian mycota. We will need many more books like this one if our fungi are ever to become adequately known and identified.

David Ratkowsky
Private Bag 54, Hobart,
Tasmania 7001

The Flight of the Emu: A Hundred Years of Australian Ornithology 1901-2001

by Libby Robin

Publisher: *Melbourne University Press, 2002. 492 pp. RRP $69.00.*

The Flight of the Emu was commissioned by the Royal Australasian Ornithologists Union (RAOU), now known as Birds Australia, to celebrate its centenary. The thrust of the book is about ornithologists, their work, beliefs and attitudes; and about how they shaped major events and policy development of the organisations to which they belonged.

The book is divided into four sections, each of three chapters. Each section covers about one quarter of the century, with the exception of the first section which includes important activities in the colonial period. Each section is followed by an 'Interlude', consisting of an essay on a particular bird species, namely the Night Parrot, the Lyrebird and the Noisy Scrub-bird.

During the colonial period and the early years of the century, museums and private individuals acquired significant bird skin and egg collections. The results of these activities, so well described, formed the basis for the understanding of the classification and distribution of Australian birds. Many of the present field naturalist societies had their beginnings during this time. It was largely from these ranks that the RAOU was formed in 1901. The stated objectives were 'the advancement and popularisation of the science of ornithology, the protection of a useful and ornamental avifauna, and the publication of a magazine called The Emu'. These have not changed significantly with time, however *The Emu* is now published by CSIRO.

By mid-century there was a growing realisation that many Australian bird species were in danger of extinction, largely due to the loss of key habitats resulting from expanding agriculture. Less important were the activities of the feather and aviary trades, the inroads of bird skin and egg collectors and the slaughter of so-called 'pest' species. These latter threats have now been largely controlled by appropriate legislation and enforcement agencies. Also discussed are the positive effects on public attitudes to birds by the successful activities of the Gould League in our schools and the influence of nature radio programs such as that of Crosbie Morrison and his magazine *Wildlife*. Studies on bird migration also increased during this period. These activities, together with the formation of the National Bird Banding Scheme, are described.

Funding for science teaching and research increased in the decades immediately after World War II and in turn this led to an expansion of Australian ornithological research. The key areas of activity and tensions within the scientific community of the period are well described. During part of this time RAOU's administration was in a state of some disarray, and there was serious debate about the place of RAOU in the ornithological community. The competing needs were from those interested in the serious study of bird biology (often conducted by professionals) versus the needs of birdwatchers whose hobby was largely concerned with personal pleasure. This debate is of course still active, and is the dilemma of all organisations with a diverse membership. The final chapter in the section covers the first International Ornithological Congress to be held in Australia in 1974.

During the last quarter of the century environmental management became part of the mainstream of Australian life. It was during this period that the modern bird field guides were published and all manner of other bird books, from the popular to the more technical, became a must in any respectable publisher's list. The most significant ornithological publishing project of the era has been RAOU's *The Handbook of Australian, New Zealand and Antarctic Birds*. The management of this project, due to be completed with Volume 7 in 2004, is well described. This section also covers in some detail the major national and regional bird atlas projects and wader bird migratory studies which commenced in this period.

An Epilogue concludes the book and comments on the differences between professionals and amateurs and their interdependence in field ornithology studies. I cannot agree with all the author's comments. Although the data collection phase is often the 'fun bit', the 'boring bits' are as much a vital part of the complete study, and often require considerable technical knowledge and training. The sentence 'There is a growing number of semi-professional publications, designed for and by amateurs, that place data in the public domain', prompts the reply, 'so what?' The fact that a publication is in the public domain does not necessarily mean that it is good science. Whether the work is conducted by professionals or amateurs is irrelevant. In my experience as a research worker, to assume that 'the amateur view is different, morally charged, more passionate' when compared to the 'professional' is not necessarily true. Neither are the attributes of 'morally charged and passionate' exclusively those of amateurs, nor are they prerequisites for the conduct of sound research and environmental management programs.

Six Appendices conclude the book. Three of these list RAOU staff, conference and camp-out venues and need no comment. Appendix 1 is a rather arbitrary list of biographies of a large number of individuals who have played a role in the history of our ornithology and related fields. Appendix 4 is a compilation of all the titles of publications relative to specialist bird study held by Birds Australia library and the National Library of Australia. It is disappointing that no distinction is made between refereed and non-refereed publications, and a number of relevant publications are omitted - *CSIRO Wildlife Research* and *The Victorian Naturalist* to name but two.

The book has many photographs and illustrations of both people and birds. Unfortunately it is spoilt somewhat by a lack of rigorous editing and contains a number of errors and inconsistencies. Two examples make the point. The chairperson of a Standing Committee on Conservation was Brigadier Hugh Officer and not Brigadier Hugh Wilson as stated on p. 140, and inconsistency of abbreviations - RAOU/BA (p. 333) versus RAOU/Birds Australia (p. 335). Despite these flaws *The Flight of the Emu* would make a valuable edition to any ornithological library and I highly recommend it to all those with an interest in Australian ornithology and related fields.

Ian Wardrop
9 Merrion Place, Kew
Victoria 3101

Citizen Labillardière: A Naturalist's Life in Revolution and Exploration (1755 – 1834)

by Edward Duyker

Publisher: *The Miegunyah Press, Melbourne 2003. 408 pp, 18 b & w illustrations, 12 maps, ISBN 0-522-85010-3, RRP $59.95*

On 28 September 1791, an expedition left revolutionary France to seek an explorer who had last been seen by Europeans at Botany Bay two and a half years earlier. The missing explorer was Jean-Francois de Galaup de la Perouse; the commander of the new expedition was Antoine Raymond Joseph Bruny d'Entrecasteaux. The vessels *Recherche* and *Esperance* carried a party aware that, with the abolition of aristocratic and clerical privileges, this expedition offered potential glory, the possibility that order and royal authority would be restored by the time the ships returned, and opportunities for astronomers, hydrographers and naturalists. One of these naturalists was Jacques-Julien Houtou de Labillardiere (1755–1834), whose luggage included 22 reams of paper for pressing plants and a letter from Sir Joseph Banks.

Labillardière had told Banks that botany was to be his principal occupation, but that he would 'endeavour not to entirely neglect the other parts of natural history.' This traveler-naturalist was born in the lace-making town of Alençon and had studied medicine at Montpellier, then at Reims and Paris, where he was influenced by Louis-Guillame Le Monnier, royal physician and professor of botany at the Jardin du Roi, who had dispatched students to Persia, French Guyana, the Indies, China, the Atlas Mountains and around the Mediterranean. Such opportunities interested Labillardière more than general medical practice or a hospital appointment.

His first overseas journey was to study exotic plants being cultivated in Britain; he also began a friendship with Sir Joseph Banks. A journey to the French Alps, Italy and Sardinia followed. A mixture of classical and applied botany provided impetus for an extended journey to Lebanon and Syria, where he intended to study 'the plants of the ancients' and the forests of the Near East with relation to the timber needs of the French Navy. Labillardière's interests, however, were not limited to plants, but included all manifestations of natural history. Such travels improved his skills as a collector and observer of nature; 'they also confirmed a resourceful, confident and independent spirit at a time when long journeys abroad were truly exceptional.'

But what was this accomplished traveller-naturalist really like? He mentions developing skills at drawing – so he could 'represent the superb mountains which I propose to see' – but there are no surviving matching manuscripts. More is known about the books in the library of his school than about the student. With no diaries, few personal letters, and only an occasional appearance in someone else's reminiscences, Labillardière appears like a blank cardboard cut-out in exotic landscapes.

He had returned to France in 1788 to find the country in the turmoil of revolution. It is known that he became a committed republican, but there are few records of his emotions or actions during this period. He apparently saw the *Academie des Sciences* and the d'Entrecasteaux expedition as keys to his advancement.

His account of this voyage conveys a sense of wonder, excitement and unsatisfied curiosity, whether scrambling up a lava-strewn dormant volcano in the Canary Islands; climbing a fissure to the top of Table Mountain; exploring the 'ancient forests' of Tasmania, where he found the tribal groups gentle and hospitable; or shooting to impress a threatening Tongan crowd; and always collecting, even in cannibal country. He was interested in fish, zooplankton, birds, crabs, fungi, mosses, lizards, seals, rocks and shells, and in the geophysical, astronomical and navigational observations of the other scientific staff.

d'Entrecasteaux wanted to go where no other Europeans had been, and after leaving Tasmania, Labillardière collected in

New Caledonia, various Melanesian islands, then Ambon. d'Entrecasteaux followed the Australian coast from Cape Leeuwin almost to Ceduna, naming the Recherche Archipelago (near Esperance). A shortage of water caused the expedition to return to Tasmania, after which it continued on to Tongatabou, New Caledonia, Santa Cruz Islands, Solomon Islands, New Britain, New Ireland, and Waigeo. There was scurvy and water shortage, spiteful tensions between naturalists and naval officers, and a 40% mortality rate. With the deaths of Huon de Kermadec, Captain of the *Esperance*, and the Commander, d'Entrecasteaux, in July 1793, the expedition disintegrated. The new commander, a royalist sympathiser, deeply resented Labillardière's lack of deference to naval authority, seized his specimens and tried to seize his journal.

At Surabaya, on 25 October, the expedition discovered that France and the Netherlands had been at war for 8 months; that France was also at war with England, Prussia, Austria and Spain; that the republic had been declared and that Louis XVI had been executed. Despite this, Labillardière took the opportunity to botanise. The Dutch feared republican mutiny on board the ships, and Labillardière was among those arrested. The ships were sold to the Dutch in an attempt to repay debts. The expedition's papers and collections were seized when British raiders captured the Dutch convoy returning to the Netherlands.

Labillardière remained in Batavia until the Dutch gave permission for his departure, then spent 6 months on Mauritius, returning to France on 12 March 1796 – four and a half years after he had left. Labillardière asked Banks and Smith (of Linnaean Society) to return his collections, which Banks described as 'a vast herbarium collected in all places where the ship touched, a large collection of dried birds, a considerable number of dried lizards and snakes, some fish in spirits, and some insects…' While Banks was using moral persuasion to get the collections returned, Labillardière was in Italy, officially 'booty-hunting' for France, selecting art works and other cultural treasures after the military victories of 1796.

The three years following his return from Italy were spent in editing his account of the voyage of d'Entrecasteaux – *Relation du voyage a la recherché de La Perouse* – with an atlas of engravings based on Piron's sketches, plant illustrations by Redoute, and bird illustrations by Audebert. This became a best-seller, not only in France, but also in England and Germany. On 26 November 1800 Labillardière was elected a full member of the botanical section of the institute which had replaced the former royal academies. Contact with international botanists was interrupted by war, but *Novae Hollandiae plantarum specimen* in two volumes with 265 plates, regarded as 'the first general flora of Australia', was published 1804-07; *Setum austro-caledonicum* in two parts followed in 1824 and 1825. The elegant plant names Labillardière coined are now part of our language. He named the floral emblems of Tasmania (*Eucalyptus globulus*) and Victoria (*Epacris impressa*).

Labillardière died 8 January 1834. In his last surviving letter, he urged the introduction into the South of France of five Eucalyptus species, including *E. globulus*, and the planting of *Casuarina*, Leatherwood, and Celery-top Pine. His library and collections were sold to pay death duties, and are now kept in the University of Florence.

The expedition failed to find La Perouse, but it is commemorated in names, both geographical and botanical. Geographical features include the Huon River and d'Entrecasteaux Channel (Tasmania), Kermadec Island (in the Pacific), Recherche Archipelago and Labillardière Peninsula (Bruny Island). At this time the discovery of new species and genera was seen as the culmination of botanical success. Some fifty of the plant genera established by Labillardière survive. His interests, however, went beyond collecting, to applied botany (such as *Phormium tenax* for naval cordage and *Eucalyptus globulus* for ship-building), studies of animal behaviour and physiology, perceptions of commercial or military value, and the ethnography of indigenous communities. In cataloguing and celebrating the many splendours of the natural world Labillardière was often a pioneer. He made important observations, for example, about how birds respire through their bones, and how the female praying mantis copulates while cannibalising her male partners.

This book is painstakingly researched and elegantly written. Unlike many books which deal with plants, there is an excellent balance between the recording of scientific names and detailed descriptions, for example, '...Labillardière noticed several exotic species brought by earlier seafarers, including the lemon balm *Melissa*; the beautiful but poisonous *Datura metel*, with its 20 centimetre-long flowers, from Southern China; and poinsettia *(Euphorbia pulcherrima)* from Mexico.'

There is little sense of Labillardière's personality, but once the reader is accustomed to this, and sees him as a very dedicated and efficient explorer and collector, in fact, as a 'type specimen' of 'naturalist', this book can be read for history, for travel, for botany – but, above all, for pleasure.

Citizen Labillardière contains useful glossaries and appendix, comprehensive notes, an extensive bibliography, and botanical, zoological and general indices.

Gwen Pascoe
192 Progress Road
Eltham, Victoria 3095

One Hundred Years Ago

EXCURSION TO LAUNCHING PLACE

This excursion, extending from Saturday, 7th November, to Monday, the 9th was well attended ad proved very enjoyable. Launching Place, [is] situated on the south bank of the Upper Yarra, distant 41 miles from Melbourne by railway, and 14 miles by road from Healesville across the Watts and Yarra divide.

Launching Place! What a misleading name! On hearing it for the first time, one, not initiated into the mysteries and incongruities of our local geographical nomenclature, might conjure up a scene on the Gippsland Lakes or the sea coast, where some stately ship might take its initial plunge into the broad waters. The shallow, crooked stream, hurrying and gurgling 'mid scented shrubberies, its surface broken by boulder and snag, could hardly accommodate a canoe for more than a few hundred yards at a stretch. Yet here, in days that passed with the opening up of country by road and rail, miners and others did their carrying trade by means of flat-bottomed boats - themselves often wading whilst towing - to parts remote from the highway. And, at this spot, the boats, kept high and dry when not in use, were launched for the water carriage of merchandise. Hence the name.

From *The Victorian Naturalist*, **XX**, p 116, January 14, 1904

AUSTRALIAN SPIDERS

At a recent meeting of the Zoological Society of London, Mr R.I. Pocock, the new superintendent of the society's gardens, called attention to a remarkable habit of some Australian spiders belonging to the genus Desis. These spiders, he stated, live in the crevices of rocks between tide-marks on the shore, and by spinning a closely woven sheet of silk over the entrance, imprison a mass of air, in which they are able to live during high tide.

From *The Victorian Naturalist* **XX**, p 140, February 4, 1904

The Field Naturalists Club of Victoria Inc.

Reg No A0033611X

Established 1880

In which is incorporated the Microscopical Society of Victoria

OBJECTIVES: ***To stimulate interest in natural history and to preserve and protect Australian flora and fauna.***

Membership is open to any person interested in natural history and includes beginners as well as experienced naturalists.

Registered Office: FNCV, 1 Gardenia Street, Blackburn, Victoria 3130, Australia.

Postal Address: FNCV, Locked Bag 3, PO Blackburn, Victoria 3130, Australia.

Phone/Fax (03) 9877 9860; International Phone/Fax 61 3 9877 9860.

Patron

John Landy, AC, MBE, The Governor of Victoria

Key Office-Bearers

President: Ms Wendy Clark, 97 Pakenham Street, Blackburn 3130. 9877 9266

Vice Presidents: Dr Noel Schleiger, 1 Astley Street, Montmorency 3094. 9435 8408 and Dr Alan Yen, 52-54 Brushy Park Road, Wonga Park, 3115. 9722 1665

Hon. Secretary: Ms Karen George, 63 Jesmond Road, Croydon 3136. AH 9725 5283

Hon. Treasurer: Ms Barbara Burns, 16 Montclair Court, Templestowe 3106. 9846 2608

Subscription-Secretary: FNCV, Locked Bag 3, PO Blackburn 3130. 9877 9860

Editors, The Vic. Nat.: Mrs Anne Morton, 10 Rupicola Court, Rowville 3178. 9790 0656, Mr Gary Presland, 40 William Street, Box Hill 3128. 9890 9288 and Dr Maria Gibson, 8 Niel Street, Croydon 3136. 9723 4772

Librarian: Mrs Sheila Houghton, FNCV, Locked Bag 3, PO Blackburn 3130. AH 5428 4097

Excursion Co-ordinator: Mr Dennis Meltzer, 8 Harcourt Avenue, Caulfield 3162. 9523 1853

Book Brokerage: Mr Ray White, 9 Longtown Court, Craigieburn 3064. AH 9308 3770

Newsletter Editors: Mrs Joan Broadberry, 2 Shaun Court, Templestowe 3106. 9846 1218 and Dr Noel Schleiger, as above.

Conservation Coordinator: Mr Jim Walker, 167 Balaclava Road, Caulfield 3162. 9527 5601

Group Secretaries

Botany: Mr Geoff Lay, 2 Kerry Pde, Box Hill North 3129. 9898 4816

Geology: Mr Rob Hamson, 5 Foster Street, McKinnon 3204. 9557 5215

Fauna Survey: Ms Sally Bewsher, 12 Hilton Grove, Belgrave 3160. AH 9754 8182

Marine Research: Mr Michael Lyons, 18 High Street, Nunawading 3131. AH 9877 3987

Microscopical: Mr Ray Power, 36 Schotters Road, Mernda 3754. 9717 3511

Terrestrial Invertebrate: Dr Alan Yen, as above.

MEMBERSHIP

Members receive *The Victorian Naturalist* and the monthly *Field Nat News* free. The Club organises several monthly meetings and excursions Members are welcome to attend all activities. Visitors are also welcomed, but please note that a $5 fee may apply to non-members on some group activities (this includes insurance).

Yearly Subscription Rates – The Field Naturalists Club of Victoria Inc.

Membership

Metropolitan	$55
Concessional (pensioner/student/unemployed)	$45
Country (more than 50 km from GPO)	$45
Junior	$15
Family (at same address)	$70

Institutional

Libraries and Institutions (within Australia)	$100
Libraries and Institutions (overseas)	AU$110
Schools/Clubs	$55

Send to: FNCV, Locked Bag 3, PO Blackburn, Victoria 3130, Australia.

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The Victorian Naturalist

Index to

Volume 120, 2003

Compiled by KN Bell

Issue 6 forms the Biodiversity Symposium Special Issue

The Field Naturalists Club of Victoria Inc.

F.N.C.V.

Reg. No A0033611X

Annual Report

Year Ending 31 December 2003

President's Report

This year we concentrated on consolidating our finances, lifting the calibre of our profile and addressing the need to upgrade our ageing systems and equipment.

Profile and Marketing

We discussed the idea of adopting a popular name that lets the public understand what we are but it was decided to educate the public by taking a higher profile and making more use of our mission statement 'Understanding our Natural World'.

We achieved this in several ways: acquisition of a banner to be used at displays and functions, running a symposium on fire called *Burning Issues* and obtaining a sponsored site at The Great Australian Science Show between 16-18 August at the Melbourne Museum.

President's Appeal

A President's Equipment Appeal to raise $20 000 was established. By the end of December 2003 we had raised $4000. The first item to be purchased early in 2004 will be a digital projector.

Program of Activities

Once again we organised a wide range of activities for our members. Notice of our activities was given in the calendar of events, published three times per year.

Publications

Early in 2003 we invested in 200 copies of *Spiders and Scorpions Commonly Found in Victoria*. As of 31/12/03 we had sold 116. Approval was given for the co-publication of *A Field Guide to the Mosses and Allied Plants of Southern Australia*.

Hall Hire and Maintenance

Hall hire netted $3605. Graham Lorimer ran a successful workshop on Grasses. Ian Kitchen upgraded our hall and its facilities. We appreciate his work immensely.

Finances

Our Treasurer announced during the year that we were in a healthy financial state, but late in 2003 we heard that the GVEHO grant ($10 000) we usually get each year would not be received, as criteria for the grant were changed and we were no longer eligible. Several of our members submitted a document protesting this and stating why we should be eligible. We still await the outcome.

We received a Parks Victoria Community Grant for a Leitz Stereo Microscope .

Web Site

Our Web site has been redesigned and updated by Leon Altoff. It is excellent.

Surge of Interest in Botany

Interest in Botany increased. Many interested people and high calibre speakers gathered for an inspiring meeting concerning the future structure and projects for the group.

The Loss of Some Members

Sadly, some of our long-term members passed away this year. We greatly miss John Seebeck, Ron Kershaw, Eric Allan, Ian McCann and Elspeth Sacco.

Journals and Newsletters

The Victorian Naturalist published its usual 6 issues during 2003 concluding with a special issue devoted to a review of the Victorian Fauna and Flora Guarantee Act 1988 and protection of biodiversity in the state. Also, 16 book and 2 software reviews were published. Books returned by reviewers were donated to the FNCV Library.

Alastair Evans and Merilyn Grey left the editorial team and were replaced by Gary Presland and Maria Gibson. Virgil Hubregtse joined earlier in 2003 as Assistant Editor.

Cover phototographs: Top, *Opodiphthera eucalypti* Emporer Gum Moth. Photo: Wendy Clark
Bottom, Terrestrial Invertebrate Group sorting day. Photo: Alan Yen

Eleven issues of *Field Nats News* (FNN) were produced. The FNN team changed to a new local printer thereby reducing expenditure below that of the previous year. Also we are actively seeking suitable advertising to help offset our costs.

FNCV Environment Fund

The Committee met for the first time in 2003, established a calendar of activities and produced grant application forms which were inserted into FNN. The seven successful candidates were presented with their grants at the FNCV General Meeting in August. Donations are tax-deductible, most welcome, gratefully accepted and definitely needed.

Australian Natural History Medallion

At the November meeting, the 2003 Medallion was awarded to Dr Clive Minton for his contributions to the study of waders and terns, particularly in Australia but also overseas. After the presentation Clive gave a lecture on his studies.

Future guidelines will stress the need for community involvement for those whose contributions predominantly form part of their professional activities. A total of $500 in donations was received.

Library

Forty-eight titles were added this year. Our CD collection also was added to and the Reference section expanded by addition of several subject dictionaries.

Enquiries during the year were mainly historic. A student from Melbourne University's History in the Field Unit investigated the effect of the Depression on the Field Naturalists Club of Victoria from 1929 to 1935 so made good use of our facilities.

General Meetings

Monthly general meetings provided a variety of topics, and comprehensive reports of most of these appeared in FNN.

Elections for councillors and office bearers were held at the AGM in May and were followed by reports of club progress. The Environment Fund Grants were awarded at the August meeting and the Presentation of the Australian Natural History Medallion was held in November.

Botany Group Annual Report 2003

The Botany Group held evening lectures and many varied weekend excursions. Following the large attendance at the 'Revival' meeting in July, several members came forth to help plan and prepare the program for the remainder of the year.

In 2002, an initial botanical survey was undertaken at the site of relocation of the Botanical Gardens Grey-headed Flying Foxes in Bulleen. This year two further surveys were carried out.

A long-term Botanical Survey of the Pyrete Range, which is south of Gisborne and east of Lerderderg Gorge will include monthly surveys in 2004.

Geology Group

During 2003 there were ten talks and six excursions. Visitors to our meetings and excursions are now charged $5 for both talks and excursions to cover expenses and encourage them to join the Club.

Sale and Bairnsdale Field Naturalists Clubs joined our most recent field trip to Buchan.

Junior Group

Average attendance is 50-60 at meetings and 20-30 at excursions. Age ranges from 3-20 yrs and, of course, the parents also attend. The average age of the Juniors is around 7. Several of the teenagers help run the club.

Nine meetings, 8 excursions and 3 camps were held. The *Junior Naturalist* is written, published and distributed by the Juniors 11 times per year.

General Excursions 2003

Nine excursions were held. While recognizing the fascination of the Dinosaur Dreaming dig, each and every excursion had its intrigue, with still more information to be gained. Thanks to all leaders who were so knowledgeable and enthusiastic.

Marine Research Group

The Marine Research Group held 7 meetings and 7 field trips during 2003. Field trips provided a wonderful opportunity to experience the myriad invertebrate life forms of our coasts. Many records were added to the Marine Research Group species database. Locations visited during 2003 included the Inverloch area, Port Fairy and surrounds, Mushroom Reef at Flinders, Bear Gully and Lorne.

Fungimap

The Fungimap scheme is jointly supported by the FNCV and Royal Botanic Gardens Melbourne and continues to collect distribution and ecological data on 100 target species of fungi. By the end of 2003, 703 people were on the mailing list, and more than 15,485 records had been entered into the Fungimap database.

The second National Fungimap Conference was held at Rawson, Victoria, from 15-20 May 2003, and after discussion it was agreed that the Fungimap scheme should be set up as a separate, incorporated organisation.

The Australian Heritage Commission (AHC) approached Fungimap for a second time to contribute data to their biodiversity database. A Fungimap book, designed as a field guide to all 100 target species, is due for publication late in 2004.

Conservation

The main activities in 2003 have been to continue to publish regular reports in the club's monthly newsletter, to promote our September Biodiversity month forum, (which in 2003 was about fire issues), and to lobby on various environmental issues, particularly those affecting forests.

Microscopical Group

Speakers from within the group spoke about and demonstrated practical aspects of microscopy such as slide making. Happily, there were more visitors during this year than past years.

Fauna Survey Group

The Fauna Survey Group had a busy program of surveys, meetings with guest speakers, and an educational workshop. We ran a bat workshop jointly with the Australasian Bat Society at Kinglake National Park in February. Robert Bender outlined the bat box project at Organ Pipes National Park, Lindy Lumsden talked about Grey-headed Flying Foxes and the insectivorous bats, and Matt Gibson discussed software he is writing to identify bat species from their sonographs.

Terrestial Invertebrate Group

Participation with other organisations, including Parks Victoria and the Entomological Society of Victoria, has allowed the Group to increase its membership and has supplied a list of potential speakers for future discussions.

The TIG received a Parks Victoria Volunteer Group Grant, allowing us to conduct surveys over spring and summer at Yarra Bend Park, and also to purchase a microscope and other equipment. TIG also received a grant from the FNCV Environment Fund.

Thank You

Finally, thanks to all my councillors, office bearers, group leaders, our Administration Officer Ann Williamson and other hard-working members without whom we could not have achieved so much. Thanks also to all who gave donations, enabling us to achieve so much more.

Wendy Clark
President

THE FIELD NATURALISTS CLUB OF VICTORIA INC.
FINANCIAL REPORT
Year ended 31 December 2003

REPORT BY COUNCIL

The members of Council hereby submit the Balance Sheet as at 31 December 2003 and the Statement of Income and Expenditure for the year ended on that date and report as follows:

1. The names of the Executive Council in office at the date of this report are as follows:

Name	Position on Council	Occupation	Council Member Since
Wendy Clark	President	Photographer	1998
Dr. Noel Schleiger	Vice President	Education Consultant	1990
Dr. Alan Yen	Vice President	Entomologist	2001
Karen George	Secretary	Ecologist	2003
Barbara Burns	Treasurer	Lecturer	2001
Jim Walker	Councillor	Ecologist	2001
Ian Kitchen	Councillor	Horticulturalist (Retired)	2001
Joan Broadberry	Councillor	Teacher (Retired)	2003
Mimi Pohl	Councillor	Zoology Student	2003
John Harris	Councillor	Environmental/Science Teacher	2003
Special Interest Group Representatives			
Jenny Porter	Botany	Biologist	2002
Russell Thompson	Fauna Survey	Horticulturalist	2002
Rob Hamson	Geology	Teacher	1998
Nick Andrewes	Juniors	Student	2002
Michael Lyons	Marine Research		2003
Leon Altoff	Marine Research	Analyst	2003
Audrey Falconer	Marine Research	Public Servant	2003
Ray Power	Microscopical	Engineer (Retired)	1993
Dr. Melanie Archer	Terrestrial Invertebrate	Entomologist	2002

2. The principal activities and object of the Club are to stimulate interest in natural history and to preserve and protect Australian fauna and flora. No significant changes in the nature of those activities occurred during the reporting period.

3. The net loss of the Club for the year ended 31 December 2003 was $178.85 (2002 loss of $507.22).

4. A review of the operations of the Club is contained in the President's Report, which forms part of this Annual Report.

5. No matter or circumstance has arisen since the end of the financial year, which has significantly affected or may significantly affect the operations or the state of affairs of the Club.

6. Other than as disclosed in the Annual Report, there are no significant developments likely to affect the financial results of the Club.

7. During the financial year, no member of the Council has received or become entitled to receive any benefit by reason of a contract made by the club with the councillor or with an entity of which the councillor is a member or in which the councillor has a substantial interest.

THE FIELD NATURALISTS CLUB OF VICTORIA

STATEMENT BY MEMBERS OF COUNCIL

In the opinion of the members of Council,

(a) The accompanying Statement of Profit and Loss is drawn up so as to give a true and fair view of the financial results of the Club for the year ended 31 December 2003.

(b) The accompanying Balance Sheet is drawn up as to give a true and fair view of the state of affairs of the Club as at 31 December 2003.

(c) As at the date of this statement there are reasonable grounds to believe that the Club will be able to pay its debts as and when they fall due.

SIGNED at Blackburn on this 23 day of March 2004 in accordance with a resolution of Council.

W. Clark
President

B. Burns
Treasurer

Wendy Clark

B.J. Burns

THE FIELD NATURALISTS CLUB OF VICTORIA
STATEMENT OF PROFIT AND LOSS
Year ended 31 December 2003

		2003	2002
INCOME	Membership	$35,267.68	$36,832.34
Sales	Bookshop sales	$9,533.06	10,841.52
	Less Bookshop - Cost of Sales	($7,066.35)	($7,395.48)
		$2,466.71	$3,446.04
Publications	FNCV Publications (net)	$944.10	1,757.90
	Calendar sales (net)	-	927.18
	Back issues Vic Nat	$565.30	$521.26
		$1,509.40	$3,206.34
Other Income	Hall Hire	$3,650.75	4,041.08
	Profits - Excursions & Seminars	$2,890.95	2,047.95
	Advertising - Field Nat News	$506.82	609.54
	Advertising - Vic Nat		470.00
	Profit sale FNCV products	$77.39	528.59
	Sundry Income	$731.09	298.62
	Ins. Levy - Excursions (non-members)	$346.36	$143.83
		$8,203.36	$8,139.61
Investments	Bank Interest	$652.64	507.11
	Interest Income	$15,563.44	$16,541.41
		$16,216.08	$17,048.52
Other Income	Grant for Volunteer Environment and Heritage Organisation	$10,000.00	7,290.00
	General Donations	$1,101.50	2107.00
	Donations President's Equipment Appeal	$3,597.25	
	Total Other Income	$14,698.75	$9,397.00
	Total Revenue	**$78,361.98**	**$78,069.85**

THE FIELD NATURALISTS CLUB OF VICTORIA
STATEMENT OF PROFIT AND LOSS
Year ended 31 December 2003 (continued)

EXPENDITURE		2003	2002
Publications	Vic. Nat. Printing	$11,890.10	$22,587.09
	Less Grants (N. Smith)	($1,243.00)	($3,400.50)
	Postage - Vic. Nat.	$2,922.04	3,553.22
	Sundry expenses- Vic Nat	$356.17	438.88
		$13,925.31	$23,178.69
	Newsletter Printing	$3,327.01	5,608.17
	Newsletter Postage etc	$3,254.90	3,631.55
	Calendar of events	$1,313.76	$1,822.23
		$7,895.67	$11,061.95
	Total Publications Expenses	$21,820.98	$34,240.64
	GROSS PROFIT	$56,541.00	$43,829.21
Other Expenses	Advertising, Market & Pub	$66.99	$719.05
	Annual report	$1,900.00	$2,520.00
	Junior Naturalists Postage	$551.13	
	Office Stationery etc	$841.79	$1,734.73
	Library Expenses	$1,761.02	$1,891.19
	Bank Fees	$1,192.75	$1,133.93
	Depreciation Expense	$4,314.62	$4,355.34
	Internet Provider & Virus Scan	$246.55	$340.69
	Volunteer Expenses Reimbursed	$196.12	$112.58
	FNCV Mugs	$727.28	$554.35
	Dues & Subscriptions	$128.17	$138.18
	Insurance	$3,119.93	$2,612.71
	Council Rates	$1,379.15	$641.40
	General Repairs & Maintenance	$1,285.42	$505.13
	Office Equip Repairs & Maintenance	$201.77	$737.41
	General Office Postage	$885.62	$1,336.18
	Kitchen & Bathroom Expenses	$351.08	$179.63
	Sundry Expenses	$109.36	$442.27
	Superannuation & Workers Comp	$2,094.32	$1,648.37
	Wages & Salaries	$20,230.38	$17,539.50
	Office Telephone	$976.29	$873.41
	Gas, Electricity, Water	$1,444.85	$1,437.16
	Donations	$100.00	$3,100.00
	Group Expenses	$241.24	$1,227.08
	FNCV Publs. Royalties-prior periods		$752.34
	Loss on Sale National Income Secs		$718.00
	Total Other Expenses	$44,345.83	$47,250.63
	Total Publication and Other Expenses	**$66,166.81**	**$81,491.27**
	OPERATING PROFIT (LOSS)	**12,195.17**	**($3,421.42)**
	Fungimap - See attached schedule (1)	($12,016.32)	$2,914.20
	NET PROFIT (LOSS)	**($178.85)**	**($507.22)**
Fungimap	Fungimap (1)		
	Sales	7,655.92	12,763.10
	Conference Profit	4,388.26	
	Interest Received	671.86	245.82
	Donations	440.00	21.73
	Less Bank Fees	(172.36)	(116.45)
	Less Contributon to Operating expenses	($25,000.00)	($10,000.00)
	Net Operating Deficit/Surplus	($12,016.32)	$2,914.20

FIELD NATURALISTS CLUB OF VICTORIA
CASH FLOW STATEMENT
For the Year Ended 31 December 2003

CASH FLOWS FROM OPERATING ACTIVITIES:		2003	2002
		Inflow no bracket, Outflow with brackets	
		$	$
Inflows	Net Inflows from Operations	10,220.77	
Outflows	Net Outflows from Operations		($2,646.52)
	GST	($450.81)	($574.39)
	Net Cash Flow from Operations	**$9,769.96**	**($3,220.91)**
CASH FLOWS FROM INVESTING ACTIVITIES:			
Inflows	Fauna Survey Equipment Fund		$1,200.00
	Proceeds Sale National Income Securities		7,282.00
	Proceeds Sale Esanda Debentures		4,590.00
Outflows	Equipment Purchases	($4,668.35)	($2,027.23)
	Library Book Purchases	($161.32)	
	Transfer AGC Debenture Stock	($4,007.15)	($3,745.00)
	Transfer Esanda Unsecured Notes	($5,166.29)	
	Net Cash Flow from Investing Activities	**($14,003.11)**	**$7,299.77**
CASH FLOWS FROM FINANCING ACTIVITIES:			
Inflows	Marine Research Fund	199.00	421.41
	FNCV Juniors	445.00	1,600.00
Outflows	Australian Natural History Medallion	($208.22)	2,266.32
	Transfer to Fungimap Bank A/c		($11,816.85)
	Net Cash Flow from Financing Activities	**$435.78**	**($7,529.12)**
DECREASE IN FNCV CHEQUE A/C BALANCE for year		**($3,797.37)**	**($3,450.26)**
	Cheque Account Bank Balance Start Year	19,390.04	22,840.30
	Cheque Account Bank Balance End Year	$15,592.67	$19,390.04

Note 1 Reconciliation of Net Profit with Cash Flow from Operations

Net Profit	$12,195.17
Increase in Inventory	(6,080.67)
Decrease stock of "T" shirts	(6.50)
Depreciation	4,314.62
Decrease in Debtors	278.00
Increase in Creditors	($930.66)
Net Cash Inflow from Operations	$9,769.96

FUNGIMAP Bank Account - CASH FLOW STATEMENT
For the Year Ended 31 December 2003

		2003	2002
Cash Flow From Operating Activities			
Inflows	Sales	7,655.92	12,763.10
	Conference Profit	4,388.26	
	Interest received	671.86	245.82
	Donations	440.00	21.73
Outflows	Bank fees	(172.36)	(116.45)
	Operating expenses	($25,000.00)	($10,000.00)
		($12,016.32)	2,914.20
GST not yet adjusted with FNCV		($580.71)	827.09
CHANGE IN FUNGIMAP BANK BALANCE		**($12,597.03)**	**$3,741.29**
	Opening Balance	$15,558.14	$11,816.85
	Balance 31 December 2003	$2,961.11	$15,558.14

THE FIELD NATURALISTS CLUB OF VICTORIA
STATEMENT OF ASSETS AND LIABILITIES
Year ended 31 December 2003

Assets	**2003**	**2002**
Current Assets		
FNCV Cheque Account - Note (3)	$15,592.67	$19,390.04
Fungimap Cheque Account - Note (3)	2,961.11	15,558.14
The Environment Fund Account - Note (3)	3,240.91	6,127.76
Trade Debtors		278.00
Stocks "T" Shirts & Lenses - Note (4)	371.50	365.00
Inventories (Books for Sale) - Note (4)	11,492.57	5,411.90
Total Current Assets	**$33,658.76**	**$47,130.84**
Non Current Assets		
AGC Debenture Stock - Note (5)	61,252.15	57,245.00
Treasury Corporation of Vic - Note (5)	50,000.00	50,000.00
Esanda Unsecured Notes - Note (5)	100,576.22	95,409.93
General Property Trust Units - Note (5)	23,851.00	23,851.00
	235,679.37	226,505.93
ANHM Charge Account		(208.22)
Library Holdings - Note (6)	46,591.11	46,429.79
	$282,270.48	**$272,727.50**
Non Current Assets		
Property, Plant and Equipment		
Maryborough Property - Note (7)	13,400.00	13,400.00
Clubhouse at Cost - Note (7)	171,512.00	171,512.00
Clubhouse Improvements - Note (7)	38,988.00	38,988.00
Equipment at Cost - Note (8)	57,431.64	52,763.29
Less Accumulated Depreciation - Note (8)	(37,481.07)	(33,166.45)
	$243,850.57	**$243,496.84**
Total Non current Assets	**$526,121.05**	**$516,224.34**
Total Assets	**$559,779.81**	**$563,355.18**
Liabilities		
Current Liabilities		
Sundry Creditors - Note (9)	250.00	243.00
GST Paid - GST Collected - Note (9)	(1,756.75)	(630.99)
PAYG Payable - Note (9)	693.00	888.00
Hall Hire Paid in Advance		291.66
Funds Held in Trust - Note (9)	271.00	271.00
Total Liabilities	**($542.75)**	**$1,062.67**
Net Assets	**$560,322.56**	**$562,292.51**
Equity		
Members Accumulated Funds		
Current Year Earnings/Loss	$178.85	($507.22)
+ Fungimap (deficit/surplus)	12,016.32	(2,914.20)
Current Year Earnings excluding Fungimap - Note (10)	12,195.17	(3,421.42)
General Fund b/f - Note (10)	$502,830.20	$506,251.62
	$515,025.37	**$502,830.20**

Total Specific Funds		
Marine Research Fund - Note (11)	25,466.75	25,267.75
Fauna Survey Equipment Fund	(1,451.25)	(1,451.25)
Fungimap Fund - Note (11)	2,808.78	14,731.05
FNCV Environment Fund - Note (11)	3,240.91	6,127.76
Asset Revaluation Reserve	13,187.00	13,187.00
FNCV Juniors - Note (11)	2,045.00	1,600.00
Total Members Accumulated Funds	**$560,322.56**	**$562,292.51**

NOTES TO AND FORMING PART OF THE ACCOUNTS FOR THE YEAR ENDED 31 DEC 2003

1. STATEMENT OF ACCOUNTING POLICIES

This special purpose financial report has been prepared for distribution to the members to fulfil the Council's financial reporting requirements under The Field Naturalists Club of Victoria Incorporated constitution. The accounting policies used in the preparation of this report, as described below, are consistent with the financial reporting requirements of the Club's constitution and with previous years, and are, in the opinion of the Council, appropriate to meet the needs of members.

(a) The financial report has been prepared on a modified accrual basis of accounting including the historical cost convention and the going concern assumption.

(b) The requirements of Accounting Standards and other professional reporting requirements in Australia do not have mandatory applicability to The Field Naturalists Club of Victoria Incorporated because it is not a "reporting entity". The Council has, however, prepared the financial report in accordance with relevant Accounting Standards and other mandatory professional reporting requirements in Australia..

(c)These accounts have been prepared on the basis of historical cost and do not take into account changing money values.

(d) The accounting policies have been consistently applied unless otherwise specified.

(e) Investments - are valued either at cost less amounts written off for permanent diminution in the value of investments, or at Council valuation. Dividends and interest are brought to account when received.

(f) Fixed Assets - Property is brought to account at cost, or where appropriate, at Council valuation. Plant, equipment, furniture and fittings are brought to account at cost less accumulated depreciation calculated on a straight line basis over the estimated life of the asset.

(g) Income tax - The club is not liable for income tax

(h) Inventories - are valued at the lower of cost and net realisable value.

2. REMUNERATION OF COUNCILLORS

No remuneration has been received by councillors for the year ended 31 December 2003.

	2003
3. CASH	
FNCV A/c - Bank of Melbourne	$15,592.67
Fungimap A/c - Bank of Melbourne	2,961.11
Environment Fund A/c - Bank Melbourne	3,240.91
	$21,794.69
4. STOCKS	
T-Shirts	371.50
Books for sale at lower of Cost or Net Realisable Value	11,492.57
	$11,864.07
5. INVESTMENTS	
AGC Debenture Stock	61,252.15
Treasury Corporation of Victoria Inscribed Stock	50,000.00
Esanda Finance Corporation Unsecured Notes	100,576.22
General Property Trust Units - at cost	23,851.00
	$235,679.37
6. Library - Books and Journals	
at Council Valuation 23/5/95 plus additions at cost	$46,591.11

7. FREEHOLD PROPERTIES	
Cosstick Reserve, Maryborough	$13,400.00
1 Gardenia Street, Blackburn - at cost	171,512.00
Improvements	38,988.00
	$223,900.00
8. OTHER FIXED ASSETS	
Plant and Equipment - at cost	57,431.64
Less Accumulated Depreciation	(37,481.07)
	$19,950.57
9. CREDITORS & PROVISIONS	
Sundry Creditors	250.00
Net GST	(1,756.75)
PAYG Liability	693.00
Funds Held in Trust	271.00
	($542.75)
MEMBERS ACCUMULATED FUNDS	
10. GENERAL FUND	
Balance Brought Forward	$502,830.20
Add Net Surplus	178.85
Add Fungimap Deficit	12,016.32
Balance at 31 December	$515,025.37
11. SPECIFIC FUNDS	
Marine Research Group Fund	
Balance Brought Forward	25,267.75
Net Addition	199.00
Balance at 31 December	$25,466.75
Fungimap Fund	
Balance Brought Forward	14,731.05
Less Net Deficit	(12,016.32)
Less Owing for GST reimbursement	94.06
Balance at 31 December	$2,808.79
FNCV Environment Fund	
Balance Brought Forward	6,127.76
Add Donations	2,080.00
Add Interest	34.15
Less Grants	(5,001.00)
Balance at 31 December	$3,240.91
Juniors Fund	
Balance Brought Forward	1,600.00
Add Additional funds contributed	445.00
Balance at 31 December	$2,045.00

12. CONTINGENT LIABILITY

The FNCV is at present working to confirm that its past and present practice of not collecting GST on its membership fees is recognised by the Australian Tax Office. It is not absolutely certain that the matter will be resolved in the club's favour.

INDEPENDENT AUDIT REPORT TO THE MEMBERS OF
THE FIELD NATURALISTS CLUB OF VICTORIA INC

Scope

I have audited the attached special purpose financial report comprising the Statement of Financial Position, Statement of Financial Performance, Cash Flow Statement and Notes to the Financial Statements, of The Field Naturalists Club of Victoria Incorporated, for the year ended 31 December 2003. The Club's Council is responsible for the financial report and have determined that the accounting policies used are consistent with the financial reporting requirements of the Club's constitution and are appropriate to meet the needs of the members. I have conducted an independent audit of the financial report in order to express an opinion on it to the members of The Field Naturalists Club of Victoria Incorporated. No opinion is expressed as to whether the accounting policies used are appropriate to the needs of the members

The financial report has been prepared for distribution to members for the purpose of fulfilling the Council's financial reporting requirements under the Club's constitution. I disclaim any assumption of responsibility for any reliance on this report or on the financial report to which it relates to any person other than the members, or for any purpose other than that for which it was prepared

The audit has been conducted in accordance with Australian Auditing Standards. Our procedures included examination, on a test basis of evidence supporting the amounts and other disclosures in the financial report and the evaluation of significant accounting estimates. These procedures have been undertaken to form an opinion whether, in all material respects the financial report is presented fairly in accordance with the accounting policies described in Note 1 to the financial statements. (These policies do not require the application of all Accounting Standards and other mandatory professional reporting requirements in Australia)

I have relied on the data for years prior to that ending 31 December 2003 as being correct No effort has been made to value the Club's assets

The audit opinion expressed in this report has been formed on the above basis

Qualification

As is common for organisations of this type, it is not practical for The Field Naturalists Club of Victoria Incorporated to maintain a tight system of internal control over donations, subscriptions and other fund raising activities until their entry in the accounting records. Accordingly the audit in relation to such receipts was limited to the amounts recorded

Qualified Audit Opinion

In my opinion, except for the effects of such adjustments, if any, as might have been determined to be necessary had the limitation discussed in the qualification paragraph not existed, the financial report presents fairly in accordance with the accounting policies described in Note 1 to the financial statements, the financial position of The Field Naturalists Club of Victoria Incorporated as at 31 December 2003 and its financial performance and its cash flows for the year then ended.

Signed:

Ray A Wells, CPA
Honorary Auditor

15 March 2003
South Melbourne

The Victorian Naturalist

Volume 121 (3) **June 2004**

Fire Symposium Special Issue

Published by The Field Naturalists Club of Victoria *since 1884*

Whitefella jump up: the shortest way to nationhood

by Germaine Greer

Quarterly Esssay (Shwartz, Melbourne). *Quarterly Essay@blackincbooks.com*

This 78 page essay is a political polemic, challenging as it is insightful and profound for Australian readers and contributing to our, hopefully, evolving 'sense of place' on this continent. Her aim, challenging us to recognise that we live in an Aboriginal continent, is to promote a new way forward for a republic and to make us more respectful of Aboriginal culture through understanding our own history in the natural and social landscape. Greer (of *Female Eunuch* fame) would not generally be associated in the minds of many readers as the "traditional" fare of *The Victorian Naturalist* - so why review her work here?

As *The Victorian Naturalist* comes to celebrate 125 years of active contribution to Victoria's scientific and cultural life it is timely to reflect on our changing consciousness of the Victorian landscape. From its inception, contributors to *The Vic Nat* were busy, as the paradigm of the Victorian age demanded, cataloguing and describing the detail of the natural, and in some cases cultural, environments, all from a European view. Some contributors, notably AW Howitt, provided perspectives on the original Koori culture and land-use. However, even in these early days, many writers were becoming aware of, and recording losses of both our natural and cultural assets. Thus a conservation ethic arose - gradually providing a framework for an enhanced 'sense of place', but still from a European viewpoint. Greer's work argues for a deeper 'sense of place' for a change in our consciousness - to accept the obvious.

One does not have to be a 'republican' to appreciate the profundity of her arguments. The canvas is broad, assertions necessarily sweeping, but still illustrative of a coherent body of historical evidence and interpretation. She explains our white fella's malaise of 'spiritual desolation': the history of hating a country which we subconsciously know is not ours; the promotion (some only for the fortunes to be made) of inappropriate land-use; and the disregarding of Aborigines and their culture despite the fact that many were heroes of pastoral settlement and rescuers of many hapless explorers. We blocked ourselves from their knowledge.

These historical themes are inter-woven with perspectives on our national behaviours (eg. use of alcohol) and their psychological meanings. Replacing our corrosive arrogance toward Aboriginal knowledge with acknowledgement that it is their land, provides a basis for progress. Indeed, Greer proposes that many of our distinctive 'national' traits indicate that aboriginality already has had a profound effect on the culture of 'gubhas' - a trajectory exists.

Greer is no shrinking violet in the force of her arguments (one chapter is entitled 'The Big Idea') and she skilfully peppers the political with the personal. Writing with the passion and insight of an expatriate, her personal experiences with Aborigines go back 30 years when she was 'adopted' by a member of the Kulin tribe in Fitzroy in the 1970s. Greer powerfully conveys the meaning of those many experiences into a new perspective of how we could (and should) be re-evaluating our 'sense of place'. If you don't get the time to read the essay Greer suggests a simple exercise: look in a mirror and say: 'I live in an Aboriginal country'.

Ian Mansergh
7 Toolangi Road,
Alphington 3078

The Victorian Naturalist

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Fire Symposium Special Issue

F.N.C.V.

June

Editors: Anne Morton, Gary Presland, Maria Gibson

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Cover: Wildfire. Photo courtesy Mike Leonard, Department of Sustainability and Environment.

Web address: http://www.vicnet.net.au/~fncv/vicnat.htm
Email fncv@vicnet.net.au

Under the terms and conditions of the natural environment: it burnt where it snows

Mark Reeves[1]

Abstract
Readers are taken on a mind journey through the 2003 Alpine fires and, through the eyes of the author, witness tornadoes of flame encircling and trapping his fire engine. The behaviour and predictability of fires in the alps and the use of grazing and dozerlines as fire mitigation techniques are discussed. Further reflections about fires included the need for dissemination of new knowledge gained by recent experiences, the importance of networking, communiuty involvement and psychological effects of the fires on a wide variety of people. (*The Victorian Naturalist* **121** (3) 2004, 84-89)

When I was first approached by the FNCV, I was both unsure about who you were and what you did, and also I was unsure what I should talk about! I have decided that I would like to frame my conversation with you in posing questions rather than attempting to provide definitive answers to so many complex issues surrounding our apparent ownership or, in reality, stewardship of the high country of Victoria.

I would like to share my experiences and interpretation of those experiences by taking you on a brief mind journey and to pose questions and promote discussion. Some of these thoughts are based upon perfect 20/20 hindsight.

Edmund Burke has described society as a partnership between those who are alive today, those who have gone before us, and those yet to come (Flint 2003). The relationship to the environment is not dissimilar. 'What we have now is not so much a function of our own efforts. We owe much if not most, to our predecessors. We ourselves are a product of the society that made us. And we clearly have a responsibility to those yet to come' (Flint 2003).

In regard to the 2003 Alpine bushfires, we have an opportunity to pass on to those following us knowledge, wisdom and understanding from our experiences, which was not possible in the past.

We have an opportunity to gather deep insight into the nature of this wonderful, unique and fragile environment. Should we not now move beyond the relatively shallow 'blaming' that has, I think, characterised much of the aftermath of the fires, especially in a political sense?

But now, I would like to take you on a mind journey... Please sit comfortably, place your feet on the floor and sit with a straight back. Breathe in and out twice, relax and close your eyes....

You are with me in my fire truck, it is Sunday 28 January 2003 and we have been engaged in the fire fighting for several weeks now. We know each other well and are familiar with the procedures and protocols of our fire team. The truck is a 15 tonne Isuzu carrying four tonnes of fire fighting water. There are four of us in the cabin of the truck, with big windows, easy to see out of.

We are cut off from our escape route in our current fire-fighting endeavours, both directions of the road aflame now with trees fallen over them. We are perched in our truck at Cobungra, and have taken time to position it as best we could to provide the best protection from the potential killer, radiant heat. We are waiting, waiting and waiting, the fires are coming towards us, but we are not quite sure what to expect.

The fire front finally arrives. It is 12:15. We have been here for one hour...

Next to us is one of the other tankers with the crew on the back in the rollover protection area...one last call out the window to them.... "You sure you don't want to jump in the cab with us fellas?"... "Nah we'll be right", comes the reply, "thanks for the offer though."..., A decision, which on later reflection they may have reviewed '*next time this happens*.'

From our apparently secure perch in the cabin, with the woollen blankets over us, we have an amazingly good view of the

[1] Principal, The Alpine School, Great Alpine Road, Dinner Plain, Victoria 3898

approaching fire. At first, a grass fire sprints down Cobungra Road in front of us from the direction of Ted's house. It variously sweeps, loops, twists and dances its way through and over one spot where we thought we could shelter. At this point, two large Grey Kangaroos hop and dart toward that fire front and stop, stunned. I watch them double back and wonder about their fate. A minute later, another fire front comes directly towards us up the gully beside our escape road. It flashes up the treetops, and the most vigorous eruption of flame takes place in the remaining pines that we had run out of time to fell. The trees are 10 metres or so tall, and they instantaneously erupt in flame to twice that height. We can feel the radiant heat. Almost simultaneously, a third and most vigorous front 'crowns' up the Cobungra Valley to our right. The flames are enormous. The heat front and flames burst anything flammable into the inferno. It is a horrible and amazing scene. We are trapped on all sides by fire fronts!

For the next 15 minutes, we witness some of the most incredible scenes. The flames rip about us and tornadoes of fire loop and dance around us. Several times, our truck is engulfed in absolute blackness, darker than a moonless night. Soot, ash, embers and earth, instantaneously baked dry and hard and blown away, rain down on us. Our truck shudders and shakes in this hurricane. Ash, embers and soot, burning branches, fire and any other moveable and burning debris blasts the too-hot-to-touch windows. Fire fighting gear that we removed from the back of the truck erupts in flames metres away, where we had thrown it. We watch what we thought was bare earth burst into flame under adjacent tankers. Many times, our partner truck radioed us and we each reported a 'welfare check'. We were all okay! Hot, but okay. I recall watching Jan through the window in the Command vehicle next to me, and thinking how it was like watching the muffins cook in the oven! The glass has become too hot to touch without gloves. The heat haze shimmers between us. I note that the frame of my seat is too hot to touch! (Three days after the event, another team using the truck find a burnt orange on the floor...actually blackened from sitting on the floor). Luckily there are several bottles of water stashed under the back seat, and we each gulp down half a litre of warm water to replace the literally litres of sweat that we are losing in our overheated sauna. I can see Arlene's house in the rear view mirror, and watch it be engulfed in flame and then disappear, only to reappear in a moment of clarity and then disappear yet again in soot, debris and smoke. At various times, the tyres of the adjacent tanker begin to smoulder and burn, and after a quick radio call for them to move forward or back it is snuffed out. It is a bizarre dance of hot trucks in a firestorm! It works....

After 20 minutes, the main flame front has passed, and we are left in a 'post-nuclear' smoking and flaming landscape. I want to get our tanker into a position that will allow us to move out to assist the residents as soon as possible. We sneak the truck around the water tank and jump in the back and get ready to move off. It is too hot to actually protect oneself, let alone render assistance to anyone else. It will be another 10 minutes before I can move, an agonising 10 minutes, as we are desperately concerned for the people in their houses. However, move we do and at 12:45 and after many 'welfare checks' and radio communications, the three trucks disperse to different sections of the estate to begin the assistance. God only knows what we will find, and the thought of 'finding the worst' funnily never crosses our mind until much later. To do other than survive does not seem an option...

I would like to reflect upon and promote discussion on five points about the fires of 2003.

- The nature of the fires in the Alps, their behaviour and predictability.
- Grazing as a fire mitigation technique.
- The use of dozer lines as a fire mitigation technique.
- The vigour with which the fires were fought.
- The issue of fuel reduction burning.

The nature of the fires in the Alps, their behaviour and predictability

The fires in the Alps behaved in an irregular and unpredictable fashion.

Are not fires supposed to behave in predicable and measurable fashions, to some extent? I saw fires that behaved in unpredictable ways and in ways contrary to the best information with which we were provided in wildfire training. I do not blame the CFA for this because there really have not been enough recent examples of fires in this region to be able to have either anecdotal or research-based experience upon which to draw.

1. I saw fires burn downhill faster than up. Local. swirling and katabatic wind conditions created most unusual and non-textbook behaviours.
2. I watched local wind effects create 'blast-furnaces' where steep and inaccessible faces burnt with incredible ferocity. The area around Little Baldy is an excellent and visible example of this.
3. The fires burnt in a mosaic pattern, which became a function of the atmospheric conditions more so than fuel loads. Some days, and for several days, the fires would creep along in a similar fashion to a cool and controlled fuel reduction burn. It was so extensive and inaccessible that there was no hope of extinguishing its entire length, even with aircraft. In these situations, one could walk up to and navigate one's way through the fire, and actually become quite intimate with it, watching it closely like a BBQ! The result was areas of low intensity burning, no crown fire and from a distance even the look of no fire until one peered between the trees at ground level. The effect of this can be clearly viewed by driving up the Great Alpine Road from Harrietville, and looking toward Mt Feathertop.
4. The fires burnt most vigorously when sufficiently high temperature, sufficiently low humidity and sufficiently strong fanning winds combined. There were subsequently days on end when the wind strength increased, backed and veered through the canyons and gullies of the Alps and fanned and increased the intensity of this cool fire (see 3 above). Hence, there would be a day (usually no more) of frenetic activity to defend properties and infrastructure from this fast moving, crowning and destructive fire. Excellent examples of the results of this can be witnessed on the Great Alpine Road below the Hotham entrance station at Buckland's Gap. There is significant tree killing and, at this stage, little evidence of epicormic regeneration, to be found only several hundred metres further down the road. This situation is the one in which my colleagues and I were caught at Cobungra.

Grazing as a fire mitigation technique

During and after the fires, a great deal of renewed interest was evident in the issue of grazing and fire mitigation. There is no doubt that there were experiences in my region where grazing lessened grassland fuel loads. No doubt Dinner Plain itself has LESS grass when the cattle are here, and yet we still slash to reduce the hazard. My experience was that, although there may have been situations where grazing might have had such an effect, what I saw, made me believe it did not mitigate the fire situation in the higher Alps for the following reasons:

1. Grazing animals tend to prefer a green picking, that is, they will eat the grass that has fresh, sweet new growth and move on. In a free grazing situation, they move to areas of their preferred diet. As a result, they leave the dry and what I would call 'flash flammable' grasses and stalks. I saw this in particular at the Hotham airport. Fires travel quickly, through low density, highly oxygenated, high surface area fuels.
2. By eating the green pickings, grazing animals tend to reduce the natural firebreaks of bog lines and gullies. They also pug the sphagnum bogs considerably, drying them out and again reducing the natural fire breaks in alpine grass fields.
3. The most vigorous fire behaviour I saw was 'crowning fire', which burnt hot, fast and intensively in the treetops or crowns of the sub-alpine woodland or montane forest of Alpine and Mountain Ash or Woolybutts. These trees tend to shed bark and carry an enormous fine fuel load in their structures, perfect for kindling crowning fires. Grazing of course does not reduce these fuel loads, nor does fuel reduction or low intensity burning, for that matter.
4. I would be keen to visit 'Maisie's Plots' on the Bogong High Plains and see the effect of the fires on these areas of grazing exclusion since the 1940s. I understand there may be some interesting outcomes from further research into their situation after the fires.

5. Cattle tend to be indiscriminate in their search for feed and selective in their ultimate diet. Their cloven hooves tend to be incompatible with the fragile alpine soils, and they may not have sufficient benefits as a fire management technique to overcome their inherent environmental impact. They seem to be there purely for commercial reasons. However, to suggest 'grazing reduces blazing' is not my experience. Omeo, for example, a region of significant grassland grazing, was severely affected by fire despite the areas of significant grazing surrounding the township.
6. The most difficult fire we dealt with was in cattle-grazed Alpine button-grass plains. It behaved like so many peat fires, smouldering on the surface and beneath the exterior and doing so for days, waiting for that lethal combination of heat, wind and humidity. It is my experience that the 'jury is still out' on the fire mitigation benefits of grazing in the alpine areas.

The use of dozer lines as a fire mitigation technique

1. I did not see a dozer line or 'mineral earth break' that succeeded in containing a fire front on its own. Eighty or so dozers were engaged in the firefight in that period. From my experience, for them to function as designed, they need to be seen as a technique to be used with fire fighters defending them.
2. The fires were SO extensive that it would have taken tens of thousands of fire fighters, all equipped with endless supplies of water and equipment, to make the dozer breaks function. Fires jumped every one I worked on. I saw them as a management technique that was not effective due to the nature of the terrain, the stretched supply lines to defend the breaks, and the isolated nature of the area.
3. The subsequent environmental issues created because of the mineral earth firebreaks and their inevitable rejuvenation could possibly be seen as 'worse' in some locations (Dinner Plain for example) than the fire threat.
4. Can we really control the natural environment and its whims with modern machinery?

The vigour with which the fire was fought

1. It has been suggested that the fire fighting was not undertaken as vigorously as it should have been because, for example, the spectre of 'Linton' was haunting the authorities and fire fighters.
2. Subsequent to the fires, a TV reporter, commenting at the Federal Inquiry at Omeo, suggested that the fires were fought with bureaucratic ends in mind. That is, the public perception of the various agencies was more important than saving property. I was alarmed at some of the comments during and after the fires in this regard. I can assure you, my experience is that the fires were fought in the Alps with every bit of skill, knowledge and experience we could muster, and courage, and some more! As per our mind journey, I was personally entrapped fighting the fires and, in retrospect, my life was probably under threat. I really was solely concerned for my friends and neighbours whose houses and families we were charged with protecting.
3. When the initial dry lightning strikes took place, hundreds of fires started, scattered over an enormous area, some hundreds of kilometres long and many kilometres wide. Fires stretched from Mt Buffalo right across the Victorian Alps into the Snowy Mountains in NSW. There was never any chance of containing the threat with the resources at our disposal, even from across Australia. Even when the full might of the CFA and DSE was mustered, it could not gather sufficient people or equipment to fight all the fires in a sufficiently concentrated manner to consider extinguishment. This is not a criticism; it is a function of our dispersed and small population.
4. Do you think that anything more could have been done to prevent the subsequent extent or ferocity of the fires?

The issue of fuel reduction burning

1. The interface of human and natural environments is a complex and difficult place. We love to live with and in the bush, and to some extent we like to feel in control of it. But is it really a place which we can control?
2. Last autumn, fuel reduction burning took place in the Bright area and Ovens

Valley. This is, apparently, the right time to do it: fuel levels are likely to be high, winds predictable and temperatures and humidity levels reach critical levels for a shorter period in the day, making containment and exposure minimal. BUT, the local tourism operators complained about the subsequent smoke during the autumn festival!

3. From my experiences of the recent fires, it is an extremely rare for the circumstances to provide a fuel reduction burn, of a nature sufficient to maintain an effective fuel reduction outcome, to coincide in the cool and often damp alpine regions. There has to be sufficiently low moisture in forest fuels, high enough temperatures, low enough humidity and sufficiently sustained favourable winds. And then there has to be the universe's biggest 'drip torch' (dry lightning, for example, over some hundreds of kilometres) to set afire to a big enough area to gather sufficient momentum to make it keep burning when any of these critical circumstances change. Could it be that these circumstances happen about every 60-100 years in the Victorian Alps? That is, 1939, 2003, and maybe next time 2068! And, is it only a problem because WE LIVE HERE? Maybe it has been doing this for the last, well, few million years?
4. I took part in back and fuel reduction burning that was often ineffective because, even in the summer we just had, the fuel could not sustain a fire! So many places we back-burnt were, within days, reburnt with the full fury of the wildfire. No one would sanction fuel reduction burning in conditions that are likely to create hot and out-of-control wildfires. Yet, for them to be effective, that may be what has to happen in the Alps!
5. There is evidence, I suggest, that regular fuel reduction burning is bad for biodiversity and good for creating environmental monoculture. There is a thought in my mind that regular fuel reduction burning will, in fact, create a forest that is resistant to damage from fires and germinates with fire. However, I believe from what I have seen, that such forests, while fire tolerant, contain the most ferocious burning trees. In effect, by too regular burning we could be creating an extremely volatile monoculture.
6. Is fuel reduction burning a regime into which we should encourage more research, especially in the Australian Alps, or is it more a political solution?

Some further reflections about the fires

1. We should learn from these experiences. What we have gained needs to be passed on to the future generation.
2. Networking. We need to work together to see the big picture and reduce rumour mongering and share our knowledge.
3. Community effort. It is a wonderful thing to volunteer in the CFA to make the community safer while minimising, I hope, the effect of fire on the environment.
4. I cannot speak more highly of the CFA as an organisation. I am proud to be a part of it, to have learnt so much as a result of my involvement, and to make a contribution as we did.
5. There were HEAPS of raptors in the area after the fires; I guess one cannot keep them away from a good 'BBQ'!
6. Fires kept igniting for weeks afterwards, when atmospheric conditions transpired to make the 'smouldering' remnant reignite.
7. Fire fighting can be 95% boredom, 5% absolute terror. I saw and experienced both.
8. The Alpine fires redefined the fire-fighting adage of 'hurry up and wait'!!
9. Dinner Plain was REALLY threatened many times. I thought we were going to lose the whole lot on five or six occasions.
10. Many of us underestimated the ability of the fires to be both huge and sustained in the Alpine environment, given what we know about the fuels, temperatures and humidity.
11. Many montane areas have encouraging signs and sometimes heaps and heaps of epicormic shoots. The Snow Gums did not fare as well as other trees, although I noted many areas of regrowth from the lignotubers.
12. The psychological effects of the fires on so many people, in so many ways, cannot be underestimated.

So, should we be, to a greater extent, living here under the terms and conditions of the natural environment? In the places and situations where human influence has radically affected the environment, is there a terminal and inevitable crisis destined to emerge? Can we 'control' and 'make safe' the environment of the Australian Alps, or other landscapes in Australia, through fuel reduction burns or cattle grazing, or use of dozers and so on? History will be the deciding factor, unless we have more and better research into these few points I have raised today from my limited experience.

While I love the place in which I live, I respect its need to function as an ecosystem with all the healthy biodiversity it should have. Perhaps we should, at times, accept that it will burn where it snows!

Reference

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Forest fire and funeral pyre: Tragedies of the Victorian bush

Peter Evans[1]

Abstract

This paper examines the European fire history of Victoria's forests and its impact on forest communities in the first half of the twentieth century. As the fire toll in sawmill communities mounted, pressure grew for some form of protection for timber workers and their families. The fire-refuge dugout became the most widespread reaction to the threat of forest fire. The remains of large numbers of these dugouts today constitute a strong physical reminder that 'the hand of man' in Victorian fire regimes created victims as well as perpetrators. (*The Victorian Naturalist* **121** (3), 2004, 89-98)

Introduction

I came to the study of fire in Victorian forests through a background in the media and as a keen bushwalker fascinated by the remains of sawmills I was finding in the forests north-east of Melbourne. I spent Ash Wednesday in 1983 recording radio commercials for the Forests Commission of Victoria. They were deliberately scripted to shock the public into a realisation of the fire danger facing Victoria in that year of drought. By the time the commercials were finished, there was no longer any need for them. That night, I stood on the balcony of the house where I was living in Kew, with the smell of smoke in the air and burnt leaves from the Otways landing at my feet. It was a sobering experience.

Returning to the forest in the first few days after the Ash Wednesday fires was both horrifying and amazing. The stillness was deathly – not a single leaf rustling and not a bird call to be heard. But at the sites of former forest settlements it was also as if a veil covering the past had been drawn away. As the ferns sprouted and trees started to sucker, I realized the veil was returning. Most weekends over the next few years were spent mapping tramways and sawmill sites. I started to talk to former sawmill residents and, as part of my research, gained access to the Forests Commission's correspondence files. I quickly appreciated that any study of the human occupation of Victoria's forests was inextricably intertwined with their fire history.

A combination of fire-adapted forests and the prevailing weather patterns in south-east Australia have created an explosive mixture that has been called the great 'fire-flume' of the south-east (Pyne 1991). The spark that has so often set this mixture ablaze is a historic European indifference to fire and its consequences for forests. The destruction of Aboriginal fire regimes, and the enshrinement of land clearing policies in government regulations, led inevitably to a series of disastrous conflagrations in which Victorians were both perpetrators and victims.

[1] 3/22 Princetown Road, Mount Waverley, 3149
email: pevans@solutionred.tv

A chronology of fire

The first large bushfire recorded in Victoria coincided with its separation from the colony of New South Wales and the discovery of gold. On 'Black Thursday', 6 February 1851, the first of Victoria's fire days to gain a name, Victoria was ablaze from the Wimmera to Bass Strait. It is impossible now to quantify exactly the extent of the fires or to say how many people died. Certainly, large areas of the Great Dividing Range were burnt. Travellers along the Yarra Track to Woods Point in the 1860s wrote in awe of the vast forest of dead trees through which they passed. (*Woods Point Times & Mountaineer*, 12 September 1866).

Bad fire seasons returned in the late 1870s (Foley 1947) and again in 1896 and 1897, culminating in January and February 1898 when large areas of Gippsland were swept by fire. The worst day, 1 February 1898, also acquired a name: 'Red Tuesday'. Despite the fact that the fires had been started in many cases by settlers 'burning off', the net result was to reinforce the efficacy of fire as a tool of settlement. When the fires had passed, open spaces stood where once there had been a forest of dead, ring-barked timber (Pyne 1991). Fire might make a bad short-term enemy but, for the settler, it was a good long-term ally. Major fires were recorded every summer from the turn of the century to 1919, when 120,000 acres of Crown lands in the Otways and the Grampians were devastated by bushfire (Foley 1947).

Only sporadic deaths due to bushfire had been recorded up until this time, but the number of people living in the bush had been steadily building up during the early years of the twentieth century. With the completion of railways to Alexandra, Warburton, Noojee, Gembrook and Walhalla, large numbers of sawmills were built in the heavily timbered Great Dividing Range (Evans 1993). It was inevitable that, given the right conditions, a bad fire would claim a large number of lives. Those conditions arose in February 1926, and added a third name to the lexicon of Victorian bushfire: 'Black Sunday'.

The loss of fourteen lives at Worlley's mill at Mt Beenak on Black Sunday was the first major disaster to turn public attention to the need to provide a refuge from fire at bush sawmills. The mill settlement was typical of many of its time: isolated, hemmed in by scrub and connected with the outside world by a slender ribbon of wooden-railed tramway (VPRS 11563: Unit 88, file 32/1288). When it became apparent that there was no hope of saving the mill, the inhabitants of the settlement attempted to escape along the tramway leading out of the forest.

Realising that their path was blocked by flames, they were forced to retreat back towards the mill. Mr. and Mrs. Rowe, their son, and Mrs. Duncan holding her three-month-old baby, managed to make their way to a race containing about a foot or two of water. Here they lay down and awaited the fire front. Mrs. Duncan became separated from her child. She had to be forcibly restrained from dashing into the flames as her baby was burnt to death before her eyes. The rest of the party reached the mill but had nowhere to go. Only two were to survive. In desperation, Henry King and Arthur Walker used their coats to shield their faces and dashed through the front of the fire. Badly burned and with their hair and eyebrows singed, they managed to reach a small creek about one hundred metres away where they lay for about three hours. When the worst of the flames had passed, they dragged themselves back to the mill site where they discovered the bodies of those who had perished. They rested for a few hours before making their way out of the forest to raise the alarm. In all, fourteen persons died at this one mill. (*The Age*: 16 and 17 February 1926; *The Sun News Pictorial*: 16, 17 and 18 February 1926; *The Lilydale Express:* 19 February 1926).

Following this disaster, isolated suggestions were made that a 'dugout', patterned on those constructed by the armies of the First World War, could be useful for saving life in a bushfire. However, the only specific action taken by the Forests Commission was to add one penny to the royalty on every hundred super feet of timber to provide additional funds for fire protection (VPRS 11563: Unit 43, file 28/430). This was primarily aimed at saving timber, not lives. Sawmilling communities continued to face the risk of death every summer.

There was another bad fire season early in 1932 and another disaster at a sawmill, this time in the Thomson valley near Erica. This particular tragedy had a typical prelude. Malicious threats to burn the forest had been made by unemployed men unable to get relief work from the Forests Commission. In January 1932, a number of fires were deliberately set by grazing interests 'setting loose the red steer' of fire to seek green pick for their stock. A large fire was discovered to be burning in the forests to the north and east of the Thomson River, probably lit by fishermen or prospectors clearing a route along the river. (VPRS 11563: Unit 88, file 32/1401). With little or no access available to fight the fires, it only required the right weather conditions for a disaster to occur.

A strong northerly gale on the evening of Thursday 4 February drove the fire down on O'Shea and Bennett's mill. Eight men stayed at the mill in order to defend it. The mill was equipped with a good water supply. However, the fire was too fierce to be resisted and, without a dugout, there was little chance of escape for the men. Six of the eight were killed. Two mill-hands, John Cabassi and James Richini, managed to escape although they were badly burned and temporarily blinded by the smoke. (VPRS 11563: Unit 86, file 32/0413). The charred remains of O'Shea and Bennett's mill were purchased by J. F. Ezard and Son, and a new mill was rebuilt on the same spot to await the challenge of the next bad fire season. There was not long to wait – the Black Friday of 1939 was only six years away.

A refuge from fire

The earliest recorded purpose-built fire-refuge was probably that constructed at another of Worlley's mills near Powelltown in early 1932. Mindful of the fourteen people who had died nearby in the 1926 fire, and of the thick scrub that had grown since that fire, several mill workers began to discuss the threat of fire as the height of summer approached. They decided the only thing to do was to go underground 'like a wombat'. A trench was started into the hillside.

The morning of Friday 5 February dawned hot and clear. Engine driver Bob Miller rose early and discovered large clouds of thick smoke billowing over the ridge on which the mill was situated. The other four men at the mill were quickly roused and sheets of corrugated iron hastily thrown over the top of the trench and covered with soil. No sooner had the five men entered the dugout when the fire roared over the mill site, destroying everything in its path. A wet blanket was used to cover the entrance and shield the men inside the dugout from the heat (Ernie Stocks, Syd Wood typescript).

Official proposals for dugouts

The first specific Forests Commission sponsored plan for a dugout based on the military principle appeared in May 1932 hard on the heels of the fire. The plan was put forward by Mervyn Bill, a Forests engineer and surveyor. He believed that thirty-six people had already needlessly lost their lives because no refuge from fire was provided at bush sawmills. He pointed out that fire escapes were provided by regulation at all city buildings, but that no law protected the inhabitants of a sawmill. His design included a tunnel with both downward and transverse deflections, underground piping and water sprinklers, hessian smoke filters and a steel-plated outer door. Fig. 1 shows a military dugout on which Bill's design may well have been based.

Bill believed that the door should point away from the north, the direction of the worst fires, as he had personal experience of seventy-five mile per hour winds generated by a fire. In most respects what he proposed has marked similarities to the 'modern' dugout except for the downward-sloping entrance and the fixed door (VPRS 11563: Unit 198, file 40/280 sub-file 32/1901). The downward-sloping entrance appears to have been an evolutionary dead-end, although one witness at the Royal Commission into the causes of the 1939 bushfires still believed that a downwards inclined tunnel was the safest because of the difficulty he experienced in trying to smoke wombats out of their tunnels (Stretton 1939a).

Implementation

On 14 November 1932 the Forests Commissioners made the following deci-

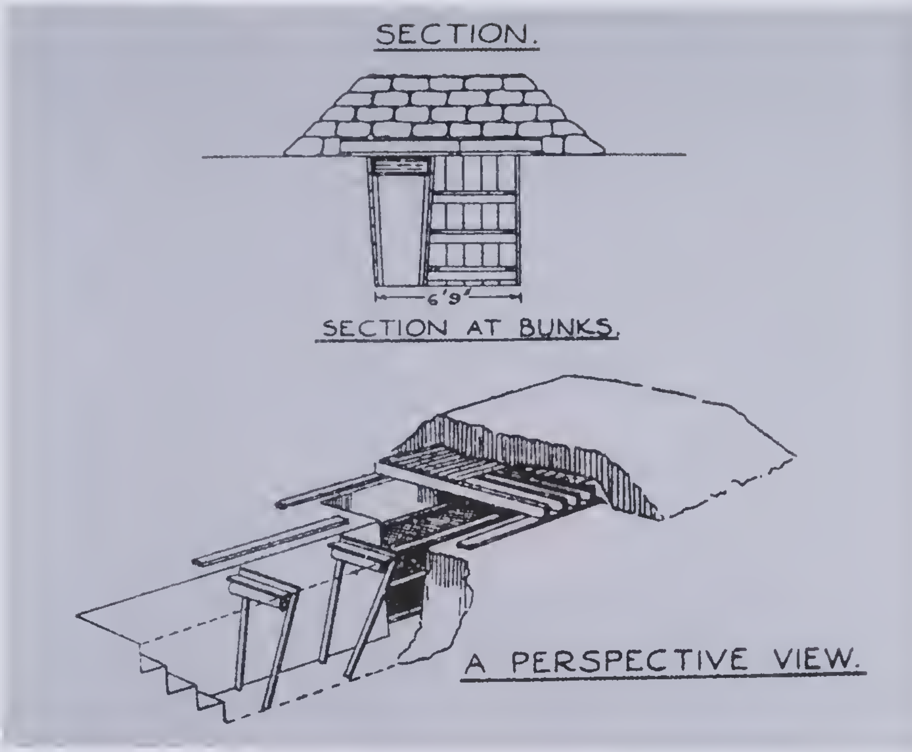

Fig. 1. The fire-refuge dugout was broadly based on the military dugouts used during the First World War. This illustration is from the 1936 *Manual of Field Engineering*.

sion: 'All sawmillers to construct efficient dugouts in close vicinity of all sawmills, particulars of such to be forwarded to the Commission'. This met with immediate opposition. Chris Ingram, a sawmiller near Erica, stated that such an action would not only reflect badly on the industry, but that danger to life could be obviated without the construction of dugouts, and he demanded that the Commission receive a deputation on the subject (VPRS 11563 unit 198 file 40/280 sub-file 32/1901). This protest was followed by official action on behalf of the sawmillers.

Representatives of the Hardwood Millers' Association told the Victorian Cabinet in 1932 that there was no necessity for legislation governing dugouts to be enacted. They gave an undertaking that all members of their association would construct dugouts immediately (Evidence of Finton Gerraty at the inquest into fire-deaths at Rubicon and Matlock, *The Sun News Pictorial* 10 February 1939). Subsequent events were to demonstrate the emptiness of that promise.

Despite the Hardwood Millers' promise, the Forests Commission pressed ahead, but the wording now changed from 'All sawmillers to construct efficient dugouts' to 'The Commission strongly advises you to construct efficient dugouts' and, somewhat loosely, defined the term dugout as 'any construction which will effectively give the required protection'. In these terms, a circular letter with a tear-off strip to be returned was sent to all sawmillers late in 1932. The returns make interesting reading: some millers underlined the words 'strongly advise' and did nothing.

George Worlley inserted the words 'when necessary' and also ignored the advice. Several millers pointed out that in the areas burnt by the fires earlier in the year there was now nothing to burn and also ignored the advice. Many did not reply at all. Only Jack Ezard replied that a dugout was being constructed but, as his

No.1 mill occupied the same site as that of O'Shea and Bennett where the six fire-deaths had occurred in 1932, he had good reason to do so. The Forests Commission tried to force the issue again ahead of the 1933-34 fire season, once again sending a circular 'strongly advising' sawmillers to construct dugouts. This time it added a plea to the emotions:

> It is pointed out that on you does the preservation of the lives of your mill employees and their families largely depend, and unless suitable precautions are taken now it is quite possible that a disaster similar to those of 1926 and 1932 may occur.

This spurred one or two sawmillers into action, but the main body of mill owners still did nothing. Various excuses were offered: there was a motor road to the mill; there was a creek or swamp handy; there was a dam or water channel handy. Most did not seem to hold with the efficacy of dugouts. JD Walker replied 'we have a small dugout in the gully on the other side of the mill if anybody prefers it to the creek'. Arthur Mackie stated 'I don't hold with dugouts, my experience of fifty-odd years is that if a fire menaces you, you must fight fire with fire ... it is the men running away from fire that gets burned'. Oliver Menz replied 'I have no dugout here as it would be useless. It is not far to get out here and I am certain that if a fire is coming there will be no-one stop to get burnt'. Whether they objected to the cost of construction, saw the relatively temporary nature of mill sites as a justification for doing nothing, or just believed that the concept held no value, few sawmill owners installed dugouts. (VPRS 11563: Unit 198, file 40/280 sub-file 32/1901).

At the Royal Commission into the causes of the 1939 bushfires, Forests Commission Officers protested that they had done their best to get people to build dugouts, but that there was no power in the Forests Act either to compel them or give them the right to do so. This was disputed by Judge Stretton, and documents produced at the Royal Commission proved that the Forests Commission was, at best, guilty of prevarication in this protest (Stretton 1939a).

Early in 1934, the Forests Commission had obtained an opinion from the Crown Solicitor as to its legal obligation if it inserted a clause in the Forest Regulations demanding the construction of dugouts. The Crown Solicitor replied that the Forests Commission could indeed insist on the construction of dugouts, but anyone getting into them must do so of their own volition, so that the Forests Commission could not be held liable if a disaster occurred. The Crown Solicitor concluded that dugouts should be fitted with a sign warning people that they used the dugout at their own risk. The Forests Commission may have indeed been caught between two evils: insisting on the construction of dugouts and then warning people against using them, or not insisting and merely encouraging the construction of dugouts in the hope of saving more lives.

Letters again went out at the start of the 1934-35 fire season 'strongly advising' the construction of dugouts. Forty-one-letters were sent out. Twenty-one replies were received and, for those sawmillers who neglected to reply, the Forests Commission had to rely on the previous year's reply for information. Over the two year period, ten sawmill managers had constructed dugouts and six stated that roads or creeks were available as escape routes or refuges. A total of twenty millers provided no information whatsoever on fire-protection for their employees. Another appeal late in 1935 brought a similar response.

A small breakthrough was achieved in the Rubicon Forest (south-east of Alexandra) the following year. Several meetings were held late in 1935 by members of the Australian Timber Workers Union at the Rubicon Forest mills, situated on the drier northern slopes of the Great Dividing Range. At these meetings, resolutions were passed requesting the construction of dugouts. The mill owners ignored the demand. The situation culminated in January 1936 in a public exchange of statements between Commissioner WW Gay of the Forests Commission, and Mr. Bodsworth, President of the Timber Workers Union. This resulted in a stern letter from the Forests Commission to the Rubicon mill owners, virtually demanding that dugouts be built. In part, the letter read:

> In order to avoid any further unpleasantness between you and your employees and also undue embarrassment to the Commission, it is

> desirable that these dugouts be constructed immediately. It must be recognised that you, your employees and the Commission are interested in the Rubicon Reserve and it is most necessary that all work in harmony. I would point out that in the past, in the event of fire in this district, the men employed at the various mills have been to a very large extent, in fact almost wholly responsible for saving of the forest and also your mills. In the event of future fires the cooperation of the men is essential. This cooperation will be given all the more willingly if the men realised that the protection of the lives of their wives and children was considered by the millers, to the extent of providing this not very costly protection. I hope that there will be no further occasion to remind you of this matter, and that the necessary dugouts will be constructed.

One month later, all eight of the mills in the Rubicon Forest had a dugout, although most were small and of rudimentary construction.

Another round of circulars was sent out at the start of the 1936-37 fire season. This time, the wording was stronger than before: 'Where considered necessary dugouts are to be constructed to provide retreats in case of danger'. This still did not persuade everyone. Forester Charles Elsey of Erica reported of one sawmiller:

> [He] has definitely intimated that he will not construct one and will contest every effort to force him to do so ... [he] claims that it is degrading for people to cramp themselves in a hole in the ground. I believe that a dugout at this mill is absolutely essential (VPRS 11563: Unit 198, file 40/280 sub-file 36/288).

1939

It is perhaps understandable that some sawmillers could not see the potential value of dugouts, which had not really been tested in a large fire. The period between 8 and 13 January 1939 provided all the testing anyone could ask for. It has not yet been possible to establish exactly how many dugouts were occupied during the 1939 fires, nor how many people survived in them. There is, however, substantial evidence to support the contention that the absence of a dugout at a sawmill, or the decision not to use one, vastly increased the chances that at least some of the mill inhabitants would be killed.

Despite the trouble taken by the mill workers to force the construction of dugouts in the Rubicon Forest, many decided not to trust them. At the Ruoak No. 3 mill, workers crammed the dugout with their furniture and fled. The four slowest died (Stretton 1939a). Some of their furniture is still there today, embedded in the collapsed remains of the dugout.

On top of the Blue Range above the Ruoak No. 2 mill, eight men attempted to save a lowering-gear winch by cutting a firebreak around it. The winch driver had begun the construction of a small dugout but, at the time of the fire, it was still incomplete (Stretton 1939; Ernie and Rose Le Brun, 'Ike' Sims interviews). All eight men died, the winch was subsequently removed and never used again.

Along the Acheron Way near Narbethong, a small group of forest residents chose to abandon Feiglin's No. 1 and No. 2 mills, both of which had dugouts. Those who died were Frank Edwards, Kenneth Kerslake, Ellen Kerslake and Ruth Kerslake. Three quarry workers who accompanied them were also killed. Those who had left with plenty of time to spare, or who took to the dugouts, survived (Noble, 1977; Sam Isaac, Keith Allan interviews).

At both Britannia Creek and Matlock, Fred and Victor Yelland had used the defence of the availability of a brick house as an excuse not to build a dugout (VPRS 11563: Unit 198, file 40/280 sub-file 32/1901). As a token gesture a small dugout was constructed at the Matlock mill, but was so poorly built that it had partially collapsed shortly after completion. When fire swept over the mill on 13 January 1939, Vera Maynard died when she was unable to escape from the brick house after it caught fire (Stretton 1939a).

Just south of Yelland's mill was the mill of JM and CV Fitzpatrick. Fifteen men died and one survived. Fire protection at this mill was the subject of scathing criticism from Royal Commissioner Stretton. Scrub came right up to the borders of the mill and there was no dugout, despite 'requests' from Forest Officers that one should be constructed. The sole survivor, George Sellars, found a cleared spot, wrapped himself in a wet blanket, and waited for the fire to pass (Stretton 1939a, 1939b). Sellars never fully recovered from his ordeal (Sam Isaac interview).

Only three people died in a dugout during the 1939 bushfires, but this may have more to do with social pressures than with any inherent drawback in the concept of the dugout. The dead were Ben Saxton, his wife Dorothy Saxton and a young mill worker named Michael Gorey. The Saxton brothers' mill was moved to Tanjil Bren, on the southern slope of the Baw Baw Range, in 1937 (Saxton). The brothers, Ben, Jack, Wilbur and Eric had been born and raised not far from the site of the 1926 disaster at Worlley's mill. Their father, Alfred Saxton, believed that, had the inhabitants of Worlley's mill sought shelter in a mine tunnel nearby, none would have been killed. The Saxton brothers were therefore favourably disposed towards dugouts and had constructed two at the Tanjil Bren sawmill (Stretton 1939a).

The first and largest of these consisted of a long tunnel into the hillside with an entrance facing south. It was intended for the mill workers. As fire approached on 13 January 1939, Jack Saxton and thirty mill workers entered the larger dugout. At the height of the fire, the six men holding the wet blankets across the entrance had to be relieved every two minutes due to the intense heat. Two others were engaged in bringing water to the entrance to keep the blankets wet. There were sufficient men in the dugout to enable enough relays at the entrance for all to survive the fire relatively unscathed. In dugouts, there was apparently safety in numbers.

The second dugout was smaller and adjacent to the house occupied by mill manager Ben Saxton and his wife Dorothy. This dugout faced east. As the fire approached, Ben Saxton, Dorothy Saxton and a young timber worker named Michael Gorey entered the smaller dugout. When the worst of the fire had passed over, all three were found dead. Ben Saxton appeared to have sustained head injuries when the front of the dugout caught fire and collapsed, but the others appeared to have died from suffocation. There was still a supply of water in the dugout (*Narracan Shire Advocate*, 7 April 1939). Social pressure may have induced the mill manager and his wife to segregate themselves from the main body of workers and, if so, this probably resulted in their deaths. With only one other person for assistance, it is unlikely that they would ever have been able to effectively protect the entrance to the dugout. Just south of Tanjil Bren, paling splitter Frank Poynton, farmer Ben Rowley, his wife Agnes Rowley and their three children all perished for want of shelter from the fire.

Post-1939 dugouts

The 1939 fires demonstrated without doubt the efficacy of dugouts as a refuge from fire. Less than a week after the fires ended, the first sawmilling company applied for particulars for the construction of a dugout. Hayden Brothers of Barwon Downs were sent plans of Ezard's dugouts at Erica, which had proved effective, and had enabled the employees to save the mill without placing themselves in danger. By early 1940, Forest Officer Torbet was able to report that most millers were eager to construct dugouts, but that they wanted plans to indicate what to build. After fighting to have dugouts constructed for seven years, the Forests Commission still had no definite design for a dugout apart from the plan put forward by Mervyn Bill in 1932. Hurried consultations were sought with the Department of Mines and the Department of Health, and minimum requirements were drawn up (VPRS 11563: Unit 198, file 40/280 sub-file 39/180). The Australian Timber Workers Union also took a hand, instructing their members not to accept employment at any mill unless the installation of a dugout was the first work carried out at the site (*The Argus*, 19 January 1939).

The *Forests Act (1939)* came into force in January 1940, and for the first time there were gazetted regulations to force sawmillers to construct dugouts. Dugouts had to be approved by a Mines Department Inspector, contain forty gallons of drinking water, electric torches with spare batteries and globes, sanitary pans with deodorants and a first-aid kit. A person in charge of the dugout had to be nominated and it was forbidden to use the dugout to store anything except the prescribed emergency equipment (*Government Gazette* No.13, 31 January 1940).

Different designs for mill and winch dugouts were drawn up and despatched to sawmillers with a general time limit for construction by the end of September 1940. Specifications included the provision of ninety cubic feet of air and forty square feet of cooling surface (walls, floor and roof) for each person. They were designed to be occupied for six hours. The entrance frame to the dugout had to be made of metal, all timber had to be protected by three feet of earth or rocks, no air vents were allowed, and there had to be a traverse at the entrance (Fig. 2). In 1948, the regulations were strengthened and the first-aid kit upgraded to include antibiotics. The location of dugouts was to be clearly indicated with a sign displaying the word 'DUGOUT' in black letters eight inches high on a yellow background. The basic design was adopted by the Country Roads Board, the Melbourne and Metropolitan Board of Works, the Forestry Commission of New South Wales and, eventually, by the Snowy Mountains Authority. (The development of the fire-refuge dugout from 1932 to 1958 is covered by the voluminous file that is VPRS 11563: Unit 198, file 40/280).

A heritage of fire

Today, our fire heritage is split into two streams – those who have experienced and survived fire and are our living heritage, and those of us who can only experience it second hand through documents and the physical environment. Of the cataclysmic fires, we have living testaments of both Black Friday of 1939 and Ash Wednesday of 1983. The survivors of the urban horror of 1983 live in a kindlier world with access to counselling. Those who experienced Black Friday by and large had only themselves and their families for support. Despite the time that has elapsed, memories of 1939 remain vivid for every survivor I have interviewed.

These include a hardened bushman used to a tough job in the forest and the management of tough men. Hard decisions had to be taken in 1939 on which lives depended. In his case, once taken, the ramifications of these decisions were never discussed with his family. Only to a comparative stranger could a lingering sense of long-repressed guilt be expressed in a voice cracking with emotion. And only in that confession could that decision be seen for what it was – driven by circumstance with no foreknowledge of how bad that particular fire would be. As Judge Stretton said in his report 'They had not lived long enough'.

Then there is the Forester, a professional man, well trained, but in 1939 young and green in the ways of the world. In helping to fight the 1939 bushfires he experienced the death of people he knew well. When the fires were over and he finally reached Melbourne, exhausted, his own mother failed to recognize him when he knocked on her door. He recovered and went on to write a seminal thesis on the use of local knowledge in fire control, and retired from the Forests Commission after a long and successful career. When asked to recount his experiences of the 1939 fires, he broke down and wept.

The silent voice of the 1939 bushfires is that of the women who lived at the sawmill settlements. Few were asked to give evidence either at the Royal Commission or the Coronial inquests. Yet their experience was no less traumatic than that of the men. Mrs Foster Potter plastered her baby's face with mud and pressed him to the floor of the dugout where it was coolest, while the men around her in the dugout recited prayers and abandoned all hope. She survived and, scant months later, was living even deeper in the forest at a newly-rebuilt mill salvaging fire-killed timber.

Finally, the words of Eileen Maxwell in a letter to her sister-in-law express the feeling of grief and dislocation experienced by many mill residents who lost everything:

> My God, May, I will never forget it. I said to Bill I am not going [to leave the mill] without you. I said we will all go together. So he knew it was no good trying to send me out without him. A tree fell in front of Kerslakes' bus, the same could of easy happened to us. So dear, we are jolly lucky to be here. Bill has gone back to work. I will be glad when they build us a house. I hate being here [in Healesville], it is that lonely and it will be worse next week when the kiddies go to school. My garden [at the mill] was a picture, the dahlias were all coming out and we were picking beans and peas and the potatoes were all ready to dig. Bill says you would not know there had been a garden there. ... The damn world is upside down ...

Fig. 2. One of the better surviving fire-refuge dugouts is this one, built by the Country Roads Board around 1946 during construction of the Reefton Spur Road near Warburton.

A cultural landscape

Even after the gradual withdrawal of sawmills from forest areas had begun, dugouts continued to be constructed at logging sites, forest work camps and road construction camps. The dugout became the universal cultural response to fire in Victorian forests, and no forest worker was far from one in the 1940s and 1950s. There are nearly 600 historic sawmill sites in or on the fringes of the Great Dividing Range north-east of Melbourne (Evans 1993). If only one third of these had dugouts there would be at least two hundred sawmill dugout sites in these Ash forest areas. Add to this an estimated one hundred constructed for logging, work camp and roading purposes, and several at the bases of fire towers and in small forest towns and the wide distribution of this reaction to the threat of death by forest fire can be readily appreciated. However, the removal of most aspects of forest industry, with the exception of logging operations to rural towns in the 1950s, diminished the need for dugouts, and most were left to decay and collapse. Many were deliberately destroyed, and only a few, mostly beside well-used forest roads, are now maintained. It is somewhat ironic that few of the post-1939 dugouts would have been tested by fire. The fire refuge dugout remains a mid-twentieth century phenomenon, a cultural reaction to the threat of fire in the Mountain Ash forests of Victoria. With few people living in the forest today, and with improved road networks, this threat has largely been ignored. With only a small number of dugouts now maintained, it is to be hoped that no forest traveller ever again has to seek safety underground.

Today, it is impossible to go far into a forest in Victoria without a reminder of past fires or the reactions to them. These reminders may be botanical in nature. A good example of this is the salvage area at the head of the East Tanjil River on the slopes of the Baw Baws, and on the southern fall of Mount Toorongo. After salvage logging, Ash regeneration has either not occurred or was destroyed at the seedling stage by logging operations. The area is now covered by wattle. Prominent when the wattle is in flower, these areas are still well defined when it is not. Although the evidence is botanical, these areas have a cultural cause. Another botanical reminder are the dead 'stags' which still rise above the areas burnt in 1939. Given that 'these fires were lit by the hand of man' the stags are again botanical evidence with a cultural cause.

The cultural elements of forest fire start with the death sites and the lucky escape sites, but do not end there. There are the fire lookout tower sites and there are scores of these. Dugouts have already been mentioned: there are hundreds of them. There are thousands of water points. And finally, there are the millions of dead Ash. The cultural landscape of the 1939 bushfires remains the greatest *visible* testament to the fire history of these forests.

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Ernie and Rose Le Brun, 12 August 1986. Residents of the Rubicon Forest in 1939 where Ernie was 'bush-boss' at the former Rubicon Lumber and Tramway Company mill.

Sam Isaac and Keith Allan, 21 July 1991 and 23 June 1995. Sam Isaac and Keith Allan worked at Feiglin's No. 1 and No. 2 mills on the Acheron Way both before and after the 1939 bushfires.

Norman 'Ike' Sims, 13 July 1992 and 19 September 1992. Resident of the Rubicon Forest in 1939 where Ike worked at the Ruoak No.2 mill.

Ernie Stocks, (date not recorded). Former timber worker Sam Isaac kindly supplied a cassette recording of an interview with the late Ernie Stocks. Ernie had worked at Worley's mill at Beenak prior to the 1926 fires and was an occupant of the earliest recorded fire-refuge dugout in 1932.

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Patterns of pre-European Aboriginal vegetation management by fire in South-eastern Australia What do we know?

Lynette C McLoughlin[1]

Abstract

Despite at least thirty-five years of debate over the scope, nature, purpose, timing, frequency and seasonality of landscape burning by Aboriginal people, and its role in shaping Australia's vegetation, knowledge is still highly patchy. In particular, there is still a great paucity of detailed studies which reconstruct past patterns of burning and fire regimes in specific regions or vegetation communities, especially across southern Australia. Yet it is these very studies which should provide the basis for the development of appropriate fire regimes for ongoing conservation management. This paper briefly reviews aspects of the debate over indigenous burning, highlighting the major role of fire in food production and management of food resources, before considering the range of evidence available to reconstruct indigenous fire regimes. A selection of studies from across the country, which have examined both pre-contact and post-contact regimes, demonstrates the richness of information available for those prepared to bring together often diverse and fragmented sources of information in the interests of better understanding and managing vegetation communities into the future. (*The Victorian Naturalist* **121** (3), 2004, 99-106)

Vigorous debate over many aspects of deliberate burning of the Australian landscape by indigenous people has ensured that it holds its place as one of a series of contested issues associated with fire in south-eastern Australia, as well as across the country. This paper will briefly raise some of those issues, as well as consider the extent of knowledge we have developed about pre-European burning which might inform conservation management of existing vegetation communities.

There are a number of aspects of 'patterns' of Aboriginal burning: simple spatial distribution, patterns related to habitat or vegetation community type, and fire regime i.e. the frequency, season and consequent intensity of the fire. Knowledge of any or all of these dimensions of pre-European indigenous landscape burning in Australia should be a useful tool in conservation management as it informs our understanding of specific communities and their dynamics, as well as providing directions for further research into appropriate fire regimes for those communities.

Dimensions of the debate over Aboriginal burning

A series of questions regarding Aboriginal landscape burning have been discussed for several decades in a range of literature from the anthropological to the ecological, particularly since Jones (1969) introduced the notion of 'firestick farming', describing it as an integral part of the Aboriginal economy. These questions include:

1. Why and to what extent did Aborigines engage in deliberate landscape burning?
2. If they did, when did it commence across the continent?
3. What level of detailed ecological knowledge informed their burning decisions?
4. What were the environmental impacts of such burning practices at macro and meso scales and over time – on the distribution, nature and structure of vegetation communities, in contributing to the extinction of Australia's megafauna, and on soil erosion and geomorphic stability?

The debate has raged between polarised generalities. On the one hand Aboriginal people rarely deliberately burnt vegetation, rather they were passive agents in the environment, only responding opportunistically to 'natural' fires (Horton 1982, 2000). At the other extreme, they burnt frequently and indiscriminately across the country (Ryan *et al.* 1995) or burnt extensively to reproduce the effects of grazing of the megafauna (they had hunted to extinction) in returning nutrients to the soil and preventing large scale fires by keeping down fuel loads (Flannery 1994). Yet others have seen little value in the conjectural nature of the historical perspective, preferring to

[1] Graduate School of the Environment, Macquarie University, Sydney, NSW 2109

develop knowledge of fire regimes and the role of fire in ecosystem functioning and dynamics purely through present ecological methods (Williams and Gill 1995).

Of the above issues, the most contentious is that of the environmental impacts of Aboriginal burning. Consideration of such impacts is also interwoven with the question of the time of their arrival on the continent and commencement of broad-scale burning, as well as the level of ecological knowledge they may have developed over time to inform their burning practices. Reviews of the evidence on this issue include those by Head (1989), Kohen (1995) and Bowman (1998).

However, debate that focuses on arrival dates and on early burning and its impacts obscures and deflects attention from the important conservation issues (Bowman 1998). Far more central to current considerations of vegetation, habitat and landscape management is knowledge of Aboriginal burning in the 4-5000 years before European arrival, when climate and sea level were reasonably stable: development of a 'coherent scientific analysis ... that can be used to buttress land management prescriptions' (Bowman 1998: 386). It is the intent of the remainder of this paper to focus on this area.

Why and how did Aboriginal people engage in landscape burning?

An understanding of the range of reasons for landscape burning (Jones 1969: Kimber 1983; Pyne 1991; Braithwaite 1994: Kohen 1996) also provides some perspectives on the nature and extent of that burning. The most commonly known and understood reason for burning was in hunting: to herd and drive large game animals to a convenient place to be killed, or to drive small animals out of thick undergrowth. Fire also was used to smoke small animals directly from burrows or out of hollow trees. Burning undergrowth exposed hidden burrows to hunters where smoke failed to drive out the game. In terms of faunal food sources, however, habitat modification may have been equally important. Frequent burning of understorey formed open forests suited to kangaroo and wallaby, and burning of specific areas created areas of known 'green pick' for game at a given time (after the next rains). Varied patterns of burning also developed habitat heterogeneity to support a range of birds and other animals used in the Aboriginal diet.

Other, more socially-based, reasons for burning were to clear travel corridors of undergrowth for swifter and more comfortable movement (usually ridges or along rivers and creeks); for signalling purposes and to clear sight lines; and as a weapon in warfare, for example in frontier conflict during the European period (Hill *et al.* 2000; Vigilante 2001). The purpose of 'cleaning up' country, often given by Aboriginal people, seems to encompass a number of these aspects of landscape suitability for travel, signalling and food resources but also includes a more spiritual dimension of caring for areas entrusted to them by their creator figures and cleansing these areas of evil spirits (Nicholson 1981; Kimber 1983).

Perhaps the least accepted and understood, but most important reason for burning in terms of reliable food resources and closest to fulfilling Jones' (1969) poetic 'firestick farming' concept, was in managing plant food resources (for detailed discussion see Hallam 1975; Pyne 1991; Latz 1995). In many parts of Australia, especially the south-east, roots were staple foods and were available year-round (Gott 1999). Burning undergrowth exposed herbaceous tuberous plants for harvesting, and burning held back shrub or forest invasion of those areas with a strong herbaceous understorey. Burning was also used to 'cure' and improve edible roots in swamps. Burning favoured, or provided appropriate growing conditions for, other food plants such as coloniser food plant species e.g. bracken (used for roots) and vines (berry-bearing) by removing competition and shading, stimulating seed germination and rootstock regeneration, and providing an ash bed. Some plants, such as Cycads (e.g. *Macrozamia* or burrawang) have unusually large and nutritive seeds and were particularly important as food sources. Both the growth of these plants and their seed production could be enhanced by burning (Nicholson 1981).

Plant resources were also managed by fire exclusion, for example to protect yam beds in their growing season (DF Thomson in Pyne 1991) or to protect foodstuffs in specific fire-sensitive sub-biotas such as rainforests and vine thickets (Nicholson 1981; Hill and Baird 2003).

How deliberate and controlled was all this use of fire by Aboriginal people? There are many accounts of apparently casual use of fire, with areas lit almost 'in passing'. On the other hand, there is evidence of deliberate burning in patches to create a mosaic of burnt and unburnt areas (which both promotes habitat diversity and creates self-limiting burn areas as protection against raging wildfire), particularly across northern Australia (Russell-Smith 2002), Central Australia (Latz 1995) and south-western Australia (Hallam 1975). Observations also have been made of beating out fires moving in an undesirable direction, and burning being entrusted to delegated tribe members as a 'special duty' (JL Stokes in Hallam 1975), as well as the specific exclusion of fire from sensitive areas, noted above, or careful manipulation of fire regimes to protect sensitive vegetation from damaging fires (Price and Bowman 1994). All these indicate sensitive and skilled use of fire, which might also assume considerable and detailed area specific ecological knowledge.

Lewis (1982) saw similarities between the use of fire technologies by North American Indians and Australian Aborigines, maintaining these technologies were no less manipulative of landscapes than those of farming:

'The overall impact ... was to intensify further and to help maintain a more pronounced mosaic of micro-habitats even than that which occurred naturally ... Thus it was not simply that Indians took advantage of the natural conditions brought about by natural fires - although naturally burned areas were exploited - but rather that they altered natural processes in ways that allowed them to plan for and create the kinds of environmental conditions favourable to their adaptations as hunters and gatherers.' (Lewis 1982: 51 on Indian use of fire in northern Alberta).

Reconstructing patterns of burning

At a general level many writers have more recently acknowledged the extent to which Aboriginal people burnt across most landscape types (Cary *et al.* 2003a). Bowman (2003) goes further to suggest that their practices were the result of a process of 'taming' wildfire in a highly fire-prone country to their own ends. However, information on burning is only truly useful for conservation management where we understand the local patterns of burning i.e. the detail of the fire regimes applied to specific vegetation communities in a region or locality.

Developing such knowledge generally involves painstaking reconstruction of burning patterns using a variety of techniques and evidence. Table 1 summarises the types of evidence currently available for reconstructing pre-European fire regimes, and each has its strengths and limitations. For example, ethnohistorical sources may be fragmentary and lack precision but provide direct observation of Aboriginal practices. South-eastern Australia is considered very rich in paleoenvironmental data sources (Dodson and Mooney 2002) but these data are generally too coarse to define fire regimes. The more 'scientific' methods (palynology, fire scars and tree growth data) also do not distinguish anthropogenic fire from the totality of pre-European fire, although this may not be important where conservation management is interested only in the fire regimes that shaped communities, rather than in the origins of the fire. Ecological studies provide precise detail about selected aspects of ecosystem responses to fire but many studies in a specific area are required to integrate these into a landscape approach to burning over time.

Some detailed studies of Aboriginal burning, post-contact changes and implications

At a broad scale, palynological studies provide information about the extent of fire activity prior to European settlement. An analysis of 58 studies across south-eastern Australia found that fire was relatively constant over the Holocene (last 11,000 years). However, there was an increase during the early part of European occupation to levels higher than at any other time during the Holocene in all major vegetation types (although lowest in wet forest), followed by decline to present lev-

Table 1. Sources of evidence for Aboriginal landscape burning

Evidence	Uses and Limitations
Practices handed down to present Aboriginal groups	Specific information about Aboriginal burning across all aspects, but available for only limited parts of the country.
Ethnohistorical evidence: explorer/traveller/settler descriptions, newspapers, official records	May provide season, place and context for Aboriginal burning but for limited periods, often with little spatial context. May also provide evidence of vegetation appearance, structure, etc. present at that time.
Palynological data: Pollen and charcoal from swamp deposits tion	Indicator of extent of species present and burning in a specific catchment over extended time. Does not distinguish between vegetation/habitat types within catchment; difficult to separate wildfire from anthropogenic fire, and poor time band discrimina- to accurately establish frequency.
Tree fire scars/markings, tree growth ring data	Precision in vegetation community and timing of fires (though limited to life of tree), but does not distinguish between wildfire and anthropogenic fire.
Ecological data: present communities, their fire tolerance, indicator species	Provides limits for possible Aboriginal fire regimes but may be confounded by impacts and changes since European settlement.
Combinations of the above	Provide a more complete picture than any one technique alone.

els which are lower than at any other time during the Holocene (although still quite high in dry forest and heath) (Kershaw *et al.* 2002).

However, this knowledge has limited usefulness in vegetation management, even where locality specific, without a broader array of evidence to develop a fuller picture of fire regimes. Despite at least thirty-five years of consideration of the role of Aboriginal people in shaping Australia's vegetation, there is still a great paucity of detailed studies that reconstruct patterns of burning and fire regimes in specific regions or vegetation communities, particularly across southern Australia. Since Hallam's (1975) landmark work in the southwest of Western Australia, few have followed with the depth of scholarship and detailed use of a variety of available evidence required to provide a useful foundation for present management strategies.

Table 2 summarises studies from around the country, many of which examine both contemporary and historic indigenous regimes and the impacts that changes in burning practices have had on present vegetation patterns and structure. A selection of studies outside south-eastern Australia is included to encompass the range of study types. They are indicative of the value of integration of different forms of evidence to form conclusions about the nature of pre-European fire regimes and burning practices, as well as post-contact changes. It is clear that those located in south-eastern Australia are very limited in both number and geographic range, given the diversity of climatic, vegetation and landscape types in that broad region.

What do we know and where are the gaps?

Prior to European disturbance, Aborigines burnt widely, systematically and purposefully, for a variety of reasons, but most importantly to control the distribution, diversity and relative abundance of plant and animal resources – in essence 'farming' and 'grazing'. To do this effectively, landscape burning regimes were specific to habitats and vegetation communities and thus varied widely across the country and within regions and localities, and were often very finely grained in both implementation and impact.

Notwithstanding more recent recognition of indigenous knowledge and a need to involve indigenous people (Gill *et al.* 2002; Cary *et al.* 2003a), Aboriginal vegetation management by fire has generally been ignored, discounted or forgotten through the European period, with traditional knowledge often 'trivialised by Western

Table 2. Selected studies reconstructing pre-European fire regimes and patterns of landscape burning. *Study areas located in southeastern Australia.

Study	Evidence used	Key findings
SJ Hallam 1975, South-west of Western Australia	Ethnohistorical evidence, anthropology, archaeology	Complex pattern of burning based on specific vegetation communities/geomorphic zones including jarrah forest, karri forest, poor coastal limestone and sand plains, rich alluvial flats, inter-dunal valleys, creeks and swamps. Included burning close to creeks and swamps for access and travel.
R Kimber 1983, Central Australia and the Western Desert	Historical records, ethnographic evidence	Detailed reconstruction of burning practices with increasing frequency and size of fires through the year/dry season.
SS Clark and LC McLoughlin 1986, *Sydney region, NSW	Ethnohistorical, ecological data	Three distinct geomorphic zones in region (sandstone, shales, alluvials) and consequent vegetation types. *Aboriginal burning* was frequent (1-5yrs) mild fires on shale ridgetops of dissected sandstone plateaux and shale plains, and moderately intense with frequency of 5-15 years on sandstone slopes. *European period*: overall reduction in fire frequency resulting in:shrub understorey and sapling growth in forests and woodland of shale plains, occasional, intense fires in outer sandstone areas with fire exclusion in inner areas, resulting in mesophyllic shift.
FD Podger, T Bird and JM Brown 1988, *Hogsback Plain region, south eastern Tasmania	Ecological evidence, historical data, palynological analysis, tree ring chronology	*Pre-settlement* fire frequency of 200 years or more, changing to a *post settlement* average 10 year frequency (from 1880), resulting in displacement of forest by sedgeland.
RC Ellis and I Thomas 1988, *North-eastern Tasmania	Archaeological, ecological and palynological data	Cool wet plateau, primarily suited to rainforest, but at contact was mix of rainforest (42%), eucalypt forest & grassland. This balance was determined by fire and had been maintained by *Aboriginal burning* for 2000-5000 years for range of resources; eucalypt forest by burning every 80-100 years, grassland by burning with occasional light fires. *Post-contact* shifts with burning of rainforests, invasion of grasslands by rainforest.
PA Gell and IM Stuart 1989, *East Gippsland Upper Delegate River	Archaeological, ethnohistoric and palynological	Cool wet area with winter snow: seasonal occupation by small bands of Aborigines, small steady increase over 900 years before contact. *Pre-contact* – low disturbance regime with infrequent intense fire associated with summer drought conditions. *Post-contact* alien regimes with evidence increase in fire frequency (grazing and mining), then more recently low intensity frequent autumn and spring burning.

Table 2. (cont.)

D Ward and G van Didden 1997, Jarrah forest of south-western Australia	Growth ring and fire scar markings on grasstrees, ethnohistoric records	Showed a gradual decline in fire frequency from an average of 3 per decade 1750 – 1859, to much less than one per decade by 1990.
LC McLoughlin 1998 *Sydney Region, NSW	Historical data, contemporary fire records	Comparison of fire season in the historical records with recent prescribed burning. *Aboriginal burning* in spring and early summer. August - January is Sydney's drier season and its identified fire season (Luke and McArthur, 1978) - Aborigines burnt with the wildfire season. *Prescribed burning* 1980-1996 strongly autumn-winter. In vegetation shaped by spring-summer burning, impacts of repeated burning in autumn-winter are likely to be high but ecological research on fire season is limited.
MA McCarthy, AM Gill and DB Lindenmayer 1999, *Mountain Ash forests, Vic.	Ecological evidence: life history forest attributes	Attributes used included stand age structure, development of tree hollows and colonisation of patches. Calculated mean fire interval for tree-killing fires at ~ 75-150 years and for any fires at ~ 37-75 years.
AM Gill 2000 (1) & Burrows et al (2) Western desert, Central Australia, quoted in Williams, 2002	(1) Historical records, archaeological/ anthropological evidence (2) Aerial photographs	Widespread *traditional burning* varied temporally but there may have been large unoccupied areas exposed to lightning ignition only. Preferred burning season August to October with patch size a few m^2 to 1000ha. Later burns October to January were often much larger (up to 100 000 ha). On east edge Great Sandy and Gibson deserts 75% burns >32ha but occasional fires up to 6000 ha under traditional regimes. *European period* – lack of planned fires, extensive wildfires with appropriate weather conditions September to March. Simplification of mosaic due to size of burnt/unburnt patches.
T Vigilante 2001, Kimberley region, Western Australia	Historical records, ethnographic evidence	Northern Kimberleys *Aboriginal burning* through dry season May to October with peaks in June & September. In southern parts fires were earlier: Feb-March to August but not late dry season. *Modern* fire history shows overall increase in burning especially in early dry season.
J Russell-Smith 2002, Northern Australian Savannas	Ethnographic, historical & contemporary observations, mapping. Synthesis of a range of previous studies plus new work.	*Indigenous fire*: early to mid-dry season in cooler, milder fire conditions, systematic across almost entire N. Australia, highly patchy - producing range of habitats. *Contemporary fire regimes*: either extensive, intense uncontrolled wildfire mainly in late dry season, or pastoral land seldom burnt. Results in: 1. loss of habitats, patchiness & fire-sensitive species on intensively burnt areas, 2. woody thickening, loss of herbaceous/grass-dominated savanna, granivorous species and biodiversity in seldom burnt areas.

science' (Cary *et al.* 2003b). Fire regimes have altered markedly, resulting in discernible significant shifts in vegetation structure, composition and/or distribution, and thus also in habitat (where these have been systematically examined, e.g. Table 2)

There has been significant work in developing knowledge of Aboriginal fire regimes and landscape burning practices across northern Australia, where Aboriginal people retain knowledge of traditional practices and sources of information are more immediately accessible. Yet, even here, incorporation of this knowledge into management strategies is slow to occur (Russell-Smith and Stanton 2002) and participation of indigenous owners and managers is beset by issues of rights and ownership of the decision-making role (Hill and Baird 2003).

Southern Australia not only differs markedly in its physical characteristics from northern Australia, so that knowledge is not necessarily transferable, but it also has great topographic, geological and climatic variety (Keith *et al.* 2002) requiring more finely grained studies than in some other parts of the continent. In addition, the south suffers greater inherent difficulties in assembling a coherent picture of indigenous burning. Here traditional knowledge has generally been dispersed or lost through 200 years of European impacts, and other information sources are highly fragmented so that reconstruction must use a variety of evidence from a range of disciplines. As a result, few integrative studies have been undertaken and there are wide gaps in information across a significant part of the continent. Yet only such studies can yield the detail required to inform locality or community specific conservation management in such an inherently diverse landscape.

Informed and appropriate conservation must include clear goals for vegetation management that acknowledge the nature and structure of vegetation communities present at contact, the Aboriginal management practices that shaped and maintained those communities, and the changes that have taken place during the European settlement period. Such knowledge of the past not only provides critical insights into the present nature of vegetation communities and their likely future trajectories, but it also assists in developing ecological hypotheses for the role of fire in specific environments that can be tested with standard ecological tools (Bowman 1998). Management plans must then set directions for future vegetation management based on those understandings, integrated with ecological knowledge of its current nature, structure and processes. The challenge now is to bring together as much evidence as possible from the range of sources available to develop a more consistent and coherent body of knowledge of Aboriginal fire regimes in south eastern Australia over the last 5,000 years.

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Plant responses to fires

David Cheal[1]

Abstract
Plants show varying adaptations to the fire regimes that are now a pervasive part of Australian landscapes. Their fire responses not only determine the nature of vegetation and habitats in the succeeding years, but also substantially determine the likelihood, intensity and other features of the next fire. The many different fire-related adaptations of plants also influence basic environmental features, such as soil nutrient availability and fertility. Understanding of plant adaptations and fire responses enables us to apply fires for ecological outcomes, and not just for 'fuel reduction' and wildfire control. (*The Victorian Naturalist* **121** (3), 2004, 107-115)

Fires, whether planned or wild, are a pervasive part of the Australian landscape and environment (Dyer *et al.* 2001; Gill 1975; Whelan 1995). The landscape burned before the arrival of Aborigines (Bowman *et al.* 1993; Truswell 1993), but in the late Pleistocene (Holocene), and well after the arrival of the first humans in Australia, a marked change appeared in the frequency and patterning of fire in the landscape (Ashton 2000; Crowley and Garnett 2000; Fensham 1997; Press 1994). Aborigines began to use fire as a landscape-scale management tool, changing previous species' abundances and occurrences and thus changing vegetation patterns (Fensham 1997; Koehn 1996; Latz 1994, 1995, 1997). Some vegetation communities and species increased as a result of this novel fire regime, whilst other vegetation communities and species decreased (Latz 1994,1997).

The arrival and settlement of Europeans led to further changes in fire management. Although in many areas there were concerted attempts to reduce fire in the landscape, ignition sources and the likelihood of large conflagrations increased (Gill 1975; Lunt 1995; Noble 1989; Williams *et al.* 1994). Research has shown that fire can be a useful tool in a fire-prone landscape and the planned application of fire has become a standard management practice (anonymous 1995; Attiwill 1994; Bell *et al.* 1984; Bowman 1994:Bradstock *et al.* 1995; Calder 1997; Dyer *et al.* 2001; Gill 1975, 1977; Lunt 1995; Murphy *et al.* 2002; Russell-Smith *et al.* 1999). Through all these changes, species have persisted or become extinct (Bradstock and Bedward 1997; Gill and Bradstock 1995; Keith 1996; Parsons and Browne 1982), depending on their ability to adapt to the new fire regimes.

And it is fire **regime** that is important. Fires vary in season of burn, intensity of burn, frequency (time between fires), time since the previous fire and in the proportion of the landscape burnt (abundance, size and distribution of unburnt remnants). Indeed, such variation may be found in various parts of a single fire. Some areas within a single fire boundary may be consumed in high intensity fire while others are only lightly burnt. Part of that same fire may burn vegetation in an area that was burnt only a few years beforehand whilst in other areas the previous fire may have occurred many decades earlier. This variation was evident in the recent fires in north-eastern Victoria and adjacent New South Wales (Cheal 2003; Green 2003). It is clear that plant species vary in their responses to individual fire events and to the fire regime.

Season

The (annual) season in which a fire burns may have a dramatic impact on vegetation landscape patterns. Mallees (multi-stemmed, lignotuberous eucalypts) are usually considered to be prime examples of plants that are relatively immune to any adverse impacts from fire. Under a natural fire regime, they appear to resprout vigorously no matter whether they have been burnt in high or low intensity fires, in spring, summer or at any other time of the year and no matter how frequently (anonymous 1996; Jacobs 1980; Macfarlane 1994). However, work at Pooncarie in far south-western New South Wales (Noble

[1] Arthur Rylah Institute for Environmental Research, 123 Brown Street, Heidelberg, 3084. Email: david.cheal@dse.vic.gov.au

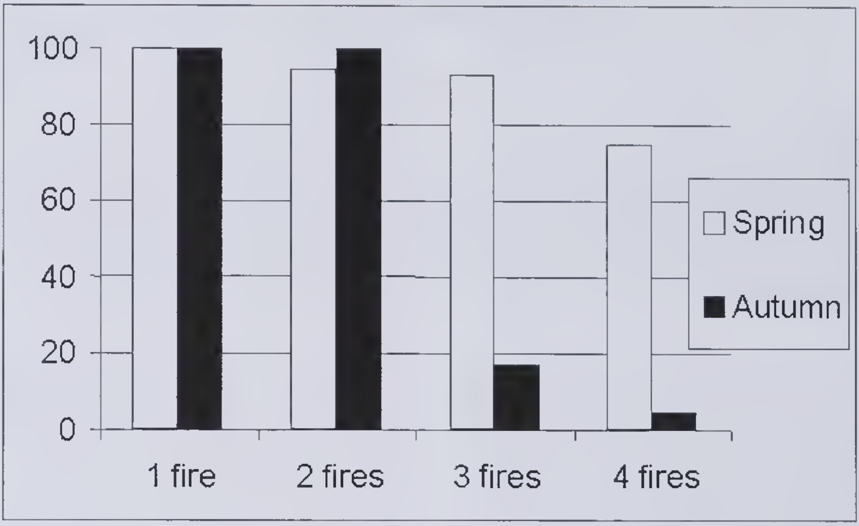

Fig. 1. Mallee eucalypt survival after annual fires (from Noble 1989).

1989) demonstrated a dramatically different response to autumn fires relative to spring fires (Fig. 1). After only three annual autumn fires (a contrived fire regime), mallee mortality increased to over 80%, whereas after three annual spring fires mallee mortality was less than 5%.

Similarly, the season immediately after a fire can have a dramatic impact on future vegetation composition and species survival for many decades. A drought immediately post-fire may prevent the establishment of most or all germinating seedlings, even leading to local extinctions (Cohn and Bradstock 2000; Enright and Lamont 1992; Griffith *et al.* 2004), whereas a wet season immediately post-fire may strongly advantage the seed regenerators over species that resprout.

Intensity

Intensity varies with season, fuel and landscape variability. Within one fire, intensity may vary little if the fuel is homogeneous (in quantity and flammability), the landscape is relatively flat and the weather is constant (no dramatic changes in wind speed and direction, nor in ambient temperatures nor moisture) (Fig. 2). In such situations, fires leave few unburnt refuges.

By contrast, where the slopes vary, wind speeds and directions vary and the fuel varies in flammability (variable moisture levels and local quantities), fires are patchy, leaving many unburnt refuges in the landscape (Fig. 3).

Frequency

Similarly, fires vary in the time between fires and whether the inter-fire intervals vary in length.

Landscape Pattern

Further components of fire regime include the patterning of fire in the landscape. The number and distribution of unburnt refuges are critical to the recovery of affected species and communities (Fig. 4).

Plant Responses

Fires can be destructive. Each plant species has different strategies for survival during fire and for exploiting the opportunities offered after fires have passed. However, many species exhibit no adaptations to survive fire nor to exploit the changed environment after fires. This is no disadvantage where fires are unlikely and may even further reduce the likelihood of fires (Fig. 5). Other species live in fire-prone environments, or even increase the likelihood of fires in their immediate environment (e.g. they may produce persistent flammable litter or foliage with abundant flammable essential oils). Consequently,

Fig. 2. Big Desert after the 1984 fire. Photo: C Meredith.

Fig. 3. Heathy Spur, Bogong High Plains, after the 2003 fire.

Fig. 4. Burnt shrubs (mostly *Hovea montana*) amongst unburnt or lightly singed grassland, Bogong High Plains, after the 2003 fire.

Fig. 5. Samphire *Sarcocornia quinqueflora*, Lake Kenyon, Sunset Country. Succulent foliage, few essential oils, little litter build- up, seed exposed, spaces between shrubs = fire resistant vegetation.

they exhibit various adaptations to survive, or even exploit, fires.

Contemporary classification of plant responses to fire is focused on whether plants survive fires or not and hence on their regeneration strategy post-fire (Gill 1981; Noble and Slatyer 1981). Obligate Seed Regenerators ('Reseeders') are killed by fire and regenerate solely from seed, whereas Obligate or Facultative Root Resprouters ('Resprouters') regenerate only from protected dormant buds (*obligate*) or also from seed (*facultative*). This is a useful distinction but, like all such simplifications, is not always the case. Under the right conditions, even the most sensitive reseeder will resprout or the most tolerant resprouter will die as a result of fire.

Each of these primary categories can be further subdivided. Resprouters may resprout from underground dormant buds or from aerial buds that are often protected by thick bark (Figs. 6 and 7). Reseeders may protect their seed from fires by storing them in aerial resistant structures (Fig. 8) or in the soil (Figs. 9 and 10). Some species respond to disturbance, whether from fire or other causes, with a flush of germination. This group includes many annual plants, which avoid the adverse impacts of fires by existing solely as a soil seed store in the dry summer fire season. They are capable of growth in unburnt vegetation but also often respond particularly luxuriantly post-fire (Fig. 9). Others cue their germination to some fire effect, such as a soluble leachate percolating into the soil profile (Auld 2001; Christensen and Muller 1975; Ramp 1994), and are restricted in germination to soon after fires – the so-called 'fire ephemerals' (Fig. 10).

All these strategies may be used by species in one vegetation community, relying on microscale variability in the local landscape to offer them their particular suite of ecological requirements. Hence,

Fig. 6. Blue Gum *Eucalyptus globulus* coppicing from dormant buds under bark after fire.

Fig. 7. Dwarf Sheoke *Casuarina pusilla sensu* Hwang 1992 resprouting from underground doormant buds after fire.

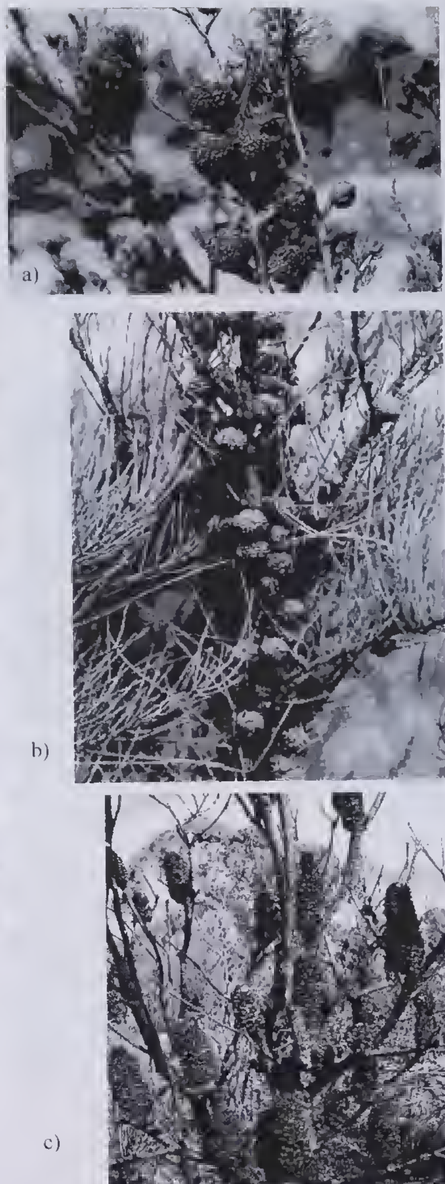

Fig. 8. Examples of protective seed storage (bradyspory). a). Scrub Cypress-pine *Callitris verrucosa*. b). Dwarf Sheoke *Casuarina pusilla*. c) Silver Banksia *Banksia marginata*.

plant communities are dynamic in composition and are often site-specific. The suite of species at each site, and their relative abundances, are partially determined by that site's fire history and the variability and patchiness of those fires. The community's fire response is a function of the suite of species present at a site, their interactions, their individual fire responses and the characteristics of the local fire regime.

Flammability

Much of the Australian vegetation is adapted to a regime of frequent fire. Features of both the plant species and the environment increase the likelihood of fires. General climatic features that increase the likelihood of fire include hot, dry summers and low relative humidity.

But features of the vegetation itself also increase the likelihood of fires. Many of

Fig. 9. Bristly Poppy *Papaver aculeatum*, a disturbance ephemeral (i.e. also found in unburnt vegetation), growing luxuriantly after fire, does not require cues from a fire to germinate and grow.

Fig. 10. *Helichrysum adenophorum* after the 2002 fires in the Big Desert. Present solely as a soil seed store beforehand, its germination was cued by fire.

the typical and dominant plant species in Australia are highly sclerophyllous. They have long-lived, nutrient-poor foliage and often contain flammable essential oils. Sclerophylly is related to growth on nutrient-poor soils (Bowen 1981; Hobbie 1992; Midgley and Enright 2000; Monk 1987; Pate 1993; Turner 1994). On such soils, limiting nutrients (nitrogen and phosphorus) are dedicated to essential cellular biochemistry, such as synthesis of nucleic acids and enzymes, and are unavailable for incorporation into structural protein. Instead, structural material is dominated by carbohydrates, notably lignin and cellulose. Before leaf drop, mobile nutrients (N, P) are retracted into the plant, leaving the litter (discarded leaves, twigs and wood) low in nitrogen (Aerts 1997; Bosatta and Staaf 1982; Entry and Backman 1995; Raison 1979) and unable to support high levels of decomposers. Decomposition is slow and litter accumulates, increasing the likelihood of another fire – which itself leads to further soil impoverishment (Cook 1994; DeBell and Ralston 1970; Pate and Dell 1984; Trabaud 1983), to even more recalcitrant litter, to a greater likelihood of the next fire, and so on – a positive feedback loop. Poor soils supporting fire-prone vegetation become poorer still and even more fire-prone over time.

Some of our most fire-prone habitats include heathlands (Fig. 11), dry forests and mallee on siliceous sands, all on relatively poor soils. They often adjoin vegetation where fire is far less common, such as rainforests, wet forests and chenopod mallee and shrublands (Fig. 12), all of which occur on more fertile soils.

Overall Fire Regime

As species have different responses to fire, it is dangerous to relate vegetation responses to a fire, or pattern of fires, as though the vegetation responds as a unit. Species respond idiosyncratically. Some will be advantaged, some disadvantaged and some neutral, all at one point in time and space.

Research into heathlands and their fire responses has focused on the fire ecology of the bradysporous[1] (Lamont 1991), woody dominants (Bell *et al.* 1984; Bradstock 1990; Enright and Goldblum 1999; Enright and Lamont 1989; Keeley 1986; Keith 1996; Lamont and Groom 1998; Richardson *et al.* 1995; Williams and Clarke 1997; Wooller and Wooller 2001). Other ecological strategies within heathlands have been less frequently studied. Recruitment in the bradysporous dom-

[1] species with woody fruit that protects seeds from being burnt and releases the seed after the fire has passed.

Fig. 11. Heathland, French Island, that is highly sclerophyllous, growing in nutrient-poor soil and fire-prone.

Fig. 12. Chenopod shrubland, Neds Corner, showing succulent growth in soils that are not nutrient-poor with little likelihood of fire.

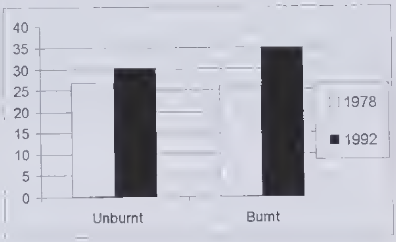

Fig. 13. Increase in species richness with time, assessed in 1978 and 1992, burnt or unburnt between assessments: heathland, Wyperfeld National Park (from Cheal 2000).

Fig. 14. Chenopod Mallee, Neds Corner. The canopy requires fire for regeneration, but the succulent shrubs are disadvantaged by fire.

inants is largely restricted to the period immediately post-fire, but recent work has suggested that, contrary to previous assumptions (Benwell 1998; Hilbert and Larigauderie 1990; Keith 1996; Keith and Bradstock 1994), recruitment of other species can occur in the inter-fire interval (Fig. 14) (Cheal 2000; Enright *et al.* 1998; Enright *et al.* 1994; Griffith *et al.* 2004; Whelan *et al.* 1998). The differences relate to the nature of the seed release mechanism within plant fruits and the generation times of the component species. The bradysporous dominants tend to be long-lived, while the smaller undershrubs have shorter generation times, often much less than the mean period between fires.

Different generation lengths may be critical in explaining the apparent strangeness of communities such as Chenopod Mallee (Fig. 14), which is widespread in the Mallee regions of New South Wales, South Australia and Victoria. Here the canopy requires fire to regenerate, yet the dominant species in the shrub layer have no adaptations to regenerate post-fire and appear to be disadvantaged by any fire. How can these two layers co-exist?

Fires are very infrequent in this habitat, and depend on a rare combination of events, probably a succession of summers with unusually high rainfall producing a grassy fuel layer. The eucalypts that dominate the canopy (usually *Eucalyptus oleosa*[2] and *Eucalyptus gracilis*) probably have generation times of 300+ years (Noble 2001; Wellington and Noble 1985). The shrubs are much shorter-lived, 10 -30 years being a reasonable estimate (Williams 1975). The likelihood of a fire within a single generation of the chenopod shrubs is low, whereas the likelihood of a fire within a generation of the canopy eucalypts is high. It makes ecological sense for the eucalypts to adapt to seed regeneration post-fire, whereas similar

[2] Nomenclature follows Walsh NG and Entwisle TJ (1994; 1996; 1999) unless indicated otherwise.

Fig. 15. Fire boundary, Wyperfeld National Park. Left side burnt in 1984 and 1959 shows heathland dominated by *Banksia/Leptospermum/Casuarina*. Right side burnt only 1959 shows shrubland dominated by Scrub Cypress-pine *Callitris verrucosa*.

selection pressure on the chenopod shrubs is much less.

Ecological Fire Planning

Fire is applied ('prescribed') for many reasons, including fuel reduction, amenity access and habitat manipulation. In addition, wildfires often intervene in a planned process of fire management. At the same time, careful land management may achieve control over the fire regime to such an extent that the survival of species or habitats requires the planned application of fire.

Attempts to manage the landscape as though it could reach some stable unchanging state fail. All communities change with time, at a greater or lesser rate (Fig. 15). Climax communities (in the sense of stable, unchanging communities) do not exist. The biological priorities and values should drive the development of a burning or protection plan. A 'one size fits all' approach to fire management is inappropriate and ecologically naïve. The application of a planned fire regime should not be stymied by fear of criticism or of 'doing the wrong thing'. Recognition that some biological values will benefit from planned fire, while others will be disadvantaged, requires that values in the affected (target) landscape be prioritized. Once values have been prioritized, and their responses to the proposed fire or fire regime explicitly identified, a plan may be prepared. Given that we know so little of the fire responses of most species and habitats, identification of the impacts of the planned regime on individual values is likely to require further research.

As a result, we will have an explicit statement of the biological values of an area; biological values (rather than public relations) will have driven the burning plan; and we will have managed for change.

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Seventy-two Years Ago

The fire of February 5 came overhead for many miles before it descended upon the various parts of the district. Pieces of bark, 10 or 12 feet in length, and up to 6 inches in width, have been found all over the district; unmistakably black bult bark (*Euc. regnans*), which must have been carried over on a terrific windstorm some time earlier in the morning. There is no black bult this side of the Ranges.

(Miss) C. C. Currie

From *The Victorian Naturalist* **XLIX**, p. 27, June, 1932

Fire impacts on fauna

Gordon Friend[1]

Abstract

A brief overview of faunal responses to fire (both prescribed fire and wildfire) is provided, focusing on small mammals and to a lesser extent on reptiles, amphibians and invertebrates. An outline of some of the broader frameworks which have developed to aid our understanding is also given, along with a brief examination of knowledge gaps and future directions. The elucidation of mechanisms and interactions between fire and ecological processes at the community level, and determining the relative importance of scale, patchiness and fire interval are seen as the principal priorities for future fire ecology research efforts in Australia. The setting of clear conservation objectives and implementation of an adaptive experimental approach to fire management are seen as the most efficient and effective means of achieving ecological sustainability in relation to fire. (*The Victorian Naturalist* **121** (3), 2004, 116-121)

Introduction

Fire and its role and impact on fauna in Australian ecosystems has been a contentious and emotional issue for many years. It is only since objective, experimental data began to be collected from the mid 1970s onwards that some scientific insights began to emerge on this topic. Indeed, the wildfire which burnt through the Nadgee Nature Reserve in New South Wales in December 1972 was a significant turning point in the development of our knowledge of fire ecology. The Nadgee fire affected an area where small mammal studies were already underway and thus presented a unique opportunity to gather before/after data on the impact of the fire on small vertebrates (see Newsome *et al.* 1975; Recher *et al.* 1975).

Since this opportunistic beginning, many studies have been carried out and much has been learnt about fire and its relationship with the biota of Australia. Most of these studies have centered on forest and heath habitats in the south-east and south-west of the continent (e.g. Nadgee and Myall Lakes in New South Wales, East Gippsland, Otways, and the south-west of Western Australia; see reviews by Catling and Newsome 1981, Suckling and MacFarlane 1984, Christensen and Abbott 1989, Friend 1993, Wilson 1996, Wilson and Friend 1999, Friend and Wayne 2003, van Heurck and Abbott 2003). Studies have also been carried out in mallee areas within Victoria and New South Wales (Cheal *et al.* 1979), spinifex areas of central Australia (Masters 1993), and most recently in the tropical savannas of Northern Australia (Andersen *et al.* 1998). Most emphasis throughout has been on small mammals, birds and invertebrates, while few studies have focused on reptiles and/or amphibians. A serious shortcoming in the work to date is that most studies have been very short-term (<5 years) and investigated only single fire events with little pre-fire data.

This paper aims to provide a brief overview of faunal responses to fire (both prescribed fire and wildfire), focusing on small mammals and to a lesser extent on reptiles, amphibians and invertebrates. An outline is also provided on some of the broader frameworks which have developed to aid our understanding. The paper concludes with a brief examination of knowledge gaps and future directions. By necessity, this review is only cursory and the reader is referred to more detailed reviews and research papers if seeking more information.

Faunal responses to fire

Small mammals

Studies of the impacts of fire on small mammals are numerous, but the most useful insights have been gleaned from the few studies which have been relatively long-term (10+ years: Wilson *et al.* 1990; Fox 1996; Wilson 1996) and/or have examined areas of very similar habitat type, but of different post-fire successional ages (space-for-time approach). Studies carried out by Barry Fox and his colleagues in the Myall Lakes area of New South Wales (Fox 1982a, 1982b, 1983,

[1]Biodiversity and Natural Resources Division, Department of Sustainability and Environment, East Melbourne, Victoria 3002

1996; Higgs and Fox 1993; Monamy and Fox 2000) have over 20 years of data, with some sites having two cycles of regeneration following fire. This also is true of studies of long-term fire effects carried out in the Wombat State Forest near Daylesford, Victoria (Tolhurst 1999).

The immediate impacts of fire on small mammals (and fauna in general) are dependent mainly on intensity and scale. This is exemplified by data on the Red-tailed Phascogale *Phascogale calura* from Tutanning Nature Reserve in the south-west of Western Australia (Friend and Friend 1993, and unpubl. data) where an autumn fire caused significant direct mortality (3/10 radio-tagged animals died), but no long-term effect on population dynamics due to recolonization from surrounding unburnt areas (small burn size, i.e. scale important).

The patchiness of a fire also has a large bearing on its impact; many animals may survive in unburnt patches especially along moist gullies and creeks (Whelan 1995). Predation following fire may also be very significant, and in some situations has been shown to be more important than the fire *per se*. Some evidence of this is emerging in Western Australia where large-scale predator control programs are in place (A Wayne pers. comm.).

High intensity wildfires may have a severe impact on small mammals, while individual low intensity fuel reduction burns generally have only minor impacts. High frequencies of such fires, however, may lead to substantial changes in vegetation richness and structure and in turn affect small mammal species abundance and community composition (Whelan 1995).

Indeed, the recovery of small mammal (and most other faunal) communities is intricately linked to the recovery patterns of the vegetation and to the life-history characteristics of the species themselves. Much of the data gathered to date (see papers/reviews by Fox 1982a, 1983; Friend 1993) have indicated there is a reasonably consistent and predictable successional sequence of small mammals following fire in forest and mallee/heath ecosystems throughout Australia. A common theme is the rapid and early colonization by the exotic House Mouse *Mus domesticus*, followed by *Pseudomys* spp., if extant. *Mus* appears to be a post-disturbance opportunist that exploits unfilled niches but does not necessarily substitute for *Pseudomys*. As vegetation density and structure increase after 3-5 years, *Mus* and *Pseudomys* begin to decline in abundance and be replaced by small dasyurids (primarily *Sminthopsis* spp.).

Later, as the dasyurids decline in response to further habitat successional changes, the larger rodents (*Rattus* spp.) become dominant if extant in the region. This latter pattern is not a consistent trend, however, and may depend on habitat characteristics (e.g. vegetation density and speed of recovery) and the patchiness of the fire allowing refugial populations (e.g. of *Rattus lutreolus*) to survive in moist areas with dense cover (Catling 1986; Monamy and Fox 2000). These patterns are discussed further in the section on frameworks.

Reptiles and amphibians

There are few published data available on the impacts of fire on herpetofauna. For reptiles, the most comprehensive community-based studies are those of Caughley (1985) from central New South Wales, Bamford (1986, 1995) from Banksia woodland and heath vegetation in Western Australia and Braithwaite (1987) from tropical savannas in the Northern Territory. Other more limited studies have been carried out in Wyperfeld National Park, Victoria (Cheal *et al.* 1979; Mather 1979) and following the 1972 wildfire in Nadgee Nature Reserve (Newsome *et al.* 1975; Fox 1978), or after logging in Mumbulla State Forest, New South Wales Lunney *et al.* 1991). For frogs, only the work of Bamford (1986, 1992) and the observations of Main (1981) have addressed this critical gap in our knowledge (see reviews by Friend 1993 and Whelan 1995).

More recently, however, a few more detailed studies have been published on the effects of fire on single species such as the Frillneck Lizard *Chlamydosaurus kingii* (Griffiths and Christian 1996) and the frog *Geocrinia lutea* (Driscoll and Roberts 1997), while Bamford and Roberts (2003) have recently carried out a review of herpetofaunal responses to fire, focussing mainly on south-west Western Australian ecosystems.

In summary, studies to date suggest that reptiles are generally more resilient to fire than mammals due to their adaptations for arid conditions. Many species are burrowers with generalised invertebrate diets and strongly seasonal activity and breeding patterns and accordingly, survival (at least of adults) may be relatively high during fire. However, those that dwell in dense leaf litter (e.g. *Morethia* spp.) may be more severely affected, while predation and starvation may be significant during the weeks/months following fire. For amphibians, relationships with fire are generally weak and, as for reptiles, this is probably a reflection of their burrowing habits and generalised invertebrate diets. Many responses are probably more tied to moisture regimes and season than fire *per se,* although some species that are tree-dwellers (e.g. *Litoria* spp.) and therefore more directly exposed to fire may be negatively affected.

Invertebrates

There has been a considerable amount of work carried out on invertebrate responses to fire in Australian ecosystems, mainly in forests, woodlands and mallee shrublands (Whelan 1995). This recognises the fact that invertebrates:

- play a crucial role in the structure and maintenance of ecosystems;
- represent important links in the food chain;
- constitute 99% of world's biodiversity; and
- potentially form excellent bio-indicators of the environmental condition.

In providing a very brief overview of these fire response data, some generalities emerge. Invertebrate responses are often very complex, but also inconsistent. In many instances this may be a reflection of experimental design and the level of taxonomic resolution undertaken (i.e. orders vs. species level identifications; Friend 1995). Although some impacts may be significant, many are only short-term (e.g. <2 years) and indicate there is a remarkable degree of resilience in the fauna. However, some specialised groups such as Gondwanan relicts that occupy mesic habitats or micro-environments may be severely affected for long periods (e.g. in the Stirling Ranges of south-west Western Australia; Harvey and Main 1998). Indeed, as with the reptile fauna, impacts seem to be tied to species adaptations to survive aridity, so there is a gradient of increasing resilience to fire as we go from wet to dry habitats (Friend 1995, 1996).

A recent study (van Heurck *et al.* 1998) and review of fire and terrestrial invertebrates in south-west Western Australia (van Heurck and Abbott 2003) provided valuable insights into the functional mechanisms underlying invertebrate response patterns. These authors analysed the fauna in terms of 'functional guilds' and showed that fire impacts manifested as a 'productivity pulse' that moves up through the trophic web. Larger predatory species (e.g. carabid beetles and spiders) often decline immediately after fire, while smaller decomposers and saprophagous species (e.g. springtails and thrips) increase dramatically. As vegetation regrowth commences over the next 1-2 years, medium-sized leaf herbivores (e.g. chrysomelid beetles and orthopterans) increase in richness and eventually, as structural complexity returns, the larger predators and pollinators return along with larger decomposers such as cockroaches and earwigs. These insights provide some degree of confidence in the predictability of these systems, but also highlight the need to analyse information at the 'morphospecies' level and to consider life-history guilds (as has been done for small mammals) if we are to better understand these interactions.

A further very important but often unrecognised factor, which applies to all groups of fauna and to vegetation, is that fire effects may combine with climatic impacts (e.g. drought) or other human-induced impacts (e.g. from logging) to selectively alter or remove critical elements of the habitat leading to marked changes in populations of both plants and animals. Factors such as season, locality and year-to-year variability in climate, and random events like droughts and floods, may exacerbate or outweigh changes attributable to fire so that post-fire succession does not eventually return ecosytems to their pre-fire condition. Indeed, in any particular landscape, unburnt areas may change in species abundance and composition as much as areas that are burnt (see Strehlow 1993). Consequently, there is not necessarily a specific 'state', such as pre-European settlement condition, for which land managers can aim.

Frameworks that aid understanding of response patterns

A number of reviews and syntheses arising out of and alongside studies of fire and small vertebrates (especially mammals) throughout south-eastern and south-western Australia have provided some insight into response mechanisms and enabled the development of unifying themes and frameworks which aid our understanding. For example, by calculating a 'fire response index' (logarithm of the ratio of post-fire to pre-fire abundance of each species), Fox (1983) was able to classify the species in his Myall Lakes study area as occupying an 'early regeneration niche' (e.g. *M. domesticus, Pseudomys gracilicaudatus, P. novaehollandiae* and *Isoodon obesulus*) or a 'late regeneration niche' (e.g. *Antechinus stuartii, Rattus fuscipes* and *R. lutreolus*). Fox (1982a, 1982b) summarized these seral responses by proposing a 'habitat accommodation model' whereby species enter the succession when their specific habitat requirements are met, and are replaced or decline in abundance as conditions become suboptimal and their competitive ability is reduced.

Such a linkage between fauna and vegetation succession has been confirmed in long-term studies in forest habitats (Fox 1996, Monamy and Fox 2000) where early successional species (e.g. *P. novaehollandiae*) began to increase in abundance in long-unburnt sites (20-30 years old) and late successional species like *R. fuscipes* began to decline. This correlated with a senescing and opening up of the understorey vegetation, in effect 'regressing' to its earlier post-fire physiognomy. This work has provided very useful insights, showing that the mammal community is not in fact responding to any temporal (time-since-fire) axis, but rather to the vegetation succession as measured through vegetation density and structure (Monamy and Fox 2000). It is important to realise that this outcome could only be identified through long-term monitoring at permanently established study sites.

Relationships between 'habitat complexity scores' and mammal distribution and abundances have also been demonstrated recently by Catling *et al.* (2001), indicating that time-since-fire *per se* is not necessarily a strong indicator of mammal presence or abundance. Utilising the ability of airborne videography accurately to predict habitat complexity (Coops and Catling 1997), Catling and Coops (1999) have used this technology to predict mammal distribution and abundances at a landscape scale and thus model and predict response patterns up to 25 years after wildfire (Catling *et al.* 2001). This offers a potentially powerful tool for testing and using in other areas and habitats.

Friend (1993) reviewed the impact of fire on small vertebrates inhabiting mallee woodland and heathlands and examined species' life-history parameters (shelter and food requirements and activity and breeding patterns) in a search for unifying patterns. Regarding small mammals, species which survive fire and/or favour early post-fire successional stages (e.g. *M. domesticus, Pseudomys* spp.) generally shelter in burrows in relatively open areas with low ground vegetation and little leaf litter cover. They have non-specialized omnivorous diets, and can vary their reproductive patterns in response to climatic or habitat cues. Mid-successional species (e.g. *Sminthopsis* spp.) require denser vegetation and shelter in more flammable refuges (e.g. hollow logs and grass trees), are less general in their diets, and have a more rigid seasonal, though polyoestrous, breeding strategy. Finally, late-successional species (e.g. *Antechinus* and *Rattus* spp.) show considerable specificity in diet, shelter in flammable refuges in relatively dense vegetation, and may have a seasonal and highly synchronized breeding season.

There is thus a trend of increased specificity and reduced flexibility in small mammal species' life-history parameters concomitant with increased impact of fire, and later post-fire recolonization. These relationships support the findings of Fox and Catling and their colleagues (noted above) that mammal species respond to habitat successional cues (e.g. cover, structure and floristics), which may or may not be closely related to a temporal axis, but which greatly influence the shelter and food resources available for mammals. For the herpetofauna, Friend (1993) concluded that reptiles showed similar, though much weaker, post-fire successional trends that could be related to life-history parameters, while the amphibia showed little relationship to fire, instead being influenced more strongly by soil and moisture patterns.

Knowledge gaps and future directions

The above very brief overview of our current knowledge of the relationships between fire and fauna in Australia indicates that we now have reasonable insight into the response patterns of a range of species and communities, as well as some degree of confidence in predicting both the short- and long-term effects of fire on the biota. This confidence, however, is tempered by recognition of the vast array of influences and events which may combine to determine post-fire outcomes. Interactions between potential threats, episodic disturbances and pressures upon species and communities mean that the exact nature of the responses to fire by different habitats and communities can be as diverse as the communities themselves. This uncertainty represents a significant barrier to confidently using fire to achieve desired conservation outcomes. Unfortunately, until we gain detailed knowledge of impacts and can model the interaction effects of various threats and disturbances, a high level of sophistication in knowledge and predictability will remain unattainable (Friend and Wayne 2003).

The key issues that require attention in future fire ecology research fall into two areas: (a) mechanisms and interactive effects at the community level, and (b) the importance of scale, patchiness and fire interval in determining mortality, emigration and survival within a site. These issues apply to flora as well as fauna.

In the case of fauna, the first set of issues can best be teased out and understood through experimental manipulations of resources (e.g. habitat, shelter, food), competitive interactions and predation rates (Sutherland and Dickman 1999). Apart from a few studies (e.g. Newsome and Catling 1983; Sutherland 1998; Higgs and Fox 1993) this whole area of important research has received scant attention. The second set of issues relating to scale, patchiness and fire interval and how they influence individual mortality, emigration and survival are, from a fire management standpoint, both the most important and the most easily manipulated. The answers to this set of issues will be gleaned only by treating prescribed management fires as a series of large-scale experiments and, through monitoring and 'learning by doing' (AM Gill, pers. comm.), refining prescriptions and management actions as one learns. Such an adaptive experimental management approach (Walters 1986) is increasingly recognised as the most fruitful path for research and management to progress.

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Victoria's parks, forests and fire

Mike Leonard[1]

Abstract
Victoria's recent wildfire history is considered in regard to the state's parks and forests and the ways that managers have to deal with wildfire threats. The nature of these threats is detailed and linked to recent developments in fire control and management. Such developments are ongoing but much research needs to be done. (*The Victorian Naturalist* **121** (3), 2004, 122-128)

Introduction

Within the international wildland fire community, the northern Mediterranean, southern California and south-eastern Australia are considered to be the most wildfire prone areas on Earth.

From the point of view of Victoria's parks and forests, this paper examines:

- the State's recent fire history;
- the development of approaches to wildfire management in Victoria over recent decades; and
- ways that managers of Victoria's parks and forests attempt to deal with both the threat posed by wildfire to human life and property, and the integral role fire plays in the maintenance of many of the State's native ecosystems.

Because results arising from wildfire inquiries at both the state and federal level recently have been reported, or will be reported in the near future, this paper attempts to avoid value judgements regarding fire management, preferring to leave that to others.

Victoria's parks and forests

Prior to the arrival of non-aboriginal people, approximately 90% of Victoria was covered by forest and woodland. Today, this figure is nearly 8 million hectares or around one-third of the state (Fig. 1). Overwhelmingly, Victoria's remaining forests and woodlands are in public ownership and comprise National and other parks, and state forests. There are around 60,000 kilometres of 'interface' between public and private land.

In rural Victoria, fire responsibility on public land rests with the Department of Sustainability and Environment (DSE), and private land with the volunteer-based Country Fire Authority (CFA). There is a long history of cooperation between both agencies.

For the managers of Victoria's parks and forests, fire represents a paradox. Fire is a serious threat to life (Fig. 2) and property (Figs. 3 and 4), while conversely playing an integral role in the maintenance of many of our native ecosystems. Arguably, it has been, until recently, the serious threat to life and property that has dominated relevant public policy debate.

Potentially each summer, Victoria's parks and forests contain large volumes of highly volatile fuels. This is due to the nature of their vegetation, climate and weather patterns.

The wildfire threat

Around 170 years ago, humans with a 'European' view of the landscape began arriving in south-eastern Australia. In 1851, around 4.4 million hectares of Victoria was burnt by wildfire with 12 lives lost. In 1939, 2 million hectares of the State were burnt with 71 fatalities and whole townships obliterated, while in 1983, some 0.2 million hectares were burnt with 47 fatalities. In 2003, fires burnt some 1.1 million hectares of park and forest over a two-month period.

Hickman and Tarrant (1986) estimated that, over the last 100 years, Victoria had 75% of all wildfire-related deaths in Australia and 55% of significantly related economic impacts.

The cyclic nature of wildfire

The cyclic nature of fire season severity in Victoria has significant implications both in terms of resourcing the State's rural fire services, and in relation to the development of community attitudes to bush fires.

[1] Department of Sustainability and Environment, PO Box 500, East Melbourne Victoria 3002

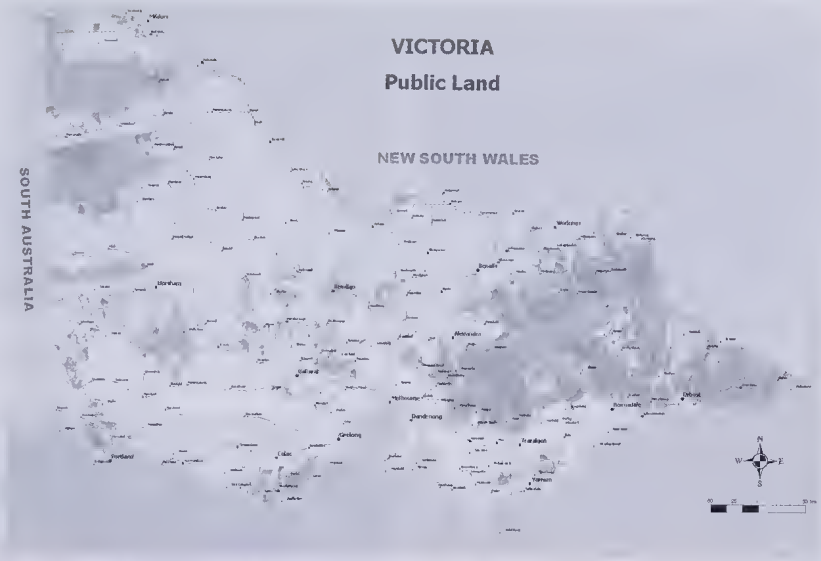

Fig. 1. Area of Victoria covered by forests and woodlands, 2003.

An analysis of fire season trends on public land in Victoria over the last 70 years (Figs. 5-7) showed a gradual increase in the number of fires attended annually by DSE, while the area of public land burnt annually by wildfire slightly decreased (Figs. 5 and 6).

An increase in the percentage of lightning-caused wildfire with the severity of the fire season was found. This has resource, mobility and budgetary implications: lightning fires often occurred in remote parts of the State's parks and forests. In an average year, lightning caused around 25% of all wildfires.

The nature of the fire risk

Measures known as the Drought Index and Drought Factor are analogues for the amount of moisture in the 'natural system'. The 'Fire Danger Index', based on daily weather variables, and the Drought Index are used to measure the daily fire danger. The Drought Index is used as a 'predictive tool' together with long-range forecasts in pre-summer planning (e.g. determining levels of employment of seasonal firefighters and commencement of specialised aircraft contracts).

In an average season in Victoria, there are over 600 wildfires on public land (DSE aims to keep at least 75% of all wildfires at less than five hectares in size, and, generally, meets this 'performance measure'). These 'average' fires burn over 120,000 hectares in total (or around 1.6% of the public land estate). Each year, DSE aims to use 'prescribed' fire to treat between 80,000 and 150,000 hectares (1-2% of the estate) for fuel management and biodiversity reasons.

Community values associated with parks and forests these days include a priority for water production (both quantity and quality), biodiversity (public lands contain many nationally and internationally significant ecosystems), visitor destinations, most of Victoria's native timber resources, and landscape/scenic and spiritual values.

'Bad fires' – the threat to life and property

The principal fire legislation governing DSE's approach in this matter is found in Section 62(2) of the Forests Act 1958:

> Not withstanding anything to the contrary in other Act or law it shall be the duty of the Secretary to carry out proper and sufficient work for the prevention and suppression of the fire in every State forest and national park and on all protected land…

Relevant legislation also is found in sections of the National Parks Act, the Country Fire Authority Act and the Emergency Management Act.

Fig. 2. Mountain Pygmy Possum *Burramys parvus* - survivor of Victorian Alps fire, 2003.

Fig. 3. Burnt remains of house in 1939 wildfire, Matlock. Photo: Forest Commission's Library, 1939 collection.

Fig. 4. Indiscriminate burning of fire, some houses remain while others are burnt. Photo: Forest Commission's Library, 1939 collection.

Remote area fire control development

In recent decades, developments in fire control in remote areas have included:

- cultural changes over the last hundred years (linked to people's attitudes to 'the bush');
- expansion of the public land road, track and fire tower network in the 1950s/1960s;
- strategic fuel management (mainly by prescribed burning), which became common in the 1960s/1970s;
- comprehensive public land fire-related planning, which has been implemented since the mid 1980s;
- refinements in the quality and deployment of fire suppressing tankers, four-wheel drive vehicles, and aircraft (particularly since the 1980s);
- increasing 'science' being employed in the understanding of 'fire danger', fire weather and fire behaviour (since the 1960s);
- the development of formal firefighter training and accreditation requirements (particularly since the 1980s); and
- the development, in 1994/95, of a *Code of Practice for Fire Management on Public Land*. The Code was developed with good support from agency and community stakeholders and was designed to facilitate a 'holistic' approach to public land 'Fire Management'.

More recent developments included:

- the strategic use of retardant and foams in wildfire suppression;
- an increasing emphasis on firefighter health and fitness issues;
- the development of Incident Management Systems (including the introduction of a joint DSE/CFA Incident Management Agreement);
- aircraft related developments including infra-red mapping, aerial mapping, aerial ignition and the use of specialist 'rappel' and 'hover exit' crews;
- the development of a significantly enhanced computer-based resource management and decision support system;
- the development of a 'model fire cover' approach to resourcing levels. The system identifies the minimum resource requirement and standards at each DSE/Parks Victoria work-centre for 'first attack' at fires; and
- the maintenance of 'Readiness and Response' Plans by DSE Regions, and State-wide, to better match resource availability to fire danger.

Fire management on public land in Victoria

The order of control and planning for fire management in Victoria occurs at several levels (Fig. 8). For a given area of Victoria,

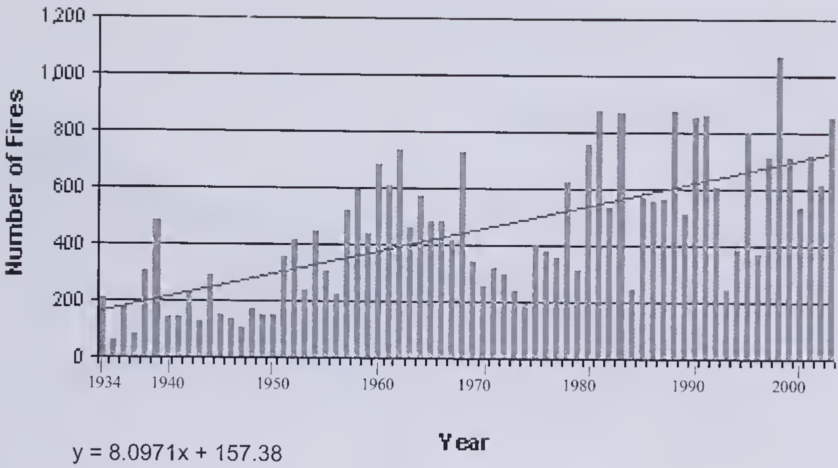

Fig. 5. Number of wildfires DSE attended 1933-34 to 2002-03 (70 yr period).

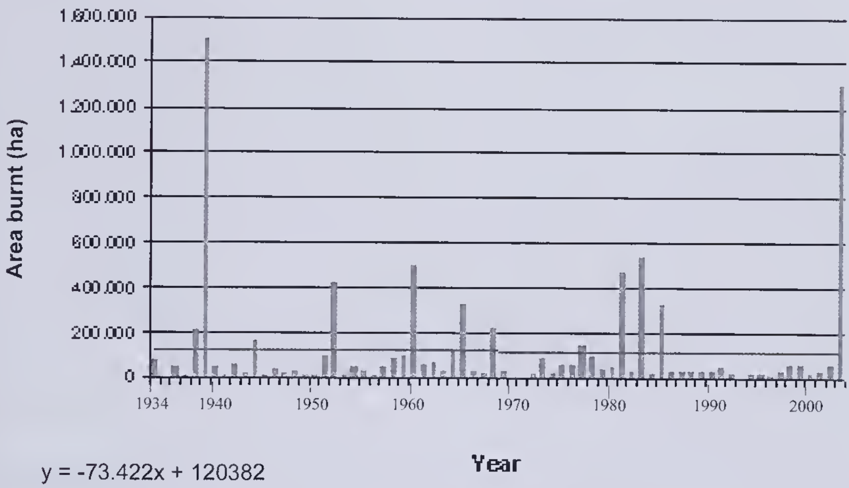

Fig. 6. Area burnt (DSE attended) 1933-34 to 2002-03 (70 yr period).

a detailed treatment of the approach to 'Fire Protection' on public land can be found in 'Fire Protection Plans'. Most plans are available at DSE's website.

There are many challenges currently confronting public land fire managers:

- the knowledge of fire behaviour variables/interaction remains imperfect, particularly at the 'extremes';
- infrastructure run-down (e.g. roads/tracks, fire towers, airstrips), identified by the Victorian Auditor-General 1992, and the Department of Treasury and Finance in 1998. In 2003, the Victorian Auditor General noted '… some progress …' in this area;
- a reducing/ageing population in many rural areas (this affects both DSE, and the CFA's volunteer base);
- smaller central government agencies, including DSE;
- agency successional planning. A potential shortage of managers may occur in the near future as the average age of more experienced public land fire controllers is 50 and recruitment of fire managers/specialists has been limited over the last 15 years.

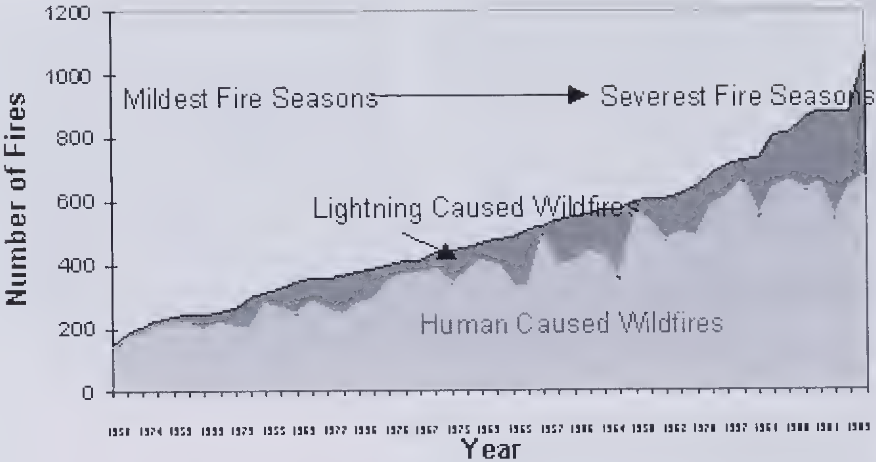

Fig. 7. Fire history and causes from 1949 to 1998.

- non-traditional residents moving into some rural areas, and subdivisions on/near the public land estate;
- an increasing tendency for land owners to litigate.

'Good' fire: the relationship between fire and biodiversity

In the past, the issue of fire was seen primarily as a threat to life and property. Until recently, the use of prescribed fire focused largely on strategically controlling fuel loads in order to reduce wildfire hazard but, in more recent years, Victoria's park and forest managers increasingly recognised that fire was a key issue in terms of ecological sustainability. There was, however, a need to develop an improved scientific basis for dealing with this issue.

In 1998, those responsible for Parks, Flora and Fauna (including Parks Victoria), for Forest Management and for public land Fire Management, agreed to address the need for a greater understanding by park and forest managers of the relationship between fire regimes and biodiversity. In relation to this issue, the *Code of Practice for Fire Management on Public Land* states in paragraph 158:

> Fire regimes appropriate for this purpose *(flora and fauna management)* will be addressed in management plans *(other than the Fire Protection Plan), which will typically specify preferred or required fire frequency, intensity, seasonality and patchiness....*

And further, in paragraph 143:

> ...Burning for fuel management and for other management objectives must be fully integrated at the local planning level...

DSE's approach to this matter is now a scientifically-based process using life history (vital) attributes of key plant species. These attributes govern how a species responds to fire and/or persists within a particular fire regime. For plants, there are three groups of vital attributes:

- method of persistence – how a species persists or arrives in an area after fire (i.e. by seed germination and/or vegetative resprouting);
- conditions required for establishment – the environmental factors required for germination and growth;
- relative longevity – this refers to the lifespan of the plant and the time necessary for production of the first seeds.

The approach for a given area involves an analysis of known fire history and vegetation age-class distributions, comparison with 'theoretical' age-class distributions, and monitoring the status or outcomes of disturbances such as wildfire, planned fire and drought. Where fire is a relevant component in plant life cycles, these factors together determine **how often** and **where to burn,** within ecological limits.

The underlying principles behind the approach include a wish to maintain current communities in their current locations, the premise that species' ecological toler-

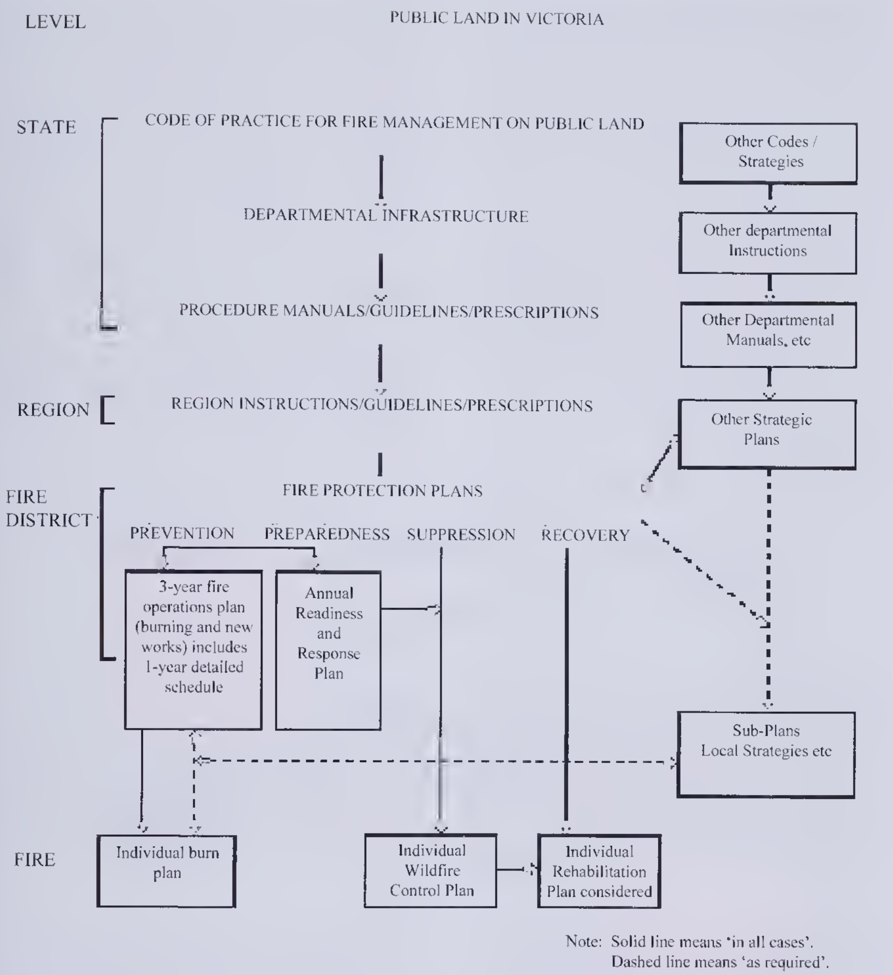

Fig. 8. The order of control and planning for fire management on public land in Victoria.

ances determine which species can and cannot exist on a site, that the life history (vital) attributes of a species are a major determinant of its ecological tolerance, and that species composition will change if tolerance limits are exceeded.

The framework on which DSE's approach has been developed is currently based on the use of plant species' 'vital attributes' to set the upper and lower tolerable fire intervals for an ecologically appropriate fire management regime. Clearly, 'vital attributes' also exist for faunal species and embody the shelter, food and breeding requirements of the various (faunal) key species. At this stage, however, considerably more work needs to be carried out to develop a practical and easily applied vital attributes framework for faunal groups. Development and extension of the framework actively to include fauna is a high priority for future work, as is the further development of the relevant flora data base.

The current initiative is designed to produce a situation whereby the use of fire to achieve both biodiversity and asset protection objectives are fully integrated into the fire management planning process across public land.

Forest fire research

Nationally, Victoria has had a long tradition of interest in forest fire research. There has, however, been a national decline in forest-fire related research in the last decade. Following the Sydney bush fires in 2001/02, the Federal Government agreed to the establishment of a wildfire 'Cooperative Research Centre'. The Australasian Fire Authorities Council is coordinating the CRC's establishment. The CRC's headquarters are in Melbourne.

Most of DSE's fire research reports, and all reports published in the last ten years, are available on the DSE website at www.dse.vic.gov.au/fires

Conclusion

For tens of thousands of years, fire has been a key component of Victoria's natural environment. While much has been learnt in the last 150 years about the management of wildfire in this part of the world, much remains unclear. Similarly, the importance of the relationship between our biodiversity and fire regimes must continue to be a priority for the managers of the state's parks and forests.

In October 2003, the report of the Victorian Inquiry into the 2002/2003 wildfires was released by the Premier. This report documented the community's most recent experiences with wildfire and makes a number of recommendations that are designed to enhance Victoria's fire management capacity. A report by the 'Council of Australian Governments' on wildfires should be available in the near future.

Community safety and biodiversity challenges

Helen Bull[1]

Abstract

Wildfire, community safety and biodiversity are strongly linked. Our natural communities are influenced by fire and many depend upon disturbance from fire. Wildfire suppression and prevention may affect vegetation and consequently biodiversity. Biodiversity management, including large-scale revegetation, can change fire risks. Residential and other development can affect both fire safety and biodiversity. CFA has developed an environment policy, an implementation plan and targeted programs to help build consideration of the environment, including biodiversity management, into its business. However, successful reconciliation of fire safety and biodiversity issues depends upon partnerships between all players. (*The Victorian Naturalist* **121** (3), 2004, 128-130)

Introduction

Protection of the environment, and ensuring the safety of the community, are two key goals for the Victorian Government. Achievement of these two goals at times provides some challenges for fire and biodiversity managers and the community in Victoria.

This article briefly explores some of these challenges and what Country Fire Authority (CFA) is doing to respond to these.

Wildfire safety

Wildfire safety in the 'Country Area of Victoria' is a responsibility shared by local government, CFA and the community.

CFA, which was formed in 1944, is one of three agencies providing fire services to the people of Victoria. CFA helps protect 2.5 million people in 980 000 homes, spread over 150 182 square kilometres in the 'Country Area of Victoria' as defined in the *CFA Act 1958*.

CFA provides a range of services to help make Victoria safer from wildfire and other emergencies. CFA not only works to control fires, but also investigates fires and fire response, and provides advice to the community, councils and other agencies on fire risks, appropriate ways of treating these risks, and planning processes.

Councils, assisted by Municipal Fire Prevention Committees, are responsible for developing Municipal Fire Prevention Plans and other plans to address fire risks on a landscape level. Plans may include treatments such as community education

[1] Environmental Manager, Country Fire Authority, 8 Lakeside Drive, Burwood East, 3151. Email: h.bull@cfa.gov.au

and reduction of vegetative fuels using techniques including burning, herbicide use or slashing, on networks of firebreaks throughout Victoria. CFA brigades may carry out these works for Councils or other land managers. Councils are also responsible for administering building and land use controls, such as the Wildfire Management Overlay which specifies vegetation clearance standards to protect new assets in areas of high fire risk.

Community members living in high fire risk areas are encouraged to plan for and be self-reliant in the event of fire. One of the main causes of houses catching fire is through ignition from burning embers, which may travel well in front of a fire. Residents are advised to maintain houses and other assets to reduce potential entry points for burning embers. Management of vegetation to reduce fuel levels also may be required to protect houses from radiant heat from fire.

Fire safety and biodiversity challenges

Fire safety presents a number of challenges for fire and biodiversity managers and the community. Four of these are outlined below.

Fire prevention and suppression

The fire safety treatments outlined above have the potential to affect biodiversity values. Fire prevention commonly involves management of vegetation to reduce fuels which may support a fire, affecting vegetation and the habitat it provides. Fire control may include the application of water or chemicals by tanker or by aircraft. Bulldozers or graders may be used to clear vegetation and expose soil to provide a fuel-free fire control line. Water and chemical use, and soil disturbance, may affect water quality and aquatic life.

The challenge for CFA, councils and the community is to develop ways of minimising impacts on the environment from fire safety practices and maximise the beneficial effects wherever possible. At a local level, residents should be encouraged to select environmentally-sensitive ways of protecting their properties where possible. At a municipal level, priority needs to be given to improving the integration and reconciliation of planning for biodiversity conservation planning, other land management and fire management. A priority for CFA is to build environmental care into our operational activities wherever possible.

Fire and biodiversity

Fire prevention and suppression may affect the fire regimes to which native vegetation is exposed. Suppressing fires may reduce beneficial fire. Alternatively, it may benefit biodiversity by reducing fire which is inappropriate to life cycle needs of the vegetation community. In addition, fuel reduction or other burning appropriate to life cycle needs can be beneficial in maintaining or restoring species or communities. For example, burning for fuel reduction has maintained diversity of native grasslands on many roadsides in south-west Victoria.

Much work has been done in Victoria to identify fire requirements of vegetation communities. However, the beneficial role of fire in biodiversity conservation is very poorly understood in the general community. Further work is required to increase understanding of the importance of appropriate fire regimes in maintaining biodiversity, and to support burning of native vegetation on private land, roadsides and other areas of native vegetation in the 'Country Area of Victoria', where appropriate, for both fire prevention and biodiversity benefits.

Land use planning

Areas of high fire risk generally support extensive areas of native vegetation which have conservation and scenic values. There may be limited options for siting or design of new buildings because of steep slopes or small block sizes, and financial considerations may discourage landowners from designing their buildings to a higher standard of fire safety. There is a high degree of reliance upon vegetation clearance to manage fire safety, which may conflict with conservation objectives. Councils are responsible for making decisions regarding applications to subdivide and build, and must take both fire safety and conservation needs into account.

Further work needs to be done to develop tools to help Councils to reconcile biodiversity and fire safety needs in assessing land use planning and development proposals.

Revegetation and fire risk

Native Vegetation Plans produced by Catchment Management Authorities propose significant increases in the extent of native vegetation in Victoria to address a range of environmental issues including biodiversity decline and land degradation. This has significant implications for fire safety. Revegetation may increase fire fuels compared with the previous agricultural use. It could also link isolated patches of native vegetation, increasing fire risks to community assets. Areas commonly favoured for revegetation include roadsides, which are important to provide access to and egress from fires and to ensure the safety of road users in the event of fire. Fire risks can be managed with careful location, design and maintenance of revegetation areas. However, community fears about the threat to fire safety from proposed revegetation programs and large scale landscape changes also need to be addressed.

What is CFA doing?

CFA is committed to the protection of life, property and the environment through the delivery of fire and emergency services for the people of Victoria. While environmental management is relatively new to CFA, it has commenced work to address a number of environmental challenges.

CFA aims to contribute to clean air, land and water and healthy ecosystems. It has devised a policy and strategies to help manage environmental issues in all aspects of its business, from administration through to service delivery.

The strategy highlights a number of issues relating to biodiversity management, including those outlined above. Some examples of where CFA is already contributing to biodiversity management include:

- building guidelines for minimising environmental impacts of wildfire suppression operations into training;
- promotion of responsible roadside fire management through publication of guidelines and support to councils and brigades planning fire prevention works;
- development of a herbicide use policy;
- supporting burning of native vegetation which is appropriate to its life cycle needs where appropriate; and
- encouraging consideration of environmental issues in municipal fire prevention planning.

Work also has commenced, in partnership with local and state government, to develop approaches to reconciling native vegetation protection and fire safety in relation to land use planning.

Conclusion

The biodiversity challenges outlined above affect us all. CFA looks forward to working further with councils, other agencies and the community to achieve the best possible outcomes for both fire safety and biodiversity.

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F.N.C.V.

Field Naturalists Club of Victoria

Digging Deeper in the Bay

Exploring the Port Phillip Bay Channel Deepening Project

Sunday 12 September 2004

The Biodiversity Symposium for 2004 will explore the possible effects of channel deepening on the marine environment, the geology and the biodiversity of the Bay. The Symposium will be held at FNCV Hall, Blackburn.

On the edge: how well do fire mitigation strategies work on the urban fringe?

Dianne Simmons[1] and Robyn Adams[1]

Abstract
The reduction of loss of lives and assets during bushfire is one of the primary aims of fire management agencies. Traditional fire mitigation strategies include strategic fire breaks, static water points, management of ignition sources, rapid detection and local response, air attack, and fuel reduction burning. There have been few quantitative studies that assess the success of these strategies. We need to promote 'new' strategies more focused on human behaviour and community preparedness. Defendable space provides our best strategy for reducing losses during major bushfires. The size of the defendable space depends on the type of house to be defended, who is defending it, and the spatial context of the property. In the urban fringe, remnant vegetation on private property often has high conservation values, and application of traditional mitigation strategies, as well as the vegetation modification required to achieve defendable space, may have significant impacts on conservation and biodiversity values. (*The Victorian Naturalist* **121** (3), 2004, 131 -135)

Introduction

The reduction of loss of lives and assets during bushfire is one of the primary aims of fire management agencies. One place where losses can be high is on the urban fringe surrounding major cities (Gill 2001; Whelan 2002). In urban interface areas, large numbers of people and houses are likely to be exposed to uncontrollable fire on several days during most years (Gill *et al.* 1987; Bradstock *et al.* 1998). For example, in Hobart in 1967 62 lives and 1,300 houses were lost, and in Victoria and South Australia in 1983 76 lives and 2,400 houses were lost.

Significant fire events are usually followed by an inquiry which aims to determine how we can better manage fires in the future. For example in 2003, the 'Esplin Report' investigated the Victorian fires and the 'McLeod Report' investigated the Canberra fires (Esplin e*t al.* 2003; McLeod 2003). Assessment of the performance of mitigation and suppression strategies often highlights the polarized, but often unsupported, views held within the community. Traditional mitigation strategies mostly have emphasised 'technical' responses by agencies, with little participation by householders. These strategies are of two main types (1) fire prevention strategies including strategic fire breaks, management of ignition sources, and fuel reduction burning, and (2) fire suppression strategies including static water points, rapid detection and local response, and air attack. There have been few quantitative studies which assess the success of these strategies on reducing loss (Meredith 1996), or their cost-benefit (Healey *et al.* 1985). Until recently, residents of the urban fringe have not expected to be responsible for their own fire safety.

The urban fringe

The urban fringe presents some unique challenges in terms of fire safety and resolution of conflicting community values. The 'urban fringe' can take several forms. It can consist of an *urban edge*, with relatively dense housing and urban development adjacent to bushland, where under extreme conditions house to house propagation of fire can occur, as in Sydney in 1994, and Canberra in 2003 (Leonard and Bowditch 2003). Ember attack (Ellis 2003) and house ignition can occur up to about 500-600 m (Tolhurst and Howlett 2003) from a vegetation boundary, with most house losses occurring within about 100 m of a vegetation boundary (Ahern and Chladil 1999). The urban fringe also can take the form of an *urban-forest interface* with houses scattered throughout bushland on the outskirts of major towns. In these areas there are often conflicts concerning competing biodiversity values and residential fire safety.

[1] School of Ecology and Environment, Deakin University, Burwood, Victoria 3125. Email: diannes@deakin.edu.au

Firebreaks

In grassland, firebreaks are seldom wide enough to stop significant fires, and breaks are likely to be breached in even moderate conditions if trees are present (Davidson 1988; Wilson 1988). There are few quantitative assessments of the widths required in forests to ensure that firebreaks will be effective. Spot fires can occur many kilometres ahead of the fire front in forests, and under extreme conditions most firebreaks fail if spotting occurs. Luke and McArthur (1978) suggest that 'fire breaks' more accurately might be regarded as 'fire brakes'.

Water Points

Static water points may aid first attack, especially during periods of drought when dams and watercourses are dry, but their relative benefits are not documented clearly.

Ignition sources

One part of a risk management process is to recognize likely ignition sources, and manage them to minimize their potential. Fuel reduction along railway lines, clearance of trees near power lines and the use of ABC (aerial bundled cable) lines are management examples of potential ignition sources. Management of arson by early intervention in schools also may be an effective strategy for reducing ignitions.

Rapid detection and suppression

During the fire season, fire spotting towers and aircraft are used to ensure rapid detection of fires, because if suppression forces are able to reach the fire quickly they can extinguish it while small. Local volunteer brigades are very effective in suppressing fires while they are small, and only a small proportion of fires build to unmanageable sizes (Leonard and Bowditch 2003). During large fires, firefighting resources are often limiting, direct attack will not always be possible (Gill *et al.* 1987), and it is unrealistic to expect that suppression capability always will be adequate under extreme conditions (Rawson *et al.* 1983). The maintenance of a volunteer base in the future also is problematic (Aldridge 2003).

Air attack

Air attack using fixed-wing aircraft or helicopters to drop water, sometimes with additives such as Class A foam or long term retardants, can be very effective. Past assessments have highlighted the complementary use of air attack and ground crews and concluded that air attack is not a replacement for ground crews. Current effectiveness of air attack, particularly by the Eriksson Air-Crane, is improving and has potential to be a major strategic tool in suppression when used in conjunction with ground crews (Esplin *et al.* 2003). There will rarely be enough aircraft to cover geographic spread of risk in major fires, and in heavy smoke and windy conditions aircraft often are unable to operate.

Fuel reduction burning

Fuel reduction burning frequently is cited as one of the strategies most likely to aid in fire control, though broad scale fuel reduction burning is difficult to achieve in the urban fringe due to the matrix of buildings, fences and other urban infrastructure not present at the same density in rural areas. Fuel reduction by burning during low-risk fire weather may reduce the intensity of bushfires, but not enough to allow suppression by direct attack (Bradstock *et al.* 1998), or to reduce losses of adjacent assets (Gill *et al.* 1987). Surface fuels do not continue to accumulate with time after-fire. They build up quickly and then reach a 'steady-state' where the fuel inputs are balanced by decomposition, and burning would need to be carried out every 3-5 years to keep fuel loads low in most vegetation types (Simmons and Adams 1986). If fuel loads were kept below 8 t/ha, there would be few days when suppression was not possible (Gill *et al.* 1987). However, it is difficult to keep fuel loads acceptably low, and there is little agreement about what levels are required, or what levels can be practically achieved (Fensham 1992). Burning to reduce the severity of ember attack also will require a frequency of five years or less (Ellis 2003).

Frequent fuel reduction burning may reduce wildfire intensity sufficiently to allow suppression by direct attack in some areas in some vegetation types at some times (McCarthy and Tolhurst 2001), and this high frequency may have undesirable biodiversity impacts (Simmons and Adams 1986; Morrison *et al.* 1996; Bradstock *et al.* 1998). Elevated fuels actually can be increased by fire, as obligate seeders such as wattles and peas often regenerate by a mass germination event after fire (Gill and Catling 2002). These obligate seeders can be eliminated by frequent fire.

In spite of many calls for more area to be fuel reduced by burning (McCarthy and Tolhurst 2001; Esplin *et al.* 2003; McLeod 2003), by itself it is not an effective strategy for reducing the threat of fire to human life and property in the context of the urban fringe (Esplin *et al.* 2003). We now need to change our approach to fire, and accept that we can rarely *stop* major bushfires. We need to focus more on how people and their assets can *survive* bushfires (Cary *et al.* 2003). This will involve a focus on 'new' strategies, with an emphasis on human behaviour and community preparedness. Introducing residents to the concept of defendable space is a new strategy with great potential to reduce loss in the urban interface.

Defendable space

Defendable space is basically the area immediately around a house with significantly reduced fuel (CFA 2002). This modifies fire behaviour in the vicinity of a house and makes it possible for a person to actively defend the house during a fire. Following the 1983 Ash Wednesday fires in Victoria, quantitative data were collected about how houses survived bushfire (Wilson and Ferguson 1984; 1986), and the factors that contributed to loss of lives (Krusel and Petris 1992) were documented. These data have been enhanced since then by data collected at all major fires (Ramsay *et al.* 1996, Gledhill 1999; 2003).

We now have ample evidence to indicate that creation of defendable space does work in reducing loss (Gledhill 1999; 2003). We need to better determine the 'setback distances' (the distance from the house which needs to be fuel modified) to enhance survival of houses, so that the community can achieve appropriate levels of preparedness. In practice, the required setback distances depend on the type of house to be defended, who is defending it, and the spatial context of the property (Ramsay and Rudolph 2003).

Type of house

The construction, design and materials used have a major impact on house survival, and appropriate building design can improve survivability of houses (Ramsay and Rudolph 2003). The requirements of AS3959 Australian Standard for Building in Bushfire Prone Areas (Standards Australia 1991; Ramsay and Dawkins 1993) address the potential of flame contact, radiant heat and ember attack to ignite houses. Ember attack is the most significant (Ramsay and Rudolph 2003), and there are many simple things householders can do to protect themselves (Webster 2000; Ramsay and Rudolph 2003). The clearing of gutters, removal of flammable materials, and blocking of ember entry points all make a significant impact on house survival. Householders can predict the likely behaviour of fires under different conditions, and can assess the safe distance (the defendable space) they need in order to protect their property from burning fuels (Butler and Cohen 1998).

The defender

The presence of an able-bodied person (owners, neighbours or fire brigade) engaged in active defence is one of the most significant factors in house survival (Wilson and Ferguson 1986). We know active defence works – for example nearly 90% of defended houses survived at Macedon compared to only 30% where no one was present (Wilson and Ferguson 1984; 1986). However, we need to recognize that some groups in the community, for example older age groups, may be at particular risk (Krusel and Petris 1992) and may have reduced capacity to be active defenders.

Spatial context

The Wildfire Management Overlay (WMO) is part of the statewide Victorian planning framework and defines appropriate setback distances based on surrounding vegetation type. The WMO specifies setback distances which increase with slope and aspect, and defines requirements for access to water, vehicle turning points and passing bays on properties. The WMO clearly defines the extent of vegetation modification required and sets standards for fuel modification within the defendable space (CFA 2002). Using 'Option 3' in the WMO provisions (CFA 2002), householders may be able to "trade-off" defence and design for distance, and incorporate novel building designs and materials to reduce the required setbacks (Ramsay and Rudolph 2003). In many areas property sizes are too small to allow for both an acceptable defendable space within the property boundaries, and the retention of some vegetation for habitat.

'New' vegetation types resulting from invasion by species such as Burgan *Kunzea ericoides* and Phalaris *Phalaris aquatica* pose an increasing risk that often is not recognized (Stoner *et al.* 2004). In many areas there are conflicts between the requirements of the WMO and other significant vegetation overlays, so that directions for modification of vegetation for fire protection and directions for revegetation following building construction, result in poor advice from planners in local government and confusion for landholders.

Defendable space provides our best strategy for reducing losses during major bushfires. Post-fire analysis of fires in Hobart in 1997 (Gledhill 1999) and Sydney in 2001, and preliminary statistics for northeast Victoria and Canberra in 2003, indicate that compliance with principles of the WMO and community preparedness, particularly households having a bushfire preplan, does work in reducing loss on the urban fringe. It also releases fire suppression agencies to focus on suppression activities and provides greater opportunity for success in suppressing fires so that their extent is minimized.

Where urban development has occurred adjacent to bushland, suburban property sizes may be too small to allow sufficient space surrounding houses to provide an appropriate defendable space. Under extreme conditions such as those in Duffy in 2003, house to house propagation of fire can occur (Leonard and Bowditch 2003), and in these situations defending householders can be exposed to radiant heat from burning neighbouring houses. In this context, planning for fire safety may need to focus more on a landscape approach (Ramsay and Rudolph 2003).

There is a role for all of the more traditional techniques, but by themselves they will not stop bushfires (Fernandes and Botelho 2003) or prevent loss of lives and houses. We need to ensure that the community accepts responsibility for its fire safety and that fire management agencies do not assume this responsibility. While we need a clearly focused response to mitigating the effects of bushfires, the techniques used to achieve fire safety can cause significant ecological damage, and they need to be justified and effective. Community attitudes and desire for achieving conservation objectives and maintenance of biodiversity must be incorporated into fire management planning. In the urban fringe, remnant vegetation on private property often bas high conservation values, and many landholders may wish to minimize their impacts on native vegetation on their property, while *at the same time* achieving an acceptable level of bushfire safety. Focusing our activities on strategies that really work, such as defendable space, has the added benefit of reducing our impacts on the flora and fauna of urban fringe areas.

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Ninety-three Years Ago

As an illustration of the botany of the district a picture of a flowering stem of a Grass-tree, Xanthorrhoea australis, measuring 5 feet 10 inches in height, was shown; and in the discussion which followed Mr. J. G. Luehmann stated he was informed that the Grass-trees growing near Frankston never flowered unless fire had gone through the country, and in support of this mentioned that he had never seen these plants in flower in the Botanical Gardens.

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Fire in south eastern Australia: a discussion summary and synthesis

TR New[1]

Abstract

An overview of the complex issues related to the management and ecological roles of fire in south eastern Australia includes a summary of major topics raised at a symposium held in Melbourne by the Field Naturalists Club of Victoria in late 2003. (*The Victorian Naturalist* **121** (3), 2004, 136-139)

Introduction

The issues outlined in the presentations at this symposium and summarized in this issue of *The Victorian Naturalist* are complex, controversial, and of considerable practical interest to all Australians. They devolve on two main themes, and the variety of opinions and established facts which can inform them. First, we live in an environment in which fire is natural and largely inevitable. Fire, therefore, is a feature to which much Australian biota is finely attuned and on which it may depend. Second, wildfires can destroy human assets, property and livelihoods. Thus, on the one hand, fire has potential to be a critical and manipulable component of managing Australia's ecosystems and biodiversity; and on the other hand is a feared threat to human life and wellbeing. Controversies and strongly held views on the management of fire are largely inevitable. Extensive media debate following the devastating bushfires in early 2003 centred on whether more extensive 'control' or 'fuel reduction' burning (i.e. deliberately imposed management burning) could have reduced the subsequent tragedies in the region. This, and related debates, are fuelled by strong opinion, even passion (but more commonly without strong objective evidence). They endorse the general agreement on the importance of fire in Australia's ecology and economy, and the need to understand it more effectively, perhaps in part by drawing more substantially on the knowledge of traditional land management practised by early Australians.

[1] Department of Zoology, La Trobe University, Victoria 3086

Levels of understanding

However, 'understanding fire' is a deceptively simple task – not least because of the difficulties of planning adequate replicated long-term experiments to quantify and determine ecological effects. This aspect is clearly a priority for those interested in using fire as a sensitive management tool but may receive little sympathy from those whose priority is personal asset protection. Literature on fire ecology in Australia is immense and burgeoning (see, for example, Bradstock *et al.* 2002), but each new published study reveals new trends and aspects, so that many such studies are context- or site-specific. Attempts to generalise, to seek to impose more widespread protocols for management of highly disparate and dynamic systems are indeed difficult, as Whelan *et al.* (2002) emphasised. The more obvious variables between studies (site, intensity of fire, season, mosaic patch size, vegetation type(s), fuel load) are inevitably augmented by others less tangible (such as weather, moisture levels, aspect and topography) to the extent that replicated or controlled studies are difficult to pursue. Many published studies are opportunistic in the sense that they appraise the after-effects of fires, but lack convincing pre-fire control data. Even though this may be extrapolated from nearby unburned sites, the unknown spatial heterogeneity of many organisms (perhaps, particularly of invertebrates) renders many such comparisons involving species abundance and diversity unconvincing. Some speakers in this symposium (Cheal, Friend) emphasised the variety of responses to fire that different plant or animal species may exhibit, and the differing levels of vulnerability they may suffer, together with the range of time scales that may be relevant in appraising effects of burning. We thus need to consider the following:

1. Management burning may need to consider a diverse array of individual species responses or, at least, to encompass these broadly and simultaneously in addressing condition of ecological communities. Management for particular focal species may differ substantially from the needs of broader community management;
2. The intervals between optimal management burns may be very difficult to define in the absence of precisely-defined management targets. Many fuel reduction burns (asset protection) are undertaken simply when ground fuel reaches particular threshold levels, and these frequencies may not be consistent with ecological optima;
3. In the absence of such knowledge, even the best-intentioned management burns may be suboptimal, but without precise management targets the 'success' of burning operations is difficult or impossible to evaluate.

Practical steps

We know far more of the responses of plants to fire than those of most animals. In part, this reflects the difficulties of pursuing long-term ecological studies in Australia. As Whelan *et al.* (2002) noted, part of this bias reflects the relatively greater suitability of plants for honours and graduate student projects extending from 1-4 years, often the greatest periods for which research funds can be assured. Some important exceptions exist. Several were noted by Friend, and York (1996) and Neville (2000) refer comprehensively to invertebrate studies. Ideally, studies should be replicated and include at least two years' (preferably more) pre-burn data and the same length of post-burn data on responses in treatment and control plots. However, and as noted above, such detail is seen commonly as low priority, and ecological consequences may be considered unimportant in relation to protection of property, so that calls for more frequent control burns (as insurance) will remain. There may well be common ground. A recent report (DNRE/PV 2002) on addressing optimal fire regimes for ecological management suggested 'that the threat which fire frequency poses to species composition and community composition in Victoria is in fact from under-exposure to fire: i.e. fire frequency is too low across the landscape'. Many ecologists would hesitate to endorse such a suggestion fully on present evidence, and considerable further research may be necessary to validate this claim.

However, the main practical need at present is to maximise use of the somewhat limited experimental detail in planning control burning exercises, and progressively to move toward more general protocols whilst continuing to acknowledge the shortcomings of our capability to do this. It could be argued that (1) any general policy founded on manifestly inadequate information is no better than 'no general policy' and current somewhat *ad hoc* approaches, and (2) the precautionary principle, if applied, should err on the side of asset protection in situations where both this and ecological management co-occur. Unusual, restricted, or especially biologically significant habitats (equated broadly to ecological vegetation classes, but not limited to these) and vulnerable human settlement (typified by affluent urban fringe extensions into natural or semi-natural bushlands) may impose more particular duty of care to regulate or protect them from burning. Both may require establishment and maintenance of buffer zones and other preventative management. But, whereas responsibility for the protection of critical ecosystems falls on 'authority', asset protection also involves people 'learning to live with fire' (Simmons), and a spread of primary preventative responsibility to include also individual landholders. This last point may need to be reinforced by regulation, likely to be unpopular as interfering with individual freedom. In principle it is an extension of existing codes of practice enforced by regulation, such as 'no fire periods' and 'fire ban days', and parallels trends such as area-wide management of some agricultural pests in seeking to promote wider scale and more effective management. Low intensity control burning to help prevent high intensity wildfires is one of the most frequently-used tools in Australian land management (Whelan 1995). Community education is essential in further honing such management, and bodies such as the Country Fire Authority (Bull) have taken important leads in creating greater awareness of individual management needs amongst their clientele.

Advance?

Much of what is desirable is patently utopian, and one need for the future is for studies to become more than data-gathering exercises, and to address practical hypotheses relating to management and how to use fire as a wider management tool (with the 'do nothing' option a clear positive alternative to ill-founded action), and with proper appreciation of the effects of scale.

This symposium provided much useful background, with the papers grouped into three main suites (1) historical and traditional perspective of fire and our attitudes toward it; (2) ecological effects; and (3) living with fire and increasing safety and protection of life and assets. Each of these themes, and most speakers, raised points that could occupy a long and valuable discussion; several have been noted above. Issues canvassed include the values of lessons to be learned from aboriginal knowledge and practice; the optimal ways forward and development of general policy; decisions over what (if any) priority to give to particular habitats or protected areas (as the putative conservation estate); and effective and socially effective mechanisms for asset protection from fire. It is highly desirable to be able to justify control burns in ecological terms, and to specify clearly the objectives of such operations beyond bland generalities, so moving beyond prescriptions for simple calendar or interval burning with little regard for the dynamics of the treated environment.

Symposia on fire ecology are by no means novel, and several have addressed the above and related issues in the region. Many of the ideas discussed at this one were raised at a Melbourne meeting held in 1974 (Leonard 1977), for example. A series of Australian Bushfire Conferences extend from 1987, and the Proceedings of several of these (e.g. McKaige *et al.* 1997, Lord *et al.* 1999) provide considerable additional background perspective. Each successive meeting has raised aspects of current best practice in fire management, and fresh viewpoints on the subject. This symposium was not intended to lead to specific resolutions or recommendations, but some of the points summarised at earlier meetings clearly remain highly pertinent. A particularly important framework was set by DEST, in a conference in Melbourne in 1994, and some priorities listed by that gathering sum up well sentiments evident at this 2003 gathering. Thus:

1. Biodiversity conservation in Australia's present landscapes requires a diversity of fire regimes, and these must be flexible;
2. Fire management regimes need to be local to succeed;
3. Fire management for protection of human life and assets can be, and is beginning to be, integrated with management for ecosystem conservation;
4. Identification of key zones for fire protection can allow separation of areas where human-oriented fire protection is of greatest priority from areas where biodiversity maintenance is the main concern. This in turn allows different fire regimes to be developed for different priorities in different places;
5. Land managers are now seeking to incorporate ecological requirements into their fire management plans;

In short, research and effective management are continuing needs in our dealings with fire in south eastern Australia. Expressions of concern that continued reorganisation of relevant state departments and other authorities may effectively preclude long-term coordination of these topics are a salutary warning that such coordination is an integral part of any regional fire management effort, and that capability must be protected and assured.

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An Introduction to Fungi on Wood in Queensland

Ian Hood

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Fungi that grow on wood are important as agents of decay and as parasites. Decay fungi can cause economic losses in timber before and after harvest, but also play vital roles in breaking down and recycling the complex organic molecules in wood (such as lignin). This book is very welcome in providing a highly-illustrated guide to wood-inhabiting fungi. The geographic scope is Queensland, but the book will be of use throughout Australia, because many fungi are geographically widespread.

The volume commences with a comprehensive and clearly written introduction to fungi on wood in relation to biology, ecology, distribution, economic importance and classification. There is a useful summary of what fungi do to wood, and the different types of rots (such as brown and white rots). Following the Introduction, there is a reasonably successful attempt at a dichotomous key to the included species (always diabolically difficult to construct for fungi on field characters alone). The final lead often contains a group of species, some of which could have been further separated (e.g. the excentric *Dictyopanus pusillus* and the centrally-stipitate *Filoboletus manipularis* in couplet 23 on p. 29).

The more than 180 species illustrated are an excellent selection of fungi on wood across all major groups, with most being agarics (gilled fungi) or polypores, but also including some slime moulds, puffballs, coral fungi, spine fungi, stereoid fungi, jelly fungi and rust fungi, as well as cup fungi and other ascomycetes such as *Xylaria* and *Biscogniauxia*. Most of the commonly encountered genera are included, often with several species (such as in *Coriolopsis*, *Ganoderma*, *Polyporus* and *Trametes*). Quite a few Fungimap targets are included (the contrast between *Microporus affinis* and *M. xanthopus* is most useful).

Each species is illustrated by line drawings of fruit bodies (often from several angles) and of micro-characters. There is a brief description, including details of colour and texture, and a list of references (which is admirably comprehensive, but unfortunately does not indicate references with colour illustrations, which would have been helpful). There is also a paragraph of comments, often quite extensive and covering not only a comparison of similar species, but also interesting information on ecology, hosts and distribution. There are a number of species identified only to genus (as expected for any Australian fungus book, given present imperfect knowledge). It would be nice to see voucher specimens cited, especially for collections identified only to genus.

There are 20 coloured illustrations in four plates, which are a mixed bag, although the first colour illustrations of the fascinating 'flat coral fungus' *Clavulicium extendens* were definitely worth including. I found the line drawings took some getting used to. I suspect that this relates in part to how fresh the material was, and that some illustrations are in fact quite good depictions of old or dried up material. The lack of substrate in many illustrations also means that it can be hard at first glance to orient the fungus (although this information is provided in the captions). Many of the fungi illustrated are polypores, and the pore surface is extremely difficult to depict accurately unless the artist has unlimited time to draw each tiny pore (or use devices such as a magnified portion in an adjacent circle). Thus, even though the outline of the fungus is quite faithfully depicted, the viewer must get used to interpolating pores from a few spots or even cross-hatching in some cases. Perhaps the inclusion of colour photos in most contemporary fungi guides means that the art of interpreting line drawings does not come so easy now, particularly the aspect of adapting the eye to individual styles, but I did miss having colour illustrations of all the taxa.

The line illustrations are all on the right hand page, with text facing; but the text for particular illustrations on occasion spills over to other pages (forward or back and not necessarily adjacent). Species are arranged more or less alphabetically by genera within families, but departures from this scheme are common, as in the agarics, where genera of Marasmiaceae, Pleurotaceae and Tricholomataceae are mixed. This perhaps results from adoption of recent changes to the higher classification, and at least the names are very up-to-date. The idiosyncrasies in layout are minor problems (as is the rather small type face); the book is good value for more than 300 pages of text and illustrations.

An Introduction to Fungi on Wood in Queensland certainly meets its aim of 'smoothing the path to recognition of wood inhabiting fungi and to an understanding of their role and function'. The book will be an essential reference for anyone with a specialist interest in Australian wood-decay fungi, and provides the best available guide to these fungi for foresters and arborists. The book will also be of interest to microscopists, especially since the illustrations of micro-features are not idealised and depict what can be readily seen under the microscope. Wood-decaying fungi are often more persistent, and tend to occur more reliably than the fleshy macrofungi (like coral fungi or agarics), and so will be more often encountered, especially outside of the autumnal fungal flush. This book will therefore be of considerable use for field naturalists, particularly if used in concert with the current crop of field guides with brief captions and copious coloured illustrations of a smaller selection of wood-decay fungi (such as Ian McCann's *Australian Fungi Illustrated* or Bruce Fuhrer's *Field Companion to Australian Fungi*).

Tom May
Royal Botanic Gardens Melbourne,
Birdwood Avenue, South Yarra 3141

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

Australia Burning: fire ecology, policy and management issues

edited by Geoffrey Cary, David Lindenmayer and Stephen Dovers

Publisher: *CSIRO Publishing, Canberra 2003. 276 pp, illus. ISBN 0 643 069267 RRP $39.95*

This book reports on a National Fire Forum conference held in 2003 immediately following the destructive Canberra fires. At the conference, each session had two key speakers, with three commentaries, and a concluding summary. I suspect that this structure worked much better at the conference than it does in this book. In spite of its aim to cover fire ecology, policy and management issues, at the end of the book we are not much wiser about our future options or directions. The structure of the book, which follows that of the conference, aims to air differing views and to seek informed comment on those views, and to then summarize the main issues. Unfortunately, it just doesn't work! The last section becomes a summary of a summary, and rather than achieving a really succinct synthesis, it remains a series of sometimes unrelated opinions and does not really inform the reader about current thinking.

Of course there are many useful points made by some contributors. I admit I am starting to agree with Cheney, who provides a refreshingly confronting and interesting view from a long-term practitioner. Probably the most useful chapter includes a discussion of indigenous input to fire management. It includes an indigenous perspective on fire generally, as well as some comments about how and why indigenous people use fire, which is at odds with most people's simplistic view of Aboriginal use of fire. At least here we get some clear indications of where we could be going with future thinking and research.

I find it hard to determine the target audience for the book. It doesn't have enough structure or background to be useful to most students, and it is not obviously aimed at the public, to raise general awareness and knowledge. The basic problem is that it does not provide much background information, and it records a range of opinions that frequently differ. This gives some insight into the many views held by fire managers and researchers, but it is hard for the reader to make judgments about 'best practice' based on these opinions.

In the end it just doesn't hit the spot. Whilst many contributors are expert in their field, the reporting and structure of the book does not come together to form a cohesive document. If you have a 'specialist' interest in fire in Australia it will be an essential addition to your basic library. If you are looking for general information and understanding of current trends in fire management and ecology, this book is probably not going to help you.

Dianne Simmons
School of Ecology and Environment
Deakin University, 221 Burwood Hwy
Burwood 3125

Landscape and Building Design for Bushfire Areas

by Caird Ramsey and Lisle Rudolph

Publisher: *CSIRO Publishing, Canberra 2003. 112 pp. paperback, illus. ISBN 0643069046. RRP $39.95*

In the past few years a number of books dealing with bushfires and their impacts on plant and animal communities have been published. However, until now, they all have avoided dealing with people and their buildings as an element in the bushfire landscape of Australia. *Landscape and Building Design for Bushfire Areas* addresses this and should be essential reading for anyone wishing to understand the relationship between bushfires and the factors influencing whether or not buildings catch fire.

For many urban dwellers, it seems self-evident that houses 'in the bush' will be destroyed if a bushfire occurs, and to them it is often incomprehensible that families deliberately choose to live in fire-prone environments. What most Australians find hard to accept is that bushfires have predictable behaviour, which people can modify, and that house survival or loss is not just a chance event but can be influenced by careful design and maintenance of dwellings, their gardens and other vegetation surrounding them.

Landscape Building and Design for Bushfire Areas develops these two themes in a way that is easy to follow and makes it possible for building designers and existing householders to choose design options that reduce the vulnerability of their dwellings during a bushfire. Section one provides a concise explanation of how bushfires spread and what causes buildings to ignite. This section is prefaced by a number of factual explanations for some of the 'bushfire myths' or misconceptions, that are in widespread circulation, about how buildings respond in fires.

The second section deals with the principles behind the design and construction of buildings and the design and maintenance of the surrounding gardens that reduce the vulnerahility of buildings to ignition. The chapters in this section adopt an 'objective-design principle-design option' approach. This illustrates that, once the factual background to buildings and bushfires is understood, effective individual solutions can be developed by designers for achieving a higher level of building security.

The text throughout the book is clear and easy to follow. The use of images of real buildings and real landscaping solutions could have added greatly to the reader's understanding of the text, but there are numerous diagrams to illustrate the general design principles discussed. *Landscape and Building Design for Bushfire Areas* is excellent value, and is guaranteed to leave the reader with a better understanding of how one can improve house survival in bushfire prone-areas.

Robyn Adams
School of Ecology and Environment
Deakin University
221 Burwood Highway
Burwood, Victoria 3125

Disputed territory in suburbia

For some years, Common Ring-tailed Possums *Pseudocheirus perigrinus* have made their home in the dense foliage of a tall Pencil Pine *Juniperus virginiana* in my garden. The possums are seldom seen but their nocturnal chirping and their droppings on the concrete drive are constant reminders of their presence. Over the past few weeks, a pair of Little Ravens *Corvus mellori* appear to have made a nest in the same tree. The nest can't be seen because of the height of the tree and its thick foliage but a broken egg on the ground tells its story. The ravens can be heard day and night making a low clucking sound in the tree as opposed to their usual raucous cawing.

From disputes that have been observed, the tree is obviously not big enough to accommodate its two resident families.

Recently a raven was seen attacking a young possum on the ground. A little later all that remained at the attack scene were splashes of blood. On other occasions, much flapping and cawing from the ravens and much chirping from the possums have drawn the eye to the tree to see a raven chasing a possum up and down and around and around the outer foliage high up in the tree. This aggressive activity can take place during daylight or darkness. On one occasion, as I watched, a raven caught another young possum and threw it to the ground. I placed the animal in an adjacent tree and it immediately made its way back to the disputed territory!

This activity is a fascinating and at the same time brutal example of (I assume) predator and prey activity. It's easy to take the view that the ravens are the baddies and the possums the goodies in this dispute. After all, the ravens are brash and black and the retiring possums at least have a white tipped tail! The law of the jungle is being played out in suburbia.

Have any readers seen similar raven/Ring-tailed Possum activity in their garden? Would any reader with a better knowledge than myself of ravens' predation upon smaller animals care to comment?

Roger Pierson
640 Ferntree Gully Rd
Wheelers Hill 3150
Email: pierson@deakin.edu.au

Australian corvids have been reported taking mammals as prey, but such instances do not seem to be documented very often. There do not appear to be any references to Little Ravens behaving this way. Several species of bird including Pied Currawongs, Magpie-larks, Noisy Miners, Blackbirds, Common Mynas and even a Lyrebird have been noted to be upset by the presence of possums. The following references are of interest in this regard.

> Although the Australian corvids are known to take small terrestrial mammals such as rats and mice, there are no previous records of arboreal marsupials as prey.

(McCulloch, EM and Thompson WM (1987) Forest Raven takes Feather-tailed Glider. *Australian Bird Watcher*, vol. 12 , no. 3, p. 99

> ...I saw a live penguin 100 m away on the beach with two adult Forest Ravens *Corvus tasmanicus* standing either side of it. When I was about 50 m from the birds I left the beach. Returniing no more than two minutes later, I found the ravens standing beside the penguin which was now dead; the only sign of injury was the loss of both eyes. On another occasion, I saw a pair of ravens walk down the beach to a penguin coming up above the tide line. The ravens approached one from each side and almost simultaneously pecked at the eyes of the penguin. It took very little time and effort to remove the eyes and the penguin died a short time later ...

> The Australian Raven *Corvus coronoides* is known to kill active vertebrates such as fledgling Galahs *Cacatua roseicapilla* and Rabbit kittens *Oryctolagus cuniculus* ... and the Forest Raven has been recorded taking the eggs and chicks of the Fairy Penguin and other sea birds.

Fell, P. (1987) Forest Ravens Preying on Fairy Penguins *Australian Bird Watcher*, vol. 12 (3), p. 97

The Editors
The Victorian Naturalist

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Eagles, Hawks and Falcons of Australia (fully revised and updated 2nd edition)

by David Hollands

Publisher: *Bloomings Books, Melbourne 2003. 212 pages, hardback; colour photographs. ISBN 1876473193. RRP $49.95*

A few years ago there was an unending stream of popular bird books, all well illustrated with photographs of their subject birds. This small flood has vanished for a time, leaving the book enthusiast with somewhat of a lull. This beautifully sourced work has made an inroad into filling that gap.

My first thought as I opened the book was how large the size of the font seemed. For those with a sight impairment this is a definite plus as well as making the work easier to read for everyone. The images are likewise of generous size and their colour lacks any apparent imperfection.

This work has been laid out to a standard consistent with the current taxonomy and while I personally cringe at the use of such names as Pacific Baza, Australian Hobby and Australian Kestrel I accept them as being current English names. The author's sections on 'Sizes' and 'Field guide' are another aspect of the book I am not readily attracted to. Any animal's size depends on how the individual watching it interprets his or her sighting. For instance, the Spotted Harrier is a medium-large bird but after watching one near a Wedge-tailed Eagle it might not be described as such. Use of the term 'field-guide' should be restricted to works specifically published for that purpose. It would have been best to refer to that section as an identification aid or even simply as an identity guide.

The inclusion of a basic glossary enables the novice reader to understand some of the terminology that is readily used by the raptor enthusiast. For the non-Australian reader local words are clearly explained. All references are seemingly well researched and plentiful for the purpose of this book.

The remaining text relating to individual species accounts is written in a pleasing way. It is not too technical but is presented in a way that should encourage the reading of this volume from end to end rather than smaller forays into accounts of individual species. It is written primarily in the first person, something for which the author should feel proud. How often do we read texts that have had to rely on accounts previously published? It reminds me of the lack of understanding we still have in Australia of the general behaviour of many of our avian species, not only raptors.

A wealth of information may be gleaned from the images alone. These range from adults in flight to young at the nest. Each has been chosen to portray the species to its best advantage. Some of the flight shots, such as that of the Australian Hobby on pages 159 and 160, are superb. My own attempts would surely produce blurred images.

I have enjoyed reading all of Dr Hollands's previous publications and similarly I have enjoyed reading this current revision. The information and illustrations are often vast improvements on his first work on this subject. His continued supply of illustrations for other publications is also to be applauded.

I have no doubt that this book will be highly acceptable to its readership specialising in birds of prey, as well as to a growing band of nature enthusiasts.

Wayne Longmore
Collection Manager
Birds and Mammals
Museum Victoria
GPO Box 666E
Melbourne 3001

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Cover: Austral Grass-tree *Xanthorrhoea australis*. See Research Report page 148. Photograph by V. and J. Hubregtse.

Web address: http://www.vicnet.net.au/~fncv/vicnat.htm
Email vicnat@vicnet.net.au

Dieback threatens endangered native plants. Will they survive?

Gretna Weste[1], Megan Hewett[2] and Noushka Reiter[3]

Abstract
This paper is concerned with the flora of the Grampians National Park and its interaction with the pathogen *Phytophthora cinnamomi*. The first section briefly describes dieback as a cycle involving the destruction of trees and shrubs, followed 20 to 30 years later by decline of the pathogen with the death of all susceptible hosts. Regeneration of the original susceptible flora was observed and its survival depended on climate. This regeneration survived the recent dry years, which is understandable as *P. cinnamomi* depends on warm, wet periods for the production and dispersal of infective swimming spores and, hence, new disease. The second section of this paper describes 12 plant species endemic to the Grampians and either endangered, vulnerable or rare. Tests showed five species at high risk of extinction due to their susceptibility and exposure to the pathogen. Each species tested and its reactions are described. Recommendations for management are discussed. (*The Victorian Naturalist* **121** (4), 2004, 148-153)

Introduction

The World Conservation Union (I.U.C.N.) has recognised the importance of biodiversity as the basis of a healthy balanced global ecology. The latter is complex, flexible, self-regulating and it reduces the effects of droughts and floods. The I.U.C.N. has recognised 5714 plants as threatened with extinction.

Approximately 40 plant species endemic (i.e. confined) to Victoria are classified as endangered, vulnerable or rare (Cameron *et al.* 1998). The distribution of these plants is usually confined to a few isolated pockets in their particular habitat. If the plants are susceptible and disease is nearby, the risks to their survival are increased. Investigation of six species endemic to the Brisbane Ranges revealed that three were susceptible to the 'cinnamon fungus' *Phytophthora cinnamomi*, and were confined to areas exposed to infection and thus in danger of extinction (Peters and Weste 1997).

There are 18 to 20 native plant species endemic to the Grampians that are classified as endangered, vulnerable or rare. Their susceptibility to the pathogen is unknown and their habitats may be exposed to infection.

The 'cinnamon fungus' and the disease cycle

The dieback caused by the 'cinnamon fungus' is evident in certain parts of the Grampians. The pathogen is no longer considered a fungus but related to certain Algae, the Chrysophyta, as it possesses similar swimming spores. It was first isolated from cinnamon trees in the mountains of Western Sumatra and has been introduced to Australia. Most field naturalists are familiar with the symptoms: dead grass-trees with their trunks collapsed, their leaves brown like a wig askew on the stump; other shrubs with their foliage turning yellow (chlorosis) then brown before death; and the stringybark eucalypts with their leading branches dead and bare. While most eucalypts are resistant, 50% to 80% of understorey species are susceptible. The death of the shrubs and the consequent loss of colourful flowers, nectar and nutritious pollen results in the disappearance of pollinating insects, birds and small mammals. Most of the latter depend on grass-trees for shelter and habitat.

Some field naturalists also have noticed the recent recovery of some old dieback sites with new grass-trees and other understorey shrubs sprouting on formerly barren sites.

Research has shown that dieback occurs as a cycle (Fig. 1), albeit a long cycle, lasting 20 to 30 years. The cycle begins with an aggressive phase, lasting about three years, during which the susceptible species are destroyed. In the next phase, field resistant species such as rushes, sedges and various teatrees colonise the devastated area. The teatrees develop dieback of the terminal branches but survive and present a scruffy appearance. The field resistant flora may be

[1]8 Rollins Ave, Kingston Beach, Tasmania 7051
[2]Botany School, University of Melbourne, Victoria 3052
[3] Dept of Biotechnology and Environmental Biology, RMIT, Bundoora, Victoria 3083

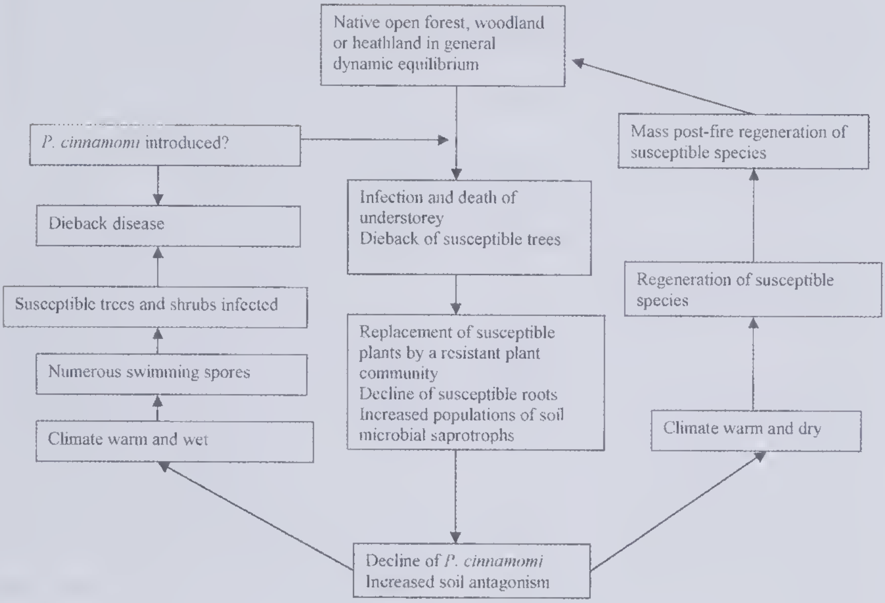

Fig. 1. *Phytophthora cinnamomi* disease cycle in native plant community

very dense and persist for about 15 years. Many observers do not recognise that its presence results from disease and that it is not the natural vegetation of the site. Once the pathogen has killed all the susceptible species it declines and may disappear due to a lack of food and habitat (susceptible roots). In the soil, its enemies (other soil micro-organisms) antagonise, engulf or outcompete it so survival in soil is usually short-lived.

When the pathogen declines, the susceptible understorey species, heaths, peas and grevilleas, all reappear, apparently germinating from seed in the soil. Small pockets of pathogen may remain and these will infect and kill any susceptible regenerating species that are contacted. The swimming spores are the principal agents of dispersal and infection for the pathogen, because these require free water to form, spread and infect. During the last seven years there has not been sufficient rain at suitably warm temperatures, such as during spring or autumn, for free dispersal of the pathogen. The pockets of infection have, therefore, remained localised and the forest, woodland or heathland has regenerated.

If, however, the climate changed to a series of seasons with warm wet periods, such as occurred in the 1970s, swimming spores would form on roots, spread disease downhill and infect new and old regenerated sites.

In defined quadrats on diseased and disease-free sites, every plant, its species, frequency, percentage cover and health have been recorded for 25 to 30 years. Records of all the changes in plants during this period have been published (Weste *et al.* 2002). These records have provided accurate and detailed information about the disease cycle. At first regeneration was slow and survival variable, but, recently, rapid regeneration of young grass trees and other susceptible species has been recorded. Native species cope much better with a drought than the 'cinnamon fungus', which, as a water mould, requires free water for part of its life.

Methods

Endangered plants

Twelve plant species, endemic to the Grampians and either endangered, vulnerable or rare, were tested in two separate experiments for susceptibility to the dieback pathogen, and then examined in their natural habitat to check what risk the pathogen posed to their survival. *Poa sieberiana* and *Xanthorrhoea australis* were used as a resistant and susceptible control respectively.

Plants of each test species were located within the Grampians National Park with the assistance of the rangers and Herbarium records. Permission to take cuttings was granted by Parks Victoria, and these were propagated at 20 °C with mist irrigation until an abundant root system had formed. All material was tested for the presence of *P. cinnamomi* as described in Weste *et al.* (2002) and discarded if the pathogen was found.

Up to 40 rooted cuttings from each plant species were grown in containers. Half were planted in infected soil, the remainder were maintained as controls in unsterilised but pathogen-free soil. A fresh isolate of the pathogen was obtained from Mount William in the Grampians and used to provide the infected soil. The pots were placed on benches and exposed to natural weather conditions. Weekly measurements included colour, vigour, height, branch number and leaf number. After eight weeks, or at death, pathogen presence was tested in both main and fine roots. Susceptibility of each species was determined from the evaluation of these results.

Observations were recorded of each test species in its natural habitat, of the plant community in which it grew, of any associated disease and of access tracks or roads. Samples of fine roots and soil from the base of living plants with symptoms were collected from the vicinity and tested for the presence of the pathogen. The risk of extinction was evaluated from susceptibility determined from the pot trials, presence of symptoms on site, distance and slope from the nearest dieback site and distance from roads or tracks.

Results

The results of tests on species endemic to the Grampians National Park are presented in Table 1. Data from experimetn 2 has recently been published (Reiter *et al.*, 2004). Each species reacted differently to infection with *P. cinnamomi*.

Two of the species tested in the first experiment, Grampians Rock Banksia *Banksia saxicola* (Rare), and Williamson's Grevillea *Grevillea williamsonii* (Endangered), were highly susceptible and at high risk of extinction. The banksia investigated, which was growing on Mount William, had necrotic lesions on the leaves. The same species was observed with the same symptoms on Sundial Peak. *Phytophthora cinnamomi* was isolated from root and soil samples collected from the road verge on Mount William. In the pot trial the infected banksias developed necrotic lesions on the leaves and had significantly higher mortalities, compared with the control, which also showed significantly greater increase in height and leaf number.

Grevillea williamsonii was considered extinct until a small colony of plants was found in 1994. It tested highly susceptible in pot trials, with withered tips to the branches, leaf abscission and significantly higher mortalities. *Phytophthora cinnamomi* was isolated from root and soil samples collected from its growing site.

Grampians Grevillea *Grevillea confertifolia* (Rare) tested moderately susceptible. Chlorosis of branch tips and of leaves was observed in the pot trial. *Phytophthora cinnamomi* was isolated from a stem canker, which formed at the collar of an inoculated plant. The pathogen was also isolated from root and soil samples collected near one population in the National Park. The species was therefore considered at moderate risk of extinction.

Grampians Bauera *Bauera sessiliflora* (Rare) tested moderately susceptible. In the pot trial, branches turned brown and died but most plants survived infection until a dry period when a significant percentage died. Branches of both inoculated and control plants rooted when in contact with soil. This trait was also observed in the wild and offered a potential to avoid infection. *Bauera* grows along streams within the Grampians, which mitigates water stress. It was considered at low risk of extinction.

Grampians Thryptomene *Thryptomene calycina* (Rare) also tested moderately susceptible. It reacted slowly to infection, exhibiting wilting, leaf and root loss. Because of its wide distribution in the Grampians and plentiful seedling regener-

Table 1. Summary of species symptoms, susceptibility and risk of extinction by *P. cinnamomi* in two separate experiments.

Species	Symptoms	Susceptibility	Risk
Experiment 1			
Banksia saxicola	Necrotic leaf lesions, leaf abscission high mortalities	Highly	High
Bauera sessiliflora	Leaf browning, abscission dieback of branches, adventitious rooting from prostrate branches, significant mortalities	Susceptible	Low
Grevillea confertifolia	Chlorosis of leaves, branches stem canker,	Susceptible	Medium
Grevillea williamsonii	Leaf abscission, withered branch tips significant mortalities	Highly susceptible	High
Thryptomene calycina	Wilting, leaf abscission, some branch and root death	Susceptible	Medium
Experiment 2			
Asterolasia phebalioides	Root death, chlorosis, abscission seedling death	Susceptible seedlings	High
Borya mirabilis	Chlorosis, browning, reduced vigour and biomass	Susceptible	High
Grevillea microstegia	Chlorosis, some orange leaves significant root loss	Slightly susceptible	Low
Hibbertia humifusa	No symptoms, pathogen harboured within roots	Tolerant	None
Pimelea pagophila	Wilting, leaf abscission without chlorosis reduced vigour, reduced biomass significant mortalities	Highly susceptible	High
Poa sieberiana (resistant control)	No symptoms, pathogen harboured within roots	Tolerant	None
Pultenaea subalpina	Chlorosis, no new growth, root loss significant mortalities	Highly susceptible	High
Sphaerolobium acanthos	Browning, blackening of plants, significant root loss	Susceptible	Medium
Xanthorrhoea australis (susceptible control)	Chlorosis, browning, abscission significant root loss, significant mortalities	Susceptible	None

ation *T. calycina* was considered at moderate risk of extinction.

In the second experiment Grampians Rice flower *Pimelea pagophila* (Vulnerable) and Rosy Bush-pea *Pultenaea subalpina* (Rare) were both found to be highly susceptible and at high risk of extinction. Both were studied in subalpine heathland on Mount William at 1300 m ASL, where, despite the cold and sometimes snowy conditions, *P. cinnamomi*, reputedly a tropical water mould, was detected from root and soil samples obtained from the road verges. *Pimelea pagophila* also grew in open woodland free from the pathogen. In the pot trials, infected plants wilted, lost leaves and died, whereas the uninfected controls flowered. In pots, the infected *P. subalpina* showed chlorosis, browning and withering of leaves, root loss and significant mortalities.

The Downy Star-bush *Asterolasia phebalioides* (Vulnerable), tested highly susceptible for seedlings. Roots and shoots withered with high mortalities, whereas mature plants survived infection. The plants were located on the verge and on the bank above the verge of a popular tourist road in the National Park. *Phytophthora cinnamomi* was isolated from root and soil samples collected there. The mature plant survived, but the seedlings were at risk. In the pot trials, infected plants showed chlorosis, leaf abscission and reduction in biomass.

The Grampians Pincushion Lily *Borya mirabilis* (Endangered) are small plants, 3-

4 cm high, resembling miniature grass trees that grow in clumps. The total population consists of 45 plants growing in five clumps on one peak on a site disturbed by animals and surrounded by other heathland species. *Phytophthora cinnamomi* was isolated both from the other heathland species and one *Borya* plant with symptoms. *Borya mirabilis* is a resurrection plant, in which the leaves turn orange in dry periods, then green again when water is available. The infected plants remained brown and did not re-green. The species tested susceptible and was at high risk of extinction. In the pot tests, inoculated plants showed a reduction in vigour and in root biomass, compared with the controls, and changed colour from green to orange and then brown. Unfortunately only four plants were available for testing: two were inoculated and compared with two controls. No statistical analysis was possible.

The Mount Cassell Grevillea *Grevillea microstegia* (Rare) and Prickly Globe-pea *Sphaerolobium acanthos* (Rare), both tested slightly susceptible with low risk of extinction. No pathogen was isolated from their woodland sites. Dieback symptoms were observed in other heathland species near the location of *S. acanthos*. In the pot trials, both showed root loss, colour change and a reduction in vigour compared with the controls. The reduction in root biomass was significant in *G. microstegia*.

The Austral Grass-tree *Xanthorrhoea australis* (common in south-east Australia) tested susceptible but not at risk of extinction because of its wide distribution and ample regeneration from seed in the soil. In the pot trials, the inoculated plants showed chlorosis, browning, leaf abscission, significant root loss and significant mortalities, compared with the controls.

The Grampians Guinea-flower *Hibbertia humifusa* subsp. *humifusa* (Rare), tested tolerant to *P. cinnamomi* with no risk of extinction. No symptoms were observed in the dry woodland where it grew and no pathogen was isolated from these sites. In the pot trials, no symptoms were observed from the inoculated plants but the pathogen was isolated from both fine root and soil samples and from the main roots as well.

Phytophthora cinnamomi was re-isolated from the fine roots and soil of all inoculated plants, but not from any of the controls in either experiment. In the second experiment the pathogen was also re-isolated from the main roots of inoculated plants and a reduction of approximately 50% in root mass was recorded.

Discussion

Evidence presented in this paper suggests that five of the species tested are susceptible to *P. cinnamomi* and at high risk of extinction because of the presence of the pathogen on or near the growing sites. These are *Banksia saxicola*, *Grevillea williamsonii*, *Borya mirabilis*, *Pimelea pagophila* and *Pultenaea subalpina*. *Asterolasia phebalioides* is also at high risk in the seedling stage. Only four plants of *B. mirabilis* were available for testing, which limited the value of the results. These plants only occur in small numbers and on a few isolated sites. The Flora and Fauna Guarantee Act (1998) and the Commonwealth Environment Conservation and Biodiversity Protection Act (1999) were enacted to reduce extinctions and maintain Australia's high level of diversity. Barker and Wardlaw (1995) have reported on risk to endangered endemic species in Tasmania.

Infection with *P. cinnamomi* resulted in approximately 50% reduction of root mass in all species tested in the second experiment. The reduction of root mass is a devastating result of susceptibility to the pathogen and an important indicator.

Management of a diseased area depends on strict hygiene and quarantine of infected areas. It requires restriction of access, installation of footbaths, the use of washing stations for vehicles, equipment and tools, and the conversion of damp tracks to boardwalks. These measures have been effective in control of Jarrah dieback in Western Australia (Wills 1993). The effectiveness of Phosphonate sprays has been demonstrated by Aberton *et al.* (1999). It does not kill the pathogen but activates host defence, and is inexpensive and non-toxic.

The policy recommended for endangered or threatened species at risk from *P. cinnamomi* includes propagation and planting on suitable sites in the vicinity but not necessarily within the National Park. Phosphonate sprays, restriction of access, footbaths and regular monitoring are important aids, but cannot be implemented on some sites. *Pimelea pagophila* and *Pultenaea subalpina* populations grow on the verge of a popular tourist road, which limits the options. The latter species also grows on Mount Rosea, but is rare and was not observed in a recent search of this site.

The research described in this paper indicates the need for testing all endangered, vulnerable or rare species endemic to Victoria where infection by *P. cinnamomi* constitutes a risk.

Acknowledgements
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Stream-rock bryophytes at Cement Creek Turntable, Victoria

Chantal Carrigan[1] and Maria Gibson[1]

Abstract
The stream-rock bryophytes at Cement Creek Turntable, Victoria were examined for bryophyte species richness, diversity, growth form and position. Ten mosses and seven liverworts were identified. Nine growth forms were described. Most species had mat or mat-like forms and thus were removed from the full force of the current. (*The Victorian Naturalist* **121** (4), 2004, 153-157)

Introduction

Little is known about stream-rock bryophytes and the role they play in the environment. Suren and Ormerod (1998) investigated species richness, cover and community structure of aquatic bryophytes in Himalayan streams. They found aquatic bryophytes had important ecological roles in headwater streams as they reduced turbulence and waterbed velocities, thereby aiding the stabilization of microhabitats in ecosystems that otherwise would be unstable. Muotka and Virtanen (1995) studied the distribution of bryophyte species in Arctic streams. Glime (1984) and Glime and Raeymaekers (1987) examined branching patterns of the moss genus *Fontinalis* L. ex Hedw. and the effect that physio-ecological factors had on reproduction. They found that sexual reproduction was more common in terrestrial environments than in aquatic environments.

In Australia, studies on aquatic bryophytes have been limited to their role

[1] School of Biological and Chemical Sciences, Deakin University, Burwood, Victoria 3125

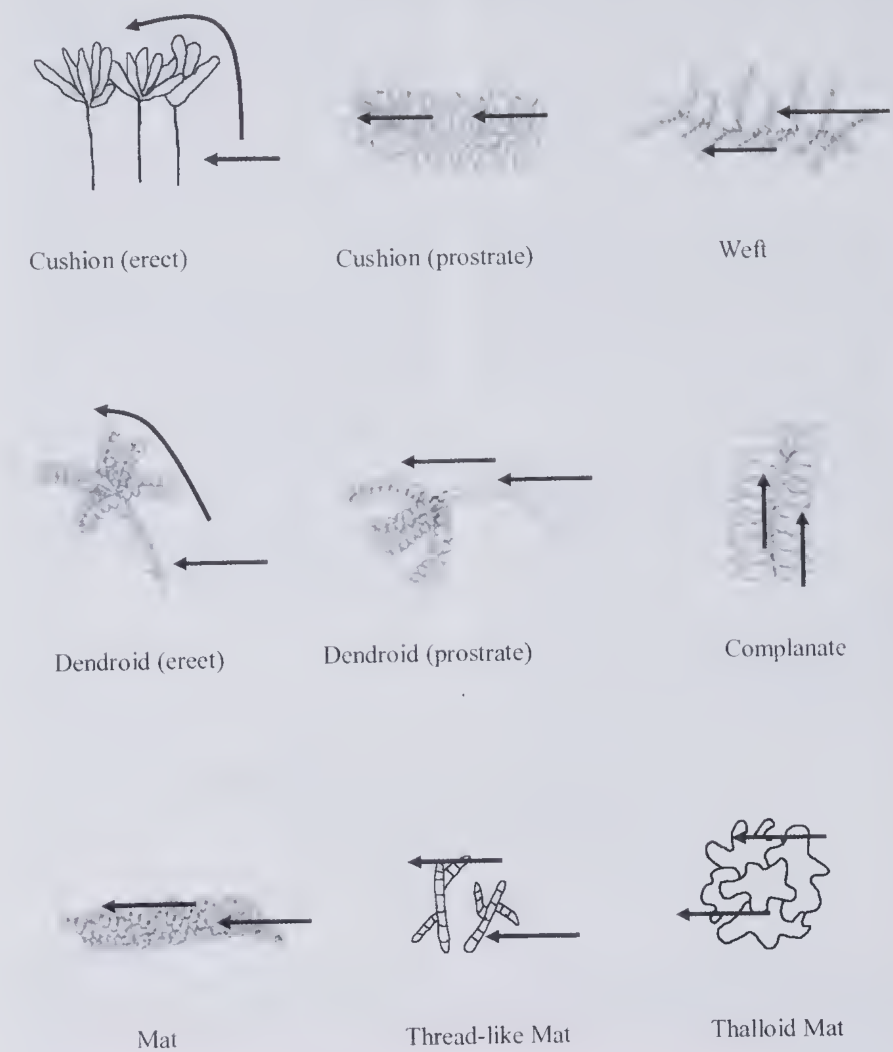

Fig. 1. Growth forms of stream-rock bryophytes. Arrows indicate direction of water flow.

as habitat for aquatic invertebrates (e.g. McKenzie-Smith 1997; Moore 2000). This study investigated species richness, diversity, growth form and position of stream-rock bryophytes at Cement Creek Turntable, near Warburton, Victoria and is part of a larger study that investigated the sexual reproduction and phenology of stream-rock bryophytes.

Study area and methods

The study site was at the Cement Creek Turntable, on the southern slope of Mt. Donna Buang, in the Yarra Ranges National Park. The park covers approximately 75 000 hectares bounded by State Forest and is roughly 69 km north-east of Melbourne. The site was within an old growth, Cool Temperate Rainforest pocket surrounded by Wet Sclerophyll Forest. The Cement Creek Turntable is a well-established tourist destination with aerial walkways. Cement Creek transects the National Park and is relatively fast flowing with fluctuating water levels.

Table 1. Growth form, percentage cover and frequency of stream-rock bryophytes at Cement Creek Turntable, Victoria.

Family	Species	Growth Form	Mean % Cover	Freq (n=5)
Bryophyta				
Bryaceae	*Rosulabryum billardieri* (Schwager). J.R.Spence	Cushion (erect)	6	1
Hypnodendraceae	*Hypnodendron spininervium* (Hook.) Jaeg. and *Hypnodendron vitiense* Mitt.	Dendroid (erect)	13	3
Ptychomniaceae	*Ptychomnion aciculare* (Brid.) Mitt	Cushion (prostrate)	<1	1
Lembophyllaceae	*Camptochaete arbuscula* (SM.) Reichdt	Dendroid (prostrate)	7	2
Hookeriaceae	*Achrophyllum dentatum* (Hook. f. & Wils.) Dix	Cushion (erect)	10	4
Hypopterygiaceae	*Cyathophorum bulbosum* (Hedw.) C. Muell.	Complanate	<1	2
Thuidiaceae	*Thuidiopsis furfurosa* (Hook. f. Wils.) Fleisch	Weft	5.4	4
Sematophyllaceae	*Sematophyllum homomallum* (Hampe) Broth.	Mat	13	3
	Wijkia extenuata (Brid.) Crum	Weft	2	3
Heptaophyta (leafy)				
Geocalycaceae	*Heteroscyphus coalitus* (Hook.) Schiffn	Thread-like mat	1.2	3
	Heteroscyphus planiusculus (Hook. f. and Taylor) J.J.Engel	Thread-like mat	17	5
Plagiochilaceae	*Plagiochila retrospectans* Nees	Cushion (erect)	9.4	4
Hepatophyta (thallose)				
Aneuraceae	*Aneura alterniloba* (Hook.f. and Taylor) Taylor and Hook.f.	Thalloid mat	8	1
	Riccardia aequicellularis (Steph.) Hewson	Thread-like mat	<1	2
Pallaviciniaceae	*Symphyogyna podophylla* (Thunb.) Mont.and Nees	Thalloid mat	1.2	3
Hymenophytaceae	*Hymenophyton flabellatum* (Labill.) Dumort. ex. Trev.	Dendroid (erect)	<1	1

The study site contained many scattered stream rocks with a lush bryoflora. Many also bore a small number of ferns, particularly *Hymenophyllum cupressiforme* Labill. and *Grammitis billardieri* Willd. Only rocks of homogenous granitic composition were examined. All were approximately the same size, with a diameter of 50 cm, and represented rocks most common to the site. All rocks were completely surrounded by water. and so could not be considered an extension of the stream bank; rather, they were islands. Five rocks were examined. This number was determined using a cumulative species area curve (Andrew and Mapstone 1987). The entire area of each rock was intensively examined to determine species composition, position, cover and growth form. Species diversity was calculated as the Shannon Index, H'. Determination of growth form followed that of Gimingham and Birse (1957) with minor adaptations.

Results

A total of 17 species from 13 families occurred, seven from the Hepatophyta (liverworts) and ten from the Bryophyta (mosses) (Table 1). *Hypnodendron spininervium* (Hook.) Jaeg. and *Hypnodendron vitiense* Mitt. grew intermingled with each other and were treated as one in terms of percentage cover and calculation of species diversity. *Hypnodendron* and *Sematophyllum homomallum* (Hampe) Broth. had the highest percentage cover of the mosses, each 13%, but *Heteroscyphus planiusculus* (Hook. f. and Taylor) J.J. Engel, a liverwort, had by far the greatest

Table 2. Variation in species richness and diversity (H') of stream-rock bryophytes at Cement Creek Turntable, Victoria.

Rock	H'	Species Richness
1	2.13	13
2	1.72	10
3	1.60	8
4	1.06	6
5	1.56	4
Mean	1.62	8.2
SD	0.38	3.5

cover, 17% (Table 1). Not surprisingly, *H. planiusculus* occurred on all rocks while most species occurred on only few rocks (Table 1). Species richness varied considerably with an average of 8.2 species per rock and a standard deviation of 3.5 species (Table 2). Species diversity ranged from 1.06 to 2.13, with a mean of 1.62 and a standard deviation of 0.38 (Table 2).

Species richness and diversity above the water line was much greater than at the water line, which, in turn, was greater than below the water line (Table 3). When these habitats were further divided, species richness and diversity was highest on the downstream side of rocks and lowest at the base of rocks while the sides of rocks parallel to the water flow, the upstream sides of rocks and the tops of rocks had similar values (Table 3). Variation in the numbers of growth forms followed the same pattern (Table 3).

A total of nine growth forms were identified (Table 1, Fig. 1). Only two of these were erect and were either dendroid or cushion-like. Both habits, however, also occurred in prostrate forms (Table 1, Fig. 1). Most species had mat or mat-like forms (Table 1) and thus were largely removed from the full force of the current. Only three of these, *H. planiusculus*, *Riccardia aequicellularis* (Steph.) Hewson and *Aneura alterniloba* (Hook. f. and Taylor) Taylor and Hook. f. occurred below the water line (Table 3), but were not restricted to this region. *Riccardia aequicellularis* was the only species able to cope with the full force of the current on the upstream side of the rocks. Other species on the upstream side of the rocks occurred well

Table 3. Position of bryophytes on stream rocks at Cement Creek Turntable, Victoria. +W above the water line, WL at the water line, -W below the water line, DS downstream side of rock, T top of rock, US upstream side of rock, LS side of rock parallel to flow of water, B base of rock.

Species	+W	WL	-W
Bryophyta			
A. dentatum	x		
C. arbuscula	x		
C. bulbosum	x		
H. spininervium and *H. vitiense*	x		
P. aciculare	x		
R. billardieri	x		
T. furfurosa	x		
S. homomallum	x	x	
W. extenuata	x	x	
Hepatophyta			
H. coalitus	x		
H. flabellatum	x		
P. retrospectans	x		
S. podophylla	x		
A. alterniloba	x	x	x
H. planiusculus	x	x	x
R. aequicellularis		x	x
Total No. Species	16	5	3
Shannon Diversity	2.59	1.49	0.9
Total No. Growth Forms	9	4	2

Species	DS	T	US	LS	B
Bryophyta					
C. bulbosum	x				
A. dentatum	x	x			
R. billardieri	x	x			
P. aciculare		x			
C. arbuscula	x	x	x	x	
H. spininervium and *H. vitiense*	x	x	x	x	
T. furfurosa	x	x	x	x	
S. homomallum	x		x	x	
W. extenuata	x		x	x	
Hepatophyta					
H. coalitus	x	x	x	x	
H. flabellatum	x	x	x	x	
A. alterniloba	x	x			x
S. podophylla	x		x	x	
R. aequicellularis	x		x	x	x
P. retrospectans		x			
H. planiusculus					x
Total No. Species	14	11	10	10	3
Shannon Diversity	2.5	2.07	2.14	2.12	0
Total No. Growth Forms	8	7	6	6	2

above the water line, except under flood conditions. Only six of the seventeen species had erect forms (Table 1). These always occurred well above the water line, except under flood conditions, and were either on the top of rocks or extended part way down the sides. The weft-like forms occurred predominantly on the sides of the rocks parallel to the direction of the current, but occurred in other areas as well. The thalli were elongated and flexible, streaming with the current rather than resisting it as occurred with the erect forms.

Discussion

It is well known that growth form and position in the habitat are important to the survival of terrestrial bryophytes (Richardson 1981). There is no reason why this should be different for stream-rock bryophytes, especially as most of them also occur on soil. Indeed, a number of studies in the Northern Hemisphere (Muotka and Virtanen 1995; Steinman and Boston 1993; Suren and Ormerod 1998; Virtanen *et al.* 2001) found a different suite of species at different levels on rocks. The microhabitat at the base of rocks had low species richness but higher cover. Communities formed strata and included dendroid canopy species and mat-like understorey species. The microhabitat at the top of rocks supported few species. These were semi-aquatic and biomass was low. The middle zone was species rich, presumably as this zone graded from a more terrestrial type habitat to an aquatic one, so species occurring at the tops of rocks could extend into this area, as could species occurring at the base of the rocks. In addition, a suite of species peculiar to an area also occurred (Muotka and Virtanen 1995; Virtanen *et al.* 2001).

The results of this study were somewhat different. Bryophytes colonized almost the entire surface area of all rocks examined. Lower areas had low species richness as occurred in Northern Hemisphere studies but the tops of rocks had comparatively high species richness. The types of species found at the tops of rocks in the Northern Hemisphere studies (Muotka and Virtanen 1995; Steinman and Boston 1993; Suren and Ormerod 1998; Virtanen *et al.* 2001) were similar to those found at the top in this study. Canopy-forming species, such as *H. spininervium* and *H. vitiense*, did not dominate the lower areas of the rocks as occurred in the Northern Hemisphere studies, but occurred on the sides or on the tops of rocks. The main species that dominated the base of rocks in this study was the leafy liverwort, *H. planiusculus* and the thallose liverwort *A. alterniloba*, both of which formed mats. The results of this study concur with those of Moore (2000) for Whitehouse Creek at Marysville, Victoria.

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A survey for Leadbeater's Possum *Gymnobelideus leadbeateri* in lowland swamp forest at Bunyip State Park

Dan Harley[1]

Abstract

A survey for Leadbeater's Possum *Gymnobelideus leadbeateri* was conducted in lowland swamp forest along sections of Diamond and Black Snake Creeks in Bunyip State Park. The habitat at these sites closely resembles that at Yellingbo Nature Conservation Reserve, where in 1986 a small outlying population of the possum was discovered. Twenty nest boxes were installed and monitored over a two year period. No evidence of the possum was found. (*The Victorian Naturalist* **121** (4), 2004, 158-163)

Introduction

Leadbeater's Possum *Gymnobelideus leadbeateri* is a small (110-160 g), arboreal marsupial that is restricted in distribution entirely to Victoria, where it is classified as 'endangered' (Macfarlane *et al.* 1995). There were no confirmed reports of the species for over 50 years and it was presumed to be extinct, until its rediscovery in 1961 in the montane ash forests of the Victorian Central Highlands (Wilkinson 1961).

Over the past two decades, the ecology and conservation of Leadbeater's Possum in montane ash forest has been the subject of numerous research projects (e.g. Smith 1984a, 1984b; Lindenmayer *et al.* 1991a, 1991b; Smith and Lindenmayer 1992; Lindenmayer and Lacy 1995; Lindenmayer and Possingham 1995, 1996). This is, in part, due to the threat posed to the possum by clearfell logging which eliminates the mature, hollow-bearing trees that the species requires for denning (Smith and Lindenmayer 1988; Lindenmayer *et al.* 1990, 1991c; Lindenmayer 1992).

During the last twenty years, Leadbeater's Possum has been detected in several forest types outside its stronghold in the montane ash forests of the Victorian Central Highlands (Harley 2004a). This includes the discovery in 1986 of a small isolated population inhabiting lowland swamp forest at Yellingbo Nature Conservation Reserve (Smales 1994). At present, this is the only known extant lowland population. However, the possum was thought to be restricted to similar lowland habitats in south-west Gippsland during the late 1800s and early 1900s, based on historical records from the Bass River near the town of Woodleigh and Koo-Wee-Rup Swamp near Tynong (McCoy 1867; Brazenor 1946). By 1910, the lowland forests in this region had been extensively cleared for agriculture (Nicholls 1911a), and as a consequence, Leadbeater's Possum was widely believed to be extinct there (Nicholls 1911b; Spencer 1921; Anon 1939).

Today, little lowland swamp forest remains other than that protected by the Yellingbo Nature Conservation Reserve. The forest type is listed under the *Flora and Fauna Guarantee Act* 1988 as a threatened community, and the reserve is considered to be of national significance (McMahon and Franklin 1993; Turner 2000). In 1990-91, during regional surveys for the endangered Helmeted Honeyeater *Lichenostomus melanops cassidix*, one additional area of high quality lowland swamp forest was identified about 25 km south-east of Yellingbo, along sections of Diamond and Black Snake Creeks in Bunyip State Park (Blackney 1991; Blackney and Menkhorst 1993). The site is midway between those of the historical records of the Leadbeaters Possum in south-west Gippsland and at Yellingbo (Fig. 1).

Recent discoveries of several Leadbeater's Possum populations have been more by good fortune than design (e.g. Smales 1994; Jelinek *et al.* 1995; Larwill *et al.* 1995). Given that the species is particularly cryptic and easily overlooked during fauna surveys

[1] Wildlife Ecology Research Group, School of Biological Sciences, PO Box 18, Monash University, Clayton, Victoria 3800.
Current address: Department for Environment and Heritage, PO Box 1046, Mt Gambier, South Australia 5290. Email: Harley.Daniel@saugov.sa.gov.au.

using standard techniques (e.g. spotlighting, trapping), there is a strong likelihood that additional populations may be discovered (Harley 2004a). This paper describes the results of a survey for the possum in lowland swamp forest along sections of both Diamond and Black Snake Creeks in Bunyip State Park, approximately 70 km east of Melbourne (Fig. 1).

Methods

Previous studies conducted in montane ash forest have found 'stagwatching' (i.e. direct counts of arboreal mammals as they emerge from tree hollows at dusk) to be the most reliable method of surveying for Leadbeater's Possum (Seebeck *et al.* 1983; Smith *et al.* 1989). The major drawback to this technique is that it is extremely labour intensive, particularly when employed over a large survey area.

Recent research conducted in lowland swamp forest at Yellingbo has found that nest boxes are an efficient survey tool for Leadbeater's Possum (Harley 2004b). The species constructs distinctive nests of shredded bark within nest boxes, which removes the necessity for animals to be actually present in a box on the day of inspection in order to establish their presence in an area. Given the large survey area in Bunyip State Park (~12 km length of riparian forest), and the similarity of the habitat to be surveyed to that at Yellingbo, nest boxes were considered to be the most appropriate survey method. The technique has also been used successfully to survey several other species of cryptic, arboreal mammals (Soderquist *et al.* 1996; Ward 2000).

Extensive research into the possum's habitat requirements in montane ash forest has found site occupancy to be positively correlated with the abundance of hollow-bearing trees and *Acacia* spp. (Lindenmayer *et al.* 1991a). The former provides diurnal den sites and the latter an important source of food (Smith 1984a; Lindenmayer *et al.* 1991c). In contrast, at Yellingbo mature trees possessing hollows are not an abundant or conspicuous feature of the habitat inhabited by Leadbeater's Possum (pers. obs.). Furthermore, *Acacia* spp. are absent from the floodplain forest utilised by possums for foraging (Harley *et al.* in press). Thus, neither were considered to be good indicators of site suitability for the possum in lowland swamp forest.

The key attributes of habitat utilised for foraging by Leadbeater's Possum at Yellingbo includes the presence of Mountain Swamp Gums *Eucalyptus camphora* and a dense middlestorey of paperbarks *Melaleuca* spp. and/or tea tree *Leptospermum* spp. (Harley *et al.* in press). The latter provides dense, structural connectance which facilitates the movement of possums through the forest, as they rarely descend to the ground (pers. obs.).

Prior to nest box installation, extensive site assessments were undertaken along the Bunyip River, Diamond and Black Snake Creeks and several smaller tributaries in order to identify the habitat most similar to that occupied by Leadbeater's Possum at Yellingbo. These sites were subsequently targeted with nest boxes.

Sixteen nest boxes were distributed over a 9 km length of riparian forest along Diamond Creek, and four boxes were installed along 2.5 km of Black Snake Creek. The two sites are approximately 4 km apart. The lowland swamp forest was restricted to a narrow floodplain in both areas, and rarely exceeded 100 m in width. The nest boxes were constructed of 19 mm timber, and the internal dimensions were 236 x 195 x 356 mm. Each had a circular entrance hole of 50 mm in diameter (which would exclude larger species of arboreal mammal). A hinged lid allowed inspection of the contents of a nest box. The boxes were installed at a height of 3-4 m on eucalypts. Particular effort was taken to ensure that there was a large amount of inter-connecting vegetation in the middlestorey or canopy between the trees that nest boxes were installed upon and adjacent trees. The orientation of the boxes varied, although most faced in a south-easterly direction to minimise exposure to the afternoon sun. Upon initial installation, creamed honey was spread on their lids as an attractant. Nest boxes of the same design, and installed according to the same criteria, have been used extensively by Leadbeater's Possums at Yellingbo (Harley 2004b).

The 20 nest boxes were installed in Bunyip State Park during September 2000. Subsequent inspections of box

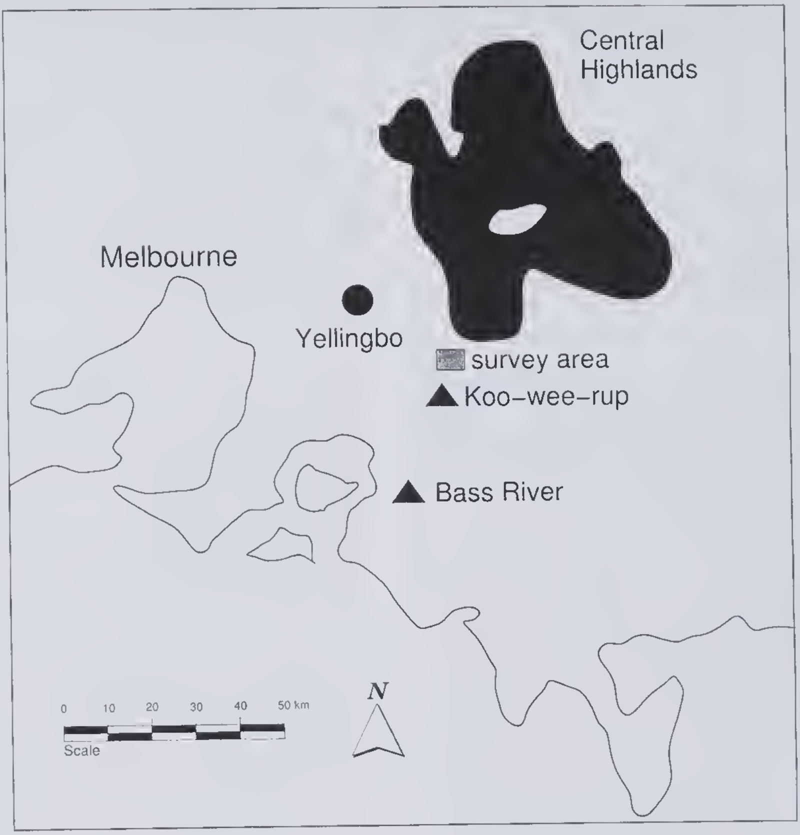

Fig. 1. Location of the survey area in Bunyip State Park in relation to extant populations of Leadbeater's Possum at Yellingbo (●) and in the Victorian Central Highlands. Historic records of the possum from lowland habitats in south-west Gippsland are also depicted (▲).

occupants/contents were undertaken during daylight hours using an extension ladder. Inspections were conducted in January 2001, February 2002 and March 2003.

Results

The nest boxes were utilised by three species of scansorial and arboreal mammal, the Agile Antechinus *Antechinus agilis*, Sugar Glider *Petaurus breviceps* and Common Ringtail Possum *Pseudocheirus peregrinus*. No evidence of Leadbeater's Possum was detected.

Table 1 details the species recorded during the nest box inspections. All of the records were obtained from just three boxes positioned along Diamond Creek. There was no sign of usage of the four boxes positioned along the Black Snake Creek.

Discussion

Based on the colonisation rate and nest box usage patterns of Leadbeater's Possums at Yellingbo (Harley 2004b), the time from installation in September 2000 to the final inspection in March 2002 (~ 2.5 years) was more than sufficient to allow for colonisation by possums, should they occur in the survey area.

The results of this survey suggest that the species does not inhabit the lowland swamp forest along Diamond and Black Snake Creeks in Bunyip State Park. The finding is disappointing, given that the survey area is within Leadbeater's Possum's former range and contains a substantial area of high quality habitat (Davey and Mayhew 2000;pers obs.). As such, it represented perhaps the most likely site of a

Table 1. Species detected using nest boxes positioned in lowland swamp forest along Diamond Creek, Bunyip State Park.

Date	Nest box no.	Species detected	Type of record
Jan 2001	DC5	*Antechinus agilis*	1 individual present
Feb 2002	DC5	*Antechinus agilis*	large nest of dry eucalyptus leaves plus scats
	DC6	*Antechinus agilis*	2 individuals present
	DC15	*Petaurus breviceps*	large nest of fresh eucalyptus leaves
Mar 2003	DC5	*Antechinus agilis*	1 individual present
	DC6	*Antechinus agilis*	1 individual present
	DC15	*Petaurus breviceps*	nest of eucalyptus leaves
		Pseudocheirus peregrinus	1 individual present

second population in lowland swamp forest.

The closest record of the possum to the survey area during the past two decades is 4 km to the north, although the majority of boxes were 7-10 km from the site of this record. This represents a considerable distance for the species, given that home ranges are small (1-3 ha) and mean dispersal distances at Yellingbo are approximately 500 m (Harley *unpubl. data*). Maximum dispersal distances detected at Yellingbo are on the order of one kilometre. These data include one observation of the species dispersing across unsuitable habitat (Harley 2002). Whilst continuous forest covers the area between the boxes at Bunyip State Park and the sites of previous records of the possum to the north, it is dominated by species of eucalyptus with rough, fibrous bark extending to their upper limbs, such as Messmate *Eucalyptus obliqua*. Leadbeater's Possum does not typically inhabit such forest types, preferring areas dominated by smooth-barked eucalypts (Smith 1982; Lindenmayer *et al.* 1989; Harley 2004a).

The floristics and structure of the vegetation at the nest box sites along both Diamond and Black Snake Creeks bear considerable resemblance to those in the territories occupied by Leadbeater's Possum at Yellingbo. Given this, it would appear to constitute suitable foraging habitat. The width of the floodplain along both creeks ranged from 50-100 m (Davey and Mayhew 2000). This is also very similar to Yellingbo, where the swamp forest rarely exceeds 100 m in width. The elevation of the nest box sites in Bunyip State Park ranged from 55-120 m ASL. This too is comparable to that at Yellingbo (120 m ASL) and of the historical collection sites in south-west Gippsland (20-60 m ASL). On this basis, the survey area would be an ideal translocation site should it be necessary to establish a second lowland population, due to the substantial declines predicted for montane populations.

In addition to Yellingbo, Leadbeater's Possum has recently been detected at one other site dominated by *E. camphora*, approximately 55 km to the north, at the Silver Gum Reserve near Buxton (280 m ASL) (K. Garth pers. comm; pers. obs.). Sections of this small, 17 ha reserve support forest resembling that at Yellingbo. The possum's abundance at this site has yet to be established. The record suggests that some of the small stands of *E. camphora* that were identified by Simmons and Brown (1986) around Healesville, approximately 20 km north of Yellingbo, may also be worth surveying for the possum. Stands of *E. camphora* that occur in north-east Victoria at 400-1600 m ASL should also be investigated.

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Description of the external anatomy of the marine snail *Cystiscus obesulus* May (Mollusca: Gastropoda: Cystiscidae)

Platon Vafiadis[1]

Abstract

Recent observations of living specimens of the marine snail *Cystiscus obesulus* (May 1919) from Victorian waters have enabled a report on the external morphology of this species. The external anatomy helps to confirm the family placement, and the distinctive colour pattern separates it from other closely related species. A brief review of other published biological and taxonomic information relating to this species is also provided. (*The Victorian Naturalist*, **121** (4), 2004, 163-168).

Introduction

On Sunday 26 January 2003, the Marine Research Group (MRG) of the Field Naturalists Club of Victoria undertook a field trip to Mushroom Reef, Flinders. There, shortly after noon, approximately half a dozen living specimens of a minute, strikingly patterned marginelliform gastropod were found by sieving through lower littoral pools containing mainly the seagrass *Amphibolis antarctica* and also some scattered brown algae. Two specimens were legally collected under MRG permits held from Parks Victoria for identification and further study. The animals were subsequently identified as *Cystiscus obesulus* (May 1919).

A further specimen of this mollusc was encountered during a personal trip to Cleeland Bight, Phillip Island on Tuesday 8 April 2003. A sieve was run through a bed of *Zostera* sp. eel-grass, unknowingly capturing a single, minute individual of *Cystiscus obesulus*. It was unexpectedly discovered the following day after a microscopic examination of the contents of the collecting vial.

[1]Marine Research Group of the FNCV, Locked Bag 3, PO Blackburn, Victoria 3130

These sightings provided good opportunities to observe and report on the living animal.

Methods

On each occasion, the animals were kept alive in seawater and placed in a shallow dish for study under a low power stereomicroscope at magnifications up to ×45, using fluorescent lighting. Notes and drawings were made at the microscope. On completion of each respective study, the animals were photographed and preserved in 70% ethanol. They have been formally lodged in Museum Victoria - registered numbers F100,027 (Mushroom Reef specimens) and F100,028 (Cleeland Bight specimen).

Observations

The shells from the Flinders specimens were approximately 2.0 mm in length, whilst the shell of the Cleeland Bight specimen was approximately 1.0 mm long. All shells were smooth, translucent, short spired and relatively broad, with a blunt apex and a long, narrrow aperture. May (1919) described six columellar plications (the first or most anterior being the

Fig. 1. *Cystiscus obesulus*; specimen from Cleeland Bight, Phillip Island, Victoria. Scale: 0.25mm. (Drawing: P. Vafiadis).

strongest, and the last four being very minute) and about nine minute denticulations on the middle portion of the outer lip. These denticulations were faintly visible in the Flinders specimens, but the outer lip of the Cleeland Bight specimen lacked any visible denticulations. The incompletely retracted foot in the preserved Flinders specimens partially obscured the columellar plications, but these were readily visible in the Cleeland Bight specimen, the shell of which is shown in Fig.1.

The animals were all active and distinctively pigmented (Figs. 2 and 3). The mantle, visible beneath the thin, translucent shell, showed patches of yellow-orange lined by a brown-black rim; these patches were separated from each other by a cream-coloured 'background'. This produced a mosaic appearance somewhat reminiscent of a giraffe's spots. The patches were present on early whorls, as well as on the body whorl. The spacing between patches was reasonably uniform, and their edges were approximately parallel to those of adjacent patches. May (1919: 58) described these features as follows: '... the very peculiar animal, ... showing through the translucent shell, exhibits a bright orange colour curiously netted with white lines, each bordered with black; empty shells show no traces of this peculiar ornamentation, which must belong to the animal.' Although the patterning of the Cleeland Bight animal was identical to those from Flinders, its colours were not as vivid. May (1919) made no further comment on the anatomy of this species.

The head of *C. obesulus* was notable (Figs. 4a and 4b). It was moderately flattened in the dorso-ventral plane, and bore prominent, round, bright red eyes laterally at the bases of what are here called 'cephalic tentacles' (see also the 'Anatomical Discussion' section below). The eyes were clearly visible from both the dorsal (Figs. 2 and 4a) and ventral (Figs. 3, 4b and 4c) aspects of the head. The 'cephalic tentacles' were semi-translucent, relatively short, bluntly rounded at their ends, and also moderately flattened dorso-ventrally. Where they touched in the dorsal midline, a full-thickness midline cleft or slit extended posteriorly to end just anterior to the eyes (Fig. 4a). The minuteness of the Cleeland Bight specimen made the precise location of the posterior aspect of this cleft more difficult but, as with the Flinders specimens, it seemed to terminate at around the level of the eyes. Ventrally, the 'cephalic tentacles' were united across their proximal halves by a membrane that was continuous with them, forming the floor of a cavity that was the entrance to the mouth (Fig. 4a). The 'cephalic tentacles' in the Cleeland Bight specimen obscured the anterior aspect of the ventral membrane when the animal was viewed dorsally.

The head was strikingly coloured with a bright red hue on both its dorsal and ventral surfaces. This colouration extended across the width of the head posterior to the eyes, and narrowed more anteriorly to occupy the central region of the head, largely sparing the 'cephalic tentacles'. This red colouration was sparsely stippled with fine black spots (the latter not prominent in the Cleeland Bight specimen). The 'cephalic tentacles' were blotched with small patches of white-cream. The animals lacked a siphon and no other accessory structures were seen on any of them. The head always protruded well in front of the anterior foot. The union between the anterior foot and the visceral mass was posterior to the eyes (Fig. 5) but could not be well seen.

The Flinders specimens often crawled up

Fig. 2. *Cystiscus obesulus*; specimen 1, from Flinders, Victoria.

Fig. 3. *Cystiscus obesulus*; specimen 2 (ventral view), from Flinders, Victoria.

the sides of the dish and inverted themselves upon the surface of the water, where, assisted by surface tension, they would 'crawl' with the foot fully extended. This allowed the ventral surface of the foot (the sole) to be well observed. (The Cleeland Bight specimen did not do this and would not allow itself to be turned to view the sole). The foot was long and relatively narrow, approximately one and a third times the length of the shell, and at the anterior end was expanded bilaterally to form two distinct rounded lobes (Figs. 3 and 4c). The middle two thirds of the sole bore a deep, midline, longitudinal cleft, which became more shallow as it extended to the anterior and posterior ends (Figs. 3 and 4c). This represented a pedal mucous gland, producing sticky, invisible mucous threads that adhered to instruments used to position the animals during observations. The sole was semi-opaque white, finely and sparsely stippled with very fine black dots. The upper surface of the foot was also a semi-opaque white, bearing blotches of whitish cream in the midline posteriorly, and to a degree anteriorly. Some reddish colouration was evident at the anterior-most margin and also on the lateral aspects posteriorly. During crawling, the anterior

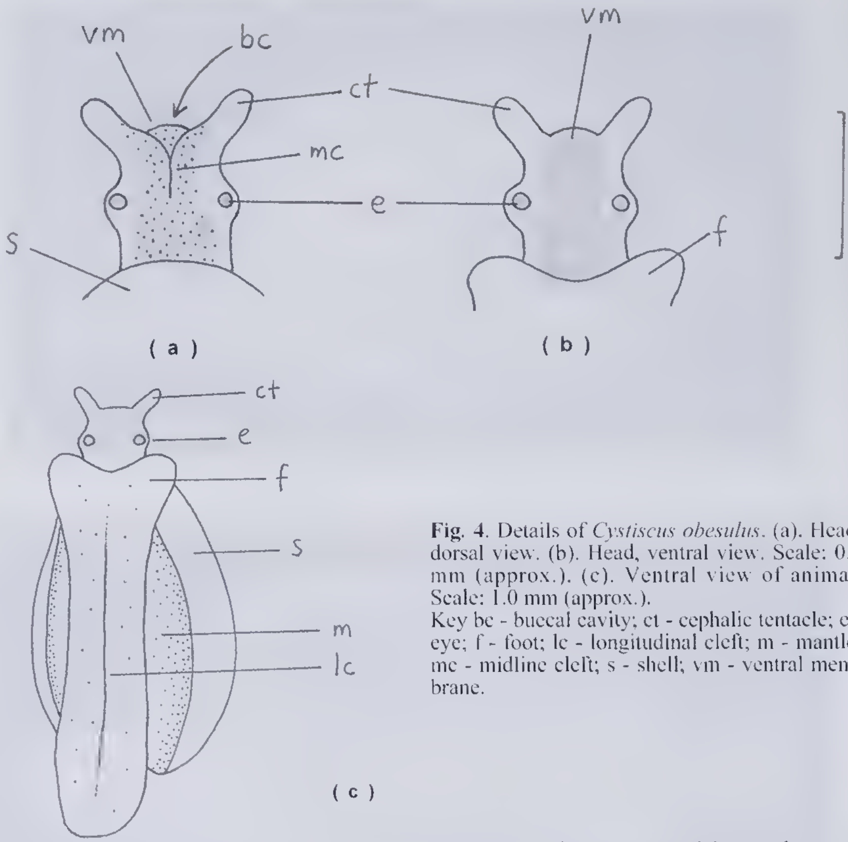

Fig. 4. Details of *Cystiscus obesulus*. (a). Head, dorsal view. (b). Head, ventral view. Scale: 0.5 mm (approx.). (c). Ventral view of animal. Scale: 1.0 mm (approx.).
Key bc - buccal cavity; ct - cephalic tentacle; e - eye; f - foot; lc - longitudinal cleft; m - mantle; mc - midline cleft; s - shell; vm - ventral membrane.

end of the foot was usually level with or slightly behind the anterior shell margin in one of the Flinders animals, whilst in the other it was in front of the shell margin and thus readily visible (Fig. 2). During observation in all individuals, the mantle did not extend beyond the base of the shell. It was translucent and stippled with very fine, black spots (the latter again not prominent in the Cleeland Bight specimen). These spots were most densely concentrated on its outer edges (Fig. 4c).

The animals crawled with a smooth, gliding motion. They were all active and could not be coaxed back into their shells. No operculum was apparent either before or after fixing.

Anatomical discussion

In a detailed review of marginelliform gastropods, Coovert and Coovert (1995) recognised the Cystiscidae as a separate family from the Marginellidae, based on characters of external and internal anatomy, and also on shell morphology. Cystiscidae shells lack a thickened outer lip, have discontinuous or internally reduced columellar plications (due to a degree of subsequent internal shell resorption), and most genera lack a distinct siphonal notch; these features are enough to separate the Cystiscidae from the Marginellidae (Coovert and Coovert 1995).

Anatomically, marginelliform gastropods have been divided into four external morphological types based mainly on features of the head and siphon (Coovert 1987; Coovert and Coovert 1995). In this classification the genus *Cystiscus* belongs to the Type 3 group, characterised by 'an elongate head that is longitudinally split dorsally, with the anterior end bifurcate. ... The siphon is either very short and not readily apparent, or completely absent. Eyes are located on the sides of the head, usually in

Fig. 5. *Cystiscus obesulus* (lateral view), from Flinders, Victoria.

a conspicuous bulge' (Coovert and Coovert 1995: 51). The emergence of this arrangement is interpreted as either a ventral fusion of the cephalic tentacles (causing a longitudinal dorsal cleft), or as a head lacking cephalic tentacles that has become split in its dorsal longitudinal aspect, but more anatomical study is needed to resolve this issue (Coovert and Coovert 1995). The remarkable head of *Cystiscus minutissimus* (Tenison Woods 1876) is figured by Murray (1970: 33, Fig. 1b.) and Coleman (2003) has photographed this species (p.37), as well as *Cystiscus cymbalum* (Tate 1878) (p. 37) and *Cystiscus angasi* (Crosse 1870) (p. 36). Burn and Hewish (unpubl.) describe the animal of the cystiscid *Gibberula subbulbosa* (Tate 1878).

When lacking the animal, the shells of *C. obesulus* and *C. angasi* are essentially indistinguishable; when alive, however, their distinctive colouration and patterns readily separate them (Burn 2003, pers. comm.; Hewish 2003, pers. comm.).

The radulae of the Cystiscidae differ from those of the Marginellidae in being longer and narrower, and exhibiting differences in their supporting structures (Coovert and Coovert 1995). Four types of cystiscid radulae and five types of marginellid radulae are described and figured in Coovert and Coovert (1995). The foregut also has taxonomic importance and its features are discussed in some detail by Coovert and Coovert (1995) for the species in which it is known.

As at 1995, internal anatomical information (excluding radular studies) was available for only three species in the Cystiscidae and none for the genus *Cystiscus* (Coovert and Coovert 1995). The radula in *Cystiscus* (a 'Type 2 radula') is long, narrow, and uniserial, with the teeth bearing 5-15 cusps on their cutting edges (Coovert and Coovert 1995).

Murray (1970) made valuable anatomical and life-cycle observations of *C. minutissimus* (Tenison Woods 1876) over many months by maintaining it and its host food source, the bryozoan *Amathia biseriata* (Krauss 1837) in glass dishes of seawater at average temperatures of 15.5 degrees celsius. *C. minutissimus* is a uniform orange-yellow colour with a dorsally bifurcate head that lacks a siphon (Murray 1970). The propodium is bifurcate, and the foot lacks an operculum (Murray 1970), consistent with observations of *C. obesulus*. Apart from the presence of a penis in male animals, Murray (1970) noted that *C. minutissimus* exhibits no other degree of external sexual dimorphism. Murray (1970) observed and described the mating process in *C. minutissimus*, and noted that every two days or so, females laid on the host bryozoan a single, ovoid-elongate egg capsule containing a single red-yolked egg (see Murray 1970, Figs. 1a, c-f). Six to seven weeks after laying, a crawling juvenile emerged from the capsule to settle directly onto the host bryozoan.

Based on shell and anatomical characteristics, Coovert and Coovert (1995) suggest that the Cystiscidae are more closely related to the Olividae than to the Marginellidae, and the Marginellidae themselves are more closely related to the Volutidae than to the Cystiscidae.

Conclusion

Micromolluscs are readily overlooked because of their size, but they have much to offer in terms of their external beauty and scientific interest. As seen with *Cystiscus obesulus*, shell characters alone may be insufficient for identification without accompanying information on colouration, patterning and anatomy of the living animal. It is hoped that simple observations, as here with *C. obesulus*, will contribute to existing knowledge of these molluscs.

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Mating behaviour, female aggression and infanticide in *Propallene saengeri* (Pycnogonida:Callipallenidae)

Bonnie A. Bain[1] and Fredric R. Govedich[1]

Abstract

Courtship and female aggression were observed in *Propallene saengeri* Staples. Courtship was initiated by the female after the departure of juveniles from the male's ovigerous legs. Courtship consisted of dancelike movements of both male and female, followed by physical contact with the legs. Once courtship was initiated between the male and one female, a second female became interested in the pair and intervened. This resulted in an aggressive response from the first female that eventually resulted in combat between the two females and the eventual death of one of them. Infanticide was also observed after juveniles had left the male with one female attacking and killing a juvenile. (*The Victorian Naturalist* **121** (4), 2004, 168-171)

Introduction

Pycnogonids or sea spiders are a large group (1200+ species) of marine chelicerates with exclusively male parental care of the eggs and young. They have been overlooked as subjects for behavioural studies. The majority of the recent pycnogonid literature consists of species descriptions with very few papers published on any other aspects of pycnogonid biology. Pycnogonid mating behaviour is virtually unknown with only a few published observations on the actual coupling between the male and the female (Table 1). Our current knowledge of premating behaviour is incomplete at best and information on competition for mates is nonexistent. Based on the observations in Table 1, courtship and mating consists of the male approaching the female, male and female assuming a close pairing or pseudocopulatory position (Jarvis and King 1978) initi-

[1]School of Biological Sciences, Monash University, Clayton, Victoria 3800
Bonnie.Bain@sci.monash.edu.au

ated when the male grasps the female and holds her so that their ventral surfaces are in contact. The male then rhythmically touches the female with his ovigerous legs, the female lays the eggs, the male fertilizes the eggs and gathers them on to his ovigerous legs (exact movements differ depending on species and type of ovigerous leg). Male and female then separate and the male carries the eggs until they hatch. Paternal care consists of keeping the eggs safe from predators and periodically ventilating the eggs by swinging the ovigerous legs back and forth. In nearly all species of pycnogonids, when the eggs hatch, the larvae leave the parent and swim or crawl away to take up an independent existence (see summary in Bain 2003a).

However, species in the family Callipallenidae and some species in the Nymphonidae have larvae, known as 'attaching larvae', that remain on the male's ovigerous legs for several more moults and eventually leave the parent as fourth or fifth instars (Table 2) (Nakamura 1981; Bain 2003a,b).

Methods

Three adult specimens (a male and two females) of *Propallene saengeri* were obtained from the Great Barrier Reef near Townsville, Queensland, Australia. The male had eggs attached to his ovigerous legs indicating that mating had occurred prior to collection. Both female specimens were reproductively mature and of equal size. Specimens were maintained in 250 ml of natural seawater at 20 °C. Observations were made with an Olympus SZH-10 dissecting microscope and photos were taken with an Olympus DP-10 digital camera.

Results and Discussion

After hatching, juveniles (n = 5) were attached to the male ovigerous legs for four moults and left the parent as fourth instar juveniles (Fig. 1) to begin a free-living existence. Once all the juveniles had left the parent, courtship behaviour was initiated between the male and one of the two females. This series of behaviours began by the female approaching the male. Prior to the juveniles leaving, no courtship behaviour had been observed and the male and two females had tended to ignore each other.

Details of the courtship behaviour were hard to observe due to the very small size of the adults (1.1 mm trunk length), but the initial courtship behaviour between the male and the first female went on for several hours. During this time, they were repeatedly interrupted by the second female. After a number of these interruptions, further attempts at courtship between the male and the first female ceased. The two females became very aggressive towards each other and eventually one of them killed the other one and ripped its appendages off. In the end, it was impossible to tell which female had killed the other one. Further courtship between the male and the remaining female was not observed and the pair failed to successfully mate.

Female infanticide

During the initial courtship attempts between the first female and the male, the following behaviour was observed in the second female: at one point, she went over to one of the fourth instars, picked it up in her chelicerae, bit it and then began to feed on it. The disturbance caused by attempts to photograph this behaviour caused her to drop the fourth instar (which died shortly after this) and move away from it. Of the original five fourth instars, only three others could be found at this time and they were promptly removed to a second container. No trace of the remaining fourth instar was ever found and it was presumably also eaten by the adults.

Observations on postembryonic development

Since Nakamura (1981) successfully reared the instars of a related species, *Propallene longiceps* Böhm, on newly hatched brine shrimp, attempts were made to feed the fourth instars of *P. saengeri* in a similar manner, but results were mixed. The biggest drawback was the considerable size difference between *Propallene saengeri* (adult size: 1.1 mm trunk length) and *P. longiceps* (adult size: 2.2 mm trunk length). Since *P. saengeri* is much smaller than *P. longiceps*, the newly hatched brine shrimp were two to three times the size of the very tiny fourth instars of *P. saengeri*. However, instead of feeding directly on the brine shrimps themselves, the fourth instars

Table 1. Courtship and mating behaviour in Pycnogonida

Species	References
Anoplodactylus lentus Wilson, 1878	Cole (1901, 1906)
Endeis laevis (Grube) (as *Phoxichilus laevis* Grube)	Hoek (1881)
Nymphon gracile Leach, 1814	King and Jarvis (1970)
Parapallene avida Stock, 1973	Hooper (1980)
Phoxichilidium femoratum (Rathke, 1799)	Loman (1907)
Propallene longiceps (Böhm, 1879)	Nakamura and Sekiguchi (1980)
Pycnogonum litorale (Ström, 1762)	Prell (1910), Jarvis and King (1972, 1978), Wilhelm *et al.* (1997)

Table 2. Instar or larval stage at which the young leave the parent

Species	Instar	References
Austropallene cornigera (Hodgson, 1915)	5th	Bain (2003b)
Propallene longiceps (Böhm, 1879)	4th	Nakamura (1981)
Propallene saengeri Staples, 1979	4th	current paper

spent most of their time scraping the bottom of the container with their proboscis and probing dead brine shrimps and scraps from newly hatched brine shrimp eggs. When not feeding in the above manner, the fourth instars were quite active and either swam or crawled around in the container. In the beginning, more time was spent crawling, but as time went on, their swimming abilities improved considerably. Three sets of exuviae were found in the container after three weeks, indicating that all three instars had moulted, but their external appearance had not changed. In contrast, Nakamura (1981) had found that the fourth instar of *P. longiceps* moulted directly from a fourth instar into a fifth instar which looks quite different from the previous instar (fourth instar has two pairs of walking legs plus limb buds for third pair; fifth instar has three pairs of walking legs plus limb buds for a fourth pair of legs in *P. longiceps*). Eight and 12 days later respectively, two of the *Propallene saengeri* fourth instars moulted into fifth instars. Two days later, the one remaining fourth instar had captured and was eating a brine shrimp. It held the brine shrimp with its front legs and took bites out of it. When the light was turned on for better viewing, it stopped feeding. A week later, one of the fifth instars was observed to have a gut full of reddish brine shrimp material, indicating that it too was capturing and eating brine shrimp. Despite the fact that as the instars got older, their hunting skills improved and they seemed to be eating quite well, no further development occurred and all three individuals died a short time later.

Fig. 1. Fourth instar of *Propallene saengeri*. Scale bar = 184µm

Acknowledgements

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Aquatic possums?

A note on the habits of the Common Brushtail Possum *Trichosurus vulpecula*

During the night of 16 March 2004, a Common Brushtail Possum *Trichosurus vulpecula* was observed swimming across the Yarra River to the western bank near the Kew Golf Course, at 03.00. The river is approximately 20 m wide at this point. The possum was first noticed when it was in the middle of the river. Its head, back and tailed seemed to float upon the surface of the water, while the underbelly and legs were submerged. Its path appeared to be direct, with no tacking in response to the current or in an attempt to orient itself.

Once on the far side of the river, the possum sat quietly on the bank with no apparent attempt at grooming. It took the possum about five minutes to travel from the middle of the river to the far bank. How it entered the river is unknown, although we did hear loud water splashes like large rocks being thrown into a pond on a number of occasions throughout the night. We also heard numerous possum fights, and branches being broken during the night. Perhaps this suggests that the Brushtail Possum may actually be the proverbial 'dropbear' from Australian tall tales to tourists.

Helena Bender and Phil Hensman
Dept of Zoology
University of Melbourne
Parkville 3010
h.bender@zoology.unimelb.edu.au

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

Testate rhizopods in *Cupressus* Litter

Whilst looking through the litter from beneath some Monterey Cypress *Cupressus macrocarpa* at Inverleigh, Victoria, during October 2002, several hundred specimens of a testate rhizopod (or 'thecamoebian') were found. There had been no rain for many weeks and the litter (bark, twigs and leaves in varying stages of decomposition) was quite dry.

The specimens, all of which belonged to the one species, were more-or-less cylindrical with a domed upper surface and had a ventral, invaginated, circular aperture. They ranged in size from 20µm to 110µm in diameter with the aperture about one-third of the test diameter. The test wall was finely agglutinated and formed of smoothly fitted quartz grains. The ventral face was quite smooth due to a glaze covering that extended part way up the walls but not over the entire test. The aperture was in a slight depression and had a smooth lip. The specimens belonged to the genus *Cyclopyxis* (Sarcodina: Difflugina: Trigonopyxidae). In this genus, only *C. kahli* Penard has been recorded for Victoria (Meisterfeld and Tan 1998) and *C. kahli* differs in having a hemispherical shape with an aperture that is rimmed with a necklace of small grains (Ogden and Hedley 1980). The present specimens seem closest to *C. arcelloides* Penard in size, shape and apertural diameter (Ellison and Ogden 1987) although that species apparently does not have a ventral organic glaze. *Cyclopyxis eurysoma* Deflandre, which has only the aperture and ventral surface covered by a smooth band of organic cement, is a much smaller species with a very large aperture (Ogden and Hedley 1980).

A sample collected on 24 March 2003 had very few free specimens; these all had a black plug covering the aperture. There were a few specimens attached to wood fragments. Several specimens, which had the apertural plug, were carefully broken open; there was no indication of protoplasm present and the plug just covered the aperture and did not enter into the chamber of the test. There had been about 4 mm of rain in the previous two weeks and, prior to that, less than 15 mm for the previous four months. The litter was quite dry and friable.

Further samples collected in May 2003 had many free specimens, some without the apertural plug. Approximately 25 mm of rain had fallen since the March collection. A number of specimens were placed in a petri dish on a damp substrate for several weeks but none were seen to extrude pseudopodia or give any indication of being alive.

Ken Bell
120 McCallum Road
Inverleigh, Victoria 3321

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One Hundred Years Ago

THE BULL-ANTS OF VICTORIA

By E.E. Barker, F.R.M.S.

In performing their toilet their attitudes are both grotesque and interesting. A favourite position is to turn the abdomen under (like a crayfish), and extend the two hind legs backwards as props, and then sit straight upright. This relieves the two fore legs, which may be used simultaneously to clean the antennae and mandibles. ...

The Bull-ants (like other ants) are very fond of water; they not only drink it, but bathe in it and swim in it. I have frequently seen them voluntarily leave one side of a 6-inch dish and swim across to the other.

From *The Victorian Naturalist*, **XX.** pp. 110-111, January 14, 1904

Hippocampus the Seahorse

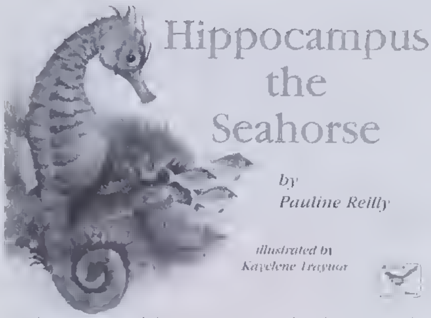
by Pauline Reilly, illustrated by Kayelene Traynor

Publisher: *Bristlebird Books, Anglesea, 2000, 32 pages, paperback. ISBN 0957778902*

Macrotis the Easter Bilby

by Pauline Reilly, illustrated by Kayelene Traynor

Publisher: *Bristlebird Books, Anglesea, 2004. Second Edition 32 pages, paperback. ISBN 0957778996 .*



These two titles are part of a large series of award-winning books on Australian animals written for children by Pauline Reilly. The reading age of the books is indicated as Age 8 – though older (and keen younger) students will find much to interest them. The books are a good size for small hands (210x280mm – about half A4 size) and the large print size is an advantage for young readers. The illustrations by Kayelene Traynor are attractive and embellish the story while showing the main features of the environments in which the animals live.

There is much to recommend in these two books. The stories trace the cycle of life of each animal, from birth to having offspring of their own. A wealth of information about the animals is incorporated into the stories, so that by the end, the young reader knows quite a deal about the life history of the animals concerned. And in case they want to know more, there are several pages of facts about the animal at the back of the book, which will prove useful for parents and teachers. The language even here, though, is suitable for young readers.

The story of Hippocampus begins when he is born under a full moon at the end of the year. He and his siblings float in the plankton, slowly grow bigger and start to swim upright. When he reaches maturity, Hippocampus is courted by a female, which lays her eggs in his pouch. After three weeks, he gives birth for the first time. By the end of the season, he has done this seven times and become the father of perhaps a thousand babies. Sadly, Hippocampus's mate is discovered by a human, who picks her up in a jar and takes her home to her aquarium. However, a new mate is soon on the scene, and the cycle of life continues.

The story of Macrotis the bilby follows a similar course. She is the size of a peanut when she is born, but quickly crawls into her mother's pouch, where she is suckled for 60 days. After leaving the pouch, she continues to be fed by her mother, but soon learns to leave the burrow at night in search of other food. The mother leaves her when she is able to fend for herself, and Macrotis then has to cope with the hazards of life alone – cattle trampling down the burrow entrance, predatory foxes and, the worst of all, feral cats. When she is half a year old, she and the dominant male of the area mate. She gives birth two weeks later, and so the cycle of life continues.

A very big plus for both books is the

description of the ways in which the animals reproduce. This is often totally lacking in children's books, but is sensitively and sensibly presented here in considerable detail. Children are fascinated by babies and baby animals, and about half of each book is devoted to describing the ways in which the animals court, mate and give birth. Not as much detail is given to other key aspects of the animals' lives, such as their food and the type of environment in which they live, which seems a pity. These aspects of the animals' lives would be of great interest to young readers, but they are not central to the 'cycle of life' theme of the books.

In conclusion, I would certainly recommend both books to young naturalists and to their parents and friends. Unlike the animals in many modern books (and animations) for children, the animals in Pauline Reilly's books are 'real'. They are not anthropomorphised – they don't 'speak', they don't engage in all-consuming romances, they don't get caught up in campaigns to eradicate evil enemies. They live out the cycle of life as the animals they are, and by the end of the story they have passed on the gift of life to the next generation. This is a way of looking at animals that will appeal to naturalists – young and old alike.

Geoff Moore
Education Officer, Melbourne Museum
GPO Box 666E, Melbourne, 3001

Editor's note: These books will be available in the Library soon

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A Complete Guide to Reptiles of Australia

by Steve Wilson and Gerry Swan

Publisher: *New Holland Publishers Pty Ltd, 2003, paperback, colour photographs. 480 pp. ISBN 1 876334 72 X. RRP $49.95*

Recently I had the good fortune to be invited to accompany Dr Jane Melville, Curator of Herpetology at Museum Victoria, to Washington DC *en route* to fieldwork further afield. Whilst in DC we spent some time at the Smithsonian Institution's National Museum of Natural History. This museum employs some of the most accomplished herpetologists in the world, and we were able to meet with most of them. In turn, each of them commented on how lucky we were to live and work on a continent blessed with such a staggering diversity of herpetofauna. We could not have agreed more! Australia is home to more than 830 species of reptiles, which are an intriguing blend of ancient Gondwanan forms and more recent (in geological terms) Asian-related taxa. And with the proliferation of modern taxonomists, armed with the latest in sub-cellular techniques, the number of described taxa will continue to grow.

One of the challenges that comes with this impressive suite of animals is the generation of useable field guides that cater for both the professional and keen amateur. Whilst I am a big fan of regional field guides that, by virtue of considering a limited geographic area, are able to eliminate extraneous species, there is clearly a need for national guides to the major classes of wildlife. Such broadscale guides permit the consideration of species' distribution beyond arbitrary political boundaries, and also allow field-observers to venture around the country with a single guidebook. For nearly 30 years, Dr Harold Cogger's *Reptiles and Amphibians of Australia* has been the ultimate identification guide to Australian herpetofauna. A staggering volume of work, Cogger's book has catalogued and differentiated between all Australian herpetofauna, and numerous new editions have attempted to keep pace with the ever-changing taxonomy of these taxa. The few downsides to this book have been its size (a hefty, full-size tome that does not easily fit in either glovebox or small daypack), and, depending upon your perspective, its price. The latest edition of Cogger's book retails at around $105. I believe this is a very reasonable price considering the enormity of the subject and the quality of the hardcover product, but I also feel that many students and field naturalists may be put off by this cost. Enter Steve Wilson and Gerry Swan's new national field guide, *A Complete Guide to Australian Reptiles*.

Both authors are accomplished herpetologists and authors of previous books on Australian herpetofauna. Wilson and Swan's book seeks to provide an alternative to Cogger's work, *sans* the amphibians and frequently confusing (to the uninitiated) dichotomous keys. *A Complete Guide to Australian Reptiles* retails at less than half the cost of the former book, and is considerably smaller and lighter, making it more attractive as a portable guide. One of the trade-offs in producing a small, relatively light book that covers so many species is that accounts of the natural history of each animal are necessarily brief. The authors suggest that their book be used in conjunction with larger format books, scientific publications and regional guides.

The structure of this book is very simple; it commences with a clear, concise guide on how to use the book to best effect, explaining the conventions used to classify, name and distinguish each taxon. Notably, the authors choose to dispense with dichotomous keys as a tool for identification. In their place, the authors refer readers to similar animals that may cause confusion, and highlight particularly diagnostic features in bold text. I find this an appealing feature, and suspect that most of the readership will do likewise. Following the "how to" section is a glossary and series of illustrations depicting diagnostic scale and marking features, as well as standard body measures for reptiles. Despite the terminology scientists have applied to these scales, the illustrations are clear and will be invaluable to those attempting the identification of an unfamiliar reptile. Similarly, I am always pleased to find a glossary in a book that, by necessity, deals with technical terms. An introduction celebrating the diversity and unique nature of Australia's reptiles follows.

As mentioned earlier, individual species' accounts are necessarily brief. A common name is provided for the small proportion of species for which there is general consensus on this issue. However, most species are relatively little known, and therefore the Latin binomial must suffice. Simple descriptions are provided, with enough detail to distinguish not only between similar species, but also between the recognised subspecies of each taxon. Similarly, maps showing each species' Australian distribution are provided, and the relative distributions of any subspecies are delimited in the text. Detailing the distribution of an animal on a small map of Australia is never easy and rarely precise (a frequent cause for frustration amongst users of Cogger's guide). The maps provided in Wilson and Swan's book are quite good, and the user must interpret them knowing that they are necessarily broad-brush. Notes on the natural history of each species are also brief, but again we must remember that this book is intended as a national guide, and follow the authors' advice to use the book in conjunction with more detailed literature for specific animals. A 'Selected Reading' section is provided at the end to prime this process. Finally, each account includes the current official conservation status according to international, national and state authorities. The photographs accompanying these accounts are, as a rule, stunning. A large proportion of them are from Steve Wilson's impressive photo library, the remainder showcase the photographic talents of herpetologists from around the country.

My only criticism of this book is the absence of a guide to First Aid for snakebite. Whilst most of us are aware that the incidence of snakebite is very rare, it is a consideration in all field situations, and a reptile guidebook is an obvious place to include instruction on this type of emergency procedure.

I am impressed with *A Complete Guide to Reptiles of Australia*. A work of this magnitude is clearly a labour of love, the authors' passion for their subject is apparent throughout this guide. The book's size and price make it an attractive addition to the glovebox or backpack, and, used with related literature, this book will foster a greater understanding and appreciation of Australia's impressive reptile fauna.

Nick Clemann
Arthur Rylah Institute for Environmental Research
Department of Sustainability and Environment
123 Brown St, Heidelberg, Victoria 3084

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Bits and Pieces: a selection of writings published between 1980 and 1995 in *The Age*, Melbourne. Volume 1: Birds

by TR Garnett

Publisher: *Mrs TR Garnett, 7 McGrath Street, Castlemaine, Victoria, 2003.*
viii + 196 pages, paperback. ISBN 0958120242.

Did you know that the world's largest collection of Gouldiana is housed in Kansas City? Or that a Pied Currawong has been known to mimic the call of a Southern Boobook? These are just two of many pieces of interesting information in this latest published collection of TR Garnett's articles that originally appeared in *The Age* column 'From the Country' between 1980 and 1995.

Having been a teacher, Garnett – who came from England in the early 1960s to take up the position of headmaster at Geelong Grammar School – has always been keen to impart information. Among many other activities, he spent some time as secretary of the Royal Australasian Ornithologists Union (now Birds Australia). He never tired of stressing the international significance of Australia's bird life, and endeavoured to make people aware of its wonderful variety, uniqueness and vulnerability: 'Birds are among the most visible barometers of pollution: that barometer is on the way down' (p. 88). Almost one third of our native bird species are now threatened with extinction.

The book contains 65 essays relating to birds and is introduced by Garnett's son Stephen, who describes the writings as representing 'a vignette of ornithological issues as they appeared at the time' (p. iv). There are five sections: 'Bird Study' includes topics such as the first *Atlas of Australian Birds*, and bird banding; 'Reviews' consists of 25 reviews covering 34 publications (mainly books); 'Bird Biographies' is about people and birds (e.g. Pauline Reilly and her studies of the Little Penguin); 'Birds at Home' details observations made in the Garden of St Erth at Blackwood; and 'Travelling Birds' covers the autbor's travels in Australia and the UK, and finishes with his impressions of Mauritius and Madagascar. A fairly comprehensive index completes tbe book.

Garnett makes incisive statements about conservation issues. In bis review of *Save the Birds* by Anthony Diamond (pp. 86-88) he says: 'There has been some progress, the sort of progress made by water dripping on a stone ... But what counts for politicians is the power conferred by electoral success.' He exposes the senselessness of 'protecting' birds while at the same time allowing the destruction of their habitat (p. 109), and criticises the idea of building a casino on Christmas Island. (The huge, luxurious casino was built, and has since been 'mothballed'.)

The high price of books is criticised, because the result is that information which should be generally available is 'accessible only to those with deep pockets'. The media's misuse of words such as 'rare' is also pointed out, as is the reason for this misuse: 'Sensibilities are stroked by the word; and one of the jobs of a headline is to stimulate sensibility' (p. 126).

What a pity that the date of publication for each article has been omitted, depriving the reader of a conceptual anchor point. This is particularly noticeable in the 'Reviews' section, where no publication dates are supplied for the items reviewed because they were obvious at the time of writing.

The number of people stated as participating in the *Atlas of Australian Birds* should be about 4000, not 300. Also, in both the text and the index, this *Atlas* is sometimes referred to as *Atlas of the Distribution of Australian Birds*, implying that two such works were published. Either 22 000 (p. 2) or 28 000 (p. 31) people took part in a similar project in Britain.

It is pleasing to see Garnett's articles on this important topic collected together, and fitting to conclude with a quote from Stephen Garnett's introduction to the book: 'Few have made birds, as he has, a means of appreciating the world at large.'

Virgil Hubregtse
6 Saniky Street,
Notting Hill. 3168

The

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Cover: Nobbi Dragon *Amphibolurus nobbi*. Photo: Damian Michael. See Research Report on page 180.

Web address: http://www.vicnet.net.au/~fncv/vicnat.htm
Email vicnat@vicnet.net.au

Distribution, habitat preferences and conservation status of reptiles in the Albury-Wodonga region

Damian R Michael[1]

Abstract

Records of reptiles from scientific literature, wildlife atlas databases, unpublished reports, verbal accounts and extensive regional surveys were reviewed and collated to produce a comprehensive list of species known to occur in the Albury-Wodonga region. In total, 52 species of reptile (91 %), from a possible 57 expected species based on current literature, have been recorded within the region and 28 (49 %) occur within the Albury-Wodonga Local Government Area (LGA). Considering zoogeographical distributions and habitat requirements an additional three species may occur within the LGA, and five within the region. Thirty-eight species (73 %) reach limits of their zoogeographical ranges in the region and 14 (27 %) occur ubiquitously in both Eyrean and Bassian regions. Twenty-eight species (54 %) are restricted in range, 17 (33 %) are localised in occurrence and 7 (14 %) are widely distributed across the region. Fifteen species (29 %) are commonly encountered, 20 (39 %) are uncommon and 17 (33 %) are considered rare. Five species recorded in the region are listed under State or National threatened species legislation: the Pink-tailed Worm-lizard *Aprasia parapulchella*, Woodland Blind Snake *Ramphotyphlops proximus*, Lace Monitor *Varanus varius*, Eastern Bandy Bandy *Vermicella annulata* and the Murray/Darling Carpet Python *Morelia spilota metcalfei*.
(*The Victorian Naturalist* **121** (5), 2004, 180-193)

Introduction

South-eastern Australia contains a rich and diverse assemblage of reptiles with representatives from ten out of the twelve Australian terrestrial families (Wilson and Swan 2003). As the study of herpetology advances, phylogenetic relationships will become clearer and additional species will be recognised, whilst others will be recorded in new locations. Much of the continent has at some time been superficially surveyed by herpetologists or collectors working for museums. However, many parts of Australia remain poorly surveyed or studied (Brown and Bennett 1995). Although distribution maps and accounts of general habitat preferences exist for most species (Cogger 2000, Wilson and Swan 2003), a vast amount of anecdotal information and faunal sightings remain unpublished (Greer 1989). Locating and identifying reptiles in the field can be difficult and time consuming to the inexperienced. This, coupled with the stigma that reptiles carry, can be disadvantageous to the study of herpetology and may even prevent valuable observations from being made, published or reported to the relevant departments. Not surprisingly, there is a dearth of information regarding the composition and status of reptiles inhabiting the Albury-Wodonga region. With little published information available to land managers, developers and environmental consultants regarding the conservation of reptiles in the region, many species may become increasingly pressured by threatening processes such as the incremental loss of habitat and may continue to experience contractions in range or suffer population declines.

The south-west slopes of NSW represent an area of zoogeographical transition from the inland Eyrean region towards the mesic, Bassian region in the east. The concept of dividing the Australian continent into subregions, such as the northern Torresian, south-eastern Bassian and an inland Eyrean region, is based on broad climate patterns and was first reported by Spencer (1896). These regions have been found to accurately reflect major biogeographic distributions in Australian fauna such as reptiles (Cogger and Heatwole 1981; Keast 1962). A high frequency of species changeover can be expected to occur near these transitional zones (Caughley and Gall 1985). Hence, a diverse assemblage of reptiles could be expected to occur in the Albury-Wodonga region. However, aside from a small number of unpublished local fauna surveys (Bos and Lockwood 1996; Davidson 2000; Klomp *et al.* 1995, 1996, 2001) few detailed herpetological studies have been

[1] School of Environmental and Information Sciences, Charles Sturt University, PO Box 789 Albury, NSW 2640

conducted in the region. Four studies have focused on the south-west slopes of NSW (Sass 2003, Annable 1995; Caughley and Gall 1985; Lemckert 1998) and one examined the Murray River region (Brown 2002). Some species can be considered widespread and common in south-eastern Australia (e.g. Marbled Gecko *Christinus marmoratus* and Boulenger's Skink *Morethia boulengeri*, Bennett et al. 1998) and others may have increased in number (e.g. Garden Skink *Lampropholis guichenoti* and Eastern Brown Snake *Pseudonaja textilis*). or adapted to urbanisation (e.g. Carnaby's Wall Skink *Cryptoblepharus carnabyi* and Common Blue-tongue *Tiliqua scincoides*). However, some are rare and others are at risk of becoming locally extinct. A complete inventory of reptiles known to inhabit the Albury-Wodonga region has never been published. Therefore, this paper aims to: (1) document all reptile species known to occur within the Albury-Wodonga Local Government Area (LGA) and within a 50 km radius of the LGA boundary; (2) assess the likelihood of rare, threatened or extralimital species occurring within the LGA and region; and (3) increase the understanding of reptile distributions, habitat requirements and conservation status within urban and rural environments in this region.

Study Area

The cities Albury and Wodonga, with a combined population of approximately 90 000, are positioned within the southwest slopes bioregion of New South Wales and north-eastern Victoria (Figure 1), at approximately 35° south, 147° west and at an altitude of 180 m above sea level. They straddle the Murray River floodplain and are bordered by low foothills covered in grassy and shrubby woodland and intergrading foothill forest vegetation communities. Remnant vegetation across the landscape is highly fragmented in lowland areas and is predominately confined to elevated ridges and hilltops. The climate for the region has been described as temperate, continental and sub-mesic (Annable 1995), and the area experiences an average annual rainfall of 765 mm. Winters are usually mild with frequent frosts and summer is typically hot and dry with occasional thunderstorms. The average annual temperature ranges from 12°C - 30°C in the summer and 0°C - 12°C in the winter (Commonwealth Bureau of Meteorology 2003). The geology of the region is complex Ordovician and has undergone 450 million years of sedimentation and volcanic activity to produce high-grade phyllite, conglomerates, slate, schist, gneiss and granite outcrops (Joplin 1944).

Vegetation communities vary across the region in relation to moisture, aspect, elevation and soil type. These communities include: (1) plains open woodland dominated by Grey Box *Eucalyptus microcarpa* and White Cypress Pine *Callitris glaucophylla* in the west: (2) riparian woodland dominated by River Red Gum *E. camuldulensis* on the floodplain and creek systems; (3) grassy woodlands dominated by White Box *E. albens*, and the endangered community White Box, Yellow Box *E. melliodora*, Blakely's Red Gum *E. blakelyi* woodland, throughout the valleys and slopes; (4) wet and dry forest in the south and east dominated by Peppermint species *E. robertsonii*, *E. dives* and Eurabbie *E. bicostata*; (5) shrubby woodland dominated by Long Leaf Box *E. goniocalyx*, Red Stringybark *E. macrorhyncha*, Currawang *Acacia doratoxylon*, Black Cypress Pine *C. enderlicheri* and Drooping Sheoak *Allocasurina verticillata* on the less fertile, elevated, rocky sites (Stelling 1994, 1998).

Methods

Records of reptiles occurring in the Albury-Wodonga LGA and surrounding region were obtained from a number of sources which included: (1) the wildlife atlas of New South Wales National Parks and Wildlife Service, Museum Victoria and Atlas of Victorian Wildlife (Department of Sustainability and Environment), (2) unpublished reports conducted by local environmental consultants and the author, (3) personal communications from local naturalists and an extensive network of local landholders and (4) personal observations from selected survey locations within the region since 1997.

Personal observations were made in NSW and Victoria and covered a range of

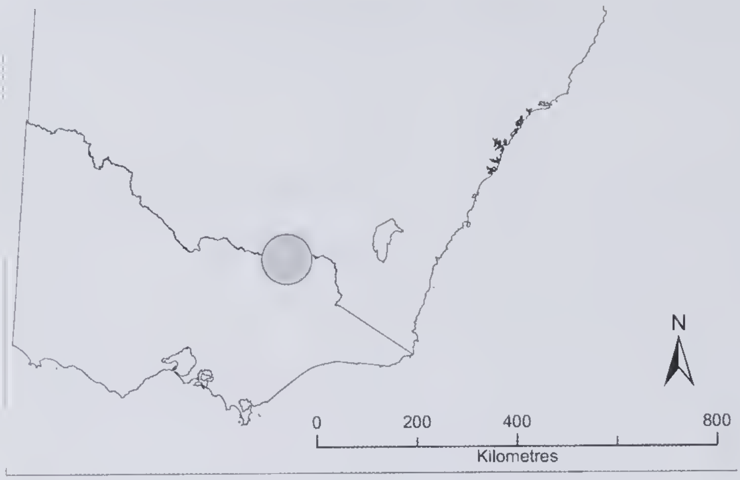

Fig. 1. Location of Albury-Wodonga study area in south-eastern Australia

climatic conditions and seasons and were conducted in areas deemed suitable for reptiles over a six-year period. Survey sites were chosen to represent the broad range of environments and vegetation types reptiles were expected to inhabit in the region. Reptiles were actively searched for beneath suitable cover such as logs, rocks, corrugated iron, leaf litter, behind bark slabs or within rock crevices.

Survey sites include locations such as: (1) in Albury: Nail Can Hill, Black Range, Mungabareena, Eastern Hill, One Tree Hill, Wonga Wetlands; (2) in Wodonga: Huon Hill, McFarlanes Hill and Bear's Hill; (3) in NSW: Gerogery Range, Morgan's Ridge, Tabletop Mountain, Woomargama National Park and Benambra National Park and (4) in Victoria: Mount Granya, Mount Lawson, Chiltern-Mount Pilot National Park and the Baranduda Ranges. Additionally, riparian areas, travelling stock reserves, road and rail reserves and remnant vegetation on private property were surveyed in both states.

An area radiating 50 km from the LGA boundaries was chosen to define the region, roughly bordered by the towns of Culcairn, Granya, Beechworth, Eldorado and Corowa (36° 35′ north, 147° 35′ east, 35° 35′ south, 146° 20′ west). This area was chosen to highlight the diversity of species within a relatively small area, and to assess the likelihood of particular species occurring within the Albury-Wodonga LGA.

An assessment of the local conservation status of reptiles was based on species' presence and abundance at 55 representative survey locations in the study area. Survey sites varied in remnant patch size from 10 - 1000 ha within the LGA to over 10 000 ha within the region. Therefore, the survey effort at each site varied but reflected the size of the patch being surveyed. For example, most sites were relatively small (< 1000 ha) and were surveyed on several occasions for a minimum of two hours each period. However, larger sites such as Nail Can Hill and Tablctop Mountain, were surveyed on more than ten occasions and encompass more than 50 hours of active search time.

Within the selected survey locations records of reptiles were obtained from the relevant wildlife atlas database or unpublished reports and supplemented with personal observations. Species recorded from 5 or less locations (< 9 % of sites) were termed 'restricted', between 6 and 27 sites (10 - 49 %) 'localised', and from more than 28 sites (> 50 %) species were considered 'widespread'. Rare species are known from less than 10 records, uncommon species from 11-50 records and common species from more than 50 records across the region. In addition to variation in search area and survey effort, many species may be more common than documented due to their fossorial, nocturnal or cryptozoic behaviour. In the future such species may prove to be more common than currently recognised. Specimens were identified using Cogger (2000) and expected species were included based on the locations in Coventry and Robertson (1991), Swan *et al.* (2004) and the broad distribution maps provided by Cogger (2000) and Wilson and Swan (2003). An additional nine species not covered in these guides have been included from other sources (author's unpubl. data, Museum Victoria database, NSW NPWS atlas database). Taxonomy and nomenclature in this paper follow Cogger (2000) and zoogeographical preferences were based on Caughley and Gall (1985).

Results

Based on the published literature a possible 57 species of reptile were expected to occur in the Albury-Wodonga region. Of these, 52 species (91 %) from 39 genera and nine families (plus one introduced family) have been recorded within the region. Twenty-eight species (49 %) from 25 genera and eight families have been recorded within the Albury-Wodonga LGA and 23 (40 %) inhabit the Nail Can Hill range in Albury (Appendix 1). Based on habitat preferences and proximity to regional records it is likely that three undetected species occur within the LGA: (1) Broad-shelled Turtle *Chelodina expansa*, (2) Red-throated Skink *Bassiana platynota* and (3) Bougainvilles's Skink *Lerista bougainvilli* and five undetected species may occur within the region: (1) Broad-shelled Turtle, (2) Thick-tailed Gecko *Underwoodisaurus milii*, (3) Striped Legless Lizard *Delma impar*, (4) Blotched Blue-tongue *Tiliqua nigrolutea* and (5) Little Whip Snake *Suta flagellum*.

The study area contains predominantly Bassian species (46 %) followed by 14 Eyrean species (27 %) and 14 ubiquitously distributed species (27 %, Table 1). At least 24 species (46 %) approach zoogeographical limits in the region and show a clear preference for either a western or eastern pattern of distribution. Due to the size of the study area a number of life-forms are present. However, terrestrial species (54 %) form the dominant group, followed by fossorial species (13 %), terrestrial/arboreal species (10 %) and terrestrial/saxicolous species (8 %). Only two species are aquatic and three species are arboreal in the region (Table 1).

The conservation status of reptiles in the region is variable and includes: (1) six widespread-common species (12 %), (2) one widespread-uncommon species, (3) nine localised-common species (17 %), (4) eight localised-uncommon species (15 %), (5) 10 restricted-uncommon species (19 %) and (6) 18 restricted-rare species (35 %, Appendix 1).

Species Composition

Chelidae (Two species)

The Eastern Long-necked Turtle *Chelodina longicollis* is common in localised areas such as the Murray River, adjacent ephemeral wetlands and farm dams, and is frequently observed crossing roads after heavy rain. The Macquarie Turtle *Emydura macquarii* is largely restricted to permanent water systems, including the Murray River and adjacent wetlands (e.g. Wonga Wetland), and some large artificial dams, (notably a dam on One Tree Hill, Albury) where it can achieve high densities. The Broad-shelled Turtle is expected to occur in the region based on the literature and has been recorded depositing eggs near Yarrawonga (100 km west of the LGA, M Herring 2001 pers. comm.). It has also been recorded in Wagga Wagga (Annable 1995) and may be a resident and even nest in the Albury-Wodonga region.

Agamidae (Three species)

The Jacky Lizard *Amphibolurus muricatus* and Eastern Bearded Dragon *Pogona barbata* are uncommonly encountered around fallen timber in open woodlands, farmland and occasionally in urban gardens, where logs and fence posts are favoured perch sites. The Nobbi Dragon *Amphibolurus nobbi* has been recorded from Benambra National Park and Mt. Lawson National Park and was first recorded on Nail Can Hill in Albury in September 2003 during a local community biodiversity survey. Twelve individuals,

Table 1. Zoogeographical distributions and life forms of reptiles in the Albury-Wodonga region.

Eyrean Species	Ubiquitous Species	Bassian Species
Emydura macquarii (AQ)	*Chelodina longicollis* (AS)	*Amphibolurus muricatus* (TA)
Amphibolurus nobbi (TA)	*Pogona barbata* (TA)	*Bassiana platynota* (T)
Christinus marmoratus (AS)	*Diplodactylus vittatus* (TS)	*Bassiana duperreyi* (T)
Diplodactylus intermedius (A)	*Delma inornata* (T)	*Carlia tetradactyla* (T)
Aprasia parapulchella (F)	*Lialis burtonis* (T)	*Ctenotus taeniolatus* (TS)
Cryptoblepharus carnabyi (A)	*Ctenotus robustus* (T)	*Egernia cunninghami* (TS)
Menetia greyii (T)	*Egernia striolata* (AS)	*Egernia saxatilis* (TS)
Morethia boulengeri (T)	*Tiliqua scincoides* (T)	*Egernia whitii* (T)
Tiliqua rugosa (T)	*Varanus varius* (TA)	*Eulamprus heatwolei* (T)
Varanus gouldii (TA)	*Ramphotyphlops nigrescens* (F)	*Eulamprus tympanum* (T)
Morelia spilota metcalfei (A)	*Demansia psammophis* (T)	*Hemiergis decresiensis* (F)
Ramphotyphlops proximus (F)	*Notechis scutatus* (T)	*Lampropholis delicata* (T)
Furina diadema (T)	*Pseudonaja textilis* (T)	*Lampropholis guichenoti* (T)
Suta dwyeri (T)	*Vermicella annulata* (F)	*Lerista bougainvilli* (F)
		Nannoscincus maccoyi (F)
		Niveoscincus coventryi (T)
		Pseudomoia entrecasteauxii (T)
		Pseudomoia pagenstrecheri (T)
		Pseudomoia spenceri (TAS)
		Saproscincus mustelinus (T)
		Austrelaps ramsayi (T)
		Drysdalia coronoides (T)
		Rhinoplocephalus nigrescens (T)
		Pseudechis porphyriacus (T)
TOTALS 14	14	24

(AQ = aquatic, S = saxicolous, A = arboreal, F = fossorial and T = terrestrial)

including eleven adults and one juvenile, were found basking on fallen timber along a westerly-facing, well-vegetated rocky ridgeline. Because of its excellent camouflage and cryptic behavior, the Nobbi Dragon may be relatively common in localised areas within the region and may be confused with the Jacky Lizard.

Gekkonidae (Three species)

The Marbled Gecko is widespread and common in woodlands, urban areas and farmlands across the region. Juvenile Marbled Geckos are frequently encountered beneath ground debris, whereas adults are particularly abundant on large, mature eucalypts with exfoliating bark, such as River Red and Blakely's Red Gums, Apple Box *E. bridgesiana* and Yellow Box. The Eastern Stone Gecko *Diplodactylus vittatus* is common in localised areas especially beneath ground debris in open woodland and dry forests and is particularly abundant where large expanses of exposed bedrock and surface rock occur together. The Southern Spiny-tailed Gecko *D. intermedius*, whilst not expected to occur, reaches it geographical limit in the region and has only been recorded from Lonesome Pine State Forest (50 km north-west of the LGA, NSW NPWS atlas database) and Galore Hill Nature Reserve (100 km north of the LGA, pers. obs.) where it is found behind the bark of exfoliating Cypress Pine trees *Callitris* spp. It may also occur in Kentucky State Forest and other areas in the region, which contain mature stands of Cypress Pine. The Thick-tailed Gecko could be expected to occur (Swan *et al.* 2004). However, there are few records south of the Murrumbidgee River in NSW (NSW NPWS atlas database) or in north-eastern Victoria, although it has been recorded approximately 80 km south-west of Wodonga (Museum Victoria).

Pygopodidae (Three species)

The Olive Legless Lizard *Delma inornata* is found uncommonly across the region in both grassy and shrubby woodland, grasslands dominated by Canary Grass *Phalaris aquatica* and grazed pastures, providing adequate cover from rocks or logs is available. Burton's Snake-lizard *Lialis burtonis* is uncommon in rocky, shrubby woodland and was first recorded on Nail Can Hill in Albury in June 2002 (pers. obs.) and again in September 2002 (G Datson 2002 pers. comm.). It has also been recorded from McFarlanes Hill, and recently (March 2004) from a back garden adjacent to the Baranduda Ranges in Victoria (Museum). This species appears to be relatively abundant in the Victorian area (G Johnson 2001 pers. comm.). Although not expected to occur in the region, the Pink-tailed Worm-lizard *Aprasia parapulchella* was first recorded on Goombargana Hill in 2000 during a NSW National Parks Association community biodiversity survey and subsequently on Nail Can Hill in August 2002 (pers. obs.) and September 2003 (pers. obs.). The Albury population was found beneath slightly embedded small rhyodacitic rocks in open grassy woodland and is likely to occur in similar areas within the LGA and region.

The Striped Legless Lizard *Delma impar* is expected to occur in the region; however it is a habitat specialist and has been recorded only from relatively undisturbed native grasslands 70 km south of the LGA (Museum Victoria atlas database) and 110 km north-east of the LGA (NSW NPWS atlas database). Some relatively small remnant native grassland areas occur in the study area (e.g. Bonegilla), which warrant further investigation for the presence of this species.

Scincidae (Twenty-six species)

The Red-throated Skink is restricted to grassy woodland and dry forest in the south and east of the region and has not been recorded west of Mt Granya or Woomargama National Park (NSW NPWS atlas database). The Eastern Three-lined Skink *Bassiana duperreyi*, Black Rock Skink *Egernia saxatilis*, White's Skink *E. whitii*, Southern Water Skink *Eulamprus tympanum*, Maccoy's Skink *Nannoscincus maccoyi*, Southern Grass Skink *Pseudomoia entrecasteauxii*, Spencer's Skink *P. spenceri* and Weasel Skink *Saproscincus mustelinus* are predominantly restricted to Victoria in the south and east of the region (Museum Victoria). However, the Eastern Three-lined Skink is known from the Tumbarumba region (Lemckert 1998) and may occur in Woomargama National Park and Mt. Granya because of the similarity in habitat and climate. The Southern Rainbow Skink *Carlia tetradactyla* is widespread and common in open grassy woodland, edge habitats, farmland and disturbed areas, especially where leaf litter and fallen branches have accumulated beneath trees. Carnaby's Wall Skink is common in localised areas and can be found in both disturbed and intact woodland, edge habitats, farmland and urban areas. It can reach high densities on dead trees and urban structures such as walls and fences.

The Eastern Striped Skink *Ctenotus robustus* is widespread in most vegetation communities including disturbed areas and occasionally in dry foothill forest where it is encountered in grassy areas near fallen timber and scattered rock. The Copper-tailed Skink *C. taeniolatus* is localised in shrubby woodland and dry forest predominantly east of Tabletop Mountain and Nail Can Hill where it is locally common, especially where large expanses of exposed bedrock and scattered surface rock occur together. Cunningham's Skink *Egernia cunninghami* reaches its western geographical limit in the region on the Black Range in Albury, occurring as a small isolated population along Bungambrawatha Creek, but it penetrates further inland in Victoria. It is predominantly localised in the south-east of the region and can be relatively abundant on granite outcrops in farmland, woodland and dry forest. The Tree Skink *E. striolata* is locally common in open woodland and dry forest and is closely associated with rocky outcrops, exfoliating bark and crevices formed in mature or stressed eucalypt trees. Only a few arboreal populations persist in the region and it could be considered predominantly saxicolous in lowland parts of the study area.

The Yellow-bellied Water Skink *Eulamprus heatwolei* is relatively common in Wodonga (Museum Victoria), particularly along the Murray River and House Creek (G Slade 2002 pers. comm.). It favours the creek systems and adjacent woodland and forest habitats and penetrates further west into Victoria via the Murray River. Within the region the Three-toed Skink *Hemiergis decresiensis* is found predominantly east of the Hume Highway in woodland, dry forest and farmland where it can be extremely abundant beneath fallen timber and surface rocks. The Delicate Skink *Lampropholis delicata* occurs in the grassy, dry forest in the east and has not been recorded west of Mt Granya. The Garden Skink *L. guichenoti* also occurs predominantly in the eastern half of the region but has been recorded from the summit of Tabletop Mountain (pers. obs.). Bougainville's Skink is extremely localised within the region and has been recorded only from Woomargama National Park and Gerogery Hill in NSW, but is relatively common in the Victorian dry foothill forests in the south and east of the region. Because it is fossorial and belonging to a specialized burrowing group of lizards, its distribution in the region may reflect a preference for a specific soil type.

Grey's Skink *Menetia greyii* is restricted to the open grassy woodlands west of Albury and the Old Olympic Highway where it has been recorded from Hamilton Valley, Howlong, Walbundrie and Walla Walla (pers. obs.). Because of its small size it can be difficult to detect and may turn out to be relatively common along well-vegetated roadsides in the north and west of the region. Boulenger's Skink *Morethia boulengeri* occurs widely across the region and in most vegetation communities, including low elevation dry forest where it can be extremely abundant around fallen timber. Coventry's Skink *Niveoscincus coventryi* is known to occur in the region only from a survey conducted in Benambra National Park by NSW State Forests in the late 1970s (B Plunket 2001 pers. comm.). It is unclear whether this species actually occurs within the region, as it typically prefers wet forests east of the study area (Bennett 1997). Similarly, the Tussock Skink *Pseudomoia pagenstecheri* is known only from a record near the township of Granya (Museum Victoria) and is typically associated with native grasslands (Bennett 1997). The Eastern Blue-tongue is widespread across the region in grassy woodlands and farmland and can reach high densities in urban areas. Although not expected in the region, the Shingleback *Tiliqua rugosa* is known from a specimen recorded on private property near Morven in NSW (35 km north of the LGA, P Herriot 2002 pers. comm.) and another specimen from Eldorado in Victoria (Museum Victoria) but is predominantly absent in the region (Swan *et al.* 2004; Wilson and Swan 2003). The occasional vagrants that appear in urban areas are undoubtedly escaped captive specimens.

No other scincids are expected; however, it is likely that Bougainville's Skink, recorded only 20 km north-west of Albury (pers. obs.) may occur within the LGA, and the Blotched Blue-tongue, recorded 75 km east of Wodonga (pers. obs.) may occur within the region.

Varanidae (Two species)

The Lace Monitor *Varanus varius* occurs as two color morphs and is widely distributed but uncommonly encountered across the region. It is usually observed along well-timbered roadsides and large areas of remnant vegetation, especially where mature, hollow bearing trees and fallen timber occur. Occasional individuals are seen on Nail Can Hill and one specimen was even retrieved from a shop door on the main street of Albury during 1997 (M Basler 1997 pers. comm.). The Sand Goanna *V. gouldii* is poorly documented in the region, but known to occur on a property 15 km west of the LGA (S Lucas 2002 pers. comm.). There are also historical records from Tabletop Mountain, 25 km north of the LGA (R Patterson 2002 pers. comm.) and from Talgarno in Victoria (Museum Victoria). However, the absence of recent reliable records tends to indicate that the species has declined dramatically in the region and now occurs at such low densities that a sustainable population is unlikely.

Boidae (One species)

The Murray/Darling Carpet Python *Morelia spilota metcalfei* is presumed to no longer occur within the LGA but is still uncommonly encountered in the region near rocky outcrops, heavily timbered woodlands and occasionally in the rafters of rural buildings. Anecdotal evidence suggests pythons from Queensland (possibly the subspecies *M. s. macdowelii*) have been introduced to some properties near Gerogery during the early 1900s to control rodents (J Nagel 2001 pers. comm.) and specimens from the NSW south-west slopes bioregion were taken and introduced to the Griffith irrigation areas. However, there have been no confirmed records of subspecies other than *M. s. metcalfei* in the region.

Typhlopidae (Two species)

The Woodland Blindsnake *Ramphotyphlops proximus* is rare in the region and has only been identified at two localities in Albury, (Hamilton Valley and Mount Budginigi). Both specimens were found beneath deeply embedded, granite rocks in open woodland and on relatively humid days after heavy winter rain (pers. obs.). Another species of Blindsnake *R. nigrescens* is often unearthed during agricultural activities in the region and can also be found beneath embedded rocks, particularly in the dry forests in the east and south of the region. It is yet to be recorded within the LGA (Museum Victoria atlas database).

No other typhlopids are expected to occur in the region, due to the fossorial and cryptic nature of these reptiles. Additional species or undescribed forms may be detected in the future.

Elapidae (Ten species)

The Highlands Copperhead *Austrelaps ramsayi*, Eastern Small-eyed Snake *Rhinoplocephalus nigrescens* and White-lipped Snake *Drysdalia coronoides* are restricted to the cooler dry forests in the east and south of the region, where they have been recorded infrequently in the past and from few locations (Museum Victoria atlas database). Although not expected, the Yellow-faced Whip Snake *Demansia psammophis* has been recorded once from Tabletop Mountain (R Patterson 2002 pers. comm.) and twice since 2001 near Talmalmo in the north-east of the region (S Hartvigson 2002 pers. comm.). It may also occur in similar habitats in Victoria. Likewise, the Red-naped Snake is not expected to occur in the region but recently an individual was uncovered beneath debris west of Tabletop Mountain near Mullengandra (C Grabham 2004 pers. comm.) and another specimen was accidentally killed on a property adjoining Woomargama National Park in 2001 just outside the region (A Hicks 2003 pers. comm.). It is a cryptozoic species and has been recorded near Tumut (Swan *et al.* 2004) and Wagga Wagga (Sass 2003, Annable 1995), and may occur in low densities in the north of the region.

The Eastern Tiger Snake *Notechis scutatus* is uncommonly encountered on the Murray River floodplain and adjacent wetlands and appears to have suffered a dramatic decline because of changes in hydrology, habitat loss and human persecution (Shine 1991). The Red-bellied Black Snake *Pseudechis porphyriacus* is commonly encountered in riparian environments, woodlands and urban areas and The Eastern Brown Snake is common in grassy woodlands, farmland and occasionally in urban areas. Dwyer's Snake has been recorded beneath surface rocks in grassy woodland on Nail Can Hill on several occasions (I Davidson 2003 pers. comm.) and on Gerogery Hill in August 2003 (pers. obs.). This species may be relatively common in the region, and is possibly mistaken for juvenile Brown Snakes and consequently killed. The Eastern Bandy Bandy *Vermicella annulata* is only known from Chiltern-Mount Pilot National Park in the south-west of the region (Museum Victoria atlas database and Atlas of Victorian Wildlife). A specimen found in a soil mixer at the old Albury-Wodonga Development Corporation nursery (Wandoo) during the early 1990's (G Datson 2003 pers. comm.) may have been a local specimen.

Although expected, the Little Whip Snake *Suta flagellum* has not been recorded south of Batlow in NSW (Lemckert 1998) or north of Tatong in Victoria (Museum Victoria), but may occur in low densities in the north-east of the region where suitable habitat and climatic patterns exist.

Colubridae

No species of colubrid are expected to occur in the region. However, a Green Tree Snake *Dendrelaphis punctulatus* was recorded from open woodland near the Hume Highway close to the township of Woomargama 50 km north-east of the LGA in 1995 (Klomp *et al.* 1995). This individual was possibly accidentally introduced during transportation of fresh goods along the Hume Highway, or may have been an escaped or released captive specimen.

Discussion

With 52 species of reptile, from 39 genera and nine families, recorded within the region, reptile diversity reflects what is expected for the area according to the current literature. A total of 52 species has been suggested as occurring within the south-west slopes of New South Wales (Caughley and Gall 1985) and approximately 50 are expected, based on the broad distribution maps and point locations provided by field guides (Cogger 2000; Coventry and Robertson 1991; Swan *et al.* 2004; Wilson and Swan 2003). Comparatively, 48 species have been documented for the Wagga Wagga LGA (Sass 2003) and 18 species for the highland region surrounding Tumbarumba (Lemckert 1998). Nine species not mentioned for the study area by field guides have been recorded either within the LGA (e.g. Pink-tailed Worm Lizard and Nobbi Dragon) or near the periphery of the region (e.g. Southern Spiny-tailed Gecko, Delicate Skink and Yellow-faced Whip Snake), giving 57 expected reptile species for the region.

The five species expected in the region but not yet recorded include the Broad-shelled Turtle, Thick-tailed Gecko, Striped Legless Lizard, Blotched Blue-tongue and Little Whip Snake. It is possible that the paucity of records surrounding the study area for some of these species (Swan *et al.* 2004; Museum Victoria) in part reflects their secretive behaviours and specialised habitat requirements, and not a genuine absence from the region. Species such as the Thick-tailed Gecko, Striped Legless Lizard and Little Whip Snake can be cryptic and difficult to detect, but all three species have disjunct populations to the north and south of the region, suggesting that they may occur in the study area in low densities. Likewise, even though the Broad-shelled Turtle prefers deeper waters downstream from Albury, the numerous oxbow lakes and ponds created below the Hume Dam are known as important nesting sites for the other chelid species (Thompson 1993). However, the Blotched Blue-tongue, which prefers higher elevations and/or a cooler climate further to the east, may truly not occur in the region.

Some species have undoubtedly declined or become locally extinct within the LGA. For example, the Carpet Python was once recorded from Pemberton Park near Monument Hill in Albury during the early 1970s (M Miles pers. comm.) but has not been recorded since within the LGA. This is surprising considering this species has adapted fairly well to urbanization in other areas of Australia such as Sydney and Brisbane (Fearn *et al.* 2001). The reasons for decline are unclear but are probably due to a combination of factors such as loss of habitat, increased predation by exotic predators and even theft (pers. obs). Also, a distressing phenomenon is that many offenders still shoot 'the odd monitor' on farmlands across the region (S Lucas May 2004 pers. comm.).

Eighteen species are considered restricted and rare in the present study. However, eleven of these are cool-temperate, Bassian species that are at the extreme western limits of their distributions within the region and prefer the cooler environments further east (Bennett 1997; Cogger 2000). Some of these species may not have experienced the same levels of environmental stress, that many ubiquitous and Eyrean species in the region might have suffered, because of differing disturbance histories and current agricultural practices associated with each region. Indeed, the wheat and sheep belt is a huge productive agricultural belt that encompasses many more Eyrean species than Bassian species in the region. Importantly, it is those species that naturally occur in low densities, occupy large home ranges, have restricted distributions or specialise in particular habitats that are of most concern in the region. Such species, which include the Nobbi Dragon, Southern Spiny-tailed Gecko, Pink-tailed Worm-lizard, Bougainville's Skink, Woodland Blindsnake, Lace Monitor, Red-naped Snake, Eastern Small-eyed Snake and Murray/Darling Carpet Python, may require further investigation.

Incremental loss of habitat is a threatening process that has been linked to declines in approximately 30 Australia reptile species, of which approximately 10 are found within open woodland habitats (Cameron 1993). This threatening process is regarded as being one of the most important issues in this region. Structurally important microhabitats which take a long time to recover or be replaced, such as native ground cover, the soil surface substrate, fallen timber, surface rocks and dead trees are continuously being removed and destroyed, exacerbating the problem in rural areas (Brown 2001; Hadden and Westbrooke 1996). Therefore, many species and populations will be viable in the long-term only if structural complexity is conserved, habitats are restored, and species are able to move freely through the landscape. For example, many reptiles, including threatened species, are known to quickly utilise old fence posts that are introduced to grazed landscapes devoid of ground debris (Michael *et al.* 2004). With some alterations to the way the rural environment is managed and wildlife habitat is valued, biodiversity conservation and agriculture can be strategically integrated (see Bennett *et al.* 1998; Lindenmayer *et al.* 2003) with positive results to the human community, economy and environment.

Conclusion

With over 50 species of reptile persisting in the Albury-Wodonga region, the area is extremely important in terms of reptile diversity and threatened species conservation. This study has identified a diverse reptile fauna inhabiting the region, with specific trends in distribution patterns and habitat preferences. Some species are abundant and widely distributed, and have even coped with and adapted to urbanisation and the persistent levels of disturbance in woodland and agricultural areas. However, many species currently occur in localised areas with suitable habitat and may be genetically isolated from neighbouring populations. Remnant habitat exists predominantly on ridges and hilltops, whereas lowland areas are particularly depauperate. This disparate distribution of remnant habitats has implications for the distribution of specialist species, dispersal patterns and gene flow. The long-term viability of many species in rural areas will largely depend on changing attitudes to biodiversity conservation and sustainable land practices, and people's willingness to become pro-active in pursuing habitat restoration.

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Pink-tailed Worm-lizard *Aprasia parapulchella.*

Appendix 1. State, national and local conservation status of reptiles in the Albury-Wodonga region.

Common Name	Scientific Name	Study area	Victoria	NSW	C'wealth	Nearest record to LGA	Sources
CHELIDAE							
Broad-shelled Turtle	*Chelodina expansa*	NA	V			Yarrawonga	1
Eastern Snake-necked Turtle	*Chelodina longicollis*	Lc				Murray River	1, 2, 3 ,6
Macquarie Turtle	*Emydura macquarii macquarii*	Ru			RI	Murray River	1, 2, 3, 6
AGAMIDAE							
Jacky Lizard	*Amphibolurus muricatus*	Lu				Nail Can Hill	1, 2, 3, 6
Nobbi Dragon #	*Amphibolurus nobbi nobbi*	Rr				Nail Can Hill	1, 2, 6
Eastern Bearded Dragon	*Pogona barbata*	Lu				Nail Can Hill	1, 2, 3, 6
GEKKONIDAE							
Marbled Gecko	*Christinus marmoratus*	Wc				Nail Can Hill	1, 2, 3, 6
Southern Spiny-tailed Gecko #	*Diplodactylus intermedius*	Rr				Lonesome Pine	1
Eastern Stone Gecko	*Diplodactylus vittatus*	Lc				Nail Can Hill	1, 2, 3, 6
Thick-tailed Gecko	*Underwoodisaurus milii*	NA				Wagga Wagga	8
PYGOPODIDAE							
Pink-tailed Worm-lizard #	*Aprasia parapulchella*	Ru	E	V	V	Nail Can Hill	6
Striped Legless Lizard	*Delma impar*	NA	E	V	V	Tarcutta	1
Olive Legless Lizard	*Delma inornata*	Lu				Nail Can Hill	1, 2, 3, 6
Burton's Snake-lizard	*Lialis burtonis*	Ru				Nail Can Hill	1, 3, 6
SCINCIDAE							
Eastern Three-lined Skink	*Bassiana duperreyi*	Ru				Mt Big Ben	3
Red-throated Skink	*Bassiana platynota*	Ru				Mt Granya	1, 3, 6
Southern Rainbow Skink	*Carlia tetradactyla*	Wc				Nail Can Hill	1, 2, 3, 6
Carnaby's Wall Skink	*Cryptoblepharus carnabyi*	Lc				Nail Can Hill	1, 2, 3, 6
Eastern Striped Skink	*Ctenotus robustus*	Wc				Nail Can Hill	1,2, 3, 6
Copper-tailed Skink	*Ctenotus taeniolatus*	Lc				Nail Can Hill	1, 2, 3, 6
Cunningham's Skink	*Egernia cunninghami*	Lc				Black Range	1, 3, 7
Black Rock Skink	*Egernia saxatilis intermedia*	Ru				Mt Stanley	1, 3
Tree Skink	*Egernia striolata*	Lc				Nail Can Hill	1, 2, 3, 6
White's Skink	*Egernia whitii*	Rr				Mt Granya	1, 3, 6
Yellow-bellied Water Skink	*Eulamprus heatwolei*	Lc				Murray River	1, 3, 6
Southern Water Skink	*Eulamprus tympanum tympanum*	Rr				Yackandandah	1, 2

Appendix I cont.

Three-toed Skink	*Hemiergis decresiensis*	Lc				Nail Can Hill	1, 3, 6
Delicate Skink #	*Lampropholis delicata*	Ru				Mt Granya	1, 6
Garden Skink	*Lampropholis guichenoti*	Lc				Nail Can Hill	1, 2, 3, 6
Bougainvilles's Skink	*Lerista bougainvilli*	Lu				Gerogery Hills	1, 3, 6
Grey's Skink	*Menetia greyii*	Ru				Nail Can Hill	6
Boulenger's Skink	*Morethia boulengeri*	Wc				Nail Can Hill	1, 2, 3, 6
Maccoy's Skink #	*Nannoscincus maccoyi*	Rr			R1	Mt Granya	1, 3, 6
Coventry's Skink	*Niveoscincus coventryi*	Rr				Benambra NP	2
Southern Grass Skink	*Pseudomoia entrecasteauxii*	Ru				Mt Big Ben	1, 6
Tussock Skink #	*Pseudomoia pagenstrecheri*	Rr				Granya area	1
Spencer's Skink	*Pseudomoia spenceri*	Rr				Mt Big Ben	1, 3
Weasel Skink	*Saproscincus mustelinus*	Rr				Tallangatta	1
Blotched Blue-tongue	*Tiliqua nigrolutea*	NA				Cudgewa Nth	1, 6
Eastern Blue-tongue	*Tiliqua scincoides scincoides*	Wc				Nail Can Hill	1, 3, 6
Shingleback #	*Tiliqua rugosa asper*	Rr				Morven	1
VARANIDAE							
Sand Goanna	*Varanus gouldii*	Rr				Bungowannah	3, 6
Lace Monitor	*Varanus varius*	Wu	dd			Nail Can Hill	1, 2, 3, 6
BOIDAE							
Murray/Darling Carpet Python	*Morelia spilota metcalfei*	Ru	E	R1		Tabletop Mt	6
TYPHLOPIDAE							
Blind Snake	*Ramphotyphlops nigrescens*	Lu				Burrumbuttock	1, 3, 6
Woodland Blind Snake	*Ramphotyphlops proximus*	Rr	V			Nail Can Hill	1, 2, 3 , 6
ELAPIDAE							
Highlands Copperhead	*Austrelaps ramsayi*	Rr				Mt Big Ben	1
Yellow-faced Whip Snake #	*Demansia psammophis*	Rr	nt			Woomargama	6
White-lipped Snake	*Drysdalia coronoides*	Rr				Mt Lawson	1, 3
Red-naped Snake #	*Furina diadema*	Rr	V			Mullengandra	6
Eastern Tiger Snake	*Notechis scutatus*	Rr				Murray River	1, 3, 6
Red-bellied Black Snake	*Pseudechis porphyriacus*	Lc				Nail Can Hill	1, 3, 6
Eastern Brown Snake	*Pseudonaja textilis*	Wc				Nail Can Hill	1, 3, 6
Eastern Small-eyed Snake	*Rhinoplocephalus nigrescens*	Lu		V		Mt Lawson	1, 3
Dwyer's Snake	*Suta dwyeri*	Lu				Nail Can Hill	1, 2, 3, 7

Appendix 1 cont.

Little Whip Snake	*Suta flagellum*	NA		V		Tumbarumba	4
Eastern Bandy Bandy	*Vermicella annulata*	Rr	nt		RI	Mt Pilot	1, 3
COLUBRIDAE							
Green Tree Snake #*	*Dendrelaphis punctulatus*	NA				Woomargama	5
Total number of speeies	57	52				28 (LGA)	

(W = widespread, L = localised, R = restricted, c = common, u = uncommon, r = rare. Victoria: FFG Act (1998) V = vulnerable, E = endangered, dd = data deficient, nt = near threatened; NSW: TSC Act (1995) and Commonwealth: EPBC Act (2000) V = vulnerable, RI = rare insufficiently known. NA = expected but not recorded, # = not represented in the region within current distribution maps in field guides, * = vagrant).

Sources:
1 - Museum Victoria wildlife atlas database (2003) Bioinformatics wildlife atlas,
2 - NSW NPWS wildlife atlas database (2003),
3 - DSE (2003) Atlas of Victorian Wildlife,
4 - Lemckert (1998),
5 - Klomp *et al.* (1995),
6 - DR Michael (unpubl. data 1997 - 2003),
7 - Davidson (2000),
8 - Annable (1995).

Eastern Stone Gecko *Diplodactylus vittatus*

Observations on the effects of the introduced parasite *Lernaea cyprinacea* on a lowland population of a small native Australian fish, Mountain Galaxias *Galaxias olidus*

Nick R Bond[1]

Abstract
Infestation by the parasitic copepod *Lernaea cyprinacea* was examined in a lowland fish community in south-eastern Australia. As well as documenting two new host species, these surveys provided preliminary evidence of a negative effect of *L. cyprinacea* on the Mountain Galaxias *Galaxias olidus*, a small species of native fish. Although preliminary, these observations highlight the potential impact of *L. cyprinacea* on *G. olidus*, which may occur as an indirect effect of the spread of its principal host the Common Carp *Cyprinus carpio*. (*The Victorian Naturalist* **121** (5), 2004, 194-198)

Introduction

Lernaeid copepods (Anchor worms) are highly specialised cyclopoid copepods that, as adult females, parasitise and can cause serious harm to freshwater fish (Reichenbach-Klinke 1973). *Lernaea cyprinacea* Linnaeus is the most widespread species of *Lernaea*, having being accidentally transferred as a result of human translocation of its cyprinid hosts, notably Common Carp *Cyprinus carpio* Linnaeus and Goldfish *Carrasius auratus* Linnaeus, with the expansion of aquaculture (Kabata 1979). The spread of *L. cyprinaceae* has been accompanied by widespread host-switching, a reflection of the morphological plasticity of *L. cyprinacea* (Kabata 1979). *Lernaea cyprinacea* has previously been recorded from more than 100 host species from 16 orders (Kabata 1979), and this number is probably now much greater.

In Australia, *L. cyprinacea* has been reported from a number of native fish hosts, including Murray Cod *Maccullochella peelii peelii* (Mitchell), Trout Cod *Maccullochella macquariensis* (Cuvier), Golden Perch *Macquaria ambigua* Richardson, Macquarie Perch *Macquaria australasica* Cuvier, Silver Perch *Bidyanus bidyanus* (Mitchell), Freshwater Catfish *Tandanus tandanus* Mitchell, and River Blackfish *Gadopsis marmoratus* Richardson (Ashburner 1978; Langdon 1990; Koehn *et al.* 2000). There is, however, little information as to whether populations of these acquired hosts are adversely affected by *L. cyprinacea* infestations in the wild. All of these host-species recognised in Australia are large fish (>200 mm as adults), which appear to suffer from *L. cyprinacea* infestations (based on observations in breeding facilities) only when infestation numbers on individual fish are high (Ashburner 1978). Arguably, smaller fish (<100 mm) are likely to succumb to negative effects at much lower parasite densities (Robinson *et al.* 1998). This paper documents the existence of *L. cyprinacea* on several new host species, and secondarily, provides several lines of evidence that collectively indicate a negative effect of *L. cyprinacea* on a wild population of the Mountain Galaxias *Galaxias olidus* Gunther, a small (<100 mm) native fish found throughout much of south-eastern Australia.

Materials and methods

Fish populations were surveyed at several sites on Creightons Creek as part of a study examining spatial patterning amongst fish populations (Fig. 1). Creightons Creek is a small stream (~100 km long) located within the Murray-Darling drainage system in south-eastern Australia (36°43'00"S, 145°25'00"E). The section studied is typical of small lowland creek systems in the Murray-Darling basin. Native fish populations in these creeks have been highly modified due to land use changes over the last century, and *G. olidus* is one of the few native species that remains locally common. Other native species found in Creightons Creek include

[1] School of Biological Sciences, Monash University, Clayton, Victoria 3800
Email: Nick.Bond@sci.monash.edu.au

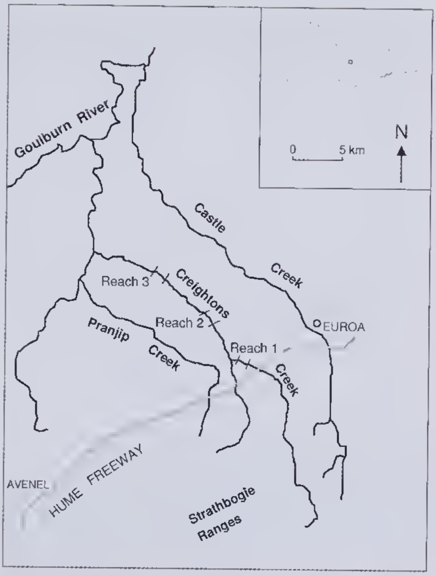

Fig. 1. Map showing the location of Creightons Creek in central Victoria, and the distribution of the three survey reaches along the creek system.

River Blackfish, Southern Pygmy Perch *Nannoperca australis* Gunther and the Western Carp Gudgeon *Hypseleotris klunzingerii* Ogilby, but these species are typically far less common. There are also several introduced species; Mosquito fish *Gambusia holbrooki* (Girard), *Cyprinus carpio* and *Carrasius auratus*. *Cyprinus carpio*, and possibly *Carrasius auratus* are thought to have been the dominant vector for the introduction of *L. cyprinacea* into this area (Langdon 1989).

Surveys were made using a backpack-mounted electrofishing unit (Model 12B; Smith-Root Inc., Vancouver, USA), with two operators wading upstream (with FBA nets to collect fish) for a single pass. In all, three separate sections were fished, each 1000 m in length (and 2-3 km apart). Each 1000 m section was broken up into 2 m cells, and the number of fish of each species caught within each cell was recorded, as were the infestation levels of *L. cyprinacea* on individual fish. Because of ongoing work within these creeks, the presence/absence of *L. cyprinacea* was visually assessed in the field, rather than returning fish to the laboratory. Records were made of fish that were in obviously poor condition, for example due to secondary infections associated with the presence of *L. cyprinacea*. A small subset of the fish caught (16) that carried *L. cyprinacea* were returned to the laboratory alive for further observations, along with a similar sized group (10 fish) of uninfected fish. Once in the laboratory these fish were held for several weeks in two separate aquaria 1.2 m × 0.4 m × 0.5 m, one containing infected fish and the other aquarium containing uninfected fish. *Lernaea cyprinacea* were photographed attached to the fish, and after their removal were identified using Kabata (1979). Species names for fish follow Allan and Allan (2002).

Results

Field surveys

Infestations of *L. cyprinacea* in *G. olidus* occurred at only one of the three stream reaches surveyed (reach three; the most downstream site), which was also the only site at which *C. carpio* was recorded during the survey (Table 1). This reach also had significantly lower densities of native fish species, and several of these (*G. olidus* and *N. australis*) were found (along with *C. carpio*) to be carrying *L. cyprinacea* (Table 1).

Although infestation rates of infected species at reach three were low overall (Table 1), the area with the highest infestations of *L. cyprinacea* on *G. olidus* coincided with locations where infected *C. carpio* occurred (Table 1). Reach three was also the only one of the three sections fished where infected fish were found. Infected *C. carpio* were all large, mature fish (>300 mm length). In contrast to the *C. carpio*, the two native species infected with *L. cyprinacea* were extremely small. *Galaxias olidus* individuals were found to be infected as 0+, 1+ and 2+ (year old) fish, and ranged in size from approximately 40 to 100 mm. Infected individuals of *N. australis* were rare, but were most probably one to two years old (and mature), ranging in size from 40 to 50 mm. Many of the infected *G. olidus* showed dramatically decreased swimming performance and were generally easier to catch with the electrofisher. The few infected *C. carpio*, on the other hand, showed no obvious ill effects.

Table 1. Fish abundances and infection rates at each of the 3 reaches electrofished in Creightons Creek.

Site	Species	No. of fish caught	No. fish infested	% infestation
1	*Galaxias olidus*	1777	0	0
	Gadopsis marmoratus	20	0	0
	Nannoperca australis	127	0	0
	Hypseleotris klunzingerii	2	0	0
	Cyprinus carpio	0	-	-
2	*Galaxias olidus*	657	0	0
	Gadopsis marmoratus	190	0	0
	Nannoperca australis	1	0	0
	Hypseleotris klunzingerii	0	-	-
	Cyprinus carpio	0	-	-
3	*Galaxias olidus*	385	27	7.01
	Gadopsis marmoratus	0	-	
	Nannoperca australis	7	1	14.2
	Hypseleotris klunzingerii	20	-	-
	Cyprinus carpio	24	3	12.5

Laboratory examinations

Fish infected with *L. cyprinacea* showed a variety of symptoms indicating a decrease in physical condition, including secondary infections at the wound site (Fig. 2a), internal bleeding, as well as poor swimming performance, both in the wild and when returned to the laboratory. *Lernaea cyprinacea* were generally attached at the anal and dorsal fin bases (Fig. 2a and b), and these fins often showed signs of secondary infections (note the cloudy nature of the fin in Fig. 2a). Mortality rates in the laboratory aquarium were very high, and despite dead fish being removed daily, along with daily water changes, all 16 infected fish died within 10 days. In contrast, uninfected fish held in a separate aquarium over the same period, as well as those collected on numerous other occasions, showed no signs of ill health when returned and kept in the laboratory.

Discussion

Lernaea cyprinacea is renowned for its morphological plasticity, and resultant ability to adapt to a diverse range of host fishes (Kabata 1979), and it is therefore not surprising when new host species are identified. Documenting new hosts is, however, an important step in understanding the effects that parasites may have on their non-native hosts, and in particular whether they might play a role in the interaction between their introduced hosts and other native species to which they can adapt (Dove and Fletcher 2000).

This study has identified two new host species of *L. cyprinacea*, both of which are small fish, and one of which (*N. australis*) is considered vulnerable to further decline (Anon. 1994). *Lernaea. cyprinacea* has almost certainly been introduced into this location via the movements of an introduced fish species (either *Cyprinus carpio* or *Carrasius auratus*). Irrespective of the mechanism by which *L. cyprinacea* arrived in this system, it is hypothesised that the low densities of *G. olidus* within reach 3 (where *L. cyprinacea* were present) may at least in part be attributable to the effects of the parasite. This hypothesis is based on the following four points of evidence:

1. Low population densities of *G. olidus* in reach 3, where *C. carpio* and *L. cyprinacea* were present as compared to the other two reaches, and to densities in neighbouring streams where *L. cyprinacea* has not been recorded.
2. High rates of secondary infections amongst infested fish.
3. Poor swimming ability of infected fish in the laboratory and in the wild.
4. High mortality rate of infected fish in the laboratory.

This evidence does not constitute a critical test of the effects of *L. cyprinacea* on *G. olidus*, and a number of issues should be mentioned. First, reach 3 consists of deep clay-lined pools, while reaches 1 and 2, which are upstream, are sandy and shallow. This difference in habitat restricts *C. carpio* to the lower sections of Creightons Creek, but in neighbouring streams with

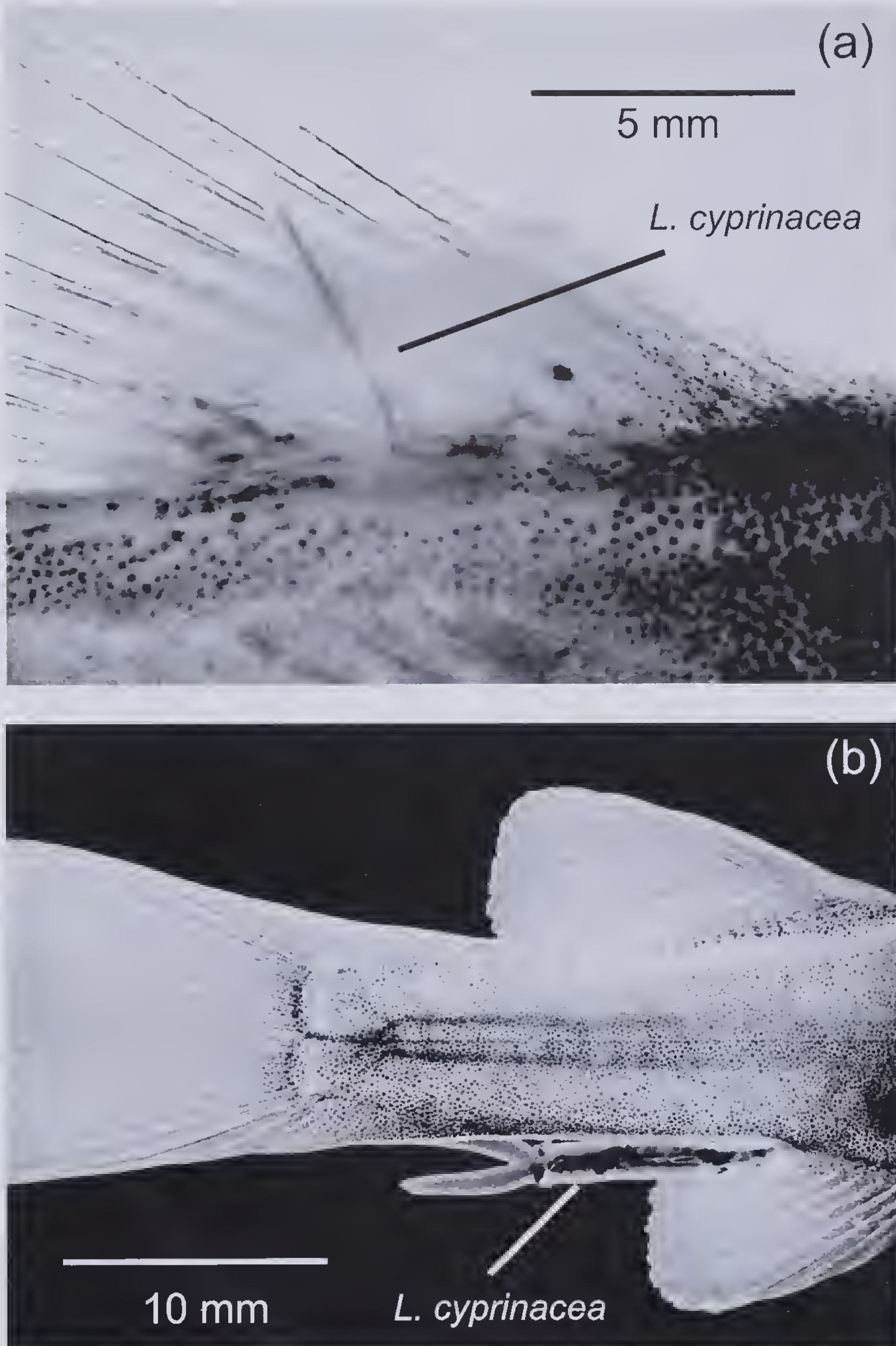

Fig. 2. Photos showing *Lernaea cyprinacea* attached to *Galaxias olidus*. Fig. 2a. shows a cloudy area which represents a region of secondary infection in the fin nearest to the attachment site. Fig. 2b shows a female carrying egg sacs, and gives some idea of the size of *L. cyprinacea* relative to the size of fully grown *G. olidus*.

similar habitat (clay-lined pools) *G. olidus* is common in the downstream sections, which suggests that habitat differences do not account for the lower densities of *G. olidus* in reach 3.

Secondly, infected fish brought back to the laboratory were housed together in just one aquarium. It is possible (but unlikely) that one or more of the fish infected with *L. cyprinacea* was also infected with another disease, although there was no evidence that this was the case.

Even with these caveats, the impact of *L. cyprinacea* on the swimming ability of individual fish was obvious. Many of the infected fish showed impaired swimming ability, with reduced fright response in the field. These fish would be far more susceptible to predation by birds. Likewise, fish already suffering from secondary infections would presumably also show higher mortality rates in the wild, and thus, at the individual level, the negative effects of *L. cyprinacea* seem clear. Whether these effects translate to a population level effect perhaps awaits more evidence.

Importantly, however, the present study clearly shows the need to better understand the true impacts of *L. cyprinacea* in wild populations of susceptible native species, and in particular, the role that *C. carpio* might (as an invasive exotic) play in this interaction. Given the general ecology of *G. olidus*, there are potentially few habitats in which its range overlaps with that of *C. carpio*, but for the other species (e.g. *N. australis*) demonstrated to be susceptible to *L. cyprinacea* in this study, this overlap is almost complete. A thorough understanding of the population level impacts of *L. cyprinacea* on *G. olidus*, and perhaps other native fish, awaits further and more critical testing (including experimentation). Subsequent to the surveys reported here, Creightons Creek dried out due to severe drought conditions (2002-2003 summer), which caused mortality of large numbers of fish (both native and introduced). The native populations have since begun to recover via adult dispersal and juvenile recruitment (N. Bond unpubl. data), while *Cyprinus carpio* and *Carrasius auratus* are still absent. Ironically this may be somewhat fortuitous in terms of removing these invasive species, but thus far it has also precluded any further research. Nevertheless, the present observations demonstrate the potential for these parasites to infect small native species in Australia, and furthermore, highlights the indirect and novel mechanisms by which (as hosts for other organisms) introduced fish may impact on native species as they expand their range.

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Walking on ashes: short term impacts of experimental trampling on soils after bushfire

Andrew J Growcock[1], Catherine M Pickering[1] and Stuart W Johnston[2]

Abstract

Fires in the Australian Alps provide an opportunity to compare the relative impacts of large-scale natural disturbance such as fires, with the impacts of tourism, specifically, trampling by walkers, on subalpine vegetation. Soon after the January-February 2003 fires, areas such as Kosciuszko National Park were being promoted as a 'once in a lifetime opportunity' for tourists to view burnt areas as vegetation began to flourish from the ashes of the fire. However, the ecological impacts caused by visitors to these burnt areas may be significant. Understanding the relationship between the intensity of use by tourists and the new environmental conditions and their degradation thresholds will be valuable for land managers. Different intensities of trampling (control, 30, 100 and 200 passes) were applied using a replicated block design to five extensively burnt sites in the subalpine area of Kosciuszko National Park six weeks after the fire occurred. Vegetation and soil conditions were examined before trampling, immediately after trampling and six weeks later. Preliminary results indicate that trampling, even at low levels, initially caused an increase in soil exposure, an increase in soil loss and a decrease in ash and burnt material. Six weeks later, changes in bare soil exposure and ash and burnt material remain evident. Land management agencies responsible for these fragile areas should still encourage walkers to spread out when walking off track in burnt areas or remain on hardened tracks. (*The Victorian Naturalist* **121** (5), 2004, 199-206)

Introduction

The Australian Alps are a popular year round tourist destination (Buckley *et al.* 2000; Worboys and Pickering 2002). During winter, most visitation is to ski resort areas while in summer, tourism is more diverse in activity and location (Buckley *et al.* 2000; Worboys and Pickering 2003). Bushwalking is one of the most popular activities during the non-winter months with most visitors undertaking a walk at some point in their visit to the Australian Alps (Mules 2003). A common motivation for visiting the Australian Alps is to view nature and the natural environment (Worthington and Di Marzio 1999).

In January-February 2003, visitation to the national parks was temporarily restricted when the Australian Alps experienced their largest bushfires in over 60 years. The fires began with a series of lightning strikes in early January 2003 and burnt out an estimated 1.73 million hectares in and around the Australian Alps, dramatically altering the landscape from the Brindabellas in the ACT, through to Bright at the foot of Mount Buffalo in Victoria's Alpine National Park (Worboys 2003; Johnston and Johnston 2003). While some areas were only partially burnt, other areas received extensive damage with fire removing not only surface vegetation, but also burning away soil organic matter horizons (Johnston pers. obs.). Previously scenic views were altered and many historic destination points such as huts, were lost. Many of the reasons visitors came to the Australian Alps were changed or destroyed.

Vegetative regeneration can occur within weeks of fire disturbance however, with increased soil nutrients, less competition and a more open habitat often favouring regeneration (Gill 1981). Many of the plants found at the lower elevations of the Australian Alps are adapted to survive and regenerate following fires, whilst other plant species require fire to germinate their seed (Gill 1981; Johnston and Johnston 2003). In many areas of the Australian Alps, germination of seed, and emergence of epicormic shoots on eucalypts was evident within two months of the fires (Growcock and Johnston pers. obs.).

In order to encourage tourists back to the areas, park agencies began promoting the burnt areas as a 'once in a lifetime opportunity' for visitors to view vegetation 'rising from the ashes' as the recovery process

[1] School of Environmental and Applied Science, Griffith University, Gold Coast, PMB 50, Gold Coast Mail Centre, Qld 9726. a.growcock@griffith.edu.au
[2] Forestry Department, Australian National University, Canberra, 0200.

began (NSW NPWS 2003). While vegetation re-establishes however, the area remains sensitive to physical disturbance (Wahren *et al.* 2001). Visitation to these areas could lead to further damage on what is currently a fragile environment (Fig. 1). For example, where previously the vegetation was able to withstand moderate intensities of trampling from bushwalking (Growcock, unpublished data), the protective vegetation cover has now either been greatly disturbed or lost altogether. Small groups of bushwalkers may now have a significant impact on the remaining surface cover and soils leading to long-term degradation of the area.

This research aims to identify the impact of different intensities of trampling on areas that have recently been extensively burnt. The specific objectives of this study are to: a) identify how trampling on burnt areas affected remaining surface cover; b) identify how trampling on burnt areas influences soil conditions such as soil loss or gain; c) identify trampling thresholds which could cause long-term damage; and d) identify management strategies so that these recovering ecosystems can still be utilised by tourists without inhibiting recovery. The results presented here are preliminary and cover the first six weeks after trampling.

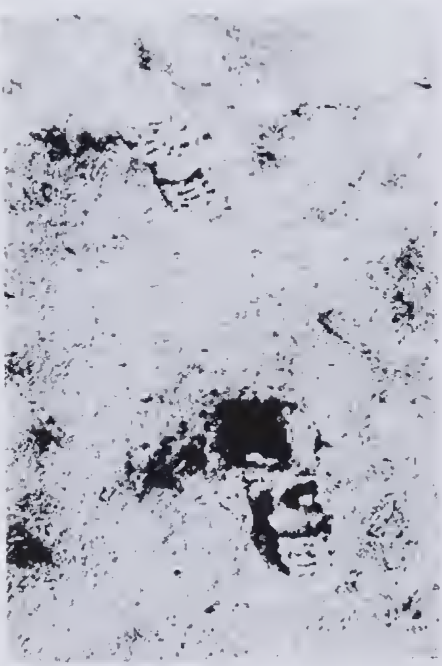

Fig.1. Footprints in an extensively burnt subalpine area of Kosciuszko National Park

Methods

The impacts resulting from increasing trampling intensity have been well documented for a range of alpine and subalpine environments (Calais and Kirkpatrick 1986; Cole 1993; Monz *et al.* 1994; Hartley 1999; Cole and Monz 2002; Whinam and Chilcott 1999, 2003; Whinam *et al.* 2003). Changes occurred to vegetation cover, composition, diversity and height. Compaction and losses of soil were also found with increased levels of use. Thresholds for long-term damage varied according to the environmental conditions and vegetation type, with a threshold of around 200 passes for undisturbed alpine/subalpine vegetation communities in Tasmania (Whinam and Chilcott 1999, 2003; Whinam *et al.* 2003).

Impacts from trampling for this study were examined using procedures developed by Cole and Bayfield (1993). A replicated block design was used, with four intensities of trampling applied at each of five sites of extensively burnt subalpine grasslands in Kosciuszko National Park (Table 1). The trampling trials were undertaken in March 2003, six weeks after the area had been burnt.

At each site, a 3.2 m by 3 m area was marked out into four lanes for trampling. Each treatment lane was 50cms wide and 3m in length. A 40cm wide access lane separated each treatment lane. The size of the treatment lanes was intended to minimize the disturbance area while allowing for natural walking conditions to be attained. The four increasing trampling treatments (0, 30, 100 and 200 passes) were randomly assigned to the four lanes. Treatment levels were selected to reflect a reasonable range of use.

The sites were trampled by volunteers wearing hiking boots and carrying backpacks (with a total weight of approximately 70kg). All trampling was undertaken under similar weather conditions to avoid confounding trampling impacts with differing environmental factors such as soil moisture. Vegetation and soil conditions

Table 1. Location of each of the five extensively burnt sites that were used for trampling trials in subalpine areas of Kosciuszko National Park.

Site	Area	Eastings	Northings	Elevation (m)
1	Wragges Creek	0630966	5973179	1626
2	Dainers Gap	0630766	5973321	1646
3	Prussian Creek	0629592	5971535	1716
4	Betts Creek	0623501	5967551	1780
5	Betts Creek	0623315	5967301	1773

were surveyed in each treatment lane at each site prior to trampling, immediately after trampling, and six weeks after trampling before autumn frosts and winter snow falls.

At each survey time, changes in soil surface cover were measured using four equally spaced 50 x 30 cm quadrats in each treatment lane. Percentage cover was measured for live vegetation, litter (unburnt detached material), bare soil, and ash and burnt material. Individual plant species were recorded when identifiable.

Changes in the surface profile were collected using methods by Whinam and Comfort (1996). Permanent PVC tubes were set into the soil, either side of each trampling lane, with adjustable vertical posts inserted into the tubes. A level cross sectional bar was then fixed to the vertical posts. Data was collected by measuring the distance from the horizontal bar to the ground surface at 5 cm intervals across each treatment lane. This method allowed for accurate relocation and repeat measurements to be made. Changes in the surface profile (through losses or gains), as a result of trampling or general soil movement, were determined by measuring differences from the initial measurements (pre-treatment) for the centre three measurements of each lane.

Bulk density samples were also taken to identify changes in soil compaction with increasing intensity of use. At each site, two samples were collected from each treatment lane (at each end of lane) using a bulk density ring (volume 95.85 cm^3). This measurement was only taken once, immediately after trampling.

Surface cover, changes in the soil profile and bulk densities were graphed (means and standard errors) and then analysed (for results immediately after trampling and at six weeks) using a split plot ANOVA (in SPSS version 10.0) with trampling treatment as the split plot. In order to satisfy the assumptions in the analysis, percentage cover data was transformed using an Arc Sine Square Root transformation. Investigation of significant effects between treatments used a simple contrast between the control and the selected treatment.

Results

Measurements of surface cover prior to trampling clearly show the extensive damage associated with the fires at each site (Fig. 2). Only 1.5 ± 0.4% of the cover consisted of live vegetation (Fig. 2a) and only 4.1 ± 1.7% was litter (Fig. 2b). Burnt material and ash accounted for 67.1 ± 2.7% of the area (Fig. 2c) with the remaining area (27.4 ± 3.6%) bare ground (Fig. 2d).

Trampling, even at low intensities, immediately affected the surface cover of these extensively burnt sites, with ash and burnt material dislodged exposing underlying bare soils (Figs. 2c and 2d, Table 2). Change was greatest in lanes receiving 200 passes with an increase in bare ground exposure of 194% (to an average of 80.6 ± 8.6%) from that prior to trampling. For 100 passes there was an increase of 162% (to 71.7 ± 7.6%) in bare ground exposure and an 89% increase (to 51.9 ± 12.7% exposed) for 30 passes. These were all significantly higher than the control (Table 2). There was little change after trampling in the small amounts of live vegetation (Figs. 2a, Table 2) but a slight increase in litter present (Fig. 2b, Table 2).

Soil profile measurements of the different trampling intensities showed some differences between initial conditions and immediately after trampling (Fig. 3a). Immediately after trampling, an average 16.1 mm of soil had been displaced from the treatment lanes subject to 200 passes while at 100 and 30 passes 11.3 mm and 10.8 mm of soil (respectively) had been displaced. There was no apparent loss of soil for the controls (Fig. 3a). However, while 200 passes was significantly different from the controls (contrast p = 0.07), there was no significant difference between the remaining treatments (p = 0.305; F = 1.350). For soil compaction (bulk density), treatment lanes receiving 200 passes differed from the controls (contrast p = 0.009), however there was no significant difference in compaction levels between any other treatments (Fig. 3b; p = 0.150, F = 2.127), though a trend is apparent.

Six weeks after trampling, the differences in cover values between the controls and the trampling treatments were reduced, partially as a result of changes to the controls. At this time, there was no significant difference in cover between treatments for live vegetation or litter (Fig. 2, Table 3). There was, however, less ash and burnt material on lanes that had been trampled, but the size of the differences was declining with reductions in the amount of ash and burnt material on the control and 30 pass lanes (Fig. 2c, Table 3). The reduction in ash and burnt material at the control and 30 passes was likely a result of natural processes such as rainfall and runoff. Significant differences between treatments were also evident for bare soil exposure at 6 weeks (Table 3), though these differences were decreasing (Fig. 2d). There was limited vegetation re-growth on all treatment lanes at six weeks.

There was no significant difference in soil loss between any treatments at six weeks (p = 0.785; F = 0.357). For 200 passes, an average 15.7 mm of soil remained displaced from the treatment lanes, while at 100 and 30 passes 14 mm and 13.3 mm of soil (respectively) had been displaced from their original levels. At the control lanes, an average 9.9mm of soil had been lost (Fig. 3a).

Discussion

Fires have been shown to increase soil loss from catchments, with carry on effects to catchment water discharges and water

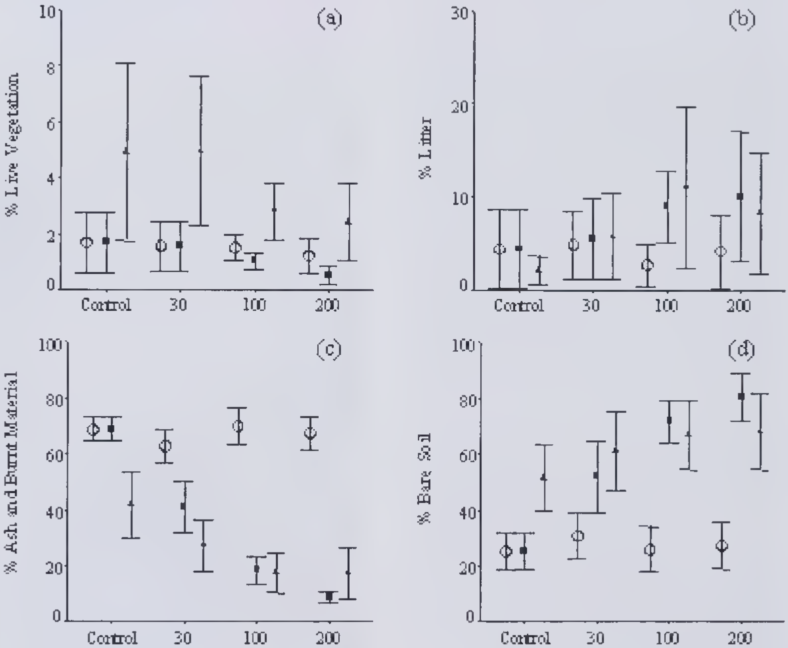

Fig. 2. Surface cover percentages (mean ± 1 standard error) for different levels of trampling (control = no trampling, 30 = 30 passes, 100 = 100 passes, and 200 = 200 passes) in extensively burnt subalpine areas. a) Percentage cover of live vegetation, b) percentage cover of litter, c) percentage cover of ash and burnt material, and d) percentage cover of bare soil. O = Initial cover prior to trampling; ■ = immediately after trampling; ▲ = six weeks after trampling.

Table 2. Results for split plot ANOVA of surface cover values immediately after trampling comparing treatments (control, 30, 100 and 200 passes) for extensively burnt subalpine areas in Kosciuszko National Park (n = 5 sites).

Cover type	D.F	F value	p value
Bare soil	3	33.565	0.000
Litter	3	4.808	0.020
Live Vegetation	3	1.718	0.216
Ash and burnt material	3	41.394	0.000

Table 3. Results for split plot ANOVA of surface cover values at six weeks after trampling comparing treatments (control, 30, 100 and 200 passes) for extensively burnt subalpine areas in Kosciuszko National Park (n = 5 sites).

Cover type	D.F	F value	p value
Bare soil	3	3.522	0.049
Litter	3	0.699	0.634
Live Vegetation	3	1.505	0.263
Ash and burnt material	3	5.133	0.016

quality (Costin 1970; Brown 1972; Good, 1973; Good 1981; Humphreys and Craig 1981; Moody and Martin 2001). This is not surprising considering that even small areas of bare soil can result in erosion in the Australian Alps (Costin *et al.* 1960). Following a fire, the greatest losses of soil and nutrients often occur during the first four months (Gimeno-Garcia et al. 2000) with changes in soil hydrophobicity and decreased litter and vegetation cover often the cause (Leitch *et al.* 1983; Prosser and Williams 1998; Shakesby *et al.* 2000; Shakesby *et al.* 2003).

Rapid recovery of vegetation is therefore important after a fire, as vegetation can bind the soil as well as protect it from rainfall and frost events. In the Australian Alps however, the recovery of alpine and subalpine vegetation is slow, and likely to take years due to the short growing season and the effects of frosts, winter snow covers and spring thaws on the soil surface (Wimbush and Costin 1979a, b and c; Leigh *et al.* 1987; Wahren *et al.* 2001). For example, in severely burnt areas, such as parts of the Brindabellas, where the fire was at its highest intensity, there remained limited vegetation cover after six months, with the area easily described as a 'black desert' due to the massive losses of topsoil (Johnston pers. obs.).

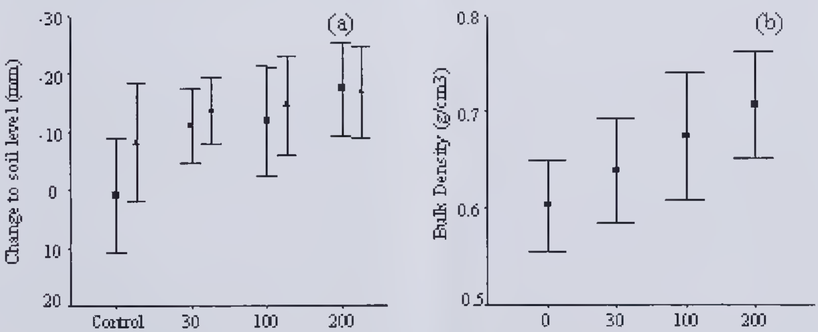

Fig. 3. Changes in soil level measurements (a) and soil bulk density (b) (mean ± 1 standard error) for different levels of trampling (control = no trampling, 30 = 30 passes, 100 = 100 passes and 200 = 200 passes) in extensively burnt subalpine areas. Initial soil levels for (a) were zero.
■ = immediately after trampling; ▲ = six weeks after trampling.

The preliminary findings presented here indicate that trampling activities on burnt areas initially exacerbated fire damage to soils. The threshold before changes occurred was quite low. Even at treatments as low as 30 passes, there was an increase in bare soil exposure as a result of the mechanical actions of trampling on the soil surface. These increases were even more prominent for 100 and 200 passes. At six weeks, the difference in bare soil exposure between treatment lanes appears to be reducing. However, significant differences remain, especially for the 100 and 200 pass treatment lanes. This suggests that while natural events such as rainfall appear to be slowly eclipsing this damage (as suggested by the control sites), trampling does have significant short-term impacts upon the exposure of the soil surface.

Ash and burnt material cover tells a similar story. At 100 and 200 passes, initial losses of ash and burnt material were substantial. At six weeks these differences remained. This may be detrimental, as reduced ash and burnt material may affect vegetation recovery in the long term, with ash supplying important nutrients for regenerating vegetation. This may also be of advantage to weed species that prefer low soil nutrient levels (Beadle 1967). Further monitoring of these sites may indicate if changes due to trampling do affect vegetation regrowth.

While soil loss between treatment lanes showed no significant difference at six weeks, there was an initial trend towards increased trampling having caused greater soil loss and increased soil compaction levels. While it appears that natural processes are eclipsing the damage caused by trampling (again, as suggested by the controls), there is concern that visitation at and above this level has the potential to exacerbate soil loss, especially considering the continuing extent of bare soil exposure. Treatments of greater than 200 passes may exceed environmental thresholds and cause channels into the ground that remain evident at six weeks. Surface runoff during and after this time has the potential to exacerbate these incisions, causing further local soil loss.

The loss of soil, increases in soil exposure and loss of ash and burnt materials may all affect regeneration. Previous studies in the Australian Alps have found initial recovery of vegetation is good, but may stall at or below 50% cover as a result of soil conditions (Wright *et al.* 2000; Wahren *et al.* 2001). Additional disturbance may further impede this recovery. Research examining recovery of alpine and subalpine ecosystems after disturbance by grazing and fire, has shown that once natural disturbance thresholds have been passed, they will remain susceptible to damage in the future, even if some natural recovery has occurred (Johnston *et al.* 2003). If this occurs it is highly unlikely that the disturbed system can return to its natural state without assistance through rehabilitation by land managers and even then, in the majority of cases, it will only re-establish as a modified ecosystem (Johnston *et al.* 2003). Minimizing disturbance on burnt areas may therefore be beneficial in assisting long-term recovery.

There are a number of implications for the management of tourists that are raised from these preliminary results. It would seem probable that restricting visitors from burnt areas, at least at low intensities, is not necessary in preventing long-term soil loss. There may, however, be implications for long-term regeneration with increases in soil exposure and the loss of ash and burnt material. Therefore, encouraging visitors to spread out when walking in burnt areas seems appropriate and will reduce the risk of causing long-term damage. Impacts to this fragile environment may also be reduced through encouraging driving tours to view the regeneration instead of bushwalking. Where visitors desire to undertake a walk, restricting walking to management trails and designated walking tracks may also be of benefit in areas severely affected by fire. National Park managers have already applied many of these restrictions.

At this time, the impact of trampling on vegetation recovery is unknown, though previous studies have indicated that recovery after fires is already slow (Wahren *et al.* 2001). Additional disturbance may be furthering already extensive damage. As such, trampling on burnt areas may be a double-edged sword, initially exacerbating soil loss and then impeding vegetation recovery. Impediments to revegetation will also lead to greater soil loss over time.

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A unique overlap rainforest in the Upper Goolengook catchment, East Gippsland

A Picone[1] and N McCaffrey[2]

Abstract

Recent observations suggest a previously undocumented association of Warm and Cool Temperate Rainforest species occurs in the Upper Goolengook catchment. Kanooka *Tristaniopsis laurina*, a warm temperate or gallery species, is dominant with Southern Sassafras *Atherosperma moschatum*, a cool temperate species, as a subdominant. A survey was undertaken to quantify anecdotal observations. As a site of significance for rainforest, the Upper Goolengook is likely to be of greater importance than existing literature suggests. (*The Victorian Naturalist*, **121** (5), 2004, 206-209)

Introduction

The Upper Goolengook catchment begins on the south-western escarpment of the Errinundra Plateau in East Gippsland. The catchment generally runs in a south-easterly direction and is flanked by steep ridgelines on the east, Mount Ellery on the west and the Errinundra Plateau to the north. The catchment ranges in altitude from over 1000 m to less than 200 m, with corresponding changes in climate and vegetation.

Cool and Warm Temperate Rainforest, including an overlap of the two, have been recorded in Goolengook (Lobert *et al.* 1991; LCC 1986). Other sites in East Gippsland known to support rainforest overlap communities are in the Brodribb, Big, Arte, Errinundra and Combienbar catchments and in the Howe Ranges (Chesterfield *et al.* 1988, Earl *et al.* 1989, Peel 1999, Westaway *et al.*1990). Four rainforest overlap floristic communities are described by Peel (1999) of which two, East Gippsland (EG) Cool Temperate Overlap Rainforest and EG Warm Temperate Overlap Rainforest, occur in Goolengook. Both these communities are endemic to East Gippsland and restricted to small areas south and south-west of the Errinundra Plateau (Peel 1999).

The presence of Southern Sassafras *Atherosperma moschatum* alongside the more dominant Kanooka *Tristaniopsis laurina* in two large stands of the Alluvial Terraces Warm Temperate Rainforest floristic community was first observed in Goolengook during 1999. This association is not known to occur in any other rainforest in Victoria (D. Cameron pers. comm.). It was not until 2002, however, that the

[1] 6 The Knoll, Mt Eliza, 3930
[2] 31 Millbank Drive, Mt Eliza, 3930
Correspondence: A. Picone, 0401 686 782 or picone@vicnet.net.au

extent of the *T. laurina-A. moschatum* association was realised, and not until 2003 that the site was surveyed specifically to document the overlap features of the rainforest.

Methods

Following initial observation of the overlap occurrences, the rainforest stands concerned were identified on the Orbost Region Ecological Vegetation Class (EVC) map and Map 3 of the Goolengook Ecological Survey Report (Lobert *et al.* 1991). Prior to the commencement of surveys, plant census data for the Goolengook Forest Management Block were obtained from the Department of Sustainability and Environment's Flora Information System (FIS). Nomenclature and conservation status follows Ross and Walsh (2003).

Quadrats were 30 m x 30 m in size and occurred on uniform alluvial terraces at 270-290 m altitude.

All vascular plant species present within each quadrat were recorded and the cover/abundance values of each species estimated. The data collected is stored in the FIS. Cover/abundance classes were based on Walker and Tunstall (1981) as cited in Lobert *et al.* (1991) (Table 1).

Results

Forty-two vascular plants in total were recorded within the two quadrats (Table 2), all of which previously had been recorded within the Forest Management Block.

In Quadrat A, the foliage projective cover of *T. laurina* was 65%, Lilly Pilly *Acmena smithii* 50%, Jungle Grape *Cissus hypoglauca* 10% and *Atherosperma moschatum* less than 5% (Table 2). In Quadrat B, the foliage projective cover of *T. laurina* was 75%, that of *A. moschatum* 40%, *A smithii* 5% and *C. hypoglauca* was absent (Table 2). River Hook-sedge *Uncinia nemoralis*, a rare species in Victoria 2001, occurred in Quadrat B.

In both quadrats, Black Olive Berry *Elaeocarpus holopetalus*, Blue Olive Berry *E. reticulatus*, Gippsland Waratah *Telopea oreades* and Banyalla *Pittosporum bicolor* were present (Table 2). Muttonwood *Rapanea howittiana* was observed outside quadrats.

Incidental records were taken outside quadrats A and B for Butterfly Orchid

Table 1. Cover/abundance (C/A) classes

C/A class	Percentage cover interval	No. of plants
+	<1	few
1	1-5	many
2	5-25	any number
3	25-50	any number
4	50-75	any number
5	75-100	any number

Sarcochilus australis, the vulnerable Skirted Tree-fern *Cyathea* X *marcescens* and the rare natural hybrid *Pittosporum bicolor* x *undulatum* which previously had not been recorded within the Forest Management Block.

Discussion

There are three core stands of rainforest on the alluvial flats of the Upper Goolengook River. They are currently mapped as representing the Warm Temperate Rainforest EVC (Orbost Region EVC Map). These three core stands are contiguous, separated only by secondary rainforest with emergent eucalypts.

Quadrat A appears to represent the limit of the association of *A. moschatum* with *T. laurina* in the Upper Goolengook. Outside the quadrat, *A. moschatum* was found consistently but sparsely scattered within the northern parts of the rainforest stand. Recruitment of *A. moschatum* was observed on trunks of the Soft Tree-fern *Dicksonia antarctica. Atherosperma moschatum* is represented both by saplings and mature canopy trees at the site.

Quadrat B, in the northernmost substantial stand of alluvial terrace rainforest along Goolengook River, supports a distinctly different composition. *Tristaniopsis laurina* is dominant with *A. moschatum* as the subdominant, while *A. smithii* and *E. holopetalus* appear subordinate to these species. The quadrat was selected in the southern part of the rainforest stand, which extends upstream for over 1 km. Earlier studies (Lobert *et al.* 1991) also recorded Slender Tree-fern *Cyathea cunninghamii* in the area. This is listed as threatened in Victoria under the Flora and Fauna Guarantee Act 1988.

The occurrence of Warm and Cool Temperate Rainforest Overlap in the Goolengook catchment is well documented

Table 2. Vascular species recorded in Quadrats A and B. Species denoted with * are characteristic of the East Gippsland Cool Temperate Rainforest floristic community (Peel 1999). Species marked with # are characteristic of the Alluvial Terraces Warm Temperate Rainforest floristic community (Peel 1999). Some species are characteristic of both floristic communities. Non-marked species are common in rainforest but not considered characteristic of these floristic communities.

		Cover abundance class	
Scientific Name	**Common Name**	**Quad. A**	**Quad. B**
#Acacia melanoxylon	Blackwood	+	
#Acmena smithii	Lilly Pilly	4	2
**Asplenium bulbiferum*	Mother Spleenwort	1	1
Asplenium flaccidum	Weeping Spleenwort	1	
**Atherosperma moschatum*	Southern Sassafras	+	3
#Blechnum cartilagineum	Gristle Fern	2	1
#Blechnum nudum	Fishbone Water-fern	2	2
#Blechnum patersonii	Strap Water-fern	1	1
**Blechnum wattsii*	Hard Water-fern	3	3
#Cissus hypoglauca	Jungle Grape	2	
**Clematis aristata*	Mountain Clematis	+	
#Coprosma quadrifida	Prickly Currant-bush	1	
Ctenopteris heterophylla	Gipsy Fern	1	1
#Cyathea australis	Rough Tree-fern	2	+
**#Dicksonia antarctica*	Soft Tree-fern	4	4
**Diplazium australe*	Austral Lady-fern	+	1
**Elaeocarpus holopetalus*	Black Olive-berry	+	+
#Elaeocarpus reticulatus	Blue Olive-berry	+	+
**Fieldia australis*	Fieldia	1	1
Gahnia clarkei	Tall Saw-sedge		+
**Grammitis billardierei*	Common Finger-fern	1	1
Hymenophyllum australe	Austral Filmy-fern	1	
Hymenophyllum cupressiforme	Common Filmy-fern	1	1
**Hymenophyllum flabellatum*	Shiny Filmy-fern	1	1
Hymenophyllum rarum	Narrow Filmy-fern	1	1
#Lastreopsis acuminata	Shiny Shield-fern	1	1
Marsdenia rostrata	Milk Vine	1	1
**#Microsorum pustulatum*	Kangaroo Fern	1	1
#Microsorum scandens	Fragrant Fern	1	1
**#Parsonsia brownii*	Twining Silkpod	+	+
**Pittosporum bicolor*	Banyalla	+	1
Rumohra adiantiformis	Leathery Shield-fern	+	1
#Smilax australis	Austral Sarsaparilla	+	
Sticherus lobatus	Spreading Fan-fern		1
**Tasmannia lanceolata*	Mountain Pepper	+	+
**Telopea oreades*	Gippsland Waratah	+	+
#Tetrarrhena juncea	Forest Wire-grass		+
Tmesipteris obliqua	Long Fork-fern	+	
Todea barbara	Austral King-fern	+	
Tristaniopsis laurina	Kanooka	4	5
**Uncinia nemoralis*	River Hook-sedge		+
#Viola hederacea	Ivy-leaf Violet	+	+

by Lobert *et al.* (1991) and formed the basis for the delineation of the Little Goolengook site of national significance for rainforest (SOSRF) (Cameron 1990, Peel 1999). The Goolengook Forest Management Block supports three SOSRF. The rainforest stands sampled in this survey lie on the western boundary of the Upper Goolengook (EG 73) SOSRF which is currently listed as a site of state significance.

Lobert *et al.* (1991) make no mention of rainforest overlap along the banks of the Goolengook River and the sites sampled in this survey are mapped as Warm Temperate Rainforest. Lobert *et al.* (1991) map other rainforest overlap sites as 'Intermediate Rainforest' and describe this phenomenon when it is encountered in the headwaters of Little Goolengook River (p. 51). The occurrence of rainforest overlap in the Little Goolengook River catchment is a major feature contributing to the identification of a site of national significance for rainforest (EG 72) (Peel 1999). Since

Lobert *et al.* (1991) map and discuss rainforest overlap sites elsewhere within the Goolengook Forest Management Block, it is apparent that the sites described in this report have not been sampled, described or encountered in any previous survey.

The authors consider that the state significance rating of the Upper Goolengook SOSRF (EG 73) requires revision, as it does not reflect the unique values inherent in the association of *T. laurina* and *A. moschatum*. Applying the methodology of Cameron (1990), Lobert *et al.* (1991) and Peel (1999), the authors consider this site to be of national significance, as discussed in detail by Picone (2004).

The Upper Goolengook SOSRF already supports various nationally significant attributes including: integrity of the catchment and rainforest stand, populations of AROTS, VROTS and significant taxa, species richness and diversity of floristic communities (Peel1999). These values, combined with the site's overlap status described here, are sufficient to warrant an elevation from state significance to national significance.

Under the East Gippsland Forest Management Plan (Department of Conservation and Natural Resources 1995) the revision from state to national significance will require a rezoning of state forest. A site of national significance requires sub-catchment protection of all rainforest stands. Logging, although under moratorium, is currently scheduled within the immediate catchment of these rainforest stands. Based on all available evidence, this is inconsistent with the objectives of the East Gippsland Forest Management Plan.

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Densities of feral Honey Bee *Apis mellifera* colonies in Victoria

R Goodman[1] and G Hepworth[2]

Abstract

Surveys for feral Honey Bee *Apis mellifera* colonies were conducted in remnant forest/woodland in five districts of the Goulburn Valley during 1994-95 and in four districts of the Box-Ironbark forests and woodlands in Victoria during 2003. Colonies were present in all five districts surveyed in the Goulburn Valley, with the highest mean concentration of 1.3 colonies per ha found in the Invergordon district. Of a total 35 one-ha blocks surveyed in the four districts of the Box-Ironbark forests and woodlands, only one contained a Honey Bee colony. The effect of drought plus a lack of nectar and pollen flora diversity are suggested as factors that influence the density of feral Honey Bee colonies. (*The Victorian Naturalist* **121**(5), 2004, 210-214)

Introduction

Paton (1996) indicated that feral Honey Bee *Apis mellifera* colonies occur throughout the non-arid areas of Australia, although their distribution may be patchy. Oldroyd *et al.* (1997) surveyed feral bees in the Wyperfeld National Park, Victoria, an area in which beekeeping had not been practised for 13 years, and found that the population of feral bees was self-sustaining, but subject to decline in drought years.

There is little data on the densities of feral colonies in Australia (Paton 1996). Oldroyd *et al.* (1994) estimated a density of 0.77 colonies per hectare in riparian River Red Gum *Eucalyptus camaldulensis* and Black Box *E. largiflorens* woodland of the Wyperfeld National Park. Paton (1996) found densities of 0.2 - 0.4 colonies/ha in the Flinders Chase National Park, Kangaroo Island, South Australia and also found 0.001 - 0.004 and 0.1 - 0.4 colonies/ha in mallee heath and eucalypt woodland respectively in the Mount Lofty Ranges. Natural aggregation of feral colonies has been reported by Oldroyd *et al.* (1995).

Feral Honey Bees commonly nest in tree hollows and sometimes in tree stumps, logs, concrete power poles, roadside drainage pipes, rabbit burrows and in the open. Rinderer *et al.* (1982) determined a minimum acceptable volume of c. 10 litres and a maximum acceptable volume of c. 40 litres for nesting cavities in Louisiana, USA, although Winston (1992) stated that cavities of between 20 and 100 litres in volume were preferred. In general, bees prefer nesting sites at an elevation of 3 m or more (Avitabile *et al.* 1978). The present paper describes two distinctly separate surveys that were conducted to record the density of feral colonies in Victoria.

[1]Department of Primary Industries, Private Bag 15, Ferntree Gully Delivery Centre, Victoria, 3156
[2]Statistical Consulting Centre, The University of Melbourne, Victoria, 3010
Email: russell.goodman@dpi.vic.gov.au

Materials and methods

Surveys were conducted when weather was fine and ambient temperature was at least 15°C, these being conditions suitable for Honey Bee flight. When possible, a known feral colony was checked to confirm that bees were flying before a day's survey was commenced. Colonies were identified by a constant stream of bees flying to and from the nest. Observations were made from ground level, aided by binoculars (10 x 50). Trees with trunks of 20 cm or less diameter at human breast height (DBHOB) were not included in the count because trees of this size were unlikely to have hollows suitable for Honey Bees (Soderquist 1999). The number of available hollows was not recorded in the Goulburn Valley survey, as this survey was originally designed only to determine the existing population of feral colonies and thus gauge their potential as vectors of Honey Bee and plant disease organisms.

Goulburn Valley Survey

Three types of remnant forest/woodland blocks (roadside strip, river frontage and 'other') were surveyed in five districts of the Goulburn valley between 28 December 1994 and 18 April 1995. Yellow Box *Eucalyptus melliodora*, Grey Box *E. microcarpa* and River Red Gum *E. camaldulensis* were the predominant flora except for river frontage blocks where River Red Gum was predominant.

Table 1. Results of survey in Goulburn Valley remnant forest/woodland by district.

District (Number of blocks surveyed)	Total number of trees surveyed	Number of trees per ha			Number of colonies per ha			Total number of colonies in trees	Number of colonies per 100 trees		
		Mean	s.e.m.	Range	Mean	s.e.m.	Range		Mean	s.e.m.	Range
Cobram (5)	1176	71	23	14 - 124	0.6	0.2	0.3 - 1.2	11	1.9	0.9	0.3 - 4.9
Invergordon (5)	397	76	15	40 - 114	1.3	0.6	0 - 3.2	6	1.9	1.0	0 - 5.7
Kyabram/Merrigum (5)	472	25	4	16 - 36	1.2	0.5	0.2 - 2.6	23	5.1	2.4	1.2 - 13.6
Shepparton East (6)	1194	73	9	45 - 105	0.5	0.2	0.3 - 1.3	8	0.8	0.3	0.4 - 2.4
Tatura/Ardmona (9)	1014	32	12	2 - 114	1.0	0.5	0 - 4.0	34	7.8	4.3	0 - 30.8

Table 2. Results of surveys in Goulburn Valley remnant forest/woodland block by category of block.

Category of remnant forest/woodland block	Number of trees per ha			Number of colonies per ha			Number of colonies per 100 trees		
	Mean	s.e.m	Range	Mean	s.e.m.	Range	Mean	s.e.m.	Range
Roadside strip	69	13	17 - 114	1.3	0.4	0 - 3.2	2.5	0.9	0 - 7.3
River frontage block	65	9	21 - 114	0.4	0.1	0 - 1.3	0.8	0.2	0 - 2.4
Other block	32	11	2 - 124	1.1	0.4	0 - 4.0	7.6	3.3	0 - 30.8

Where possible, the 30 survey blocks were 30 000 m^2 (100 x 300 m) in area, but ranged from 4656 to 99 000 m^2. To account for this variation, we calculated the number of trees per hectare, number of honey bee colonies per ha and the number of colonies per 100 trees (Tables 1 and 2). The mean of each variable (trees and colonies) was derived by calculating the value of the variable in each block, and then averaging across the blocks in the district or category. This was more appropriate than calculating a figure directly from Table 1 or 2 because of the variation in the area and number of trees in the blocks.

Statistical Analysis

Relationships between the number of colonies per hectare, the number of colonies per 100 trees, the number of trees per hectare, and district were examined using scatterplots and analysis of covariance (ANCOVA). The response variable was either the number of colonies per hectare or the number of colonies per 100 trees, and the explanatory variables were the number of trees per hectare, and district.

Box-Ironbark forests and woodlands survey

One-hectare blocks with some large mature trees, potentially containing hollows, were chosen. The volume of hollows was not physically measured to determine their suitability for bee colonies. However, where close inspection of hollows was possible, those judged to have a volume of seven litres or less and those entirely open to the weather above, or almost so, were considered unsuitable for Honey Bee nests and not counted. Surveys were conducted in the following districts:

- Wellsford State Forest Bendigo: twelve one-hectare blocks of predominantly Grey Box, surveyed 12-16 April 2003
- Whela State Forest: eleven one-hectare blocks of predominantly Grey Box but with some Yellow Box, Yellow Gum *E. leucoxylon* and White Box *E. albens*, surveyed 24-25 April 2003
- Black Mountain Flora Reserve: six one-hectare blocks, predominantly Grey Box but with some Yellow Gum, surveyed 5-6 May 2003
- Environs adjacent to and including the disused railway reserve west of Murchison: six one-hectare blocks (two roadside strips, two rail reserve strips and two woodland blocks), of predominantly Grey Box and River Red Gum, surveyed 7 May 2003.

Results

Goulburn Valley survey

The highest concentration of colonies, calculated as the mean number of colonies per hectare, occurred in the Invergordon and Kyabram districts (1.3 and 1.2 respectively, Table 1). The next highest concentration (1.0) occurred in the Tatura/Ardmona district which also had the highest mean number of colonies per 100 trees (7.8).

Scatterplots of the number of colonies per hectare or the number of colonies per 100 trees vs the number of trees per hectare showed little relationship between these variables, and an ANCOVA, with district included as a factor, confirmed these results   neither the number of trees per hectare nor district were close to being significant at p   0.05.

Roadside strips had a similar mean number of colonies per hectare to 'other blocks' (1.3 cf. 1.1, Table 2). 'Other blocks' (neither roadside strips nor river frontages) had by far the greatest mean number of colonies per 100 trees (7.6). River frontage blocks had the lowest mean number of colonies per hectare (0.4) and the lowest mean number of colonies per 100 trees (0.8) of all the categories of remnant forest/woodland.

The number of colonies detected in individual remnant forest/woodland blocks ranged from 0 to 12. Five blocks had more than four colonies and four blocks had no colonies. Twelve colonies were found in a three hectare block of forty, predominantly large Yellow Box trees at Tatura. In another Tatura block, a colony occupied a log on the ground.

Box-Ironbark forests and woodlands survey

In the Wellsford State Forest, a single colony only was detected in one of the twelve blocks. The colony was situated in a fork hollow of a Grey Box tree (DBHOB exceeding 1 m), about 3 m above ground. A small piece of comb in a hollow at ground level in a Grey Box coppice regrowth stump indicated occupation by

Table 3. Results of survey in Box-Ironbark forests and woodlands by district.

Survey district	Trees per ha Mean	Trees per ha Range	Hollows per ha Mean	Hollows per ha Range
Wellsford State Forest	95.1	48 - 185	3.4	0 - 10
Whela State Forest	85.7	60- 115	8.7	3 - 18
Black Mountain Flora Reserve	58.0	37 - 97	6.2	3 - 10
Environs west of Murchison	45.7	16 - 66	2.5	0 - 4

bees that had either died or absconded. A live colony was noticed in a fork (elevation 7 m) of a Grey Box tree (DBHOB exceeding 1.3 m) outside the perimeter of a survey block. These latter two observations were not included as part of our tally. Of the total number of 41 hollows found in this forest, 17 (41.5%) were found in coppice regrowth stumps or dead stumps. Bees were not detected in any of the blocks in the remaining survey districts. Data on the mean number of trees and hollows per block for all districts are presented in Table 3. Statistical analysis was not employed due to the occurrence of only one colony.

Discussion

The study showed a wide distribution of feral bees in the Goulburn Valley. There was considerable variation in the number of colonies per 100 trees (range 0.8-7.8, Table 1) and mean number of colonies per hectare (range 0.5 - 1.3, Table 1) in the five districts surveyed. This range was larger than that reported by Paton (1996) who found densities of 0.001 to 0.4 colonies/ha in South Australia. Factors such as hollow availability and application of agricultural chemicals in horticultural areas adjacent to the survey blocks may in part explain the variation in colony numbers. The occurrence of twelve colonies in a three hectare block of forty large trees at Tatura suggests a trend to colony aggregation, though not to the extent described by Oldroyd *et al.* (1995) who found clumping of up to 10 colonies/ha in the Wyperfeld National Park.

Only one live colony was detected by the Box-Ironbark forest and woodlands surveys. These surveys were conducted during a severe drought and it is possible that any colonies (if they existed) may have perished as occurred in the study of Oldroyd *et al.* (1997). We were unable to confirm that every hollow was suitable for bees because our observations were made at ground level. Some of the hollows included in our count were estimated to have a volume of seven to ten litres, which is below the minimum acceptable volume as determined by Rinderer *et al.* (1982). With these constraints, the number of hollows available to bees may be less than that indicated by our total count. Despite this, we suggest that the number of hollows was not a factor contributing to the low number of colonies detected. It was more likely that the sporadic flowering of eucalypt species and presence of few other nectar and pollen yielding species in the Box-Ironbark forests and woodlands were contributing factors. In contrast, there is a diverse range of flora in the Goulburn Valley, some of which is irrigated, and this potentially provides forage for bees over a longer period than what is available in Box-Ironbark forests and woodlands. However, any explanation of the differing colony densities in the two surveys should be treated cautiously, as the surveys were conducted in different years and under different field conditions.

In the Box-Ironbark study, survey blocks were carefully chosen so that they contained some large mature trees in which hollows might exist, and as a result many of the blocks were in areas largely undisturbed by forest management. Management of the Wellsford and Whela forests has resulted in many trees of relatively small diameter, in which few above ground hollows would be expected (Soderquist 1999). Therefore, our surveys in these two districts would not be representative of the entire forest and we suggest that the potential for suitable hollows and their occupation by bees may be less than our data suggests.

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Further strategic additions to Victoria's public protected area system: 2002-2004

James A. Fitzsimons[1,2], Paul FitzSimons[1] and Chris Ashe[1]

Abstract

The development of a comprehensive, adequate and representative (CAR) reserve system is the key objective of the National Reserve System, and is supported by all Australian States and Territories. In Victoria, purchase of private land for incorporation into the protected area system of parks and reserves is one of the only means of protecting some of the State's most endangered ecosystems. This article outlines the ecological attributes of private land purchased for addition to the Victorian protected area system between 2002 and 2004. (*The Victorian Naturalist* **121** (5) 2004, 214-225)

Introduction

This paper documents the more significant land purchases made by the Department of Sustainability and Environment for addition to the public conservation estate in Victoria from mid-2002 until early 2004, and provides a brief description of their natural attributes. It serves as an extension of a previous description of the conservation land purchase program, which aims to improve the comprehensiveness, adequacy, and representativeness of the reserve system (Fitzsimons and Ashe 2003).

[1] Public Land Management – Parks Branch, Department of Sustainability and Environment, Level 14, 8 Nicholson Street, East Melbourne, Victoria 3002
Email: James.Fitzsimons@dse.vic.gov.au

[2] School of Ecology and Environment, Deakin University, 221 Burwood Highway, Burwood, Victoria 3125

Arising from the international Convention on Biological Diversity (1992) and the *National Strategy for the Conservation of Australia's Biological Diversity* (Commonwealth of Australia 1996), all Australian States and Territories have been working toward the development of a comprehensive, adequate and representative system of protected areas.

In Victoria in the past, the identification of public land areas to be added to the protected area system was undertaken by the Land Conservation Council, Environment Conservation Council and through the Regional Forest Agreements. The process of public land use assessment is continued today through the work of the Victorian Environmental Assessment Council.

The above regional assessment programs cover Crown land owned by the State and do not investigate privately owned land. However, certain ecosystems are absent from the protected area system and remain mostly on private land. In a systematic process to increase the reservation levels of Victoria's most threatened ecosystems, particularly native grasslands and grassy woodlands, the Department of Sustainability and Environment's conservation land purchase program aims to acquire high quality samples of such ecosystems from private land for addition to the reserve system. All acquisitions are on a completely voluntary basis. Purchase priorities are derived from inventories of the most significant sites of 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. Land purchased and added to adjoining reserves is managed as part of those reserves. On some sites, such as the Wanurp grasslands and Mount Mercer grasslands, which have a past history of grazing, a strictly controlled grazing regime has been retained as a management tool to enhance the biodiversity value of particular grassy ecosystems.

The conservation status of all species listed in this paper is outlined in Appendix 1, while Appendix 2 presents communities listed under the *Flora and Fauna Guarantee Act 1988* protected by the new reserves. The abbreviated threat status used for species in this paper is as follows (derived from DSE (2003a, 2003b), the *Flora and Fauna Guarantee Act 1988* and the *Environment Protection and Biodiversity Conservation Act 1999*): Victorian Status - ce (critically endangered); e (endangered); v (vulnerable); r (rare); n (near threatened); k (poorly known/data deficient); L (listed as threatened under the *Flora and Fauna Guarantee Act 1988*); National Status – CE (critically endangered); E (endangered); V (vulnerable).

Fig. 1 indicates the location of recent purchases within Victoria.

1. 'North Mount' and 'Swans' Grassy Woodlands, Yarram Park, Grampians

Two separate blocks, 'North Mount' and 'Swans', totalling 387 ha, have been purchased for addition to the Grampians National Park. Both properties straddle the Greater Grampians and Dundas Tablelands bioregions and thus contain a variety of species and vegetation communities. Significantly, the properties support over 170 ha of high quality Plains Grassy Woodland. Of the 323 000 ha of Plains Grassy Woodland that occurred in the Dundas Tableland and Greater Grampians bioregions, less than 21 000 ha (6.5%) remains and less than 2250 ha (0.7%) is protected in dedicated reserves.

The North Mount property also supports Alluvial Terraces Herb-rich Woodland which is endangered in the Dundas Tablelands and remains under-reserved. Other Ecological Vegetation Classes (EVCs) are Damp Sands Herb-rich Woodland, Heathy Dry Forest, Heathy Woodland and Shrubby Woodland. A feature of the properties is the large trees that provide habitat for hollow-dependent fauna.

The properties are likely to provide habitat for a number of threatened flora and fauna species recorded in the adjacent park, namely Blotched Sun-orchid *Thelymitra benthamiana* (v), Grampians Rice-flower *Pimelea pagophila* (V,v), Green Leek-orchid *Prasophyllum lindleyanum* (v), Tufted Grass-tree *Xanthorrhoea caespitosa* (r), Veined Beard-heath *Leucopogon neurophyllus* (r), Smoky Mouse *Pseudomys fumeus* (E,e), Heath Mouse *Pseudomys shortridgei* (V,n), Long-nosed Potoroo *Potorous tridactylus tridactylus* (V,e) and Powerful Owl *Ninox strenua* (v).

2. Ledcourt Grassy Woodland, Grampians

This 32 ha block links the lower slopes of the Mount Difficult Range of the Grampians National Park to public land along a tributary of Mount William Creek.

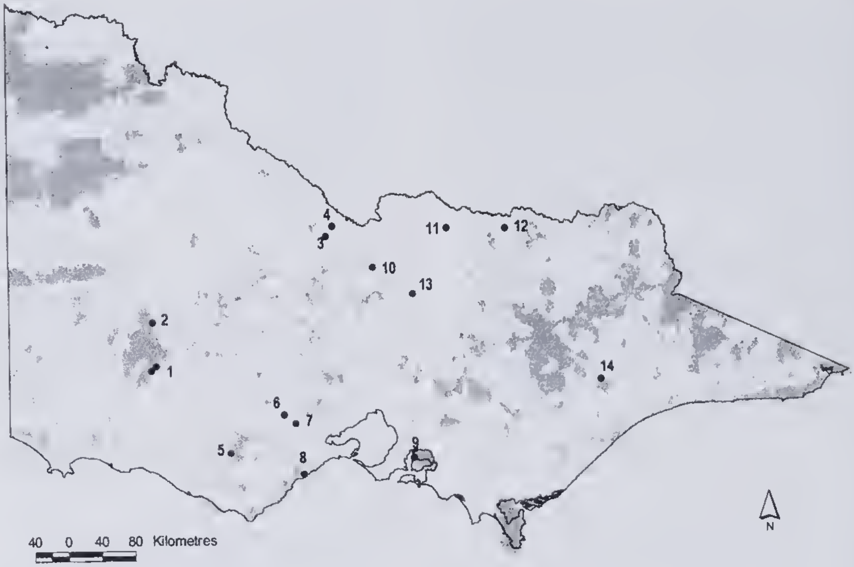

Fig. 1. Location of recent land purchases (numbered) for addition to the reserve system (existing reserve system shaded).

Significantly, both the purchased property and the water frontage reserve contain stands of the highly-depleted Plains Grassy Woodland EVC and will be added to the National Park. Other EVCs represented include Sand Heathland and Shrubby Woodland. The block has some large hollows present amongst the heathland and large River Red Gums *Eucalyptus camaldulensis* and Yellow Gums *E. leucoxylon* along the creekline. The *Flora and Fauna Guarantee*-listed Mountain Galaxias *Galaxias olidus* (k) has been recorded upstream of the property.

3. Wanurp Grasslands

This 121 ha Northern Plains Grassland is located to the east of Mitiamo and forms part of a network of native grasslands in the area purchased for conservation (see Fitzsimons and Ashe 2003 for details of previous purchases) (Fig. 2).

The grasslands are dominated by Common Wallaby Grass *Austrodanthonia caespitosa*, Rough Spear-grass *Austrostipa scabra*, Spider Grass *Enteropogon acicularis* and Windmill Grass *Chloris truncata*, with a diverse array of other native species present. Patches of Buloke *Allocasuarina luehmannii* and River Red Gum occur at the southern end of the property (Marshall 2002). Significant flora species include Woolly Buttons *Leiocarpa panaetioides* (r), and Plains Joyweed *Alternanthera* sp. 1 (Plains) (k).

The Wanurp property is known habitat for the Bush Stone-curlew *Burhinus grallarius* (e) and provides potential habitat for the nationally vulnerable Plains-wanderer *Pedionomus torquatus*.

The grasslands are reserved as the Wanurp Nature Conservation Reserve.

4. Kotta Grasslands

This large (226 ha) Northern Plains Grassland to the northwest of Kotta, near Mitiamo, adds to a network of protected grasslands in the Terrick Terrick area (Fig. 2). Parts of the Kotta property have never been cropped, which is unusual on the Patho Plains, and intact gilgais are present. Like the Wanurp grasslands, Common Wallaby Grass, Spider Grass and Windmill Grass (as well as Plump Spear-grass *Austrostipa aristiglumis*) dominate the Kotta Grasslands. A diverse array of other

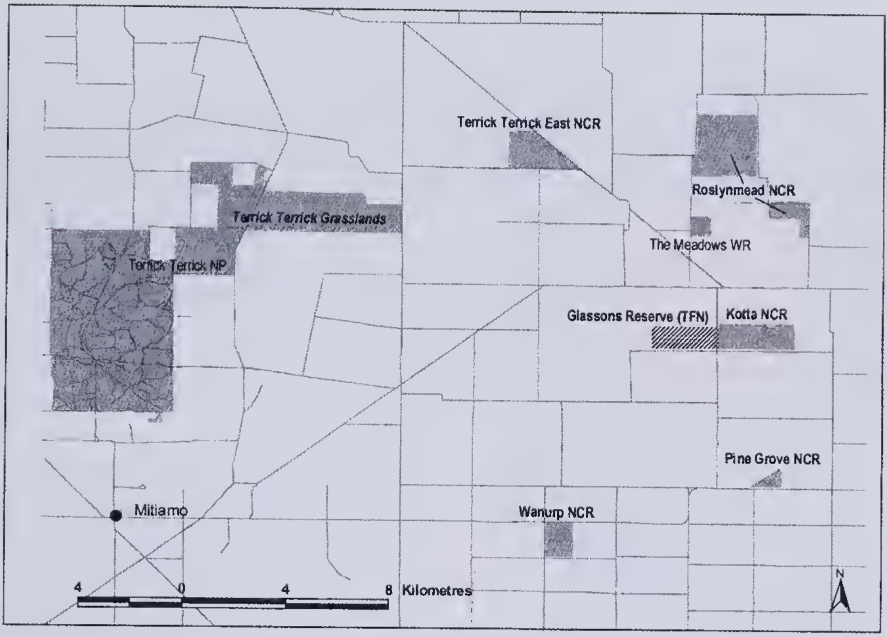

Fig. 2. Location of Wanurp and Kotta Grasslands and other recently purchased Northern Plains Grasslands in the Mitiamo district. Reserves in bold indicate land purchased for conservation. Abbreviations: NCR (Nature Conservation Reserve), NP (National Park), TFN (Trust for Nature) and WR (Wildlife Reserve).

native species is also present, including a number of significant species: Red Swainson-pea *Swainsona plagiotropis* (V,e), Silky Swainson-pea *Swainsona sericea* (v), Umbrella Wattle *Acacia oswaldii* (v), Bluish Raspwort *Haloragis glauca* f. *glauca* (k), Frosted Goosefoot *Chenopodium desertorum* ssp. *virosum* (k) and Plains Joyweed (k).

The grasslands also provide habitat for Plains-wanderer, Barking Marsh Frog *Limnodynastes fletcheri* (k) and Fat-tailed Dunnart *Sminthopsis crassicaudata* (k). Additional threatened taxa are likely to be identified following more intensive surveys.

The new Kotta Nature Conservation Reserve adjoins Glassons Grassland Reserve (a Private Protected Area owned by the Trust for Nature) to the west, and a property with a conservation covenant to the south, forming a consolidated unit of some 550 ha of protected Northern Plains Grasslands.

5. Corangamite Stony Rises Woodland, Pomborneit North

The endangered Stony Rises Herb-rich Woodlands remains almost unreserved in the eastern Victorian Volcanic Plain and, therefore, the purchase and reservation of this 53 ha woodland adjoining the western shores of the Lake Corangamite Ramsar wetland site is highly significant. Freshwater springs percolate through the basalt and form freshwater refuge areas that do not exist within Lake Corangamite due to its naturally high saline levels. This section of the lake frontage is significant due to the diversity of habitats that are linked along the western shoreline, specifically rocky outcrops, protected bays, freshwater springs and remnant vegetation (Fig. 3).

Manna Gum *Eucalyptus viminalis* and a Blackwood *Acacia melanoxylon*-Lightwood *A. implexa* woodland dominate the site. The area is likely to contain threatened flora such as the nationally vulnerable Spiny Pepper-cress *Lepidium aschersonii* (E,v), Button Immortelle

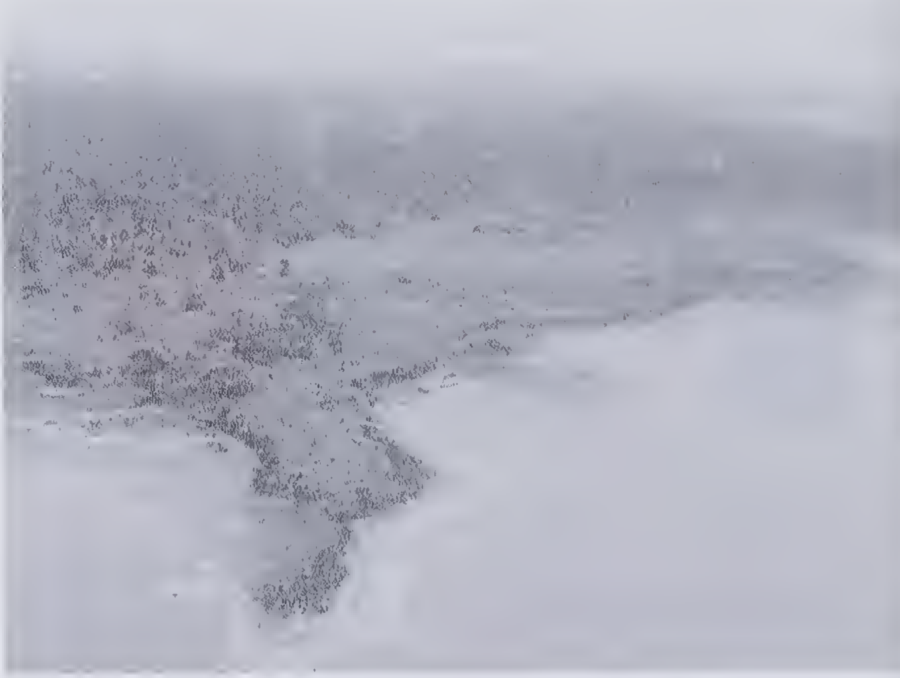

Fig 3. Bays and Stony Rises Herb-rich Woodland at the Pomborneit North Nature Conservation Reserve. Photo: Ian Smith.

Leptorhynchos waitzia (v) and Golden Dodder *Cuscuta tasmanica* (k). The area is known to contain the nationally endangered Corangamite Water Skink (Intermediate form) *Eulamprus tympanum marnieae* (E,ee). This species has an extremely limited area of suitable habitat that is not subject to disturbance from land management practices. A number of other threatened fauna species occur in the area.

The woodlands are reserved as the Pomborneit North Nature Conservation Reserve.

6. Mount Mercer Grasslands

The Mount Mercer Grassland is a relatively large remnant of Western (Basalt) Plains Grasslands located between Mount Mercer and Shelford. Only around 0.5% of the original extent of this community remains in the Victorian Volcanic Plain bioregion today (Barlow and Ross 2001).

Finer scale vegetation units include an extensive area of a Red Soils Grassland (low rainfall) and smaller areas of Grey-Brown Soils Grassland (low rainfall), Low rainfall Plains Grassy Wetland, Gorge Shrubland, Creekline Tussock Grassland and grassy woodland on the Leigh River escarpment (Ross 1999).

The Mount Mercer Grasslands adjoins other significant grassland remnants along the Shelford-Mount Mercer Road and gorge vegetation associated with the Leigh River and Cargerie bushland reserves.

Present on the site is the nationally endangered Small Scurf-pea *Cullen parvum* and Early Golden Moths *Diuris* sp. aff. *lanceolata* (Derrinallum), Clover Glycine *Glycine latrobeana* (V,v), Golden Cowslips *Diuris behrii* (v), Small Milkwort *Comesperma polygaloides* (v) and Hairy-tails *Ptilotus erubescens* (L). Mount Mercer Grasslands contains habitat suitable for the Plains-wanderer, Striped Legless Lizard *Delma impar* (V,e) and Golden Sun Moth *Synemon plana* (CE) (Ross 1999).

The grasslands are reserved within the 215 ha the Mount Mercer Nature Conservation Reserve.

7. Boonderoo Grasslands, Lethbridge

The Boonderoo Grasslands represent some 188 ha of Western (Basalt) Plains Grassland at Lethbridge, near Meredith. Three finer-scale Native Vegetation Units have been identified on the site – Grey-brown Soils Grassland, Plains Stony Knoll Grassland and Black Soils (Gilgai Plain) Grassland, with Red Soils Grassland occurring just to the north (Barlow 2001).

An assessment of Boonderoo Grassland and the adjoining grassland paddock to the north recorded 63 indigenous flora species (Barlow 2001). The Small Scurf-pea previously has been recorded on grasslands adjoining the new reserve. Other significant flora species include Spurred Spear-grass *Austrostipa gibbosa* and Rye Beetle-grass *Tripogon loliiformis* (r). The availability of habitat for threatened grassland fauna such as the Fat-tailed Dunnart and Striped Legless Lizard is confirmed, and is provided mainly by areas with extensive cover of surface rock.

The property also has significant landscape qualities, providing views which are largely uninterrupted by roads, developments and plantations which are increasingly common on the Victorian Volcanic Plain. The presence of undisturbed basalt rocky outcrops which cover the grassland are an important habitat and landscape feature, particularly considering their removal in other parts of the region to enable cropping and for stone industries. The property adjoins native grasslands to the north and south, effectively acting as a much larger grassland remnant.

The property is reserved as the Boonderoo Nature Conservation Reserve.

8. Urquhart Bluff Heathlands, Anglesea

This purchase protects an additional 48 ha of the Anglesea Heathlands, a National Trust listed landscape. The majority of the heathlands were purchased in the early 1990s (see Mosley 1993 and AHC 1997 for biological values of this area, and Thackway and Olsson 1999 for details of the purchase process). This particular part of the heathland provides habitat for Variable Bossiaea *Bossiaea heterophylla* (r), Rufous Bristlebird *Dasyornis broadbenti* (n) and Swamp Antechinus *Antechinus minimus* (n) (DSE 2003c). The Urquhart Bluff land is surrounded by the proposed Otway Ranges National Park (VEAC 2004).

9. Bullock and Decoy Swamps, French Island

The purchase of 75 ha of land surrounding the Bullock and Decoy Swamps on the northwest of French Island links the wetlands (which are already in French Island National Park) to the main body of the Park and consolidates the coastal strip which adjoins the newly-declared French Island Marine National Park.

French Island supports one of the largest relatively intact wetland areas remaining in south-eastern Victoria and acquisition of significant areas adjacent to the Park is seen as a high priority. The purchased land contains mosaics of heathlands and wetlands fringed by dense stands of Swamp Paperbark *Melaleuca ericifolia* and Coast Tea-tree *Leptospermum laevigatum*, as well as some disturbed areas. Specific EVCs are Swamp Scrub, Aquatic Herbland/Swamp Scrub Mosaic, Damp Sands Herb-rich Woodland, Coastal Saltmarsh, Estuarine Wetland/Estuarine Swamp Scrub Mosaic, Sand Heathland and Heathy Woodland. The Swamp Scrub EVC originally covered 163 000 ha of the Gippsland Plain bioregion, but has been reduced through clearing and draining to less than 8000 ha, which occurs mostly as small patches on private land.

The wetlands provide habitat for a variety of waterbirds, particularly waders (see Quinn and Lacey 1999). Significant species recorded from the swamps include King Quail *Coturnix chinensis* (ce), Great Egret *Ardea alba* (v), Caspian Tern *Sterna caspia* (v), Royal Spoonbill *Platalea regia* (v), Hardhead *Aythya australis* (v), Musk Duck *Biziura lobata* (v), Nankeen Night Heron *Nycticorax caledonicus* (n) and Blue-billed Duck *Oxyura australis* (v). Orange-bellied Parrots *Neophema chrysogaster* (E,ce) are known to visit both swamps during winter.

10. One Tree Swamp, Wanalta

This large 651 ha Cane Grass Wetland near Wanalta is part of a nationally important and interconnected chain of wetlands in the Victorian Riverina. This wetland type, dominated by Southern Cane Grass *Eragrostis infecunda*, is highly depleted in the bioregion. Other EVCs occurring on the site – Plains Grassy Wetland, Plains Woodland/Wetland Mosaic, Wetland Formation and Plains Grassland – are also all considered endangered.

One Tree Swamp is part of the Wallenjoe Wetland system which is listed under the *Directory of Important Wetlands in Australia* (Environment Australia 2001) and is also an Indicative Place on the Register of the National Estate (as part of the Lake Cooper Wetland System). The Australian Heritage Commission noted that 'out of 400 wetlands surveyed in Victoria, the Lake Cooper Wetland System is the most important system, in terms of numbers, for the Black-fronted Dotterel *Elseyornis melanops*. Fifty-one species of waterbird are found in the Lake Cooper Wetland System. This number of species is very large compared to numbers of species found on wetlands elsewhere in Victoria' (AHC 1995).

One Tree Swamp is considered one of the most important sites in Victoria for the Brolga *Grus rubicunda* (v). Other significant fauna recorded on the swamp includes Intermediate Egret *Ardea intermedia* (ce), Australasian Bittern *Botaurus poiciloptilus* (e), Great Egret (v) and White-bellied Sea-Eagle *Haliaeetus leucogaster* (v).

Based on presence in similar vegetation types nearby, One Tree Swamp is likely to provide habitat for Turnip-fruit Copperburr *Sclerolaena napiformis* (E,e), Stiff Groundsel *Senecio behrianus* (E,e), Slender Darling-pea *Swainsona murrayana* (V,e), Red Swainson-pea (V,e), Western Water-starwort *Callitriche cyclocarpa* (V,v), Ridged Water-milfoil *Myriophyllum porcatum* (V,v), Swamp Leek-orchid *Prasophyllum* sp. (Nagambie) (e) and Yellow-tongue Daisy *Brachyscome chrysoglossa* (v).

The new reserve adjoins the Two Tree Swamp Nature Conservation Reserve to the north, which also protects Cane Grassland Wetland, forming a combined protected area totalling approximately 790 ha. The new reserve is known as the One Tree Swamp Nature Conservation Reserve.

11. Youanmite Grassy Woodland

This block of 101 ha at Youanmite in the Riverina supports Plains Woodland, Drainage Line Complex and Shallow Sands Woodland/Plains Woodland Mosaic EVCs, ecosystems which have been severely depleted and are considered endangered in the bioregion. Of the estimated 67 000 ha of Shallow Sands Woodland/Plains Woodland Mosaic originally occurring in the Victorian Riverina, less than 350 ha has been mapped as remaining. This vegetation type was not previously represented in the reserve system. The size, mix of vegetation communities, and overall richness and diversity of the flora make this property significant. The large woodland patch provides a significant addition to the reserve estate as it includes examples of Buloke, cypress-pine and box woodlands and drainage-lines (in parts representative of the *Flora and Fauna Guarantee*-listed Grey Box-Buloke Grassy Woodland Community).

Significant flora species include Corkscrew Spear-grass *Austrostipa setacea* (r), Buloke, Smooth Minuria *Minuria integerrima* (r) and Forde Poa *Poa fordeana* (k). The property represents a range extension on the previous known extent for two species – Feather-heads *Ptilotus macrocephalus* and Hairy-tails (D Robinson pers. comm. 2002). In addition, a number of regionally significant flora and fauna have been recorded on the property. The Youanmite grassy woodland is also important for a number of representatives of the *Flora and Fauna Guarantee Act*-listed Victorian Temperate-woodland Bird Community.

The purchased land is near the Katamatite-Dookie Disused Railway Bushland Reserve which links to the Broken-Boosey State Park and will form an important part of the Broken Boosey Conservation Management Network (see ECC 2001). The woodlands are reserved as the Youanmite Nature Conservation Reserve.

12. Black Swamp, Boorhaman East

This new 16.2 ha Nature Conservation Reserve adjoins and consolidates the 126 ha Black Swamp (Black Dog Creek) Wildlife Reserve in Boorhaman East, northeastern Victoria (Fig. 4). The purchased land protects areas of Plains Woodland, with a sparse Grey Box *Eucalyptus microcarpa* overstorey, as well as a smaller area of the River Red Gum-dominated Wetland Formation EVC.

Fig. 4. Old River Red Gums, Black Swamp. Photo: James Fitzsimons.

Black Swamp is considered a significant example of a shallow freshwater marsh, a wetland type which may have been a relatively common feature in this part of Victorian Riverina (Environment Australia 2001). The swamp is listed on the *Directory of Important Wetlands in Australia* due to its importance for a large number and diversity of bird species and has supported regionally-important populations of nine species of colonial nesting birds including ibis, spoonbills, herons and cormorants (Environment Australia 2001). A number of significant species have been recorded on the swamp including: Intermediate Egret (ce), Barking Owl *Ninox connivens* (e), Australasian Bittern (e), Bush Stone-curlew (e), Little Egret *Egretta garzetta* (e), Freckled Duck *Stictonetta naevosa* (e), Squirrel Glider *Petaurus norfolcensis* (e), Australasian Shoveller *Anas rhynchotis* (v), Hardhead (v), Royal Spoonbill (v), Great Egret (v), and Nankeen Night Heron (n).

The site is reserved as the Black Swamp Nature Conservation Reserve.

13. Monea North Grassy Woodland

This 43 ha Riverina Plains Woodland remnant on the Euroa-Nagambie Plains also supports the severely depleted and under-reserved Gilgai Plains Woodland and Creekline Grassy Woodland EVCs (Fig. 5).

The woodland is dominated by a Grey Box overstorey with areas of Buloke and shrubs. Importantly, the site has never been cultivated, reflected by the high diversity and quality of the understorey, which is dominated by herbs and lilies. Significant flora species recorded on the property include Mueller Daisy *Brachyscome muelleroides* (V,e), Swamp Billy-buttons *Craspedia paludicola* (v) and Buloke.

The site provides habitat for three fauna species considered endangered in Victoria – Grey-crowned Babbler *Pomatostomus temporalis*, Squirrel Glider and Bush Stone-curlew, all of which are the focus of a strategic habitat protection and enhancement program on the Euroa-Nagambie Plains (see Ahern *et al.* 2003, Robinson and Howell 2003).

The purchase of the Monea North Grassy Woodland increases protection on the poorly-reserved Euroa-Nagambie Plains together with other recent purchases (e.g. Balmattum Nature Conservation Reserve) and conservation covenants signed on private land in the region (e.g. Creighton Hills woodland). The purchased land is

Fig. 5. Monea North Plains Grassy Woodland. Photo: James Fitzsimons.

reserved as the Monea North Nature Conservation Reserve.

14. Mitchelldale Grassy Woodlands, Tabberabbera

The 522 ha property, 'Mitchelldale', protects remote and scenic river frontages adjacent to the Mitchell and Wentworth Rivers near Tabberabbera in Gippsland, and includes forested ridgelines and gullies. The property adjoins 13 km of the Mitchell and Wonnangatta Rivers Heritage River.

Mitchelldale contains five EVCs – Grassy Woodland (approximately 50% of the property), Grassy Dry Forest (30%) and smaller occurrences of Herb-rich Foothill Forest, Dry Valley Forest and Valley Slopes Dry Forest. The property contains extensive areas of Grassy Woodland dominated by Red Box *Eucalyptus polyanthemos*, Yellow Box *E. melliodora*, Red Stringybark *E. macrorhyncha* and White Stringybark *E. globoidea*. It is believed that this overstorey combination only occurred at one other locality in east Gippsland, but that site has now been cleared. Grassy Woodland is considered an endangered and vulnerable EVC in the Gippsland Regional Forest Agreement having been reduced to less than 29% of its original extent. Some of this community is considered to be old growth. The juxtaposition of a rainshadow river valley with Grassy Woodlands and Warm Temperate Rainforest and Dry Rainforest is not matched by any reserve in Victoria. The Grassy Woodland EVC supports bird species more typical of woodlands north of the Great Dividing Range, many of which have declined rapidly in population size and extent over the last twenty years.

Surveys have identified up to 116 indigenous flora species of which up to six are rare or threatened: Clover Glycine (V,v), Large Tick-foil *Desmodium brachypodum* (v), Delicate New Holland Daisy *Vittadinia tenuissima* (r), Spicy Everlasting *Ozothamnus argophyllus* (r) and Skeleton Vine *Clematis microphylla* var. *leptophylla* (k).

Along with Mitchelldale, other land totalling some 2 160 ha was added to the Mitchell River National Park in 2002. These other additions included the formerly proposed dam site at Angusvale, adjacent Crown land water frontages and some linking areas of non-productive State forest.

Other purchases

Other small purchases for conservation and/or heritage purposes include Steiglitz township land within the Steiglitz Historic Park, a 45 ha addition to the Castlemaine Diggings National Heritage Park, a 6 ha Buloke woodland at Cardross and an addition to the Phillip Island Nature Park. The State also received a generous donation of a 179 ha property containing Loamy Sands Mallee, Broombush Mallee and Red-swale Mallee EVCs for addition to the Wyperfeld National Park.

Future directions for land purchase and the protected area system

Negotiations for the purchase of other properties with poorly reserved 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. 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.

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Appendix 1. Some species occurring (or likely to occur) in 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) CE, critically endangered; E, endangered; V, vulnerable. Derived from DSE (2003a, 2003b), *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*	Swamp Antechinus	n	L	
	Petaurus norfolcensis	Squirrel Glider	e	L	
	Potorous tridactylus tridactylus	Long-nosed Potoroo	e	L	V
	Pseudomys fumeus	Smoky Mouse	e	L	E
	Pseudomys shortridgei	Heath Mouse	n	L	V
	Sminthopsis crassicaudata	Fat-tailed Dunnart	n		
Birds	*Anas rhynchotis*	Australasian Shoveller	v		
	Ardea alba	Great Egret	v	L	
	Ardea intermedia	Intermediate Egret	ce	L	
	Aythya australis	Hardhead	v		
	Biziura lobata	Musk Duck	v		
	Botaurus poiciloptilus	Australasian Bittern	e	L	
	Burhinus grallarius	Bush Stone-curlew	e	L	
	Coturnix chinensis	King Quail	ce	L	
	Dasyornis broadbenti broadbenti	Rufous Bristlebird	n	L	
	Egretta garzetta	Little Egret	e	L	
	Elseyornis melanops	Black-fronted Dotterel			
	Grus rubicunda	Brolga	v	L	
	Haliaeetus leucogaster	White-bellied Sea-Eagle	v	L	
	Neophema chrysogaster	Orange-bellied Parrot	ce	L	E
	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		
	Pomatostomus temporalis	Grey-crowned Babbler	e	L	
	Sterna caspia	Caspian Tern	n	L	
	Stictonetta naevosa	Freckled Duck	e	L	
Reptiles	*Eulamprus tympanum marnieae*	Corangamite Water Skink (Intermediate form)	ce	L	E
	Delma impar	Striped Legless Lizard	e	L	V
Amphibians	*Limnodynastes fletcheri*	Barking Marsh Frog	k		
Fishes	*Galaxias olidus*	Mountain Galaxias	k	L	
Invertebrates	*Synemon plana*	Golden Sun Moth		L	CE
Plants	*Acacia implexa*	Lightwood			
	Acacia melanoxylon	Blackwood			
	Acacia oswaldii	Umbrella Wattle	v		
	Allocasuarina luehmannii	Buloke		L	
	Alternanthera sp. 1 (Plains)	Plains Joyweed	k		
	Austrodanthonia caespitosa	Common Wallaby Grass			
	Austrostipa aristiglumis	Plump Spear-grass			
	Austrostipa gibbosa	Spurred Spear-grass			
	Austrostipa scabra	Rough Spear-grass			
	Austrostipa setacea	Corkscrew Spear-grass	r		
	Bossiaea heterophylla	Variable Bossiaea	r		
	Brachyscome chrysoglossa	Yellow-tongue Daisy	v	L	
	Brachyscome muelleroides	Mueller Daisy	e	L	V

Scientifie Name	Common Name	Vie Status	FFG	Cwlth Status
Callitriche cyclocarpa	Western Water-starwort	v	L	V
Chenopodium desertorum ssp. *virosum*	Frosted Goosefoot	k		
Chloris truncata	Windmill Grass			
Clematis microphylla var. *leptophylla*	Skeleton Vine	k		
Comesperma polygaloides	Small Milkwort	v	L	
Craspedia paludicola	Swamp Billy-buttons	v		
Cullen parvum	Small Scurf-pea	e	L	E
Cuscuta tasmanica	Golden Dodder	k		
Desmodium brachypodum	Large Tick-foil	v		
Diuris behrii	Golden Cowslips	v		
Diuris sp. aff. *lanceolata* (Derrinallum)	Early Golden Moths	e	L	E
Enteropogon acicularis	Spider Grass			
Eragrostis infecunda	Southern Cane Grass			
Eucalyptus camaldulensis	River Red Gum			
Eucalyptus globoidea	White Stringybark			
Eucalyptus leucoxylon	Yellow Gum			
Eucalyptus macrorhyncha	Red Stringybark			
Eucalyptus melliodora	Yellow Box			
Eucalyptus microcarpa	Grey Box			
Eucalyptus polyanthemos	Red Box			
Eucalyptus viminalis	Manna Gum			
Glycine latrobeana	Clover Glycine	v	L	V
Haloragis glauca f. *glauca*	Bluish Raspwort	k		
Leiocarpa panaetioides	Woolly Buttons	r		
Lepidium aschersonii	Spiny Peppercress	v	L	E
Leptorhynchos waitzia	Button Immortelle	v		
Leptospermum laevigatum	Coast Tea-tree			
Leucopogon neurophyllus	Veined Beard-heath	r		
Melaleuca ericifolia	Swamp Paperbark			
Minuria integerrima	Smooth Minuria	r		
Myriophyllum porcatum	Ridged Water-milfoil	v	L	V
Ozothamnus argophyllus	Spicy Everlasting	r		
Pimelea pagophila	Grampians Rice-flower	v		V
Poa fordeana	Forde Poa	k		
Prasophyllum lindleyanum	Green Leek-orchid	v		
Prasophyllum sp. (Nagambie)	Swamp Leek-orchid	e	L	
Ptilotus erubescens	Hairy-tails		L	
Ptilotus macrocephalus	Feather-heads			
Sclerolaena napiformis	Turnip-fruit Copperburr	e	L	E
Senecio behrianus	Stiff Groundsel	e	L	E
Swainsona murrayana	Slender Darling-pea	e	L	V
Swainsona plagiotropis	Red Swainson-pea	e	L	V
Swainsona sericea	Silky Swainson-pea	v		
Thelymitra benthamiana	Blotched Sun-orchid	v		
Tripogon loliiformis	Rye Beetle-grass	r		
Vittadinia tenuissima	Delicate New Holland Daisy	r		
Xanthorrhoea caespitosa	Tufted Grass-tree	r		

Appendix 2. Some listed *Flora and Fauna Guarantee Act 1988* communities occurring on recently purchased land.

Western (Basalt) Plains Grassland Community	Grey Box-Buloke Grassy Woodland Community
Northern Plains Grassland Community	Victorian Temperate-woodland Bird Community

James Howard Browne OAM

5 September 1919 – 31 March 2004

Howard Browne was born in Melbourne and grew up in Red Cliffs in north-west Victoria. He served in the Australian Army in World War II, including service as an anti-aircraft gunner during the Japanese bombardment of Darwin, and in the 2/8th Commando Squadron. After the war, he returned to Red Cliffs and worked as a landscape gardener for the Mildura Shire Council. In that capacity, he designed and established innovative street plantations of native plant species. By the early 1970s, Howard Browne had developed a keen interest in the flora of north-west Victoria, and had become a competent amateur botanist. The region's flora had been studied since 1836, beginning with Major Mitchell. In the immediate post-WWII era, important contributions had been made by Mr Tom Henshall and Mrs Eileen Ramsay, who identified ten new native species for the Victorian flora. Their work was so substantial that, in 1975, the retired Acting Government Botanist, Dr JH Willis, wrote 'as a result of Ramsay's & Henshall's ... efforts, it is unlikely that any substantial additions will ever be made to the present list of species for far north-west Victoria' (Willis 1975).

Howard's first important discovery was in 1974, when he made the first Victorian record of Twining Purslane *Calandrinia volubilis*. This was the first time since 1863 that the plant had been collected anywhere in Australia.

Since that time, Howard identified a further 17 species of Victorian flora (see Appendix 1) as well as contributing many other important records. In the course of his field work, Howard prepared many excellent herbarium specimens and donated them to the National Herbarium. He also made a major contribution to searching for, and mapping, those north-west Victorian plant species which are at risk or threatened with extinction, having studied in detail the surviving stands of 25 such species. His liaison with local authorities and government departments during this work made a very valuable contribution to plant conservation. His interest in plants has also been brought to bear on local weed problems – e.g. his discovery and subsequent notification of the noxious weed Ivy-Leaf Sida (*Malvella leprosa*) in the Irymple area.

From 1978 to 2002, Howard was of tremendous help to teaching and research at La Trobe University's Botany Department. On a purely voluntary basis, he worked for literally thousands of hours as a co-worker on projects on the taxonomy, ecology and conservation of Victorian native plants. Because he knew north-west Victoria and its vegetation so well, he was invaluable in guiding other research workers to plants and areas for use in research work, and in helping initiate new field research projects for Honours and post-graduate students. Being on the spot, he often monitored plots, watered experimental plantings and advised on growth, flowering and fruiting behaviour. Every year he collected and sent arid zone plants for undergraduate practical classes. He was an obliging guide for visiting botanists who wanted to see the local plants. He also collected seeds and specimens for many overseas laboratories.

In October 1988, Howard took part in the Chowilla Floodplain Biological Study of the Nature Conservation Society of South Australia, which helped determine land use of the Chowilla Floodplain. During that project he made the first collection of Wavy Marshwort *Nymphoides crenata* in South Australia since 1924, as well as other important records.

The Victorian Land Conservation Council determined future land use for Public Land in the Mallee in 1989. Howard's data were invaluable in establishing what plants and plant communities were under-reserved.

From 20 to 23 October 1989, at the invitation of the Museum of Victoria, Howard helped to lead the Vegetation Section of their Mallee Environment Education Project at Hattah-Kulkyne National Park. This involved supervising the field work of the participants, who were secondary

Howard Browne at his home in Red Cliffs in 1991. Photo supplied by Faye Browne.

school teachers from all parts of Victoria, but especially the Mallee.

Howard was a highly skilled plant photographer, both for whole-plant photos and for close-ups. Some of his work appears in Margaret Kelly's book 'An Introduction to the Wildflowers of the Millewa' (Kelly 1989).

From 1991 to 1995, Howard made valuable collections of mosses and liverworts. Nearly all are from grid A (far north-west Victoria); these records were published as part of Table 2 in Eldridge and Tozer (1996). His list of 22 moss species and 14 liverworts is the most detailed one from north-west Victoria. Nine of those species are not on the other two published lists for semi-arid Victoria (Eldridge and Tozer 1996). Most of these records are from the Merbein-Mildura-Red Cliffs area, and from Hattah-Kulkyne National Park and Murray-Kulkyne Regional Park. However, there are also important collections from the Raak Plain and from Yarrara and Mallanbool Flora Reserves. The collections were lodged at the National Herbarium of Victoria (where they were determined by AW Thies) and at the School of Botany, University of Melbourne (determined by the late Dr GAM Scott). Howard also made a few lichen collections in 1996-97; eight collections housed at the Tasmanian Herbarium (determined by Dr G Kantvilas) and eight collections housed at the National Herbarium of Victoria (determined by Dr DJ Eldridge).

A striking step Howard always took was to ensure that important data he collected were regularly forwarded to the relevant authority. He believed that the relevant land manager was best placed to apply protective measures to conserve the threatened plant populations that he so often discovered. He understood that no protection could be assured whilst he alone held the knowledge that he gathered. He applied the principle, outlined in Victoria's Biodiversity Strategy over a decade later, that everyday action by individuals in concert with government authorities was essential to achieve conservation objectives. Howard submitted species lists for in excess of 400 sites, most of which contained threatened species. As a consequence, conservation of many of the Victorian Mallee's threatened plant populations has been significantly enhanced, an outcome that was always Howard's aim.

Records of various populations of threatened species (e.g. the nationally threatened Club Spear-grass *Austrostipa nullanulla*) that Howard discovered on the Raak Plain, his favourite haunt, have lead to protective works being implemented there. Similarly, Howard's revelations of Limestone Sida *Sida spodochroma* locations, led to fencing of four populations from rabbit, kangaroo and vehicle damage, as well as an ongoing monitoring study of the relative importance of these disturbances to survival of this species. The regular monitoring Howard completed on the four tiny Victorian populations of Mallow-leaf Lantern-flower *Abutilon oxycarpum*, and the only known Victorian population of Low Hibiscus *Hibiscus brachysiphonius*, led to the publication of a paper revealing the key meteorological conditions required for germination and growth of these two endangered species (Parsons and Browne 2000). This information was otherwise not known to science.

Much of Howard's work has led to formal recognition of the threatened status of many species. A number of Action

Statements have been prepared by the Department of Sustainability and Environment on the basis of data and advice from Howard. Dwarf Lantern-bush *Abutilon fraseri*, Pale Plover-daisy *Leiocarpa leptolepis*, Bead Glasswort *Halosarcia flabelliformis*, and Limestone Sida are Mallee species listed as threatened on the Flora and Fauna Guarantee Act 1988. Formal Action Statements have been published to provide for their ongoing protection and a lasting legacy for all.

In 1991, Howard was awarded a medal of the Order of Australia and in 1992 an honorary Master of Science by La Trobe University.

Although Howard Browne had no formal training in botany, his botanical work is a striking example of what can be achieved by enthusiasm, tenacity and a flair for spotting differences between plants in the field, as well as the drive and intelligence to read widely and think deeply about botanical concepts. The legacy of his work is an improved understanding of the flora of north-west Victoria and how to conserve it. For this, future generations will be greatly in his debt.

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JH Browne – other research

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RF Parsons
Botany Department, La Trobe University
Bundoora, Victoria 3086

and

GG Allen
Department of Sustainability and Environment
PO Box 905, Mildura, Victoria 3500

Appendix 1. JH Browne – significant plant records. *indicates introduced species.

A. 1st record for Victoria
- *Abutilon oxycarpum*
- *Austrostipa nullanulla*
- *Bergia trimera*
- *Calandrinia volubilis*
- *Dysphania simulans*
- *Halosarcia flabelliformis*
- *Hibiscus brachysiphonius*
- *Limonium companyonis*
- *Phyllanthus lacunellus*
- *Rhagodia ulicina*
- *Sclerolaena decurrens*
- *S. intricata*
- *S. lanicuspis*
- *S. ventricosa*
- *Sida spodochroma*
- **Suaeda linifolia*
- *Swainsona stipularis*
- *Tribulus minutus*

B. 1st Victorian collection since 1897
- *Halosarcia syncarpa*

C. 2nd record for Victoria
- *Aristida holathera*
- **Frankenia pulverulenta*
- *Frankenia serpyllifolia*
- *Halosarcia nitida*
- *Hemichroa diandra*
- *Maireana georgei*
- *Rhodanthe stricta*
- *Sauropus trachyspermus*
- *Sclerostegia moniliformis*
- *Zygophyllum compressum*

D. 3rd record for Victoria
- *Brachyscome trachycarpa*

E. 4th record for Victoria
- *Bergia ammanioides*

F. 1st record for New South Wales
- *Halosarcia lylei*
- *H. nitida*
- *H. pruinosa*
- **Neatostema apulum*

G. 2nd record for New South Wales
- *Atriplex papillata*

H. 1st record for South Australia
- *Atriplex papillata*

Stephen Alfred Craig

1953 - 2004

Family and friends celebrated the life of Steve Craig, conservationist and naturalist, on 30 June 2004. Steve passed away after a courageous four-year battle with cancer.

Steve's career commenced with the Fisheries and Wildlife Department at the Arthur Rylah Institute where he worked in research teams led by Robert Warneke and John Seebeck. He studied various species of native fauna, including the Australian Fur Seal, Mountain Brushtail Possum, Brush-tailed Phascogale, Long-footed Potoroo, Leadbeater's Possum and Yellow-bellied Glider. Steve helped set up the Forest Ecology Research Station at Cambarville where research into possums, gliders and small mammals was undertaken. His research contributed greatly to the knowledge of the then little-known Yellow-bellied Glider, and he became an expert on the ecology of this species (Craig 1985; Craig 1986; Craig and Belcher 1980; Henry and Craig 1984).

Steve later moved into the Field Management section of the department where he felt he could have a greater influence on issues relating to conservation and the environment. He was particularly concerned with the loss of mature forests and hollow bearing trees and the impact this would have on many wildlife species. He was convinced also of the importance of conservation on private land and assessed many properties, encouraging landholders to undertake voluntary conservation of habitat, many of whom joined the Land For Wildlife program.

Steve joined the Field Naturalist Club of Victoria in 1986. He contacted the Fauna Survey Group in 1988 about his concerns regarding the lack of knowledge of Leadbeater's Possum distribution in Mountain Ash timber production forests. Fauna Survey Group (FSG) stagwatching surveys commenced in July 1988 in the forests near Powelltown, and continue to this day. In his capacity as a Flora and Fauna Planning Officer he used information gained from these surveys to argue the case for the conservation of Leadbeater's Possum habitat in production forests destined for clearfelling.

Steve attended most of the surveys and, when possible, still came along during his years of illness. He was always willing to convey his knowledge of wildlife and forest conservation issues to the many people who have attended these surveys.

In 1996 Steve and the FSG revived a nest box survey for Brush-tailed Phascogales in the Christmas Hills area, which he had undertaken a few years earlier. The FSG checks and maintains these nest boxes annually and Steve considered the continued monitoring of this species an important conservation objective. He served on the Brush-tailed Phascogale Co-ordinating Group as the Port Phillip representative for the Department of Sustainability and Environment (DSE).

Steve was a resident of the 'Round the Bend Co-operative' in the environmental living zone at Christmas Hills, where he was involved with community conservation and environmental pursuits. He was a committee member of the Bend of Islands Conservation Association and represented the Association on various environmental issues. He organised activities such as the erection and checking of nest boxes on residents' properties, Koala counts and night walks and campaigned to encourage the use of plantation-grown Sugar Gum firewood instead of box and Red Gum.

Powerful Owls were also one of his major interests. He was an expert tree climber and, making use of this skill, spent many years in partnership with Ed McNab banding Powerful Owl chicks, which he carefully removed from the nest, returning them safely to their deep hollows after banding. At other times he was out alone or with Bob Taylor and other friends searching for breeding pairs and their nest locations.

Steve instigated formation of 'The Friends of the Helmeted Honeyeater' in May 1989 and served on the first committee. Steve brought much relevant information to the notice of members and was actively involved in fencing and tree planting. He was made an early life member of that group. He inspired the formation of the Yarra Valley Tree Group in the same year and remained an active member with that organisation.

DSE has commemorated Steve Craig's passing with the introduction of the Stephen A Craig Fellowship – Graduate Program to be awarded every two years.

Another tribute comes from the Healesville Sanctuary Staff who will erect a commemorative plaque in recognition of his conservation work, especially with the Powerful Owl.

Steve will be sadly missed by his partner Val, his children Marnie and Ben, their mother Annys, and by many friends who will continue to be inspired by his dedication to wildlife conservation and the environment.

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Raymond Gibson
26 McCulloch Street
Nunawading 3131

Australian trees in southern India

I am currently working as an environmental volunteer in the mountainous Nilgiris District of Tamil Nadu State, southern India.

The Nilgiri mountains form part of the Western Ghats, a long mountain range extending down the western side of peninsular India. An abruptly elevated area known as the 'upper plateau' dominates the Nilgiris, beginning on average at about 1800 metres and reaching an altitudinal peak of over 2630 metres. The plateau is a very scenic landscape of rolling hills and valleys, with virtually no areas of flat land. Whilst located in the tropical zone of southern India, the plateau has a temperate climate due to its high elevation. As such it was a favoured spot for the English Raj to escape the hot summer months on the plains and they subsequently established a hill station in the Nilgiris from the 1820s onwards.

The Nilgiri mountains are an ecologically rich landscape and make up part of the Nilgiri Biosphere Reserve. Historically, the plateau itself supported two distinctive vegetation communities. Wet Montane Temperate Forest (locally known as Sholas) is a rainforest community and is mainly restricted to the stream heads and upper valleys in the folds of the rolling hills, where it is protected from the harsh weather conditions. The second, most extensive, community was Grassland, which occurred over the rolling hills and valleys not occupied by Shola.

Whilst the physical boundaries of the Sholas and Grasslands are very abrupt and appear almost unnatural, there is a relationship between the two communities. The Grasslands have a tremendous water harvesting capacity, not only of the monsoon rains, but even more importantly of the year round mist and dew which is so prevalent on the plateau. In the cool of the mountain slopes, the moisture is captured by the leaf blades and absorbed by the roots of the grass, then gradually percolates down into the Shola forests. The Sholas act as huge sponges, retaining and then slowly releasing this water, with the result that most of the streams on the plateau were once perennial.

Change in land use since the early to mid 1800s has resulted in major clearing and disturbance of these communities. The plateau is now dominated by monocultures of tea plantations and vegetables, along with extensive plantations of Australian tree species, predominantly Blue Gum *Eucalyptus globulus* and Black and Silver Wattle *Acacia mearnsii* and *A. dealbata* respectively. The eucalypts were planted as a source of fuelwood between the mid 1800s and the early 1990s, and now cover over 20 000 acres of land owned by the Forest Department. Wattles, also introduced in the 1800s, were extensively planted for fuelwood and later the tannin industry.

Major remnants of the Sholas and Grasslands currently exist only in the south-west corner of the plateau, with one of the remaining strongholds being Mukurthi National Park. This park, which is located south-west of Ooty (the District's main town), has an average elevation of 2400 metres. I spent a very wet weekend in Mukurthi in late August 2003. I arranged accommodation at the 'Fishing Hut', owned by the Nilgiri Wildlife and Environment Association, an organisation with similar aims and activities to the FNCV. The Hut is located in Reserved Forest (a land category that can include indigenous or plantation forest areas that are usually utilised for wood production) just outside the Park boundary, set amongst thick stands of wattle. The wattle thickets are so dense that virtually nothing grows underneath them, with all other species displaced.

I set off for a walk from the Hut to explore the National Park. After a while I asked my guide at what point we would cross the boundary from Reserved Forest into National Park. To my surprise, he replied that we had entered the Park some distance back. My shock stemmed from the fact that we were still walking through dense thickets of wattle.

After progressing a little further, we finally emerged from the wattle onto the open native Grasslands. A rush of excitement came as I discovered a high diversity of species all around me, from grasses to orchids, many in flower. As we walked on we passed in and out of sheltered gullies that supported thin strips of Shola forest, dissected by small raging streams fed by the monsoon rains.

However, as the mist and rain cleared, enthusiasm for the scene waned as I looked across the valleys and hills and observed Wattles slowly creeping in from all directions. From dense thickets of a few hectares, to isolated clumps of a dozen or so trees, or individuals dotted on high slopes in the distance, the scene was horrifying. The advance of the wattles was outcompeting the Grasslands.

As previously mentioned, the Park is considered one of the last strongholds for extensive tracts of Shola and Grassland communities on the plateau. Yet here they were, being invaded by trees from my own country. Having spent the last 10 years experiencing and confronting foreign plant invaders in Victoria, I was now in the position of appreciating the reversed role, my loved plants destroying a different ecosystem.

Damian Magner
sophdamc@yahoo.com.au

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The Nature of the Midlands

by J Dean, J Kirkpatrick, L Gilfedder, H and A Wapstra

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The 'Midlands' of the book title is a distinctive area of Tasmania – essentially the lowland plains, now largely cleared for agriculture, which are flanked by the Eastern and Western Tiers. *The Nature of the Midlands* is an unusual and interesting book: it is interesting in that it contains very different sorts of information – an overview of the environmental history of the Midlands, oral histories from Midlands land owners, and what is essentially a guide to the flora of the Midlands. It is unusual in that it is a community-driven product: it has been developed out of a broader community environmental project (the Midlands Bushweb Project) and its purpose is to draw together the various information from that project to provide a resource to the people of the Midlands for ongoing land management.

In spite of its local focus, it is a book that should appeal to a range of readers – for example field naturalists interested in identifying Tasmanian species in a particular environment; Tasmanians who are interested to know more about this particular part of Tasmania; and visitors to Tasmania with an interest in the vegetation and environmental history of Tasmania.

The book is an attractive and colourful 172 page paperback publication with three distinct sections:–

1. *Glimpses of a Changing Landscape* (41 pages) which is a collection of nine edited oral histories that explore local landowners' relationship with the Midlands. This section is valuable as a rare collection of oral history material from the area, and is a delight to read as these voices bring the Midlands alive for the reader. The observations of the oral informants are at times thought provoking and there is considerable reassurance for those who are concerned with rural environmental degradation.
2. An offering entitled *Natural History* (12 pages), which is a high-powered ramble through the history and present day environment of the Midlands, covering its geological evolution, a description of the soils, what is known of the Aboriginal history, a description and (in places) reconstruction of the vegetation and its history, a brief description of the fauna, and the ecosystems and human (Aboriginal and non-Aboriginal) impacts on the Midlands. Although dense and with quite a high content of scientific terms, it is packed with information and synthesises a wide range of often inaccessible sources. The reference list alone is of value as a list of 'further reading' on the Midlands environment and Aboriginal history.
3. *Focus on the Flora*, which is the core part of the publication (107 pages). This section is essentially a photographic guide to the flora of the Midlands with an introductory description of major Midlands vegetation types and some contextual information, a checklist of native plants of the Midlands (by family) and an index (of botanical and common names) to the illustrated plants. This guide is written in a way that makes it highly accessible to any readers regardless of their level of knowledge of botany – with the introduction and plant descriptions being brief and written in clear, plain English with minimal use of technical terms. Each plant description consists of a photograph, a description of the plant, including typical location, conservation status, whether used by Aboriginal people and its economic use, if any. The photographs are in general excellent.

Although this is a quality product, I have a few criticisms. My main criticism is that the title gives one few clues about what is really between the covers. It was no doubt difficult to find a title which accurately reflects the unusual style of this book. However, I do feel that something such as 'The Flora of the Midlands and its environmental and human history' would have been a somewhat truer title. Given the title, the information on aspects such as the fauna and the landforms (geomorphology) is very limited, there is no consideration of the cultural landscapes of farming history (i.e. introduced vegetation), which are notable in the northern Midlands, and I question the appropriateness of including Aboriginal history.

Some readers may require visual aid: the font size throughout the book is very small.

I was also disappointed in the lack of geographic information (i.e. spatial distribution information). This is frustratingly sparse in the text and there is not a single map - not even one of the Midlands showing the major place names. While this may be understood given the aim and origin of the book, it is a frustrating gap and, in my view, detracts from what is otherwise a very informative and accessible publication.

There are some minor blemishes that affect the appearance, but do not affect overall performance.These include some aspects of the presentation that could have been improved by tighter editorial control – e.g. lack of linkage of photographs to text in much of Sections 1 and 2; and some difficult-to-read paragraphs in Section 2.

In spite of my quibbles about the book, it is a valuable addition to the Tasmanian library of environment and history related books. It provides the first comprehensive listing of the native plants of the Midlands and an excellent guide to over 50 % of the known plants of the area: and it provides an insight into the human history of the Midlands and the stories, views and values of the present-day people of the Midlands. I will be keeping and using my copy, and commend the book to those with an interest in native vegetation or who are visiting the Midlands!

Anne McConnell
Consultant, Cultural Heritage Management
Archaeology and Quaternary Geoscience,
Hobart, Tasmania 7000

Bush Seasons: an affectionate study of a tiny bushland

by Joan Semmens

Publisher: *Hyland House Publishing, Flemington, Victoria, 2002.*
320 pages, colour. ISBN 1864470518. RRP $49.95.

Bush Seasons is truly a delight to read and admire. It is the work of a keen observer with highly developed skills of observation and reporting. Joan Semmens starts her year in the month of May and records with obvious delight the events of the passing seasons in words and exquisite watercolour paintings. It is the work of a true naturalist and should become a classic in the Australian natural history literature.

Bush Seasons is the story of a small Bushland Reserve (McKenzie Reserve) of about 45 hectares near the town of Alexandra in Victoria. In her introduction Joan Semmens says 'The Bushland has no spectacular beauty, no instant gratification – only an artless placement of colour, shape and shadow … a purity of sound … a fragrance of leaf and of earth … and a quiet stillness.' Her heart is exposed when she goes on to say 'That (this) is the true enchantment of the Australian bush. It reveals itself slowly to those who open their senses to it.' The reader is led with real delight into this enchantment through the eyes and the words of the author.

The introductory chapter is an essay on the history and environment of the reserve. It deals with the geological history, the Aboriginal history, and the different periods of European occupancy, from the squatter, the gold miner and then the farming settlement. The administrative history of the reserve reflects changing community attitudes towards the land and the bush. Probably its greatest asset was the fact that

the land was considered too poor for agricultural development, so it was never taken up for private tenure. It was common land used for grazing and limited timber and firewood harvesting.

Only as recently as 1978 was the land reserved as a Bushland Reserve under the Lands Act, with a Committee of Management comprising representatives of the Shire and local naturalists. Only then was grazing discontinued. In a real sense the history of this Reserve represents a microcosm of historical and environmental changes which have taken place in the broader Australian landscape since settlement.

The main section of the book is the visual diary, detailing the annual march of seasons from May to April. The May start certainly reflects the reality of the seasons in this part of Victoria. Autumn rains usually become established by May and the bush reacts to what farmers call 'The Break'. Each chapter/month is prefaced with a very sensitive full page watercolour of a bush scene. This is followed by illustrations and descriptions of notable species of plant and animal. The dominance of fungi during the autumn and winter is reflected in the illustrations of June and July. Wattles, lichens and mosses dominate in August, followed by the great diversity of 'wildflowers' in September through to November. Both native and introduced plants are included, which honestly reflects the reality of the part 'weeds' play in these small areas of bushland formerly used for grazing etc.

Both scientific and common names are given for the plants, along with the authority. Brackets below the name explain the meanings of both the generic and specific names. The very informative description includes features of the ecology and distribution that convey so much more about the nature of the plant. Obviously this book has been well researched.

The book concludes with three important lists: first, an illustrated list of birds seen in the reserve, then a Flora list and finally a Fauna list. In future these will be very important for those who are inspired to continue this study. There is a substantial bibliography and an index, which makes information in the book very accessible. The aerial photograph of Alexandra and district certainly highlights the extent of landscape change that has occurred in 200 years, and the extreme value of the bushland reserve, providing a reference point to our understanding of our bush heritage.

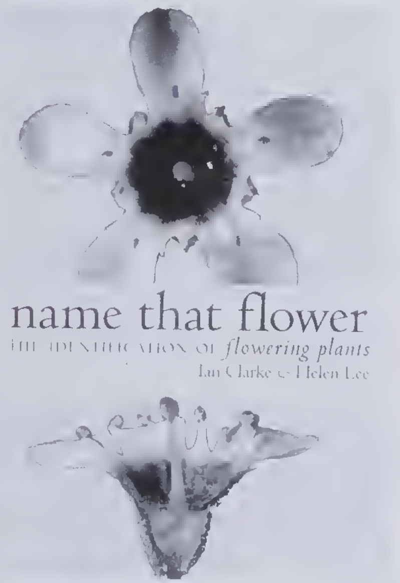
To me, this is a most impressive publication, reflecting exceptional skills in observation and research. Joan Semmens has brought to all field naturalists a wonderful work of love, commitment, beauty and knowledge which sets the standard for all future personal studies of our local bushland. It should be on all our shelves as a case study of inspiration.

Malcolm Calder
375 Pinnacle Lane
Steels Creek, Victoria 3775

Name that Flower: the Identification of Flowering Plants

by Ian Clarke and Helen Lee

Publisher: *Melbourne University Press, Carlton, Victoria, 2003. 2nd edition. 344 pages, paperback, colour photographs, line drawings. ISBN 052285060 X. RRP $34.95.*



Plant identification often is regarded as a simple process – by those who read the tags on plants they've bought or ask someone else, or, of course, the expert. But for most who wish to do the identification themselves, it is not necessarily an easy task, especially for the amateur. There are many illustrated coffee table books but which of these should one delve through to identify a particular specimen? There also are many regional floras, but to choose the appropriate flora one must know the natural distribution of the plant of interest. Much redistribution has occurred in the time of European settlement. This is where *Name that Flower* comes to the rescue. It explains the mysteries of floral structure with the aid of excellent diagrams, photographs and a glossary. Similarly, plant classification is explained simply and concisely as is the use of various types of botanical keys, for which worked examples are provided. Clarke and Lee make an important point in the use of keys, which is sometimes forgotten by the novice: that is, once a plant has been 'keyed out', it is important to check the identification against written descriptions or illustrations. Most keys are written for the plants of a particular region, so, plants introduced to an area frequently are not included although they may key out quite easily, but to an incorrect answer!

In this edition a number of changes and additions are listed in the Introduction. Needless to say, nomenclature has been updated. The treatment of the family Chenopodiaceae has been enlarged, and treatments of the Solanaceae and Myoporaceae have been included. Notes on the relevance of computers to plant identification and the use of the internet in accessing information have been added. The bibliography has been enlarged to include most of the relevant books published in the last fifteen years. Also, discussion of classificatory problems, such as the assignation of rank, has been included using the genera *Eucalyptus*, *Corymbia* and *Angophora* in the treatment of the Myrtaceae.

Treatments of 35 families are provided. Each treatment includes a brief overview of the family, for example, derivation of the family name, distribution of the family, the number of Australian representatives and commercial examples of the family. The floral structure and spotting characters are provided to aid rapid identification of the family. Drawings of half flower diagrams and ovary cross sections of representative species also are provided with their floral formulae. In the treatment of the Myrtaceae, there is a considerable discussion of the genus Eucalyptus, including its classification, bud, flower, fruit, leaf and bark characteristics, growth form and recovery after fire. Considering the size of the genus and its importance to the Australian landscape. this is appropriate. Considerable space is devoted to describing the complex floral structure of the Asteraceae and the variation in inflorescence structure. Again, this is appropriate because of the size and worldwide importance of the family.

The first edition of *Name that Flower* was excellent. The second edition is even better! It contains more. However, it can be improved – by including even more. No drawings have been provided for the Lauraceae, Loranthaceae, Droseraceae, Myoporaceae, Brunoniaceae or Xanthorrhoeaceae, although photographs of representative species of each of these families are included. Hopefully the third edition will include yet other families. This book is well worth the $34.95!!!

Maria Gibson
School of Biological and Chemical sciences
Deakin University
Burwood, Victoria 3125

FNCV Environment Fund

Final and Interim Reports for the grants of 2003

The FNCV Environment Fund supported several projects in 2003. Some projects have been completed while others are still in progress. The reports are presented here.

Bat trap renovation project

For many years, the Fauna Survey group has used four bat traps to survey bat populations throughout the state. Unfortunately, as with all things, time takes its toll on our equipment and we had to decide what to do.

One of our traps had been donated by a company whose apprentices had built it as a project. This was the trap that was in the worst condition because they used the wrong quality tubing. Affectionately known as 'The Rattler', it had served us well over the years and we were sorry to see it go. We decided to seek funding for a replacement.

The other three traps were in sound condition structurally. However, they needed restringing. Also the catch bags and the carry bags that the traps pack away in needed replacing.

We found a source for this equipment and obtained costing for the manufacture of the required bags. When we applied to the FNCV Environment Fund for a grant to cover the cost, the application was successful.

We had the chance to improve the design of the bags so we had the carry bags made larger than the originals. This enabled the hips to be packed in the bags. The hips are an important part of the trap and on occasion had been forgotten when the traps had been taken on surveys. We also had the drainage hole in the catch bags moved in order to improve their efficiency.

We received our new bags and found that we needed to change the holders on the hips, which we did quite readily by contacting the makers, so we were all set to try out our new bat traps.

We have used the traps several times with success since they have been renovated, the most memorable being at the pre-trip for the Scotia Camp where we caught 101 bats, many in just one night, thus proving the efficiency of the system.

We would like to thank the people who donated to the Environment Fund and also the Managing Committee of the Environment Fund who approved our grant application.

You can be assured that our renovated bat traps have been put to good use and this will be continued in the future. Thanks also to Rob Gration of Ecological Consulting Services for his assistance.

Ian Kitchen
Chairperson
Fauna Survey Group
Field Naturalists Club of Victoria

Studies in the geological evolution in Plenty Gorge

The Project arose from a work assignment checking on the two lakes at Hawkestowe Park for Parks Victoria, when it became apparent that this park is situated on an old meander of the Plenty River. The intriguing part is that this meander is now 20 m *above* the current level of the River, indicating that it must be a remnant of an older gorge that existed in a stable state for a considerable time (not just a progressive down-cutting as normally occurs). A check of Melbourne Water contour maps indicates that there are similar features elsewhere along the gorge, which it is my intention to document photographically as well as trace out former levels. There appears to be no prior reference to this by anyone, not Jutson in Royal Society, through to more recent Melbourne Water geological studies. Unfortunately, all Melbourne Water references record the capping sands of the Bundoora area as being Werribee Formation when they have all the character of Pliocene (Brighton Formation), and overlie what has been identified as Quarternary basalt. The project is focused on elucidating the origins of these latter formations and the implications that this has for the staged development of the Gorge.

I have found that the radio dating on the finger flow of basalt along the Plenty Valley has been done by Ray Cooney of Mining and Engineering Department. This puts the age at 4 million years, as compared with 1 million years for the rest of the Newer Basalts in the region, yet all the geological maps show the lot in one colour, as one single event – clearly it was not! There was a pre-existing basalt at the time the Plenty River was diverted by the Newer Basalt.

In November 2003 I sampled an oriented block of basalt from the Janefield Common (an outcropping above the Plenty River) and arranged for three orthogonal thin sections to be cut by Robert Douglas at Monash University Earth Sciences Department. Noel Schleiger has provided the expertise for petrographic examination of these slides, which we hope will shed light on the age and affiliation of this basalt finger and the direction and source of its flow. At the time of sampling, Noel did a survey of gas vesicles and jointing along parts of this outcrop as a means of checking flow direction, and observed that this is an augite basalt, rather than having the generally olivine character of the Newer Basalt. We also took a sample of weathered soil from just below the outcrop and panned out a sample of grit, to be examined for the presence of heavy minerals, also a valuable strategy for identification.

Possible origins for this basalt could be Mt Cooper (Bundoora) or Flintoffs Hill (North Greensborough), although activity at these points has been dated around 8 million years (appreciably older), but the source could be a minor eruption vent in the vicinity of South Morang. A considerable cluster of these is still evident between Morang and Mernda, and any one of these may have been responsible, but it is also possible that the relevant vent has since been buried under the subsequent Newer Basalt sheet.

I have now visited six of the identified ancestral meanders and prepared site maps of these at large scale and 1 m contour intervals. Some of these are inaccessible and some barely recognisable, either because of thick vegetation or being cleared to rolling pasture land. For each of these localities I have field traversed on foot to define geology that is mapped onto my plans to determine what influence that has had on the development of the meanders.

At this stage I am keen to identify all indicative features through the gorge and from these to plot a course and vertical profile of the ancestral gorge. Hopefully, this will locate a point of interest where the River encountered a pre-existing basalt barrier. I want to document this photographically from the waterfall at the head through the whole length of the Gorge. This is not all straightforward as access to much of the area is difficult or through private land. Some of it might best be captured from the air. Future costs may relate to photos and printing.

Noel Schleiger and I will be conducting an excursion for the FNCV to the Plenty Gorge on 27 November.

Alan Parkin
Geology Group
Field Naturalists Club of Victoria

Casterton Minnie Hole bird hide project

Casterton Field Naturalists Club is developing an area of land within Casterton. The land was the former railway precinct and it contains a small, permanent waterhole. Pest plants and animals have been controlled and indigenous vegetation planted with the aim of increasing the biodiversity of the site. The current project is the construction of a bird hide and information board beside the waterhole. A shed on another site was donated to the project for removal by the Club. The application for funds was for the construction of the hide.

Unfortunately the Club received a temporary hold-up to their plans. The promise to donate a building was broken but the local Shire Council did the right thing and provided a grant to compensate for the loss of those materials. New plans have been forwarded to Council for approval. The group now hopes that the completed building will be operating by December 2004.

Ian McCallum
President
Casterton Field Naturalists Club

Recruitment processes of alpine plants over elevational and environmental gradients

Alpine areas in Australia are small and fragmented, with only 0.02 percent of the mainland considered alpine, and have an average of 60 days snow cover per year (Green 1998). Alpine plant communities face several threatening processes such as pressure from human activities, rarity, low nutrient availability and climate change. Australian climate change models of the best-case scenario suggest that snow cover in alpine areas will decline by about 18% by 2030, and 39% by 2070 (Whetton *et al.* 1996). Reduced snow cover during winter is likely to be a critical factor in plant survival, leading to a longer snow-free period, and therefore a longer growing season.

Few studies have examined the possible responses of the Australian alpine vegetation to climate change, and little research in Australia has utilized natural environmental gradients as 'experiments by nature' (Körner 1999). Naturally occurring gradients can be useful tools, compared to manipulative environmental experiments that can represent a pulsed event with a pulsed answer and therefore may not reflect persistent long-term species responses (Körner 1999). When plant regeneration processes are compared across elevation gradients, theory assumes that at higher, colder elevations, plants are likely to be more stressed, suffer reduced regeneration and be growth limited. Seedling establishment and the persistence of newly emerged individuals is also predicted to be rare in alpine environments because of predicted life history trade-offs, the high clonality of alpine species and the harshness of an alpine climate (Forbis 2003). Seedling establishment is therefore expected to be more common at lower, sheltered sites, even among the same species. Will the influence of climate change be enough to alter these processes? In the future, could the higher mountains support species and communities that were previously restricted to lower elevations? How will plant communities be affected? How will the animal populations be affected if habitat opportunities change?

This PhD study investigates the role of alpine plant regeneration processes with regard to environmental gradients and assess how Australian alpine plants may respond to a changed climate in the future. Using mountain peaks of varying elevations as a naturally occurring environmental gradient, I may be able to predict how climate change will influence plant communities in the future by assessing how recruitment processes are already affected by climate regimes at different altitudes. The patterns in these processes will be correlated to the patterns in species' spatial and temporal distributions, within and between Victorian mountain tops. Patterns seen in field experiments will be supported by glasshouse and growth-cabinet experiments examining seed-set, seed viability and germination rates. I will also run field experiments examining soil nitrogen availability across a range of altitudes and investigate the prediction that lower available nitrogen at higher, cooler altitudinal sites holds true; and relate this to plant species distribution patterns and species long-term survival with the additional effects of a warmer climate.

In summary, the following questions are being addressed:

- which species or life-forms may be able to adapt to rapid climatic changes?
- which species or life-forms may be able to tolerate rapid change?
- which will become more competitive for resources?
- are species' geographic locations restricted by nitrogen availability and uptake?
- will rare and threatened species be at further risk of extinction?

Funds provided by the Field Naturalists Club of Victoria have primarily been put towards the purchase of temperature data-loggers and other field equipment. Electronic data-loggers have been set to air and soil temperatures bi-hourly. They can be left in place over several months and measurements downloaded after a whole summer or winter season. Currently I have five such data-loggers erected on different peaks in Victoria. The differences observed in temperatures over the elevational gradient are correlated with patterns in species, life-forms, seedling abundances and the change in plant-plant interactions.

Initial results have indicated that a change in species composition changes with altitude. There appear to be no strong trends with changes in plant life-forms over the gradient. Other results indicate that the perceived decrease in abundance in seedlings at higher elevations may not be the case in the Victorian Alps, with no measurable change in seedling abundances from the lower mountains to the higher mountains. Further results and analysis will be obtained during the next summer season 2004 – 2005. Currently seed viability and germinability experiments are being conducted in the glasshouse and growth cabinets to assess these attributes of alpine plants over the elevational gradient.

Susanna Venn
Department of Botany, LaTrobe University
Bundoora, Victoria 3083

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One Hundred Years Ago

Mr. G.A. Keartland drew attention to the reports in the news-papers of the enormous quantities of caterpillars which were doing great damage to the grass and crops in various parts of the State.
Mr. C. French, jun., stated that they were the larvae of the well-known moth *Heliothis armigera.*
Mr. J. Gabriel stated that the European Starlings were eating large quantities of the caterpillars, and that the farmers recommended their protection on that account.
Mr. A. Coles endorsed what Mr. Gabriel said regarding the value of the Starling. He also furnished a newspaper cutting regarding the destructiveness of sparrows to grain.
Mr. D. Best remarked on the enormous quantities of the common white butterfly, *Belenois java*, spar., usually known as *Pieris teutonia*, Fab. on the Buffalo Mountains, where they appeared in thousands.
Mr. J. A. Kershaw, F.E.S., stated that these butterflies were unusually numerous this season almost all over the State. They were to be seen almost every day flying along some of the principal streets in the city and suburbs. Sydney entomologists had also remarked on the large numbers in that State. In answer to a question, Mr. Kershaw stated that the larvae of this species feed on the leaves of *Capparis mitchelli.*

Natural History Notes
From *The Victorian Naturalist* **XX**, p. 115, January, 1904

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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Membership is open to any person interested in natural history and includes beginners as well as experienced naturalists.

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Postal Address: FNCV, Locked Bag 3, PO Blackburn, Victoria 3130, Australia.
Phone/Fax (03) 9877 9860; International Phone/Fax 61 3 9877 9860.
email: fncv@vicnet.net.au
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Terrestrial Invertebrate: Dr Alan Yen, as above.

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Members receive *The Victorian Naturalist* and the monthly *Field Nat News* free. The Club organises several monthly meetings and excursions Members are welcome to attend all activities. Visitors are also welcomed, but please note that a $5 fee may apply to non-members on some group activities (this includes insurance).

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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 2004:

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Chris Tzaros
Anneke Veenstra-Quah
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Alan Yen

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Nick Clemann
Maria Gibson
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Web address: http://www.vicnet.net.au/~fncv/vicnat.htm
Email vicnat@vicnet.net.au

Movement and use of added hollows by River Blackfish *Gadopsis marmoratus* R. in an agricultural catchment stream

Minal T Khan[1,2], Tariq A Khan[1,2] and Michael E Wilson[1,3]

Abstract

River Blackfish *Gadopsis marmoratus* R. are said to be dependent on hollows in submerged wood for spawning, yet fish can be abundant in agricultural zones with heavily modified riparian vegetation. To explore if hollows were limiting as a refuge and spawning sites for River Blackfish, we added 15 hollows to each of three pools with known River Blackfish populations in a multiple-BACI design. The study stream was Birch Creek in central Victoria and hollows were placed prior to the spawning season. Before treatment River Blackfish used undercut banks followed by boulder cover as the preferred daytime refuge at both control and treatment sites. There were no substantial changes in the daytime refuge of River Blackfish after addition of hollows. River Blackfish typically occupied restricted daytime movement range of 1-26 m. After 206 days River Blackfish were found on average, only 3.2 m from their original location. However, cumulative movements during this time were relatively larger (22.3 m). As newly placed hollows were not immediately utilised for spawning we concluded that either spawning occurred but hollows were not a limiting factor or that spawning failed to occur in any location tested. (*The Victorian Naturalist*, **121** (6), 2004, 244-253)

Introduction

River Blackfish *Gadopsis marmoratus* Richardson belongs to the family Gadopsidae. The family is endemic to freshwater habitats of south-eastern Australia including Tasmania. The family consists of two species, River Blackfish and Two-Spined Blackfish *Gadopsis bispinosus*. Sanger (1986) considers that River Blackfish is a complex of two species and these taxa evolved in allopatry following the isolation of Tasmania from the mainland. An examination of mitochondrial DNA of River Blackfish has also supported this interpretation of two taxa within this species (Ovenden *et al.* 1988). There are suggestions that River Blackfish should be further broken into a northern species (north of Great Dividing Range) and a southern species (south of Great Dividing Range) (Sanger 1986; Koehn *et al.* 1994). In the present study area River Blackfish, northern form, north of Great Dividing Range is recorded.

The population of the River Blackfish has declined since European settlement (Koehn and O'Connor 1990a; 1990b; Allen *et al.* 2002). River Blackfish were widely distributed in Victoria, Australia. However, many regions within the historical distribution of this species have seen a decline in both distribution and abundance, including the Loddon River system (DNRE 2002). Like the River Blackfish, many native freshwater fish species in Australian river systems have declined in their range and abundance during the last 100 years and habitat changes are frequently considered a major cause (Koehn and Morison 1990; Koehn and O'Connor 1990a and b).

River Blackfish are generally secretive, preferring habitat such as large woody debris (LWD) and undercut banks where they shelter during the day (Cadwallader and Backhouse 1983). They lay demersal, adhesive eggs onto a hard clean substrate, normally within hollow logs or underneath larger rocks and boulders (Probsting *et al.* 1974), which are then guarded by the male until all eggs have hatched (Jackson 1978). The widespread removal of logs from streams has presumably reduced the amount of spawning substrates available and clearing of riparian trees has reduced delivery of hollow LWD. In Victoria, the removal of woody debris from streams and the degradation of native riparian habitat are listed as 'potentially threatening processes' under the Flora and Fauna Guarantee Act 1998 (DCNR 1996a; 1996b). The loss of habitat for any species may lead to a reduction in numbers. This is particularly important for habitat-depen-

[1] Centre for Environmental Management, University of Ballarat, Ballarat, 3353.
[2] Present address: Queensland Department of Natural Resources and Mines, Northern Basin Laboratory, CRC for Freshwater Ecology, PO Box 1176, Goondiwindi, Qld. 4390.
[3] Present address: Murray-Darling Basin Commission, Canberra, ACT 2601.

dent species and for those species that require that particular habitat for a critical purpose, such as spawning. At least 15 native freshwater fish species across Australia use LWD as a location for spawning (Treadwell *et al.* 1999). River Blackfish are said to be dependent on hollows in submerged wood for spawning (Jackson 1978) yet they can be abundant in agricultural zones with heavily modified riparian vegetation and scant LWD (Khan 2004).

There have been limited studies on the movement and habitat use by River Blackfish. Koehn (1986) and Koehn *et al.* (1994) showed that River Blackfish had a preference for slow water velocities, and mean preferred water depth of River Blackfish increased with fish size. They also showed that River Blackfish were strongly associated with in-stream debris cover in the form of woody debris. Koehn (1986) used tags to obtain a preliminary estimate of home range between 25-30 m for River Blackfish in Armstrong Creek, Victoria. Recently Khan *et al.* (2004) used radio-telemetry to show that River Blackfish had a small home range of 10-26 m with strong affinity to a pool. River Blackfish utilised slow flowing (0-20 cm/sec) and deep (40-60 cm) waters. River Blackfish were also strongly associated with the in-stream cover habitats of undercut banks and boulders. Lintermans (1998), while tagging the Two-Spined Blackfish in Cotter River, ACT, showed that the species is relatively sedentary with an adult home range of 15 m.

Experimental studies based on introducing habitat have been undertaken extensively in the Northern Hemisphere (Angermeier and Karr 1984; Sandström and Karås 2002). These studies have identified the importance of introduced habitat and observed subsequent increases in fish abundance and distribution after their addition. Australian studies that manipulate variables to elucidate the mechanisms controlling habitat selection by fish are limited. Koehn (1987) recorded an increase in the abundance of Two-Spined Blackfish after the introduction of habitat consisting of boulders and a log weir. However, this study contains only a single sample before and after the habitat improvement works, thus the results need to be interpreted with caution. Given the limited information on the habitat that limits River Blackfish abundance, the present study was designed as a standard Before-After-Control-Impact (BACI) design experiment, with three control and three treatment sites. To explore if hollows were limiting for River Blackfish we added hollows at three treatment sites

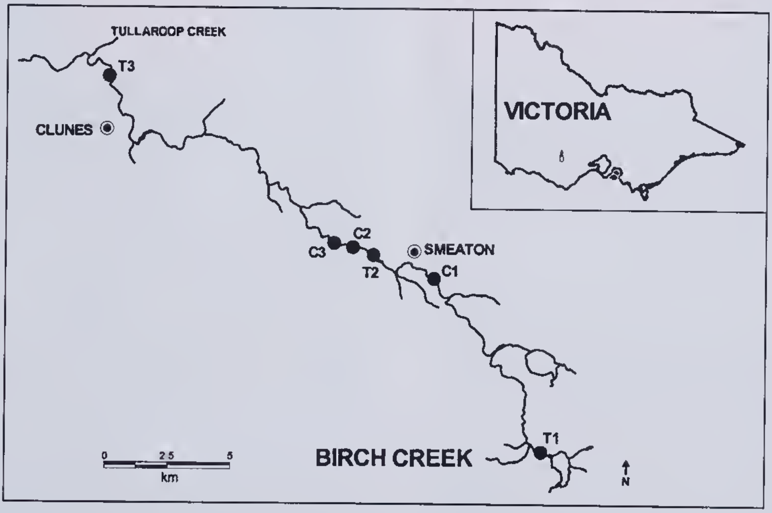


Fig. 1. Location of study sites in Birch Creek in the upper Loddon River catchment. T1, T2, T3 refer to three treatment sites and C1, C2, C3 refer to three control sites. Treatment and control sites were selected randomly.

and monitored the River Blackfish use of added hollows either for refuge or spawning. The present study also used mark-recapture techniques to provide information on movement, home range and habitat preference of River Blackfish in a modified agricultural stream. There is increasing interest in restoration of critical habitat, including LWD, for native fish (Brooks 2002; NCCMA 2002; Brooks *et al.* 2004; Koehn *et al.* 2004). Results from the present study can be used to evaluate habitat and spawning requirements of River Blackfish and inform habitat restoration programs.

Material and Methods

Study sites

The study was conducted on six sites in Birch Creek (Victoria, Australia) between October 2001 and May 2002. The creek lies in the headwaters of the Loddon River. The creek runs for approximately 45 km from its headwaters flowing through the township of Smeaton and then to the north-east of Clunes (latitude 37°24' S, longitude 144°00' E, Fig. 1). The creek joins Creswick Creek and at the confluence they are named Tullaroop Creek, which joins the Loddon River to the north. Birch Creek flows through a gently undulating plain formed by episodic extrusion of lava from numerous volcanoes which gave rise to the underlying quaternary olivine basalt geology (Schoknecht 1988). Birch Creek flows throughout the year because of its regulated nature with water periodically released in summer for crop irrigation purposes. Land adjacent to the creek is used predominantly for broad acre cropping and as pasture for grazing livestock. Exotic willows dominate the riparian cover of the creek. The two willow species present are Crack Willow *Salix fragilis* var. *fragilis* and Weeping Willow *Salix babylonica*, with the latter less common. Birch Creek is considered regionally significant because it supports a population of River Blackfish (McGuckin and Doeg 2000).

The mean width of the sites ranged between 4.3 and 5.6 m and mean depth between 32.3 and 41.4 cm (Table 1). Mean surface water velocity ranged between 28 and 57 cm/sec. Undercut banks and boulders were the main in-stream cover. The substrate was a mixture of bedrock, boulders, pebble, sand and cobble (Table 1). A constructed weir of approximately 0.3 m height (passable by fish) served as the upstream boundary of site 3. However, other sites had no natural or artificial barriers upstream or downstream. The majority of the sites consisted of large but not deep pools.

Six pools of varying length (20-50 m) were selected in Birch Creek and three pools were randomly selected for treatment (T1, T2 and T3) and three for control (C1, C2 and C3, Fig.1, Table 1). Transects perpendicular to stream flow were positioned at all sites at 1 m intervals and permanent markers installed to monitor fish movements, their utilisation of in-stream cover habitat and other physical variables.

River Blackfish capture and tagging

River Blackfish were captured and tagged at all the sites using a pulsed DC powered backpack electrofisher (Model 12, Smith-Root Inc., USA) set at 600 volts. Before electrofishing, stopper nets were placed at the upstream and downstream limits of the study site and were left until the last run. A check on the efficiency of electrofishing was made at the start of the study by making five consecutive runs at two study sites. The efficiency of each electrofishing run was expressed as the percentage of the total number of River Blackfish obtained in each run. Electrofishing efficiency calculated for River Blackfish indicated that between 81 and 90% were obtained in first two runs.

Three runs were made at each site at all sampling events to capture the tagged fish in the reach. On occasions when a fish was missed during the third run, an additional fourth run was undertaken to capture the missed individual.

A total of 113 River Blackfish were marked. All River Blackfish >12 cm (to maximise fish size relative to tag weight) total length were tagged with sequentially numbered modified dart tags. All collected fish, irrespective of total length, were fin clipped on the anterior and posterior of the dorsal fin (Wydoski and Emery 1983). These individuals were recognised by their unique combination of length, weight and fin clipping. Fish were anaesthetised in 10 l

Table 1. Average of physical and in-stream cover variables recorded at six study sites in Birch Creek used for movement and habitat studies on River Blackfish. * = treatment sites; # = control sites

Habitat variables	Study sites					
	1*	2#	3*	4#	5#	6*
Width (m)	4.3	4.6	4.7	5.1	4.8	5.6
Depth (cm)	38.2	38.1	34.6	32.3	41.4	39.4
Velocity (cm-sec)	30	36	57	41	28	32
In-stream cover (%)						
Undercut banks	9	19	6	8	4	5
Boulders	4	7	11	4	1	16
Large woody debris	3	0	0	0	0	0
Coarse woody debris	6	2	4	0	0	2
In-stream vegetation	7	3	5	7	11	2
Open areas	71	69	74	81	84	75
Substrate composition (%)						
Bedrock	12	22	14	0	0	2
Boulder	12	14	27	14	6	34
Cobble	12	14	19	11	15	26
Pebble	26	14	15	23	22	12
Sand	20	14	10	22	19	11
Silt	9	11	9	18	24	10
Clay	10	11	6	12	14	6

of creek water with 10 ml clove oil as described in Anderson *et al.* (1997). After regular opercular movement had ceased, each individual was weighed and total length measured to the nearest mm. Fish were then placed dorsal side down on a moist wooden board and held in that position during surgery. Tags were threaded with monofilament plastic thread and the thread inserted by needle through the musculature of the upper back, immediately anterior of the insertion point of the dorsal fin, and the tag was then tied close to the body. Earlier aquarium trials using tags (N=6) over a fortnight on River Blackfish did not show adverse effects or any observable change in locomotion ability and all fish retained tags. Fish were placed in holding buckets for a minimum one-hour recovery period, during which time they were observed frequently. After recovery they were released as close as possible to the initial point of capture. Mature fish were considered those >15 cm in total length (Koehn *et al.* 1994).

Addition of hollows

The experimental design was based on a multiple BACI design (Underwood 1996), with the intent to search for differences in habitat use by River Blackfish between sites with added hollows (treatment) and those without added hollows (control). At each treatment site (T1, T2 and T3) five hollow wooden logs, five hollow bricks and five hollow PVC pipes were added to the centre of the channel at randomly selected locations. Wooden logs varied in length from 24-28 cm and in diameter from 12-26 cm with a hollow diameter of 4-20 cm. Hollow concrete bricks were 40 cm long and 19 cm wide with two rectangular 'hollows' of 15x7 cm. PVC pipes were 35 cm in length and 8 cm in diameter.

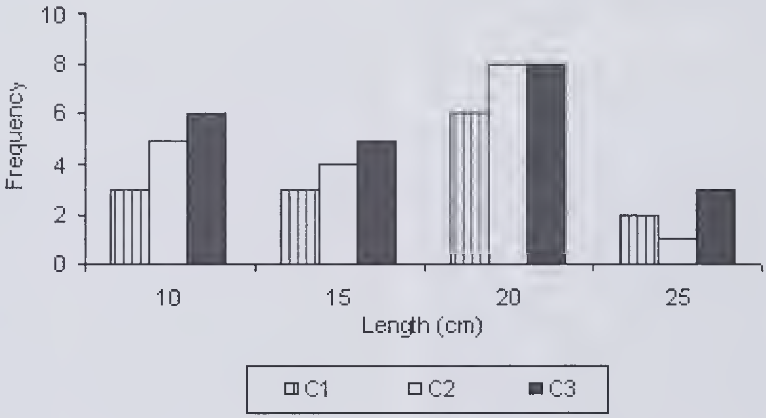
All sites were monitored on 13/10/01 and 20/10/01 prior to adding hollows. Sites were monitored two days after hollows were added, then fortnightly for six weeks, then monthly for five months to assess occupation.

Fish movement

At all the sampling events both treatment and control sites were electrofished to capture the tagged fish and record their daytime refuge and location relative to the permanent bank markers. Initially fish movement at all sites was monitored 7 days after release, followed by 11 days, then fortnightly for six weeks, then monthly for five months. The daytime refuge occupied by each fish was recorded and the move-

Table 2. Total number of fish present, length range (cm), weight range (g) and mean percentage of fish (±SE) occupying each daytime refuge prior to addition of hollows at treatment and control sites. Mean of two sampling events, 13/10/01 and 20/10/01 Ucb=undercut bank, Bld=boulder, Inv=instream vegetation, Opn=open areas.

	Total fish	Length (cm)	Weight (g)	Daytime refuge Ucb	Bld	Inv	Opn
Control							
C1	14	7-22	8-85	68±4	28±7	0	4±4
C2	18	6.5-21.5	7-80	56±6	19±3	14±3	11±0
C3	22	6.5-22	7-85	70±2	7±2	16±2	7±2
Treatment							
T1	21	8-24	9-95	69±7	7±2	17±2	7±2
T2	19	6-22	7-85	58±5	32±0	8±3	3±3
T3	19	7.5-23.5	8-90	53±5	47±5	0	0
All sites	113	6-24	7-95	63±3	23±6	9±3	5±2



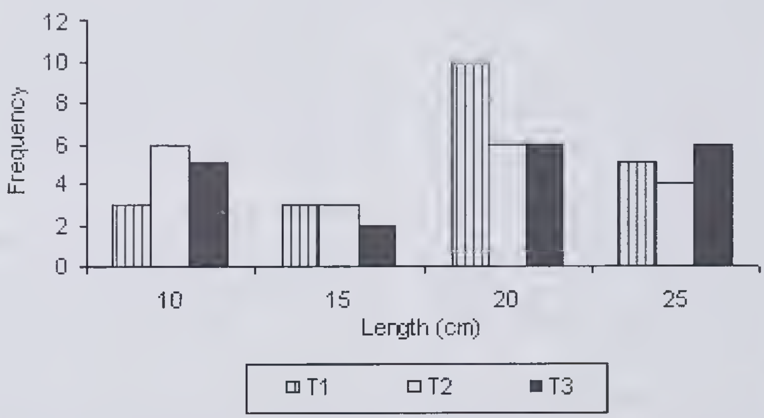


Fig. 2. Length frequency distribution graphs of River Blackfish at three control (C1-C3, upper graph) and three treatment (T1-T3, lower graph) sites in Birch Creek before additon of hollows.

ment range of an individual fish was determined as the furthest distance upstream and downstream from the original position at which the fish was observed. The distance moved between each sampling event and the distance moved from the original location at each sampling event was also determined.

Habitat use measurement

The in-stream cover variables utilised by River Blackfish over the study period were measured quantitatively. Tagged fish were captured at each sampling event using a pulsed DC backpack electrofisher. The exact position where each individual fish was first seen was marked with a numbered float attached by a cord to a sinker (Gatz *et al.* 1987). The fish were placed in a bucket for later data collection with a number corresponding to a number on the weight and float in the creek. After electrofishing was completed, in-stream cover habitats such as undercut banks, boulders, in-stream vegetation and open areas were measured at the position of each float. Fish presence in the added hollows was confirmed by putting a hand net around the hollow, covering it fully and then disturbing the hollow and collecting the fish in the net. This procedure was repeated until no more fish were present in hollows. The fish were placed in a bucket for later data collection.

Results

Habitat occupation before treatment

Before adding hollows there were 21 River Blackfish at site T1, 19 at site T2 and 19 at site T3 (Table 2). River Blackfish were strongly associated with the in-stream cover habitats of undercut banks, boulders and in-stream vegetation. Undercut banks were the preferred daytime refuge (60%) of River Blackfish, followed by boulder cover (29%), in-stream vegetation (8%) and open areas (3%). Control sites had 14, 18 and 22 River Blackfish at C1, C2 and C3 respectively, with similar daytime refuge preferences (65% undercut bank, 18% boulder cover, 10% in-stream vegetation and 7% open areas).

Size class distribution of River Blackfish suggested that adults (>15 cm in length) were dominant at all sites, forming 56% of the total population, followed by young-of-the-year (<10 cm, 25%) and yearlings (10-15 cm, 19%, Fig. 2). Recapture rates were not different between the size classes of River Blackfish.

Habitat occupation after treatment

There were only slight changes in the abundance of fish at treatment and control sites. Of the 113 fish, 101 fish were recaptured seven months after adding hollows (Table 3). After adding hollows, only four out of 101 fish were ever found in an added refuge structure. One River Blackfish selected a hollow wooden log and another selected a PVC pipe at site T1 two months after introduction. At sites T1 and T2 a total of two River Blackfish each selected a concrete block after approximately two months. No fish selected added refugia at site T3. No fish were recorded in the same hollow on two consecutive sampling events. Over the sampling period we found 20% of added hollows (9) blocked by sediment, and 60% of added hollows (27) occupied by Common Yabbies *Cherax destructor*. There were no substantial changes in the overall proportion of each daytime refuge type at any sampling event (Table 3). However, individual fish did alter their location and preference between sampling events.

Fish movement

There were no observable ill effects of the repeated electrofishing on the River Blackfish. Similarly there were no negative impacts of tags on condition of River Blackfish. Individual River Blackfish showed affinity to a site with the recapture rate above 90% across all sampling events. Only 12 of 113 fish were unaccounted for over the seven month study period. However, small-scale movements were recorded at each site. Over 60% of fish were located at least one metre from their previous position for samples taken four days apart (Table 4). This percentage increased to 70-84% as the time between consecutive sample events increased to between 7 and 40 days. Over a study period daytime movement range of River Blackfish varied from 1-26 m and mean movement range for all fish was 8 m. On average fish were found approximately 1.5 m from their original location when sampled at a four-day interval. As the time

Table 3. Mean percentage (± SE) of River Blackfish occupying daytime refuges in three control and three treatment sites in Birch Creek for 10 sampling events after addition of hollows to treatment sites. Wol=wooden log, Cbl=concrete block, Pvp=PVC pipe, Ucb=undercut bank, Bld=boulder, Inv=in-stream vegetation, Opn=open areas.

	Total fish	Added hollows Wol	Cbl	Pvp	Daytime refuge Ucb	Bld	Inv	Opn
Controls								
C1	13	-	-	-	70±4	24±3	0	6±2
C1	15	-	-	-	70±4	18±1	7±2	5±2
C3	20	-	-	-	77±2	10±1	10±1	3±1
Treatments								
T1	18	1±1	1±1	1±1	65±3	14±3	13±2	5±1
T2	17	0	1±1	0	71±1	18±1	9±1	1±1
T3	18	0	0	0	70±2	30±2	0	0
All sites	101	<1	<1	<1	71±2	19±2	7±1	3±1

between sampling events increased fish were found, on average, 2-3 m from their original location. Even after 206 days fish were found, on average, only 3.2±0.4 m (mean±S.E) from their original location. During that time average cumulative movements were relatively larger (mean cumulative distance moved 22.3 m).

Discussion

In the present study there were no negative impacts of tags on condition of River Blackfish presumably because the ratio of tag to body weight was low. Recapture rate of the tagged fish was high, with over 90% of marked fish being recaptured in the same pool seven months later. The few fish not recaptured may have died or emigrated or not been recaptured. The reasons for high recapture rates were the shallow nature of the creek and small home range of River Blackfish. Water depth at the study sites rarely exceeded 50 cm.

River Blackfish did not spawn in added hollows. It is unknown whether spawning did not occur at any site or spawning occurred but not in added hollows. Spawning of River Blackfish occurs during October and November when water temperature exceeds 16° C (Cadwallader and Backhouse 1983). The spawning period of Blackfish coincided with the present study; however, we could not conclusively identify the spawning locations of River Blackfish at any of the six sites. Similarly Khan (2004) failed to identify conclusively spawning locations in Birch Creek over two years of observations (2000 and 2001). However, in each year electro-fishing surveys recorded young-of-the-year recruits across the nine surveyed sites (Khan 2004). Six of these sites were used in the present study and there were no notable differences in environmental characteristics between the present study period and that of 2000 and 2001 spawning seasons.

The importance of cover to fishes in the lotic (running water) environments arises because they serve as protection from high current velocities and predation (Fausch and White 1981; Angermeier 1992). The most obvious reason why River Blackfish did not use the added hollows is because abundant preferable cover was available nearby. Fausch (1993) reported only a weak response by Coho Salmon *Oncorhynchus kisutch* to added overhead cover in a natural stream and he noted that few Coho Salmon used artificial structures because abundant natural cover was available nearby.

Koehn (1987) found that boulders placed in the Ovens River markedly increased the numbers of Two-Spined Blackfish; however, the author concluded that Two-Spined Blackfish, being smaller and more slightly built than River Blackfish, appeared to be able to utilise such in-stream niches more effectively. The hollows in the present study were added to the center of the channel. This may have been a disadvantageous position in terms of overall cover and fish exposure to high stream velocity. Koehn *et al.* (1994) showed that River Blackfish had a preference for slow water velocities.

Table 4. Mean percentage of fish that moved >1 m, mean distance moved from original location and mean cumulative movement between sampling events for River Blackfish at six sites in Birch Creek. Sampling events represent days elapsed since beginning of experiment. All fish tagged on 13/10/01. * = Hollows added

Sampling dates (2001)	13/10	20/10	22/10*	24/10	8/11	23/11	8/12	7/01/02	6/02	8/03	7/04	7/05
Sampling events (days)	0	7	9*	11	26	41	56	86	116	146	176	206
Fish moved between sampling events (%) -	-	70		63	83	84	80	72	69	79	84	81
Total number of fish	113	113		108	108	107	110	110	106	105	101	101
Distance from original position (m)	-	1.3		1.7	2.1	2.7	2.4	2	2.5	3.1	2.7	3.2
Cumulative distance moved (m)	-	1.4		3.2	5.1	7.4	10	12.5	14.8	17.7	20	22.3

Similarly Khan *et al.* (2004) using radio-telemetry showed that River Blackfish utilised slow flowing (0-20 cm/sec) waters. Future research may involve testing addition of hollows in close proximity to the abundant cover adjacent to stream banks and testing whether River Blackfish utilise the added hollows.

The location of egg laying in the highly modified study stream is clearly critical to ongoing maintenance of the River Blackfish population. Hollows are rare at all the sites studied (Khan 2004). Khan (2004) recorded only one substantial piece of LWD from the six studied sites. This was exotic willow wood and without substantial hollows. The stream is predominantly lined by willows and exotic pasture, with the former expected to deliver LWD with lower longevity and propensity for hollows than that of the indigenous River Red-gum *Eucalyptus camaldulensis*. River Red-gum would have been expected to dominate the riparian zone prior to European settlement. Hollows may be important spawning sites in other systems (Jackson 1978; Koehn and O'Connor 1990b) but do not appear to be so in selected sites of Birch Creek. River Blackfish have adhesive eggs and may use the underside of cobbles and boulders for spawning (Probsting *et al.* 1974). During electrofishing surveys, River Blackfish were frequently captured from boulder refuges and some of these may have been spawning sites. However, boulders were not always present in reaches that appeared to support spawning.

Large differences were also recorded in the type of in-stream cover used by River Blackfish in the present study than that in previous studies. For example, Jackson (1978) found a close association between River Blackfish and stream snag areas. Koehn (1986) showed River Blackfish were positively associated with organic debris 50% in density. These studies were conducted in streams with undisturbed native riparian vegetation and the streams contained considerable quantities of woody debris. In the present study River Blackfish were most strongly associated with undercut banks. In agricultural streams such as the study creek, with heavily modified riparian vegetation and in which woody debris is lacking, River Blackfish are occupying novel habitats. Two interesting conclusions can be drawn from this observation. Firstly, river restoration works must be informed by empirical evidence of habitat flexibility in target organisms. In some locations woody debris may be appropriate and in other circumstances undercut banks may achieve a similar outcome for River Blackfish habitat restoration. Secondly, the undercut banks in the study creek were associated with willows, a weed of national significance. Willow removal is ongoing along Birch Creek and many other Victorian streams and the consequences for in-stream habitat and aquatic fauna have not been examined.

Most River Blackfish were using undercut banks as daytime refuges. Most undercut banks appeared to be a complex of cavities and hollows frequently armoured by willow root mats. It is possible that these are used as spawning sites for two possible reasons: firstly, undercut banks were most frequently occupied by River Blackfish; secondly, they appear to be the only suitable habitat in some silt lined channels devoid of LWD. Underwater surveys of undercut banks would aid our understanding of the nature of River Blackfish refuges and whether they are used as spawning sites.

River Blackfish typically occupied restricted daytime movement range (1-26 m) throughout the study period. Affinity to a pool but frequent movements between refuges is indicated by the observation that, on average, fish had moved only 3.2 m from their original position but had mean cumulative movements of 22.3 m by the end of the study. These results are similar to those obtained from other studies on River Blackfish (Koehn 1986; Khan *et al.* 2004) and Two-Spined Blackfish (Lintermans 1998). Koehn (1986), while studying the movement of River Blackfish in Armstrong Creek, Victoria, using mark-recapture methods, showed a preliminary estimate for River Blackfish home range was 25-30 m. Khan *et al.* (2004), while studying the movement and habitat use of River Blackfish in a highly modified central Victorian stream (Birch Creek), using radio-telemetry, concluded that the River Blackfish is a sedentary species with a small home range and strong affinity to a pool. At a diel scale they reported that there were no significant differences in River Blackfish movement between day and night. River Blackfish were also strongly associated with the in-stream cover habitats of undercut banks and boulders (Khan *et al.* 2004). Lintermans (1998) showed that the Two-Spined Blackfish is a relatively sedentary species with an adult home range of approximately 15 m in Cotter River, ACT. These results on the movement and habitat use of River Blackfish and Two-Spined Blackfish are similar to the present study and confirm that the River Blackfish is a sedentary species with a small home range and are strongly associated with in-stream cover habitats.

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Are intertidal invertebrates adequately protected in Victoria?

Karen McNaught[1,2] and Geoff Wescott[1]

Abstract

Intertidal invertebrates are under pressure from both direct and indirect threats, the most serious being from over-exploitation, habitat loss and alteration, decline in water quality, introduced species and pathogens, and global warming. This article explores the current protective mechanisms in place that provide some protection to intertidal invertebrates in Victoria and looks at a case study of Western Port, Victoria. The results of the case study indicated a general consensus that intertidal invertebrates are not adequately protected in Victoria. The recommended actions to ensure adequate protection in the future are an amendment to current legislation, increased education and greater law enforcement, and further implementation of the concept of integrated coastal zone management. (*The Victorian Naturalist* **121** (6) 2004, 254-263)

Introduction

Of the 33 recognised animal phyla, 32 are made up of invertebrates, 28 of which are found in the sea and 13 of which are exclusively marine (Land Conservation Council (LCC) 1993). Despite this, the knowledge of invertebrates (animals without backbones), particularly marine macro and micro-invertebrates, is generally poor and their 'public image' is generally low.

The intertidal zone is defined as the area between low and high tides that is subject to daily changes in physical conditions from tidal movement (Environment Conservation Council (ECC) 2000). Victoria's intertidal zone consists of a variety of habitat types including sandy beaches, mud and sand flats, rocky platforms, seagrass meadows, saltmarshes, estuaries and mangrove forests. Animals living in this zone have had to adapt to the constant changes and extreme conditions of exposure at low tide to ensure their survival.

Coastal zones throughout the world are among the most heavily exploited areas because of their rich resources (Post and Lundin 1996). It is commonly realised that human populations are increasing faster in coastal areas than in areas inland, which puts increased pressures on infrastructures, natural habitats and other resources. Approximately 80% of Victorians live within the coastal zone (Wescott and McBurnie 2000), and because the intertidal zone is the most accessible coastal area it is consequently under pressure from human visitation and use.

Cicin-Sain and Knecht (1998) outlined two reasons why an integrated approach to management is favourable for the marine environment. The first reason is due to the dynamic physical nature of the coastal zone; various uses, both marine and terrestrial, can affect other parts of the coastal zone. The second reason is due to the effects ocean and coastal users can have on one another. This integrated approach to management maximises the benefits provided to humans by the coastal zone and minimises the conflicts and harmful effects of human activities upon each other, on resources and on the environment.

Beatley (1991) reported that coastal and marine biodiversity had received much less attention in recent years compared with the terrestrial environment. Yet the threats to coastal biodiversity are no less serious than the threats to the terrestrial environment. The major threats and impacts resulting from human use have been described by a number of authors (Traill and Porter 2001; Australia State of the Environment Committee 2001; Natural Resources and Environment (NRE) 1997; New 1995) and can be summarised as:

- overexploitation of resources,
- habitat loss and alterations,
- decline in water quality,
- introduced species and pathogens and
- global warming.

[1] School of Ecology and Environment, Deakin University, 221 Burwood Hwy, Burwood, Victoria 3125. Email: wescott@deakin.edu.au
[2] School of Psychology and Sociology, Central Queensland University, Bruce Hwy, Rockhampton, Queensland 4701

The Australian and New Zealand Environment and Conservation Council (ANZECC) and Biological Diversity Advisory Committee (2001) report that highest priority research for conservation should include areas with communities that are poorly understood such as marine, especially littoral (intertidal) and also poorly known taxonomic groups such as invertebrates.

There are a number of reasons why knowledge of marine invertebrates is limited:

- Invertebrates lack the popular appeal or profile of the more studied charismatic megafauna such as dolphins or penguins.
- Marine studies typically focus on commercially exploited species, usually fish or larger invertebrates.
- Scientific expertise in these fields is limited.
- Funding for research in general is limited.

The importance of improving knowledge of marine invertebrates is crucial. As an example, around one third of Victoria's crab species are restricted to intertidal habitats, therefore to preserve crab species diversity, protection of the intertidal zone is essential (Traill and Porter 2001). There is also an obligation to conserve all species for future generations. Without knowledge of the needs and wants of future generations it is not possible to say which species will prove to be useful. Most importantly there is an obligation to conserve all species for ethical and moral reasons whether they are of immediate benefit to humans or not.

A number of authors (Horwitz *et al.* 1999; Allen 1999; Lunney 1999) have made reference to the importance of improving the 'public image' of invertebrates if they are to be successfully conserved. In conclusion this short review highlights the potential threats to intertidal invertebrates in general and the need to conserve their associated communities.

Review of Current Protective Status in Victoria

This study was established to answer the question: Are intertidal invertebrates adequately protected in Victoria?

Two approaches to the protection of intertidal invertebrates can be adopted, the first being protection of individual species. This requires identifying vulnerable or threatened species so they can be managed to ensure they are successfully conserved. The second approach is protection of entire ecosystems or habitat types. This approach is generally favoured for invertebrate conservation as it does not require specific knowledge of the taxonomic composition of the community or life histories of component species.

There is no form of legislation established primarily for the protection of intertidal invertebrates in Victoria. Apart from the Whale Protection Act 1980, marine protection in Australia is not generally a systematic species-level approach (Jones and Kaly 1995). However, the protection of intertidal invertebrates in Victoria falls under a number of other institutional arrangements, and given that the jurisdiction of the Victorian coastline is at the state government level, the following is an outline of the most prominent Victorian arrangements for the protection of intertidal invertebrates.

Fisheries Act 1995

The primary purpose of the Fisheries Act 1995 is to provide a modern legislative framework for the regulation, management and conservation of Victorian fisheries including aquatic habitats (Fisheries Act, Section 1, 1995).

Fisheries Regulations 1998 under the Fisheries Act 1995

The Fisheries Regulations 1998 are made under sections 153 and 155C of the Fisheries Act 1995 (Fisheries Regulations, Section 102, 1998). Formerly known as the 'Shellfish Protection Regulations' they provide direct protection to intertidal invertebrates as follows:

Under Division 3 – General fishing offences:

- Regulation No. 512. States that a person must not take marine invertebrates other than marine worms from Port Phillip Bay in the intertidal zone.
- Regulation No. 524. States that a person must not, between the eastern side of Thompsons Creek at Breamlea and Arch Rock at Venus Bay, take any mollusc from the intertidal zone.
- Regulation No. 525. States that a person must not use a scoop, dredge, fork, spade,

rake, shovel or other hand-held digging implement for taking or attempting to take molluscs or other marine invertebrates; or use a bait pump with a barrel exceeding 8·5 centimetres in diameter, in the intertidal zone (Fisheries Regulations, Division 3, 1998) in Victoria.

Flora and Fauna Guarantee (FFG) Act 1988

The only marine invertebrates listed on the FFG Act 1988 are two species of marine opisthobranch (sea slugs), which are listed as threatened under Schedule 2. The taxa are *Platydoris galbana* and genus *Rhodope*. However, neither of these has an Action Statement for its conservation. The main threats to these two taxa are from loss of habitat through coastal development, decline in water quality, and invasion by other species due to physical disturbances. The San Remo Marine Community is also listed as threatened under Schedule 2 of the FFG Act 1988 and this has an Action Statement.

Coastal Management Act 1995

The primary purpose of the Coastal Management Act 1995 was to establish the Victorian Coastal Council (VCC) and to conserve the Victorian coast. This Act is described by Wescott (1998) as having a pivotal role in the implementation of integrated coastal zone management in the State. This Act indirectly assists in protection of intertidal invertebrates through recommending the management of entire ecosystems and habitat protection.

Victorian Coastal Strategy 2002 under the Coastal Management Act 1995

The Victorian Coastal Strategy 2002 was prepared by the VCC and approved by the state government in line with the Coastal Management Act 1995. The Strategy is a legislative document based on integrated coastal zone management principles and aims to provide for long-term planning of the Victorian coast (VCC 2002).

National Parks (Marine National Parks and Marine Sanctuaries) Act 2002 (amendment of the National Parks Act 1975)

Ninety-six percent of the Victorian coast is crown land, and more than one third of this is managed under the National Parks Act 1975 (VCC 2002). The protection of the intertidal zone under this Act is a 'grey' area, as in most cases the Fisheries Act 1995 takes precedence over any other legislation. The National Parks Act 1975 is primarily concerned with the conservation of terrestrial ecosystems (ECC 1998), which is one of the reasons why in the past various reports have made recommendations for either new legislation or an amendment to existing legislation for marine protected areas (ECC 1998, 1999, 2000). The National Parks Act 1975 was amended in 2002 to make provisions for marine protected areas (MPA). MPAs are one way to improve marine conservation but high protection (or 'no-take' areas') in Victoria currently cover only 5.3% of coastal waters.

Victoria's System of Marine National Parks and Marine Sanctuaries – Draft Management Strategy 2002

This draft Strategy applies specifically to the 13 marine national parks and the 11 marine sanctuaries that were legislated in June 2002. The main purpose of this draft Strategy is to provide the manager (Parks Victoria) of these highly protected areas clear and consistent planning and management guidelines for the next 7-10 years (Parks Victoria 2002). This Strategy will provide protection to intertidal invertebrates through habitat protection but only if they are located inside a reserve.

Crown Land (Reserves) Act 1978

The majority of the remaining coastal Crown land not managed under the National Parks Act is managed under the Crown Land (Reserves) Act 1978. Marine and coastal environments can be reserved under this Act (ECC 2000). Land reserved under this Act may have a Committee of Management appointed by the Minister of Environment. This Act provides protection to intertidal invertebrates in the form of habitat and entire ecosystem protection if the reserve is declared to low tide mark or lower.

Victorian Biodiversity Strategy 1997

This Strategy is a policy document rather than legislative and therefore has a less direct impact on marine protection compared with other legislations. However, this is a significant document for conservation of intertidal invertebrates in terms of maintaining healthy ecosystems. Additionally, this document provides an educational tool which is an important factor in marine conservation.

Overall, Victoria has no specific legislation or regulations aimed primarily at the protection of intertidal invertebrates across the State. Instead there is a 'mosaic' of individual regulations and legislation that contribute to intertidal invertebrate conservation in specific sections of the coastline. Even in these limited areas it is doubtful if there is any effective direct conservation of intertidal invertebrates.

In an attempt to further clarify the current position in Victoria a case study of Western Port was carried out by the senior author.

Case Study: Analysis of the Adequacy of Protection of Intertidal Invertebrates in Western Port

Western Port was chosen as the site for a case study for a number of reasons:

- Western Port has a tidal range of up to 3.1 metres, compared to both Port Phillip Bay and the Victorian open coast, which are on average around 0.9 metres (LCC 1993).
- Western Port supports a particularly diverse range of intertidal habitat types (NRE 2002).
- The vast majority of Western Port (52 325 ha) is listed as a Ramsar[1] site and is well known to support large numbers of migratory wading birds (Western Port Regional Planning and Co-ordination Committee 1992).
- Western Port has a well-documented history particularly in relation to seagrass dieback during the 1970s and 1980s (NRE 1997).

Western Port was first explored by Europeans in 1798 by George Bass (Shapiro and Connell 1975) and it is the more eastern of two major bays in the Melbourne region. It is situated around 80 kilometres south-east of Melbourne, bordered by the Mornington Peninsula to the west, Koo Wee Rup plain (formerly 'Swamp') to the north and the South Gippsland hills to the east. Intertidal habitat types surrounding Western Port include intertidal rocky reefs, mud and sand flats, mangroves, seagrass beds and sandy beaches.

The method adopted for the case study was a literature review of material pertaining to intertidal invertebrate protection, and a mailout questionnaire asking those with assumed knowledge in this area for their expert opinions on intertidal invertebrate conservation issues. A mailout questionnaire is the most efficient method to gain information for this type of research project in terms of researcher time, effort and cost (Robson 1993; Burdess 1994). The sample type as described by Robson (1993) was 'extreme case' which is defined as concentrating on extreme values when sampling, to throw a particularly strong light on a phenomenon of interest, in this case the protection of intertidal invertebrates in Western Port. The questionnaire was designed to be answered by a number of coastal stakeholders.

The methods used to obtain the list of potential participants was similar to the method used by Knecht *et al.* (1996) where knowledgeable individuals were contacted to obtain their perception of a particular issue, in this case the protection of intertidal invertebrates. Knecht *et al.* (1996) identified three major groups that they believed were the most knowledgeable, these being coastal managers, coastal interest groups and academics.

The same questionnaire was sent to the three 'stakeholder' groups in this study. The format of the questionnaire consisted of both open-ended and closed-ended questions. Although a number of authors (Dillman 1978; Lockhart 1984; Bourque and Fielder 1995) have found that open-ended questions are not preferable for mailout questionnaires, including some of this type of question allowed for the participants to express their opinions and perceptions. The open-ended questions were designed specifically so the responses could be divided into a limited number of categories. This ensured that the responses could be analysed in a meaningful way.

The majority of the questions were closed-ended although many of the questions requested further comments. This format was aimed at gaining as much

[1] Convention on Wetlands held in Ramsar, Iran in 1971 for Wetlands of International Importance particularly for waterbird habitat.

information as possible about this specialised topic.

Potential participants were sourced from a wide range. Generally coastal managers' names were obtained from the internet or via phone. Coastal interest groups were obtained primarily from relevant friends groups and committees of management. The academic and individual researchers were compiled by networking with individuals with coastal expertise, especially expertise with intertidal invertebrates.

The questionnaire was divided into four parts: background information, threats, intertidal protection and personal information. The questions were short and specific to encourage a higher response rate (a copy can be obtained from the senior author).

Results and Discussion

One hundred and sixty-six questionnaires were sent out to coastal 'stakeholders' inviting them to participate in this research. Table 1 summarises the overall response rate to the questionnaire. Table 2 summarises the response rate for each of the three stakeholder groups.

The sample size for each group was relatively small when treated individually, and as there was no significant difference between the three groups in relation to the rate of questionnaires returned or answers provided, it was decided to combine the results into just the one group for analysis.

The response rate of the questionnaires that can be used (42% were returned with the consent form) was fairly evenly distributed across the three stakeholder groups. This is a very good response rate as Bourque and Fielder (1995) report that for a single mailing with no incentives, such as this project, the researcher should expect no better than a 20% response rate. This possibly reflects the interest in the topic amongst the stakeholders.

The major threats and impacts to intertidal invertebrates in Western Port perceived by respondents

The results basically fell into two broad categories: direct and indirect threats. The issues causing the highest concern among the participants are the indirect threats, especially loss of critical habitat types such as mangroves and seagrass. In the past mangrove forests have been cleared to make way for coastal development (Chapman and Underwood 1995; LCC 1993). However, the greatest loss of mangroves in Western Port has not been from clearing but from die-back, probably due to the disturbance of water currents and sand movement from activities such as dredging (Western Port Regional Planning and Co-ordination Committee 1992; Chapman and Underwood 1995). Loss of seagrass in Western Port has been an issue dating back to the early 1970s (LCC 1993). Participants believe that the health of seagrass is vital for the survival of the entire food chain including invertebrates, fish and wading birds. When asked how important habitat protection is in terms of maintaining biodiversity of intertidal invertebrates, 67 out of 68 of the participants answered very important, the other person thought it was fairly important.

Most of the participants recognised habitat protection as the key to maintaining biodiversity; a common response was 'no habitat, no invertebrates'. One typical response was, 'habitat destruction is the quickest road to species extinction'. The need to protect whole ecosystems rather than individual species was also commented on, as often it is not known exactly what species exist.

Water quality was also a concern particularly in relation to sedimentation and nutrients from the catchment area. One typical

Table 1. Participants' response to the questionnaire.

Response	No. of Questionnaires
Returned with consent form	68
Returned with out consent form	7
Phoned or wrote to say they could not complete the questionnaire	7
Returned to sender	3
Did not respond at all	81
Total sent out	166

Table 2. Response rate of different stakeholder groups.

	No. Sent	No. Returned	Rate
Coastal managers	54	24	44%
Coastal interest groups	79	31	39%
Academics	30	13	43%
Total	163	68	

response was 'I'm more concerned about habitat degradation from sediments and nutrients in the catchment, I'm not that concerned about the 'take' (collection) of marine invertebrates'. The health of the catchment area is important for the dominant intertidal habitat types in Western Port including seagrass, mangrove forests and mud flats.

The direct threat to intertidal invertebrates was said to be from overexploitation resulting from collection of invertebrates for bait and illegal harvesting. Participants also seemed concerned about the overall lack of general awareness of intertidal invertebrates. Previous studies have shown that despite legislation and sign posting illegal collecting still occurs in some areas (Keough *et al.* 1993; Keough and Quinn 2000). It is not known whether illegal harvesting occurs because of a lack of awareness or if it is deliberate.

Authorities with primary responsibility for the protection of intertidal invertebrates in Western Port

Participants were asked who they believed was responsible for the protection of intertidal invertebrates in Western Port. It is interesting to note that whilst most participants thought more than one organisation had primary responsibility for the protection of intertidal invertebrates, some actually wrote that they were not sure who was responsible, and five participants thought no one was responsible. If these specific coastal 'stakeholders' selected for their assumed knowledge of invertebrates and coastal management are unsure who has primary responsibility for the protection of intertidal invertebrates, then it seems unlikely that the general public would be able to make the distinction. Similar conclusions were drawn by the Australia State of the Environment Committee (2001), which described management of the coastal environment including the catchment and estuaries as fragmented among many agencies at local and state level. Wescott (1995) had reported that there were 29 separate acts and about 160 separate agencies with a role on the Victorian coast prior to the Coastal Management Act 1995 being declared, therefore it is not surprising that there is some confusion! Even after the Act came into force and there were some departmental amalgamations, the VCC (2002) reported a multitude of agencies and regulations/ legislation.

Authorities that should be given primary responsibility for the protection of intertidal invertebrates in Western Port

The majority of participants believe that Natural Resources and Environment (NRE) (now split into the Department of Sustainability and Environment (DSE) and Department of Primary Industries (DPI)) should be given primary responsibility for the protection of intertidal invertebrates. This is probably because NRE was responsible (at the time of the survey) for the enforcement of the Fisheries Act 1995 and especially the Fisheries Regulations 1998 under which the majority of the infringements in relation to illegal collecting of invertebrate species occur. The participants did not specify which agency/group of NRE should have the responsibility, e.g. Fisheries (now DPI) or Flora and Fauna (now DSE). However, some made the comment that it should be a conservation focused agency as opposed to an exploitive focused agency (not the Fisheries Department). Two people actually suggested a new organisation be established primarily for the protection of intertidal invertebrates, although as previously stated, since many separate agencies already have a role in the coastal zone, it is difficult to argue for an additional one.

Actions required to ensure intertidal invertebrates are adequately protected in Western Port

Participants were asked what they believed needed to be done (if anything) to improve the protection of invertebrate species in the intertidal zone in Western Port. The responses could be divided into two categories, firstly the **direct threat** of overexploitation needs to be addressed. The participants believed that the most appropriate action to resolve this was increased education and public awareness. They believed this should be done through a variety of education programs including school programs, TV campaigns and regular newspaper articles. The ultimate goal is to change community values and behaviours. One person wrote 'most people see little or no value in species which they can't see and which live in black smelly mud.' With attitudes like this, conserving intertidal invertebrates will be very difficult. There needs to be a balance between the needs of those who enjoy Western Port and the need to enhance and maintain the Western Port environment. Interpretive sign posting highlighting vulnerable species was another way suggested to increase awareness in the area. As well as education, participants believed there needed to be an increase in enforcement of existing legislative and regulative agreements.

Secondly, respondents identified that the **indirect threats** to intertidal invertebrates were particularly related to the catchment area. Many of the participants commented on sediments and nutrients entering the bay from the surrounding area. Increased sediment levels have been associated with loss of seagrass, a critical habitat. Numerous studies have been undertaken into the cause of seagrass loss, but the exact cause is still not known. Since 1973 the total area covered by seagrass has shrunk from 250 square kilometres to 72 square kilometres and the fish catch has dropped from 250 to 185 tonnes (LCC 1993), which illustrates the scale of the problem.

Other suggestions made by the participants to ensure adequate protection of intertidal invertebrates included a complete review of current legislation, consistent legislation for all intertidal areas and the introduction of more legislation to protect habitat and prevent further degradation.

Are intertidal invertebrates adequately protected in Western Port?

Fig. 1 illustrates the participants' response to the question 'are intertidal invertebrates adequately protected?' This shows that a clear majority of the coastal stakeholders do *not* believe intertidal invertebrates are adequately protected.

Participants were also asked if they were aware of any legislation that protects intertidal invertebrates in Western Port. The majority (74%) of the respondents were aware of the existing legislation that is in place to protect intertidal invertebrates. Yet the majority believed that intertidal invertebrates are still *not* adequately protected in Western Port. Figs. 2 and 3 summarise the comments made by participants in support of their responses.

The most frequent supporting comments were in relation to over-exploitation and inadequate enforcement, in particular the low staff numbers trying to deal with the scale of illegal fishing/collecting, mainly of abalone from the subtidal region. The participants were also concerned about the control of indirect threats, particularly in relation to the catchment area. One person wrote, 'who is monitoring changes? No-one. So who knows what is happening?'

Fig. 3 indicates that a low number of participants believe that the current legislation, particularly the Fisheries Regulation 1998, is adequate. However adequate legislation does not necessarily provide adequate protection: this requires effective enforcement and education as well.

Conclusions

This case study of the perceptions of coastal 'experts'/stakeholders as to the adequacy of protection of intertidal invertebrates in Western Port conclusively demonstrated that existing regulatory protection is seen to be inadequate.

The major threats to intertidal invertebrates, perceived by the stakeholders, were the indirect effects of loss of critical habitat and poor water quality, and the direct threat of over-exploitation of invertebrates through collection for bait and food.

The stakeholders were able to identify many of the existing regulations in place for intertidal invertebrate protection, and clearly identified the Department of Natural Resources and Environment as the agency with this responsibility in Victoria at the time of the case study. The Department of Natural Resources and Environment is now the Department of Sustainability and Environment (DSE, responsible for flora and fauna protection) and the Department of Primary Industries (DPI, responsible for fisheries regulations). The key elements of action required to adequately protect intertidal invertebrates, outlined by the stakeholders, were: improved education, information and sign-posting, improved catchment management to enhance water quality, greater enforce-

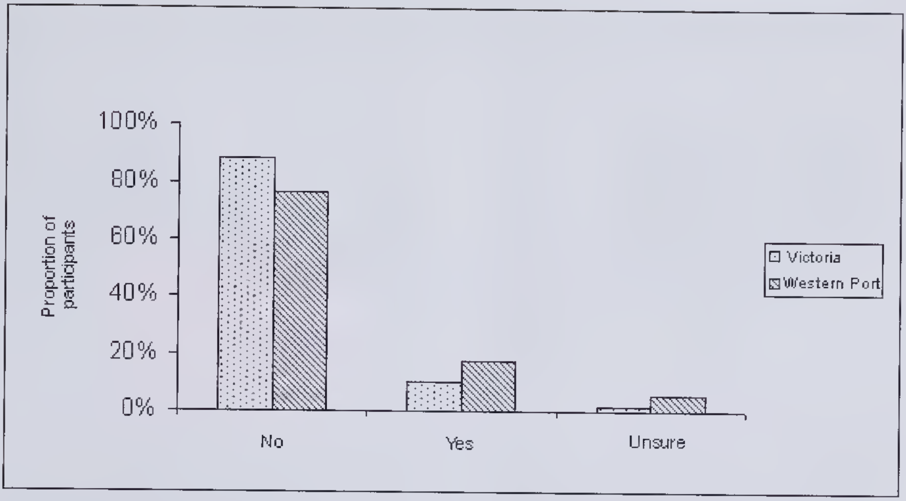

Fig.1. Participants response to whether intertidal invertebrates are adequately protected.

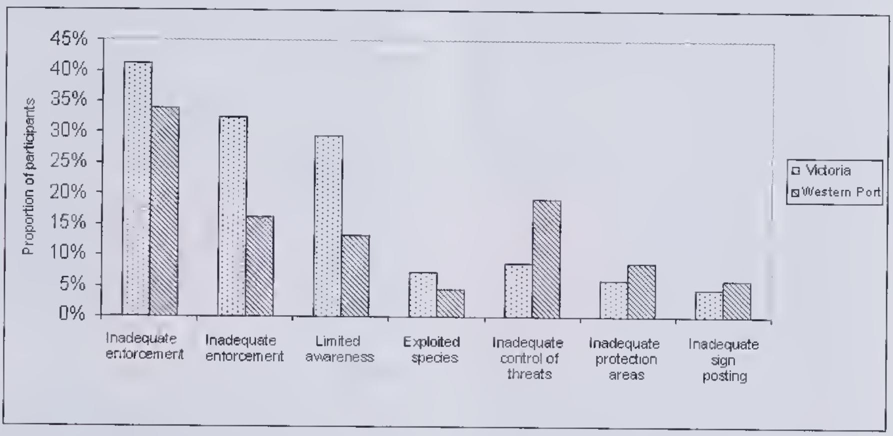

Fig.2. Graph showing the reasons why participants believe intertidal invertebrates ARE NOT adequately protected.

ment of commercial regulations, and a review of correct protective regulations and legislation.

The stakeholders concluded that the current protection of intertidal invertebrates was inadequate not only in Western Port but also across all of Victoria.

In light of these findings the authors recommend an escalating three tiered approach to improving the protection of intertidal invertebrates in Victoria. The proposed concept is to establish a monitoring program of intertidal invertebrates to assess the first tier. This monitoring program would be the responsibility of DSE. The recent (2004) project commencing at Museum Victoria to establish a rocky shores monitoring program could be tailored to meet this need.

If after an agreed period of time no improvement is detectable in the protection of intertidal invertebrates then the second tier would be adopted. If it fails after a prescribed period of time the third tier would be introduced.

First Tier Recommendations:

- To further strengthen integrated coastal and catchment management approaches in Victoria to improve water quality in our coastal waters.

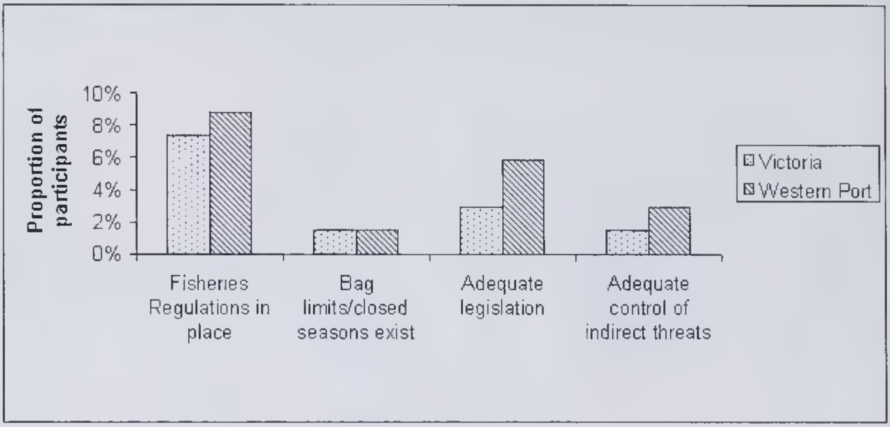

Fig. 3. Graph showing the reasons why participants believe intertidal invertebrates ARE adequately protected.

- VCC, DSE, DPI and Parks Victoria to jointly design a three-year educational program in association with key stakeholder groups to raise public awareness of the need to protect intertidal invertebrates in Victoria.
- A review of the current fisheries regulatory approach with the objective of providing an approach which targets all intertidal environments in Victoria, with the aim of protection of intertidal invertebrates within the current protected area system of Marine National Parks and Marine Sanctuaries, extended Crown Land (Reserves) Act areas and the National Parks Act 1975 to ensure full protection of intertidal invertebrates in parks and reserves under the Acts declared to low water mark. This would remove the 'grey area' of whether invertebrates are protected in the intertidal area within these predominantly terrestrial parks and reserves that have been declared to the low water mark.
- Specific protection throughout highly used or populated areas for all intertidal invertebrates.
- The duties of all Fisheries Officers and all marine and coastal Park Rangers to be extended to enforce the revised regulatory system.

Second Tier of Recommendation (implemented after five years if no improvement evident)

If after five years of establishment of the first tier recommendation there is no detectable improvement in the protection of intertidal invertebrates in Victoria then in addition to the above approach on areas of the Victorian coastline where protection of intertidal invertebrates does not occur (i.e. outside existing parks and reserves):

- Extend the Coastal Protection Zones identified by the ECC in its final recommendation for the marine and coastal areas (ECC 2000) to low water mark to cover the intertidal zones and amend the Crown Land (Reserves) Act 1978 regulations to ensure protection of all intertidal habitat and intertidal invertebrates in these areas.

Third Tier of Recommendation

If after a further three years, after all tier 1 and 2 recommendations have been implemented there is still inadequate protection of intertidal invertebrates in Victoria, reverse the 'onus of proof' inherent in the above (and the current) approach.

- In effect reserve the entire Victorian intertidal zone in a protected area except for areas identified by user groups. In these User Areas sustainable use would have to be demonstrated by the user groups. Other protected areas would not be available for substitution if user groups were unable to maintain a viable invertebrate population in these User Areas.

In all cases above, the lead agency would be the Department of Sustainability and Environment based on current Government structures.

The authors believe that the above approach is fair and equitable to all Victorians (present and future) and allows a staggered approach of improved protection, through increased restriction, only when the previous less restrictive mechanism has failed.

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Survey for Leadbeater's Possum *Gymnobelideus leadbeateri* in the Macedon Region, Victoria

S. Larwill[1,2]

Abstract

A tuft of hair collected from the forest floor edge of the Black Forest, Macedon was identified as hair from Leadbeater's Possum *Gymnobelideus leadbeateri* McCoy, yet the closest known extant population of the species is over 85 km away. Both biotic characteristics of the Macedon region and prior bioclimatic habitat predictions, using historical records of Leadbeater's Possum, support the possible occurrence of the species in the area, thus a targeted survey for Leadbeater's Possum was conducted throughout the local catchment, but without success. (*The Victorian Naturalist* **121** (6) 2004, 264-273).

Introduction

A mammal survey was undertaken as part of the preparation of an Environmental Effects Statement for the proposed upgrade of the Calder Highway (VicRoads 1995a). During the survey a tuft of hair was collected from the ground layer in Swamp Gum *Eucalyptus ovata* Riparian Woodland within the road reserve of Blackwood Road, Macedon, adjacent to Slatey Creek (37°26'6''S 144°32'48''E). Using molecular genetic analysis as an adjunct to the standard morphometric analysis used in inventory surveys, the hair was identified as belonging to Leadbeater's Possum (Larwill *et al.* 2003). A targeted survey for Leadbeater's Possum *Gymnobelideus leadbeateri* McCoy was commissioned by VicRoads as part of the Environment Effects Study (VicRoads 1995a) in order to locate the source population.

Leadbeater's Possum is endemic to Victoria, occurring mainly in the Mountain Ash Forests of the Central Highlands (Fig. 1). It is a nationally endangered species (Menkhorst 1995; (Commonwealth) *Environment Protection and Biodiversity Conservation Act*, 1999).

The majority of records of Leadbeater's Possum are from Mountain Ash Forests with the dominant trees comprising Mountain Ash *Eucalyptus regnans*, Alpine Ash *E. delegatensis* and Shining Gum *E. nitens* (Smith and Lindenmayer 1988).

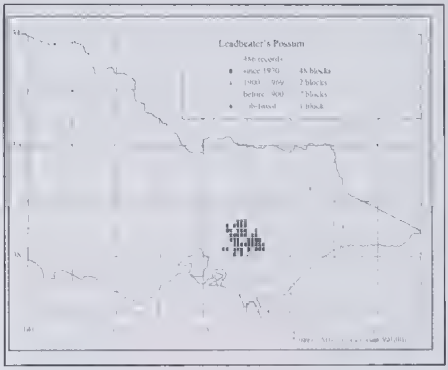

Fig. 1. The distribution of Leadbeater's Possum.

However, Leadbeater's Possum has a limited occurrence in significantly different habitats. Smales (1994) recorded the species in Yellingbo State Nature Reserve in Lowland Swamp Forest habitat, where it is generally confined to a Mountain Swamp Gum *Eucalyptus camphora* community. Other surveys have recorded the species in Subalpine Woodland habitat at Mt Baw Baw and Lake Mountain (Menkhorst 1995; Jelinek *et al.* 1995).

Methods

Study Area

The Macedon-Woodend region is located at the eastern limit of the Western Highlands, Victoria. A previous fauna survey of the Black Forest area west of Macedon township, concentrating on the Slatey Creek catchment (Fig. 2), was conducted between 29 November 1993 and 12 April 1995 (VicRoads 1995b; Larwill *et al.* 2003). The vegetation in the survey area

[1]Biosis Research Pty Ltd. PO Box 489 Port Melbourne, Victoria, 3207. Phone: +61 (03) 9646 9499; Fax: +61 (03) 9646 9242.

[2]Current address: 3473 Old Geelong Road, Stockyard Hill, Victoria, 3373. Phone: +61 (03) 5349 8245; Email: sidsam@smartchat.net.au

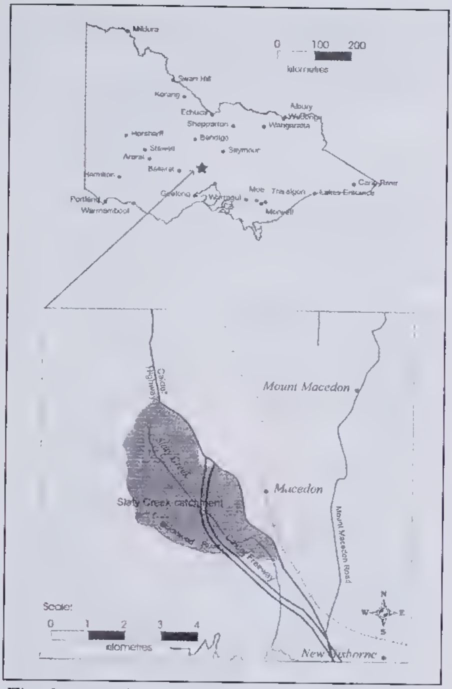

Fig. 2. Macedon-Woodend region study area.

comprises Swamp Gum Riparian Woodland and Manna Gum *E. viminalis* Riparian Forest. Surrounding hillslopes support Messmate *E. obliqua* - Peppermint *E. dives* Dry Forest, which is the most extensive native vegetation community within the Black Forest area.

Identification of Potential Habitat Areas

All sites selected for survey were within the Slatey Creek Catchment and either within or adjacent to (then) proposed alignments for the upgraded Calder Highway.

The vegetation of the Black Forest was reviewed by Yugovic *et al.* (1994a; 1994b). Of the vegetation communities described for the study area, two communities were considered to be potential habitat for Leadbeater's Possum: Swamp Gum Riparian Woodland and Manna Gum Riparian Forest. Whilst neither community provides habitat similar to Mountain Ash Forest, both have similarities to the fringing vegetation of the Lowland Swamp Forest at Yellingbo State Nature Reserve. Messmate - Peppermint Dry Forest is considered unsuitable for Leadbeater's Possum due to the open structure of the shrub-layer (where present).

Within the study area, examples of Swamp Gum Riparian Woodland and Manna Gum Riparian Forest were inspected on 15 March 1995 (Table 1). The upgrade of the Calder Highway - Black Forest Section has been constructed since the time of this survey so a number of the sites have been partially or completely altered as a result of construction.

Field survey methodology

Field surveys took place between 15 March and 12 April 1995. Survey effort is summarised in Table 2.

Stagwatching

In Mountain Ash Forest stagwatching is the preferred survey technique for Leadbeater's Possum as it is up to 10 times more successful at recording the species than spotlighting and four times more successful than trapping (Smith *et al.* 1989). Similar techniques have been used to survey for Leadbeater's Possum at Yellingbo State Nature Reserve (e.g. Thomas 1989). Stagwatching was conducted following methods outlined in Smith *et al.* (1989) and Seebeck *et al.* (1983). Stagwatching involves counts of arboreal mammals emerging from tree hollows at dusk.

Stagwatching was conducted for a total of 132 person-hours. As the possible habitat in the study area is considerably different from the Mountain Ash Forests, potential nest trees (stags) were determined by comparison of nest trees used by the species at Yellingbo State Nature Reserve. Potential nest trees for the field survey were identified by visual assessment of the following attributes, suitable trees usually having two or more such attributes in combination:

- mature or old age trees based on qualitative assessment of age by a combination of canopy height and trunk girth
- dead trees
- the presence of spouts (large hollow stumps left after fall of branches)
- the presence of obvious hollows visible from the ground
- visible disease or scarring of trunks and large branches suggestive of the presence of hollows

Table 1. Site Descriptions. Note that sites 2, 3, 4 and 5 have been partially or completely destroyed since this survey was completed, in the process of construction of the upgrade of the Calder Highway, Macedon Section.

Site No.	Description	AMG Grid Reference
1	Strip of Manna Gum riparian forest bordering Slatey Creek south of Blackwood Rd, east of Mount View Rd intersection.	BU835541
2	Swamp Gum riparian woodland on both sides of Blackwood Rd, from approx. 200m NE of Blackwood Rd - Wiltshire Rd intersection to Slatey Creek bridge.	BU830538
3	Dense Manna Gum riparian forest adjacent to Slatey Creek, further upstream from Site 2.	BU828542
4	Riparian forest (Manna and Swamp Gum) bordering Slatey Creek at the end of Ellandee Cres, upsteam from Site 3.	BU827547
5	Principally Manna Gum riparian forest bordering Slatey Creek near the fire access track at the end of Walgood Gve, upstream from Site 4.	BU825550
6	Manna Gum riparian forest at the confluence of Slatey Creek and a tributary near the end of Willey Rd, upstream from Site 5.	BU820555
7	Swamp Gum woodland within a shallow drainage line running south from Blackwood Road to a confluence with Gisborne Creek at Mulcahye Road.	BU811538
8	Patch of Swamp Gum riparian woodland surrounded by messmate open woodland, east of extensive softwood plantation and south of Fingerpost Rd.	BU810574
9	Strip of dense Manna Gum riparian forest bordering a deep drainage line in the softwood plantations north of the Old Calder Hwy.	BU827566

Table 2. Summary of survey methods and intensity.

Survey Method and Intensity	Site Number 1	2	3	4	5	6	7	8	9	Total
Stagwatching (total no of trees watched)	7	16	4	30	48	15	7	15	18	145
Elliott trapping (trap-nights)	28	50	70	90	nil	50	30	49	nil	367
Cage trapping (trap-nights)	28	nil	nil	nil	nil	nil	nil	nil	nil	28
Call imitation / broadcast conducted Y = yes	Y	Y	Y	Y	Y	Y	Y	Y	Y	all sites
Owl call broadcast conducted Y = yes)		Y	-	-	-	-	-	-	-	one site
Nest boxes (no of boxes)	1	6	nil	3	2	4	1	2	1	20

- the presence of surrounding dense vegetation (follows Smith and Lindenmayer 1988).

A total of 145 potential nest trees was identified, flagged and mapped. On each evening of stagwatching, between 3 and 27 observers were each stationed beside a stag at approximately 30 minutes before dusk. In general, observers were stationed along a linear transect of identified stags ranging between 5 and 40 m apart. Stagwatching was completed after one hour, and all observations of arboreal mammals were collated.

Active Searching

Active searching was conducted during mapping of stag trees. Dreys of Common Ringtail Possum were gently shaken and emergent mammals identified.

Scat and Hair Analysis

Predator scats and hair samples were collected, analysed and identified. Hair and skeletal remains contained in predator scats were analysed and prey species were identified. Scats were analysed by B. Triggs. In some cases, identification to species level was not possible due to the poor quality of the remains.

Elliott Trapping

Arboreal mammals were surveyed using Elliott traps (325 x 85 x 95 mm) baited with a mixture of rolled oats, honey and peanut butter. Each tree was sprayed with a fluid mixture of honey and water along trunks and branches close to the trap. Traps were set in trees at varying intervals along eight transects consisting of 3 to15 traps for a total of 367 trap-nights. One 'trap-night' is equivalent to one trap left open for one night. Traps were set in place for 11 days' duration, with two trapping phases conducted between days one and four, and days nine and eleven.

Cage Trapping

Arboreal mammals were surveyed using large cage traps (measuring 590 x 290 x 290 mm) set in trees at heights between 3.5 and 6 m. Each trap was baited with a mixture of rolled oats, honey and peanut butter. Branches and trunks of the tree were sprayed with a mixture of honey and water. Traps were set in eight trees at one sampling site for a total of 28 trap-nights.

Spotlighting

Spotlighting was conducted in conjunction with other field activities (notably for short periods after stagwatching and after periods of call broadcast and imitation). Systematic spotlighting was not undertaken, emphasis instead being placed on stagwatching and trapping, which have been found to be respectively 10 times and 2.5 times more effective than spotlighting in detecting Leadbeater's Possum (Smith *et al.* 1989).

Call Broadcast/Imitation

Broadcast of pre-recorded calls has been used at other sites with variable success to attract individuals into view of the field worker. Pre-recorded calls of Leadbeater's Possum were broadcast through a hand-held loudspeaker at two sites for a total of four hours. Calls were broadcast for five minutes' duration, followed by listening and looking for movements and sounds with limited use of spotlight.

Vocal imitation of territorial calls has been successful in attracting individuals to within 2-3 m of the field worker at Yellingbo State Park and this is considered a useful technique for detecting the presence of the species (e.g. Lindenmayer *et al.* 1989; Lindenmayer 1996). Calls were imitated for 10 minutes' duration. This was followed by a period of quiet observation with limited use of spotlight. Call imitation was conducted at seven sites for a total of 5.5 hours.

Owl Call Play-back Census

Owl call broadcast has been used at some sites to increase activity (and therefore detectability) of arboreal mammals. Owl calls were broadcast through a loudspeaker for a duration of 20-30 minutes at Site two. After an interval of 10-15 minutes the immediate area was searched by spotlight.

Nest Boxes

Installation of nest boxes has been used with varying success as a technique for detecting the presence of Leadbeater's Possum (e.g. Smales 1994). A total of twenty nest boxes was installed at eight sites (Table 2) between 4-6 April. Nest box design was modelled on nest boxes currently used by Leadbeater's Possum in Montane Ash Forests in the Central Highlands. Boxes measuring 300 x 300 x 600 mm were constructed from 12 mm structural ply. Each box was provided with a hinged lid, drainage holes in the box floor and an oval entrance hole of 40 x 65 mm. Each box was attached to a tree by means of a steel bracket at a height of between 4.5 and 5.5 m from the ground. Nest boxes were inspected four times between 12 April and 20 December 1995.

Results

Sixteen mammal species were recorded during the targeted fauna survey (Appendix 1).

Stagwatching

Six mammal species were recorded during stagwatching (Table 3). The Common Ringtail Possum was most common and recorded 70 times from stag trees and 55 times in foliage or other trees. The Common Brushtail Possum and Sugar Glider were far fewer and only noted about nine times, while the Agile Antechinus, White-striped Freetail Bat and Feathertail glider were recorded less often. Most observations were from stag trees, in foliage or other trees and very few observations were made from the ground or by being heard.

Elliott Trapping

Only three mammal species were recorded using Elliott trapping (Table 4). The Agile Antechinus and Bush Rat were caught at each study site, but the Feathertail Glider was caught only once at one site. Animals were not marked, therefore total numbers of trapped species may have included some recaptures of single individuals.

Table 3. Stagwatching survey results

Site	Date	Weather	No. stags	Pers-hours	Confirmed observations s = from stag tree f = in foliage or other tree g = on ground h = heard
1	30/3	clear, still	7	3	3 Common Brushtail Possum (s) 1 Common Ringtail Possum (s) 1 Common Ringtail Possum (f)
2	24/3	overcast, wet, still	16	12	5 Common Ringtail Possum (s) 9 Common Ringtail Possum (f) 1 Agile Antechinus (g)
3	24/3	as above	4	4	8 Common Ringtail Possum (s)
4	1/4	overcast, occas. Breeze	15	13	9 Common Ringtail Possum (s) 8 Common Ringtail Possum (f
	4/4	heavy rain (watch shortened by 15 minutes)	15	12	5 Common Ringtail Possum (s) 4 Common Ringtail Possum (f)
5	23/3	mild, clear, still	18	16	3 Common Ringtail Possum (s) 14 Common Ringtail Possum (f) 2 Sugar Glider (s) 1 Sugar Glider (f) 2 Agile Antechinus (g) White-striped Freetail Bat (h)
	1/4	overcast, occas. breeze	27	26	13 Common Ringtail Possum (s) 5 Common Ringtail Possum (f) Sugar Glider (h) White-striped Freetail Bat (h)
	3/4	clear, still	3 (repeats)	3	3 Common Ringtail Possum (s)
6	27/3	occas. cloud, breezy	15	12	2 Common Brushtail Possum (s) 3 Common Brushtail Possum (f) 7 Common Ringtail Possum (s) 6 Common Ringtail Possum (f) 1 Sugar Glider (f)
7	30/3	clear, still	7	5	1 Common Ringtail Possum (s) 2 Common Ringtail Possum (f) 3 Agile Antechinus (g)
8	18/3	clear, occas. breeze (full moon)	15	12	1 Common Brushtail Possum (f) 4 Common Ringtail Possum (s) 3 Common Ringtail Possum (f) 1 Feathertail Glider (f)
9	26/3	clear, occas. Breeze	18	14	11 Common Ringtail Possum (s) 3 Common Ringtail Possum (f) 4 Sugar Glider (s) White-striped Freetail Bat (h)
TOTAL			145	132	9 Common Brushtail Possum 125 Common Ringtail Possum 8+ Sugar Glider 1 Feathertail Glider 6 Agile Antechinus 3+White-striped Freetail Bat

Cage Trapping

Cage trapping from eight traps over 28 trap nights caught two sub-adult and three adult Common Ringtail Possums.

Active Searching / Scat and Hair Analysis

Eleven mammals were identified from a total of 25 predator scats and five hair samples (Table 5). The record of the Common Dunnart *Sminthopsis murina* from a dog scat collected at Site 4 was notable. It is the first record of the species from the Macedon-Woodend area but as dogs are wide-ranging, the exact source of the record is unknown. Human hair was recorded in domestic dog scats but this is not unusual and commonly is derived from household refuse and litter.

Table 4. Elliott trapping results

Site	No. traps	Trap nights week 1	Species trapped	Trap nights week 2	Species trapped
1	5	13	3 Agile Antechinus 2 Bush Rat	15	2 Agile Antechinus 6 Bush Rat
2	8	26	3 Agile Antechinus 3 Bush Rat	24	10 Agile Antechinus 7 Bush Rat
3	10	40	14 Agile Antechinus 3 Bush Rat	30	13 Agile Antechinus 4 Bush Rat
4	15	45	11 Agile Antechinus 7 Bush Rat	45	17 Agile Antechinus 9 Bush Rat 1 Feathertail Glider
6	10	20	3 Agile Antechinus 6 Bush Rat	30	7 Agile Antechinus 17 Bush Rat
7	5	15	2 Agile Antechinus 1 Bush Rat	15	11 Agile Antechinus 1 Bush Rat
8	7	28	6 Agile Antechinus 1 Bush Rat	21	13 Agile Antechinus 4 Bush Rat
TOTAL	60	187	42 Agile Antechinus 23 Bush Rat	180	73 Agile Antechinus 48 Bush Rat 1 Feathertail Glider

Call Broadcast / Imitation and Owl call Playback Census

No Leadbeater's Possums or other mammals were recorded during call broadcast / imitation and owl call playback sampling.

Nest Boxes

Neither Leadbeater's Possum nor other mammal nor bird species were observed in the nest boxes. The presence of scats indicated the use of a nest box at Site 2 by an unidentified Dasyurid (probably Agile Antechinus), and at Sites 2 and 5 by Common Ringtail Possum. The presence of nesting material inside indicated use of nest boxes at Site 2, probably by Sugar Glider. At other sites, some evidence of chewing around the entrance hole to the nest boxes indicated activity but no identifiable evidence was found.

Discussion

The failure to find a population of Leadbeater's Possum in the present survey means that the provenance of the Leadbeater's Possum hair found on the forest floor adjacent to Slatey Creek remains unresolved.

Being the eastern limit of the Western Highlands, the Macedon-Woodend area has natural affinities with the Central Highlands. It is the only area west of the Hume Highway that demonstrates montane affinities in its climate and associated biota. Mt Macedon is the only peak in the western half of Victoria where snow is regularly recorded. It supports an isolated occurrence of Alpine Ash *Eucalyptus delegatensis* and Mountain Ash *E. regnans*, which, apart from the occurence of Mountain Ash in the Otway Ranges, forms the western limit of both species' distribution. Other montane or alpine species occurring at the western limit of their known range in the Woodend-Macedon area include Snow Gum *E. pauciflora*, Lanky Fescue *Austrofestuca eriopoda*, Mountain Mirbelia *Mirbelia oxylobioides* and Mountain Brushtail Possum *Trichosurus caninus* (Yugovic *et al.* 1993; VicRoads 1995a). All these species are absent from extensively cleared and drier forested areas between Mount Macedon and the Central Highlands. The Macedon-Woodend area is characterized by these

Table 5. Results of scat and hair analysis

Site	Date	Sample type	Mammal species identified
2	15/3	Dog scat	Dog
	15/3	Dog scat	Brushtail Possum (*Trichosurus* sp.)
	15/3	Dog scat	Black Wallaby
	15/3	Fox scat	Common Ringtail Possum
	20/3	hair	Common Ringtail Possum
	31/3	hair	Black Wallaby
3	15/3	Dog scat	Black Wallaby
	22/3	Fox scat	Black Wallaby
	23/3	hair	Common Ringtail Possum
	30/3	Fox scat	Fox
4	21/3	hair	Common Ringtail Possum
	21/3	Dog scat	Goat Dog
	22/3	prob. Fox scat	Rabbit
	22/3	Dog scat	Common Dunnart
	30/3	Dog scat	Goat
	30/3	prob. Fox scat	Common Ringtail Possum
5	15/3	Fox scat	Rabbit
	15/3	Fox scat	Rabbit
	15/3	Dog (domestic)	Human
6	22/3	Dog scat	Sheep
	28/3	prob. Dog scat	Common Ringtail Possum
7	15/3	Dog scat	Rabbit
	15/3	Dog scat	Black Wallaby
	15/3	Fox scat	Dog
	21/3	hair	Rabbit Cow
8	15/3	Fox scat	Black Wallaby
	20/3	Dog scat	Dog
	30/3	Fox scat	Fox

atypical occurrences of species otherwise restricted to the montane and subalpine habitats of the highlands in the eastern half of the state.

Similarly, Leadbeater's Possum also has a Victorian distribution concentrated in montane habitats of the eastern half of the state. The record of the species from Slatey Creek, Macedon, is consistent with other biotic characteristics of the region. It also correlates with the predicted occurrence of the species in the Macedon-Woodend region by bioclimatic analysis incorporating historical records of the species by Lindenmayer *et al.* (1991).

The riparian habitat in the Slatey Creek catchment is structurally similar to habitat in Yellingbo State Nature Reserve (Smales 1994). Recent records of Leadbeater's Possum at Yellingbo, Mt Baw Baw and Lake Mountain, in habitat very different from Mountain Ash Forest in species composition and structure, suggest the species may have broader habitat requirements than previously thought. This is supported by historical records of Leadbeater's Possum (Lindenmayer and Dixon 1992), which indicate the occurrence of the species over a wider area and in a more diverse range of habitats.

The most parsimonious interpretation of the hair record is that there is a resident population in the local area. However, this intensive survey of parts of the Slatey Creek catchment failed to record the species. The survey was sufficiently intense, in the vicinity of the location of the hair, to conclude with moderate confidence that the species does not occur in the immediate area.

If there is no population of Leadbeater's Possum in the immediate area, then whence did the hair originate? The location where the hair was found is over 85 km west of the nearest confirmed record of the species, at Toolangi. Could the hair have originated from Central Highland populations in eastern Victoria and been transported to the study area either from captive animals or by a predator?

Leadbeater's Possum is likely to be only a very rare prey item for terrestrial predators, including introduced feral predators and native quolls (Lindenmayer 1996). Owl predation on Leadbeater's Possum has not been observed in the field (Smith 1995; Higgins 1999). However, analysis of fossilised owl pellets, deposited by either the Sooty Owl or Masked Owl, and dating between 5000 and 30 000 years ago, have shown the presence of Leadbeater's Possum remains (Lindenmayer 1996). Neither the Sooty Owl nor the Masked Owl occurs in the Macedon region. The Powerful Owl *Ninox strenua*, which has been recorded 4 km east of the hair record

(Atlas of Victorian Wildlife) and is regularly recorded in the Wombat State Forest 25 km west of the hair record, like the Sooty Owl and Masked Owl, feeds on arboreal mammals. Powerful Owls are known to feed on arboreal mammals of a similar size to Leadbeater's Possum, such as Sugar Gliders and Squirrel Gliders *Petaurus norfolcensis* (e.g. Traill 1993; Higgins 1999) and Agile Antechinus (Higgins 1999). Adult Powerful Owls may hold partly consumed prey items during daytime roosting and are known to have multiple roosting sites in their territory. The remains of a prey item may therefore be found some distance from the point of capture. It is not uncommon to find the tail of a Leadbeater's Possum on the forest floor (e.g. Smith 1995; Lindenmayer 1996; Meredith *et al.* 1992) presumably snipped off by owls. It is possible that the tuft of hair fell from an animal transported to a nearby roosting site for consumption.

The size of the home range of the Powerful Owl depends on the productivity and the structure of the habitat, and the geography of the area (Kavanagh 1997 cited in Higgins 1999). Estimates range from 300 – 1500 ha. The maximum recorded distance at which a bird has ranged while foraging is 4.1 km (Kavanagh 1997 cited in Higgins 1999). It is impossible that the Slatey Creek site and eastern Victorian populations of Leadbeater's Possum occur within the home range of a Powerful Owl.

Little is known about the dispersal of Powerful Owls. Of 40 owls that have been banded, 4 have been recovered of which 3 were found less than 10 km from the site of banding (Higgins 1999). The possibility that a single Powerful Owl dispersed over 85 km from the eastern Victorian highlands to the Macedon region, whilst carrying a prey item, can be discounted.

Could the hair have originated from artificially released animals or from captive colonies? The only captive individuals of Leadbeater's Possum in Australia are held at Melbourne Zoo and Healesville Sanctuary. Strict studbooks are kept on all captive animals including all offspring and deaths. It is illegal under both State and Commonwealth legislation to hold the animal in private collections. There is only one incident of release of captive animals known to me: a release of a number of animals at Marysville by the (then) Department of Conservation and Forests and Lands, all of which are believed to have died soon after release.

The hair located in the Slatey Creek catchment must therefore have originated from a resident population of Leadbeater's Possum in the Macedon region. The variation in hair morphology of the Leadbeater's Possum hair found in the study area compared to reference collections for the species, as reported in Larwill *et al.* (2003) supports this hypothesis, suggesting some morphological variation between the source of the hair and the eastern Victorian populations from which hair in reference collections is derived.

If the hair was from the prey item of a resident Powerful Owl, it may have originated from up to four or five kilometres from the site where it was found. It may therefore have originated from the small area of Mountain Ash Forest, and adjacent Snow Gum Woodland, on the slopes of Mount Macedon itself. Past survey work in the Macedon Ranges Regional Park did not record Leadbeater's Possum (Elkington *et al.* 1985).

The occurrence of extant populations of the Leadbeater's Possum at localities distant from its range in Mountain Ash Forest habitats in the Central Highlands would have implications for the species' long-term prospects for survival. Due to the long-term effects of the 1939 bushfires, nest hollows are expected to become a limiting resource for the species as old burnt trees collapse, and a decline in species abundance and range is predicted in the next 75 year period (Lindenmayer *et al.* 1990; Lindenmayer 1996; Lindenmayer *et al.* 1997). Old-growth forest represents the only long-term refuge for the species within Mountain Ash habitats, and needs to be adequately protected. Occurrences of the species outside the Central Highlands Mountain Ash habitats, such as those at Yellingbo State Nature Reserve, Mt Baw Baw and Lake Mountain, provide supplementary refuge sites for the species' long term survival. A population in the Macedon-Woodend region would do likewise.

Further survey work in the region is warranted and should be particularly focused on suitable areas of Mountain Ash and Snow Gum Woodland habitat on Mount Macedon itself. The Macedon Ranges Conservation Society (MRCS), which assisted with this survey, is taking an ongoing interest in the mystery posed by the hair record. The MRCS is continuing nest box programs in the region, including some new nest boxes installed in Mountain Ash Forest in Macedon Ranges Regional Park. Confirming the location of a population in the region would be a significant find for the future conservation of the species. However, if we fail to find a population, the hair record reported in Larwill (*et al.* 2003) will remain a conundrum.

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Appendix
Species list. Mammal species recorded during the targeted fauna survey. Scientific names are from Menkhorst (1995) and Dickman *et al.* (1998).

Common Name	Scientific Name
Agile Antechinus	*Antechinus agilis*
Black Wallaby	*Wallabia bicolor*
Bush Rat	*Rattus fuscipes*
Common Dunnart	*Sminthopsis murina*
Common Brushtail Possum	*Trichosurus vulpecula*
Common Ringtail Possum	*Pseudocheirus peregrinus*
Cow	*Bos taurus*
Dog	*Canis familiaris*
European Rabbit	*Oryctolagus cuniculus*
Feathertail Glider	*Acrobates pygmaeus*
Goat	*Capra hircus*
Human	*Homo sapien*
Red Fox	*Canis vulpes*
Sheep	*Ovis aries*
Sugar Glider	*Petaurus breviceps*
White-striped Freetail Bat	*Tadarida australis*

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One Hundred Years Ago

PRESIDENT'S ADDRESS. July 7th, 1904
"THE COLLECTING OF NATURAL HISTORY SPECIMENS"
[Delivered by the president, Mr. O.A. Sayce]

Whatever group of organisms you study, be sure not to neglect to observe the common forms. These are often the most important; they have at least shown, in virtue of their numbers, that they have been the most successful in the struggle for existence, and therefore possess dominant characters. It is also a good thing to collect thoroughly whatever group of organisms you are studying from at least one restricted locality, and compare them with collections from elsewhere. At any rate, consider your organisms from the point of view of locality and range; one often gets interesting reading from nature in this way. As only one instance, I may mention a little freshwater crustacean, called *Phreatoicus australis*, which was first found on the summit of Mt. Kosciusko; later it was recorded from Mt. Wellington; later still I identified it from Lake Petrach, a mountain lake in Tasmania; and again from material received from a member of the last Club Excursion to Mt. Buffalo, collected from the top of the mountain. It therefore appears to be an inhabitant only of Alpine regions, and the reason why this should be so is raised in our minds. Of course considerable data are required before we can satisfactorily answer many questions that may arise in this way, but we have a better prospect of working to good purpose when we try to answer definite questions.

From *The Victorian Naturalist* **XX**, pp 35-36, July 1904

The occurrence of Hooded Plovers in Port Phillip Bay

Michael A Weston[1] and John M Peter[1]

Abstract

In Victoria, Hooded Plovers *Thinornis rubricollis* are generally confined to ocean beaches. Here we review reports of the species inside Port Phillip Bay. We located reports from 15 sites within the Bay, though at least one is doubtful, and another almost certainly does not accurately indicate the collection site; some other reports and specimens lack detail. Hooded Plovers have occurred in the north of the Bay – as far from ocean beaches as the Bay permits – and probably as far from the ocean beach of any record in south-eastern Australia. They have been recorded at least five times from the inner-northern part of the Bay, with at least one record that involved a bird that apparently remained for several months in 1949. Reports of breeding are confined to the far south of the Bay, and no reports from the eastern shores of the Bay were located, despite the sandy nature of the beaches there. The species occurred intermittently on Mud Islands (near the entrance to the Bay). We also challenge an extraordinary report from the You Yangs, 15 kilometres inland from the Bay. (*The Victorian Naturalist* **121** (6), 2004, 274-283)

Introduction

Ornithological publications offer a multitude of opportunities for reporting sightings of rare species, or sightings which are interesting in other ways, such as records beyond the usual range or those in unusual habitats. The newsletters and magazines of bird clubs often contain regular articles where members contribute their sightings (see, for example, the *Bird Observer* or *Wingspan*). Taken separately, the value of these reports is limited. However, when enough reports are available, reviews of the data can elucidate biologically relevant information such as patterns of movement (e.g. Joseph 1978) or possible changes in distribution (e.g. Cameron and Weston 1999).

This paper reviews such incidental reports of Hooded Plovers *Thinornis rubricollis* in Port Phillip Bay. In eastern Australia, this vulnerable species is found almost exclusively on ocean beaches, and rarely enters embayments. However, in Western Australia the species also occurs on lakes, sometimes hundreds of kilometres from the coast (Marchant and Higgins 1993). The review was prompted by a report of two adult Hooded Plovers at Westgate Park, beneath the Westgate Bridge at Fisherman's Bend, about 6 km west of Melbourne in February 1999. This was particularly interesting because the report referred to a site within an embayment, and the habitat was very different from open ocean beaches where the species usually occurs (Marchant and Higgins 1993). A follow-up visit (by MAW) six days after the sighting revealed no Hooded Plovers but three Red-kneed Dotterels *Erythrogonys cinctus*. The observer who reported the plovers had field experience with both Hooded Plovers and Red-kneed Dotterels and, though preferring to withdraw his record, still felt that the birds in question were Hooded Plovers.

Methods

This study compiled all known reports from the following sources:

1. A literature search concentrating largely on local content, such as the *Bird Observer*, *The Geelong Bird Report* and *Victorian Ornithological Research Group* (VORG) *Notes*. The search was not confined to periodicals, as we also searched various regional bird books, such as Belcher (1914).

2. A questionnaire sent to all Australasian Wader Studies Group (AWSG) National Hooded Plover Count participants asking for records of Hooded Plovers away from open ocean beaches.

3. A search of all correspondence collected over ten years of the 'Hooded Plover Project', a community-based project run by Birds Australia. This correspondence included a list of specimens examined by DI Rogers in his work for Volume 2 of the *Handbook of Australian, New Zealand and Antarctic Birds* (Marchant and Higgins 1993).

[1] Birds Australia National Office, 415 Riversdale Road, Hawthorn East, 3123. Email: m.weston@birdsaustralia.com.au or j.peter@birdsaustralia.com.au

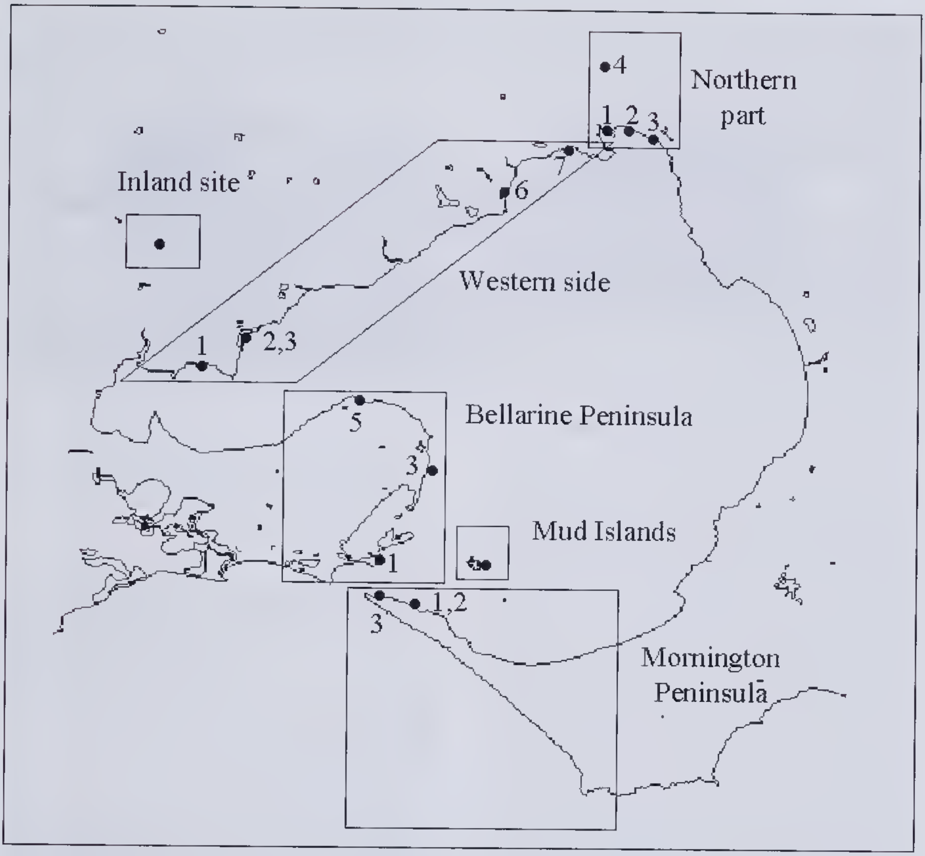

Fig. 1. The distribution of site-specific reports of Hooded Plovers inside Port Phillip Bay (black dots). Boxes indicate the regions used in the text, site numbers refer to those used in the text.

4. A search of the records generated in the original *Atlas of Australian Birds* (Blakers *et al.* 1984), hereafter referred to as the 'Field Atlas'. These records are within one degree blocks. We attempted to contact the observers who submitted data sheets to clarify the precise location of their observations. In some cases the observers could not be contacted or were unable to provide details of the exact location.

5. A search of the historical Atlas of Australian Birds (see Blakers *et al.* 1984).

6. A search of the data in the *New Atlas of Australian Birds* (courtesy of Birds Australia and now published [Barrett *et al.* 2003]). Again, we followed up reports with the observers who submitted the data sheets.

7. A search of data in the Atlas of Victorian Wildlife (courtesy of the Department of Sustainability and Environment).

8. An examination of the records in the AWSG National Wader Count database. These counts have been conducted biannually at sites around Australia, both in winter and in summer, since 1980. We generated a list of data sheets recording the species in the grid that included the entire area of Port Phillip Bay, and we then examined the original data sheets to derive the exact location of each count. Of 42 count sheets examined, only two reported Hooded Plovers inside the Bay.

9. Correspondence with selected birdwatchers active in the Port Phillip Bay area.

10. Correspondence with three museums (Australian Museum, Museum Victoria and American Museum of Natural History).

For each report we have attempted to access the source of the report. This was particularly important where:

Hooded Plover chicks, The Oaks, Victoria. Photo by Mike Weston.

1. Primary information had been pooled. For example, Barter (1992) presented combined data from wader counts of Lake Victoria, Mud Islands and Swan Bay. He recorded Hooded Plovers, but it was unclear as to which of the three locations held Hooded Plovers. We were able to access the AWSG data he used and thus refer to specific locations.

2. Sources contained only general positional information, so we attempted to determine the location more precisely. Low spatial resolution was a feature of several databases, which often meant it was unclear whether a report referred to a site inside or outside the Bay, especially in southern Port Phillip Bay on Mornington or Bellarine Peninsulas.

3. We needed to establish whether multiple reports had been made of the same bird or group of birds.

We have defined Port Phillip Bay as the shores of the Bay proper, inside the 'Heads', between Point Lonsdale and Point Nepean. We have excluded Lake Victoria, where Hooded Plovers occur regularly (Hewish 2004; unpubl. data), and Lake Connewarre, where at least one report exists (J Mitchell pers. comm., and possibly Field Atlas sheets 79850, 79985, 15272). We have, however, dealt with reports from the You Yangs, a series of hills north of Corio Bay in the south-western part of Port Phillip Bay (see Fig. 1, 'inland site').

We have attempted to find as many reports of Hooded Plovers inside Port Phillip Bay as possible, but there may be some that we have overlooked, particularly those published in obscure literature, or those not published at all.

Results

Our search revealed the following site-specific reports from Port Phillip Bay. Locations of sites within the Bay are shown in Fig. 1. Locations and dates of reports from the various databases are listed in Appendix 1.

Mornington Peninsula

1. A single pair has bred on the northern shores of the Point Nepean School of Army Health, between 1991 and 1998 (Dowling and Weston 1999). Birds continue to occur here (V Teoh pers. comm.).

2. A questionnaire asking for details of occurrence of Hooded Plovers away from ocean beaches led to R Fernley reporting a single Plover near the Quarantine Station at Point Nepean on 5 March 1995. It is likely that this was from the same site as the above record.

3. Two Plovers, probably adults, were seen from a boat on a beach just inside the Bay near Point Nepean (MJ Carter and PS Lansley pers. comms). The date of this report is unknown. These were the only Hooded Plovers Carter recalls having seen inside the Bay despite actively bird-watching there, particularly on the eastern side of the Bay, since 1964.

4. 'Back of Rye' (North 1913-14). It is difficult to determine whether the author meant the Bay or ocean side of the Mornington Peninsula, but it was probably the latter, because Hooded Plovers would

probably have been more common there, and the ocean beaches of the Peninsula are usually referred to as 'back beaches'.

5. MacRae. The Field Atlas contains reports from MacRae in January 1977, January-February 1978 and January-February 1979. All these sheets were submitted by I Endersby and all refer to sections of ocean beach. One record sheet refers to Gunnamatta Beach (23 January 1977), while the two others both refer to Bushrangers Bay (19 January 1978 and 30 January 1979, respectively) (I Endersby pers. comm.). These locations are both on the ocean-facing shore of the Peninsula, not in Port Phillip Bay.

6. Dromana. A Field Atlas report from between March and May 1979. This was submitted by S Steele, and the observer thinks that the Hooded Plovers he saw were in Westernport Bay, probably at Shoreham or Flinders (ocean-facing beaches); he does not recall seeing any Hooded Plovers inside Port Phillip Bay.

Bellarine Peninsula

1. Queenscliff. This section is presented in four parts: (i) reports from Queenscliff itself, (ii) reports from nearby Sand Island, (iii) reports from nearby Duck Island and (iv) specimens labelled 'Queenscliff'.

(i). There are 16 Field Atlas sheets referring to the species at Queenscliff between April 1977 and December 1981. All but three of these sheets were submitted by JM Pratt, and the reports probably refer to Sand Island (see below) where he made regular observations. Drummond (1985) documented a breeding record from Queenscliff in February 1984 (made by Pratt), and this, presumably, was also from Sand Island (see below). We have not considered sheets that include Queenscliff along with other ocean beach locations such as Ocean Grove and Barwon Heads. One Atlas of Victorian Wildlife report from 'Queenscliff', in fact, refers to Portsea (indicated in Appendix 1 and determined by reference to the original sheet).

Two participants in the Birds Australia Beach Patrol Scheme, K Bartram and DW Eades, regularly located a pair of Hooded Plovers between Point Lonsdale and Queenscliff, from 1977 to about 1980. They were seen on most visits and throughout the year. The birds were generally confined to the area north of the rocky breakwater, and were thus closer to Queenscliff than Point Lonsdale. Recent surveys have failed to locate Hooded Plovers along this stretch of beach. These surveys were conducted in October 1988, November 1992, May 1994, November 1994, November 1996, November 1998, November 2000 and November 2002 (Weston and Schipper 1994; AWSG unpubl. data).

(ii). Pairs have bred at Swan Island, on the dredge spoil island known as Sand Island (Garnett *et al.* 1986; MA Cameron pers. comm.). DCE (1991) and Barter *et al.* (1988) considered Hooded Plovers as a regular and breeding species in Swan Bay, but the only record in the summer AWSG wader counts in the Swan Bay-Mud Islands complex was of two birds in summer 1984 (DCE 1991); JM Pratt listed two birds on 'Queenscliff Spit', apparently nesting on 11 February 1984 (AWSG unpubl. data). About 20 years ago, up to three pairs bred on the northern part of Sand Island, and at least some bred successfully (JM Pratt pers. comm.). Recent surveys, in October 1988, November 1992 and November 1994, have failed to locate breeding Hooded Plovers on the island (AWSG unpubl. data). The AWSG surveys did not cover any areas inside the Bay in 1982. There is a recent record of a juvenile on Sand Island in February 2000 (Lingham 2000). This bird appears to have been reported several times: the New Atlas of Australian Birds records the species at Sand Island on 13 February 2000 (C Morley and G Gibbs pers. comm.); a juvenile also was recorded on an AWSG wader count at the same time (G Gibbs pers. comm.; AWSG sheet).

(iii). One report from St Leonards may in fact refer to Duck Island in Swan Bay (see below).

(iv). Two specimens in Museum Victoria (R11570 and R11568) are marked 'Queenscliff, Victoria' (DI Rogers pers. comm.; RM O'Brien pers. comm.). These were purchased by Museum Victoria from Ninian Batchelor, a taxidermist with a business in Queenscliff, and were registered on 21 May 1871. A third skin (R11569) was sent on exchange to the US National Museum (Smithsonian) on 16

October 1930 (RM O'Brien pers. comm.). The locality where these specimens were collected is unclear.

2. Geelong. There are a few reports that imply Hooded Plovers were seen in Geelong (e.g. Wheeler 1982), but they probably refer to the ocean beaches of the Bellarine Peninsula (FTH Smith pers. comm.).

3. St Leonards. Two records in the Atlas of Victorian Wildlife report the species from this locality. However, one record is indicated as being from Mud Islands (but must have been from the Mornington Peninsula, see below). The second record refers to Portsea (indicated in Appendix 1). On 15 January 1994, there was a report of two adults and two young at St Leonards (P Bright in Hewish 1995). The observer has no recollection of the sighting but located the record in his notebook. That day he was participating in a fishing trip in a boat, beginning at the boat launching ramp at Indented Head, with the route extending south past St Leonards to within the northern part of Swan Bay. Bright considered that the most likely site where he would have been close enough to shore to see Hooded Plovers was Duck Island in Swan Bay (P Bright pers. comm.). The location of this sighting given in Fig. 1 refers to the published location. On 26 October 1997, MAW conducted a survey from Indented Head south, past St Leonards, to the northern entrance to Swan Bay to search for any resident breeding pairs, as implied by the record. No Hooded Plovers were located and the habitat seemed entirely unsuitable for all but transitory Hooded Plovers.

4. Leopold. A Field Atlas report of the species between June and August 1980. The sheet was submitted by DW Eades. No further details are available, but this sheet possibly refers to ocean beaches (and so is excluded from Fig. 1).

5. Portarlington. GA Keartland, writing to North (1913-14), stated that the species was in especially limited numbers near Portarlington, though the exact location of any records was not stated. This report implied that the species had been seen in the area, but should not be taken as definite evidence of its occurrence there.

Mud Islands

The Mud Islands have been the focus of many ornithological expeditions dating back to the late 1890s and early 1900s when the area first came under the notice of naturalists (see Pescott 1970). Hooded Plovers were first seen on the islands in 1931 (Pescott 1983), and were recorded at least four times between then and the early 1960s, with about ten birds recorded in January 1940 and three in January 1961 (Stevens 1933; Heathcote 1936; Barrett 1940; Wheeler 1961). The species was seen on the islands again in 1976, although further details are unavailable (BA Lane pers. comm.); this is the only record of Hooded Plovers inside the Heads made by Lane. In addition, FTH Smith reported that he saw the species on the islands 'over 50 years ago' (pers. comm. August 2002, but see Smith 1969). In fact, Smith was present on 26 January 1940, on the expedition reported by Barrett (1940), when he saw the species for the first time (FTH Smith pers. comm.). Between one and seventeen birds were recorded in 'Mud Islands/E. PPB (region)' in the AWSG database in both summer and winter, 1990-2001. However, all of these refer to the ocean beaches of either the Mornington or Bellarine Peninsulas.

Mud Islands were often visited without Hooded Plovers being seen: e.g., January 1938 (Barrett 1938), January 1959 (Anon. 1959), January 1960 (Anon. 1960), 1964 (Davis 1964), January-February 1965 (Smith 1965), January 1967 (Pescott 1968), January 1968 (Smith 1968), January 1970 (Carter 1970), January 1973 (Anon. 1974) and July 1993 (AWSG unpubl. data). Several birdwatchers who have made numerous trips to the islands have never seen the species there (MJ Carter, MA Cameron and CDT Minton pers. comms).

An Atlas of Australian Birds sheet submitted by PS Lansley in December 1979 records the species in the grid, the locality of which is referred to as Mud Islands. This is also apparently recorded in the Atlas of Victorian Wildlife. However, Lansley had never seen Hooded Plovers on the islands, and the records must have come from the Mornington Peninsula (PS Lansley pers. comm.).

Western side of Port Phillip Bay

There are several reports from the northern-central shores of the western side of Port Phillip Bay.

1. Avalon Saltworks. P Dann (pers. comm.) recorded two adults at the Avalon Saltworks on 22 February 1997. The birds were absent the following day.

2. Point Wilson. A Field Atlas report of the species. However, none was recorded during intensive avifaunal surveys conducted at that time (Chandler *et al.* 1981). The Field Atlas sheet was submitted by T Aumann and, although he has no recollection of the record, he informed us that it would have been made at the Western Treatment Plant, Werribee (then the Werribee Sewage Farm) during his fieldwork on raptors.

3. Western Treatment Plant, Werribee (WTP). The species was recorded by T Aumann on an Atlas of Australian Birds sheet on 3 June 1979. Aumann was working with DJ Baker-Gabb at Werribee, but neither can recall any details.

Some information is available from lists of birds which have been recorded from the treatment plant. These lists summarise data collected by many observers, and are not simple data sheets. One list of the birds at the farm does not record the Hooded Plover (Smith and Wheeler undated); this appears to be a rather early list, though the date of its compilation is unknown and, although it is in the HL White Library at Birds Australia, there is no date in the Accession list. In over 50 years of fairly regular observations at the WTP, Werribee, FTH Smith (pers. comm.) has not recorded the species there. Most later lists of birds at the WTP, which apparently include various species that have occurred only as vagrants, do not include Hooded Plovers (Board of Works Undated [post 1987]; Melbourne Water 1998), but the species is included in one list (Lane and Peake 1990).

4. Point Cook Metropolitan Park. A report in the Atlas of Victorian Wildlife from this location, in fact, refers to the record by Wheeler (1955) from Laverton Saltworks.

5. Altona. The Altona Survey Group recorded 'Hooded Dotterel' in autumn 1951 (Wheeler 1951), but this group also operated outside Altona and so may have seen it there or elsewhere.

6. Altona or Laverton Saltworks. The historical Atlas of Australian Birds contains a record by J Richardson of an immature bird at the saltworks in December 1975. Wheeler (1955) reported a single Hooded Plover among Red-capped Plovers *Charadrius ruficapillus* at the Laverton Saltworks on 4 March 1951, and an immature Hooded Plover was seen feeding on the edge of a salt-pan within 50 m of the No 2 Pumphouse on 15 May 1977 (FTH Smith pers. comm.). This is the only record Smith has made of this species at the Saltworks, and this report was submitted to the Atlas of Victorian Wildlife.

7. Seaholme (note that the boundaries of this suburb have expanded since the report was made). In a record submitted to the Atlas of Australian Birds, the species was recorded at 'Williamstown' between February 1977 and May 1978 by C Corben; DW Eades was present when the bird was seen, and reports that the location was Seaholme beach and that the bird was a juvenile.

Inland site

You Yangs (on nearby Wooloomanata; Pescott 1983). An extraordinary, unconfirmed report of two adults was made at Lascelles Dam on 10 March 1957 (Hore-Lacy 1957); they were in the company of five Black-fronted Dotterels *Elseyornis melanops*. There is some confusion over the details of this report, because another publication by the same author stated that only a single bird was present at the dam (Hore-Lacy 1959). In a subsequent publication by the same author, which lists vagrants as well as common species, the species is not listed in the area (Hore-Lacy 1964).

Northern part of Port Phillip Bay

Although six records were made as part of the Urban Wildlife Watch project in 1988, the study area included open ocean beaches of both the Mornington and Bellarine Peninsulas (Wilson 1991), and it is likely that the reports emanated from along these ocean beaches.

There are several records from the northern part of Port Phillip Bay:

1. Fisherman's Bend. Robinson (1999) mentioned that he found Hooded Plovers

on 25 April 1949 on the sandy beach between Station and Princes Piers and at the mouth of the Yarra River. However, it is not known how many birds were present (L Robinson pers. comm.). Wheeler (1950) reported a single bird 'in fine plumage' on 14 May 1949 at Fisherman's Bend. The bird was in company of Red-capped Plovers and Double-banded Plovers *Charadrius bicinctus*. It remained in the area until the end of August. A single adult was recorded twice about 250 m east of the Yarra River on 11 and 18 June 1949 (FTH Smith pers. comm.). The bird actively foraged on a mudflat. It is likely that these reports were all of the same bird.

2. The historical Atlas of Australian Birds contained a record by A Von Hugel from 'Port Philip Bay' in September 1894. This specimen is part of the Rothschild Collection at the American Museum of Natural History (specimen 736306). The details contained in the Rothschild collection are 'Port Philip, Victoria, date IX – 1894 Male A.V.Hugel Coll.' The details on the specimen label are: 'A. Von Hugel – Sandridy [which is somewhat illegible] Port Philip' (J Nielsen pers. comm.). This almost certainly refers to Sandridge, now the suburb of Port Melbourne.

3. St Kilda. North (1913-14) refers to a specimen in the Australian Museum collection labelled 'St Kilda Lagoon, Melbourne, 1873'. Few details are available for this specimen (O.18427) which is labelled as an adult male. The collector is unknown (WE Boles pers. comm.). The record was considered to refer to either Bayside or the City of Port Phillip (Norris *et al.* 1995). The species is not listed as having occurred in the City of Port Phillip, which includes St Kilda (Roseby 1997), though this could be an omission.

4. During his research for the 'Plumages' section of Marchant and Higgins (1993), DI Rogers checked many skins from a variety of museums. Two skins from Museum Victoria (5739 and 5740) were marked as 'Essendon, Victoria'. Both were dated 18 May 1902, and both were adult males (DI Rogers pers. comm.). The collector of specimen 5739 is unknown, but the bird was from the HL White collection, and was donated to the museum, where it was received on 4 August 1917. The same details apply to specimen 5740, except the collector was Robert Grant. It is almost certain that the labels do not reflect the collection sites (DI Rogers pers. comm.).

The locations of the above reports are presented in Fig. 1.

Discussion

Considering the high number of birdwatchers active around Port Phillip Bay, very few records of Hooded Plovers have been made from the Bay. In eastern Australia, Hooded Plovers occasionally move away from ocean beaches (Marchant and Higgins 1993), so it is not surprising that some are recorded in Port Phillip Bay, where some have been recorded breeding (e.g. Sand Island and the sheltered northern shores of the Mornington Peninsula). All confirmed breeding records are from the far south of the Bay, and it is here that records seem most frequent. It is clear that records of Hooded Plovers in the northern and western parts of the Bay are very rare, particularly given the high number of birdwatchers active around those areas (see Lane *et al.* 1984). Nevertheless, the records indicate that the species has occurred as far into an embayment from the ocean beaches as is possible in south-eastern Australia – the Fisherman's Bend record was over 55 km straight line distance to the nearest ocean beach.

The overall pattern of records in Port Phillip Bay is very similar to that in Westernport Bay. There, Hooded Plovers are breeding residents at a few sites inside the Bay, all near the entrance, e.g. Observation Point and Sandy Point (Smith 1966; Loyn 1978; Dann *et al.* 1994; Loyn *et al.* 2001). Reports further north in the Bay are very rare, with a few reports from French Island (e.g. Rams Island [Quinn and Lacey 1999] and Tortoise Head [BA Lane pers. comm.]). Hooded Plovers are more common on the exposed ocean beaches outside the entrances to both Westernport and Port Phillip Bays than on the sheltered shores inside either bay (see Weston 2003).

The species is thought to be declining in Victoria (Weston 2003), and there is some evidence of a decline in the south-western part of Port Phillip Bay, between southern Swan Bay and Point Lonsdale: breeding has not been recorded on Sand Island for years, and neither has the pair that occurred between Queenscliff and Point Lonsdale. It seems likely that birds no longer regularly occur in the south-western part of Port Phillip Bay. The beach between Point Lonsdale and Queenscliff is used intensively by recreationists (MAW pers. obs.) and the sensitivity of the species to disturbance may explain why birds no longer regularly use this section of beach (Weston 2000). The reasons for the apparent abandonment of Sand Island as a breeding site are less clear, but may involve changed topography, and possibly feral and domestic predators. Breeding persists in the south-eastern part of the Bay, where the species is intensively managed (see Dowling and Weston 1999).

Assessing the validity of records is an inexact science, but most records presented here are beyond doubt; they are sightings by experienced birdwatchers, and there are even some specimens. In our opinion, only the You Yangs sighting and some of the specimen locations must be treated cautiously, while the reports from Western Treatment Plant and Point Wilson and St Leonards lack detail. The You Yangs sighting was made at a freshwater dam; the species has never been recorded utilising this habitat in eastern Australia. However, vagrants often occur in unusual habitats, making this an uncertain basis upon which to assess the validity of the report (Cameron and Weston 1999). Consistency of reporting can provide clues as to the certainty that an observer has in a sighting. In particular, omitting a species in subsequent lists from the same site suggests that the original report has been effectively retracted (see, for example, Cameron and Weston 1999). The You Yangs report was omitted from a subsequent list by the same author. Taken together with the inconsistent details reported, we suggest that the You Yangs sighting should be considered doubtful unless further information becomes available. The specimens marked 'Essendon' (a northern suburb of Melbourne) almost certainly refer to the site where a collection of specimens was held, rather than the collection site of the specimens. The same may be true for the specimens collected by N Batchelor, and possibly also the report from 'Sandridy'. We were able to determine that many data sheets apparently recording the species in the Bay, in fact, referred to areas of ocean beach outside the Bay.

It is interesting that the sightings are generally in the western half of the Bay. Much of the western side is mudflats, hardly the preferred habitat of Hooded Plovers. The sites at Seaholme, Altona, Avalon, Point Wilson and Werribee are predominantly mudflats, although they do embrace stretches of sandy beaches. The eastern side, on the other hand, has more sandy beaches but fewer records of Hooded Plovers. The reasons for this are unknown, but might involve the higher levels of human activity on the eastern side of the Bay compared with the western side, and the apparent sensitivity of Hooded Plovers to human disturbance (Schulz and Bamford 1987). Also, birdwatchers tend to focus their efforts on the western side of the Bay as the mudflats attract high numbers of waders that prefer those habitats.

This review has highlighted the unusual nature of the occurrence of Hooded Plovers in Port Phillip Bay, which may encourage any future sightings to be published. Additionally, this review has challenged an extraordinary report that has received little attention until now.

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Appendix 1

Details of information from various databases mentioned in the text.

Site	Sheet Number	Source–Database	Dates	Actually refers to (if applicable)
Altona–Laverton Saltworks	000881	Atlas Victorian Wildlife	May 1977	
Dromana	51157	Atlas of Australian Birds	Mar–May 1979	Westernport Bay (possibly Shoreham or Flinders)
Leopold	79985	Atlas of Australian Birds	Jun–Aug 1980	ocean beach?
MacRae	384	Atlas of Australian Birds	Jan 1977	Gunnamatta Beach
	22923	Atlas of Australian Birds	Jan–Feb 1978	Bushrangers Bay
	47939	Atlas of Australian Birds	Jan–Feb 1979	Bushrangers Bay
Mud Islands	93682	Atlas of Australian Birds	Dec 1979	Mornington Peninsula
	5113311 (same record as above)	Atlas Victorian Wildlife	Dec 1979	Mornington Peninsula
Point Cook	1003753	Atlas Victorian Wildlife	Mar 1951	Laverton Saltworks
Point Wilson	51155	Atlas of Australian Birds	Jun 1979–Jan 1980	Western Treatment Plant, Werribee
Queenscliff	5787	Atlas of Australian Birds	Apr 1977	
	40087	Atlas of Australian Birds	Jun–Jul 1980	
	69995	Atlas of Australian Birds	Jan 1980	
	79857	Atlas of Australian Birds	Aug 1980	
	79869	Atlas of Australian Birds	Sep 1980	
	79874	Atlas of Australian Birds	Jun–Jul 1980	
	79894	Atlas of Australian Birds	Feb 1980	
	93650	Atlas of Australian Birds	Nov 1980	
	93652	Atlas of Australian Birds	Oct 1980	
	93750	Atlas of Australian Birds	May 1981	
	108082	Atlas of Australian Birds	Nov 1981	
	108123	Atlas of Australian Birds	Apr 1981	
	108129	Atlas of Australian Birds	Jul 1981	
	108131	Atlas of Australian Birds	Jun 1981	
	108139	Atlas of Australian Birds	Sep 1981	
	112809	Atlas of Australian Birds	Dec 1981	
	22894	Atlas of Australian Birds	Jul–Dec 1977	also includes Ocean Grove and Barwon Heads
	79817	Atlas of Australian Birds	Jan 1979–Jun 1980	also includes Ocean Grove and Barwon Heads
	93728	Atlas of Australian Birds	Jan–May 1981	also includes Ocean Grove and Barwon Heads
	1000696	Atlas Victorian Wildlife	Dec 1987	Portsea
St Leonards	5113279	Atlas Victorian Wildlife	Sep 1977–Feb 1978	Portsea
	5113311	Atlas Victorian Wildlife	Dec 1979	Mornington Peninsula
Swan Island	S84-189	Australasian Wader Studies Group	Feb 1984	
Williamstown	69763	Atlas Victorian Wildlife	Feb 1977–May 1978	Seaholme

Winged Everlasting *Ammobium alatum* – threatened species, weed or itinerant?

Keith McDougall[1]

Abstract

The Winged Everlasting *Ammobium alatum*, a native of south-eastern Australia, is an attractive daisy with white and yellow papery flowers. In south-eastern New South Wales, this species is apparently found only on disturbed roadsides. Populations on the banks of the Snowy River in Victoria may have originated from roadside populations upstream in New South Wales. Although Winged Everlasting does occur in natural vegetation in northern New South Wales, it is not necessarily a weed in the southern part of its range, there being 19th Century records from places such as Wagga Wagga and Genoa. Whilst the status of Winged Everlasting in parts of south-eastern Australia is somewhat uncertain, its increasing commercial availability and propensity to establish in disturbed situations makes the species one to watch as a potential weed outside its natural range. (*The Victorian Naturalist* **121** (6), 2004, 284-288)

Introduction

There are two species of *Ammobium* (Family Asteraceae), both native to eastern Australia. While preparing a recovery plan for one of them (Yass Daisy *A. craspedioides*, which is listed as vulnerable in NSW), I was alerted by colleague Max Gray (ex-CSIRO) to the curious distribution and habitat preference of the other species, Winged Everlasting *A. alatum*. In south-eastern NSW at least, this species seems to occur solely on disturbed roadsides. Max posed the question 'where is its natural habitat?'

One of the major populations of Winged Everlasting in south-eastern NSW is on the Kings Highway, east of Braidwood (where I live). The other is in the Jindabyne area, which I often drive through for work. In both cases, Winged Everlasting is confined to the road verge, often growing in the gravel rather than amongst other plants. The attractive white and yellow papery flowers of this species have made it a popular landscaping plant in the Braidwood area, and there have been major plantings in the main street of Braidwood. I became interested in Max's question after Winged Everlasting started to appear in cracks in the pavement of the town's streets, both adjacent to the plantings and some distance from them (Fig. 1). In the past two years, I have also noticed Winged Everlasting for the first time in several places on the Bungendore Road between Bungendore and Bywong (following roadworks), on the Kings Highway near Queanbeyan, and on the Kosciuszko Road near Sawpit Creek (again following roadworks). The Sawpit Creek record is the first of this species for Kosciuszko National Park, although I have seen it growing in a garden at Thredbo. Winged Everlasting is clearly spreading along roads in south-eastern NSW. It has also escaped from plantings in the Canberra Botanic Gardens and become well-established on many track edges. As a result several questions arose in my mind . Where is its native habitat (Max's original question)? Should it be regarded as a threatened species because many populations are precariously positioned on roadsides (albeit seemingly favoured by roadworks)? Should it be regarded as a weed in new locations where it becomes established? Where it is not a native, should there be concern about its apparent capacity for invading disturbed vegetation? This contribution is my attempt to address these questions.

[1] 38 Elrington Street, Braidwood, NSW 2622.

Species biology and ecology

Winged Everlasting is a perennial (or occasionally annual) herb with winged, woolly upright stems, grey woolly basal leaves and many papery white and yellow flower heads (Jeanes 1999). Flowering occurs in spring but in well-tended garden habitat may continue into autumn.

Fig. 1. Plants of Winged Everlasting growing on the edge of a street pavement in Braidwood, New South Wales. The plants escaped from the landscaping feature in the background. Further escapes are scattered through the township, up to 250 m from garden plantings. Establishment has presumably occurred following dispersal by wind.

Distribution

The following information about the distribution of Winged Everlasting in Australia is based on my own observations, collection data from the National Herbarium of NSW, National Herbarium of Victoria and Australian National Herbarium, and checklists of flora in Tasmania and South Australia.

Winged Everlasting has been recorded in Queensland, New South Wales, Victoria, South Australia and Tasmania. It is regarded as an introduction in the latter two States. In the States where it is considered

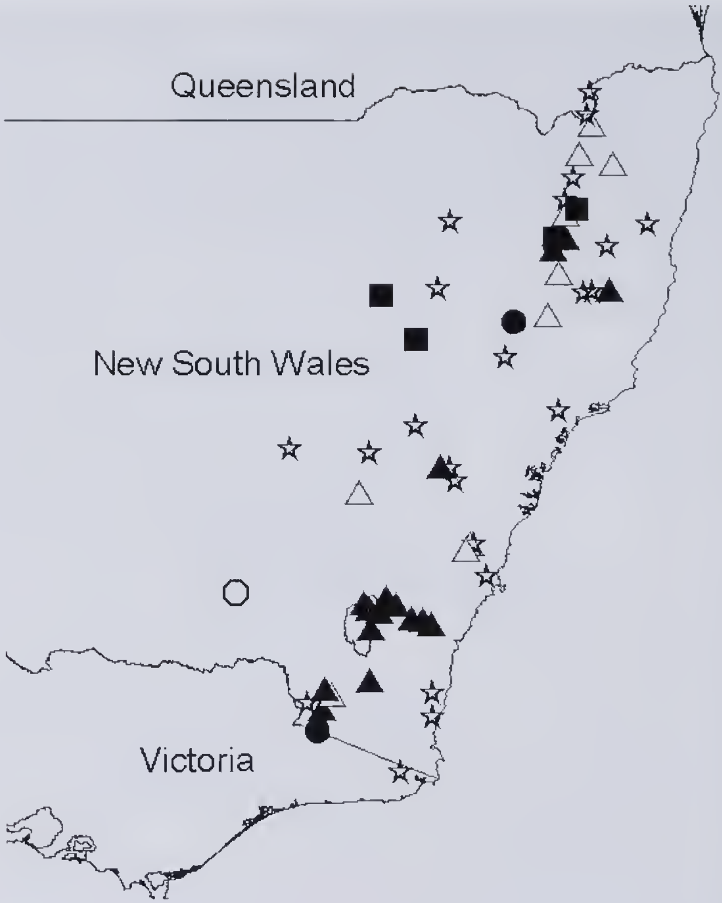

Fig. 2. Location of Winged Everlasting records in Victoria, the ACT, NSW and Queensland. Data were obtained from herbarium collections and personal records. KEY: Solid symbols indicate records of the last 30 years; square = natural forest habitat; circle = riverbed; triangle = disturbed habitat (mostly roadsides); star = unspecified habitat.

native, populations have been recorded mostly on the Tablelands, extending from far eastern Gippsland in Victoria to the Queensland border (Fig. 2). Most records are from grossly disturbed habitat, principally roadsides but also some farm paddocks. The few records of Winged Everlasting in natural habitat are from forests of various eucalypts (*Eucalyptus caliginosa, E. dalrympleana, E. laevopinea, E. nobilis, E. obliqua, E. pauciflora, E. viminalis*) on plateau and rocky cliffs in northern NSW, and on gravelly river banks of the upper Snowy River in Victoria, the Murrumbidgee River in the Wagga Wagga area, and the Namoi River in Wallabadah National Park. Whilst river banks may be within natural vegetation, their vegetation is often the product of flood events that carry seed downstream from disturbed areas. It is therefore tempting to postulate that the Victorian (Snowy River) populations were derived from the roadside populations upstream at Jindabyne.

Although a natural origin for Winged Everlasting populations in south-eastern NSW cannot be categorically identified in herbarium records or from extant populations, the history of its collection makes it difficult to be confident that the species is an introduction there either. The

Murrumbidgee River collection was made in 1888. Other old collections in the south-east of its range are Genoa 1887 (uncertainly from the town in Victoria or the river, which could be in NSW or Victoria), Nowra 1917, Jindabyne 1924, Cobargo 1935, and Mittagong 1938. No habitat information is given with these collections. Of these locations, the species is known to persist only in the Jindabyne area, where it is extremely abundant on roadsides. In northern NSW, based on the available collections, Winged Everlasting grows in natural forest vegetation but also invades grossly disturbed areas such as roadsides and paddocks.

Where is the native habitat of Winged Everlasting?

Winged Everlasting appears to be an itinerant, and weedy in much of its natural range. The difficulty with assessing its status, though, lies in the determination of its natural range. It may be a native species of east Gippsland and south-eastern NSW but its range within that area has both expanded (in the Jindabyne and Braidwood areas) and contracted (in other places). It is probably an introduction in the Braidwood–Queanbeyan district of New South Wales and the Australian Capital Territory, there being no historic records of its presence nearby. Winged Everlasting does appear to be a native species of the Northern Tablelands and North-west Slopes of NSW but even there it is weedy in places, and its presence in natural vegetation as the result of invasion from elsewhere cannot be discounted. Genetic studies of population variation might clarify the issue of natural origins.

Should Winged Everlasting be regarded as a threatened species?

In Victoria, Winged Everlasting is listed as rare (Cross *et al.* 2001) but might equally be regarded as a threatened species under the criteria of the IUCN (2001), based on number of populations and extent. As a species, Winged Everlasting might not be eligible for listing as a threatened species in NSW but, if it is not considered to be a weed, individual populations might be eligible for listing as endangered in south-eastern NSW, where they are all threatened by destructive disturbances such as weed spraying. The choice between weed and threatened species is a potentially stark one for land managers. In my opinion, the disturbed road edge populations should not be regarded as threatened in the legal sense. They are hardly natural populations. They do contribute to the security of the species as an entity but no more so perhaps than the sprawling collections in the Canberra Botanic Gardens and the burgeoning horticultural populations worldwide.

Should new roadside populations of Winged Everlasting be regarded as weedy?

Given the range of Winged Everlasting in eastern Australia based on historical collections and the uncertainty about its natural distribution, there would seem to be no reason to regard new populations in disturbed habitat within that range as weeds. They are simply native plants growing in a weedy habitat. There would also seem to be no justification for deliberately removing them, just as there would be no justification for intentionally protecting them. As long as they are not posing a threat to natural vegetation nearby, the plants are a pleasant roadside feature, far preferable in looks and biomass to tall perennial grasses, for instance. Well outside its historic range, new populations rightly should be regarded as weedy in whatever situation they occur.

Should there be concern about its invasive capacity?

Even though Winged Everlasting is perhaps native in much of eastern NSW, based on its collection history, it was probably absent from most plant communities. Its capacity for growing in great abundance on disturbed ground may make it a threat to plant communities containing abundant bare ground (e.g. rocky outcrops), and a threat to plant communities after fire. Land managers need to acquire a good knowledge of plant community composition now so that invasions by native species such as Winged Everlasting can be readily detected and dealt with.

The increasing availability of Winged Everlasting in the nursery and landscaping trade in Australia (and overseas) suggests that it will be an important weed in the future. Those with a say in what is sold in nurseries in places outside the natural range of Winged Everlasting may wish to carefully consider the potential future costs of allowing this plant into new habitat.

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Are wide revegetated riparian strips better for birds and frogs than narrow ones?

Bronwyn Merritt[1] and Robert Wallis[2]

Abstract
A survey of wide and narrow revegetated riparian strips was conducted in western Victoria for birds and frogs. There were 43 bird species detected, of which only three species were introduced. A small number of species (13) constituted 78% of all sightings. Four species of birds were more commonly detected in narrow sites than wide sites. The species were the Red-rumped Parrot, White-plumed Honeyeater, Welcome Swallow and Long-billed Corella. All except the honeyeater used the sites for shelter but foraged in open pasture. On the other hand, 23 species were more likely to be observed in the wider than the narrower strips. The most common of these species were the Superb Fairy-wren, Crimson Rosella, Striated Thornbill, New Holland Honeyeater, Australian Magpie, Yellow-rumped Thornbill and Red-browed Finch. Wider sites reduce the effects of edges and provide birds with more protection from weather and predators. Increasing width of revegetated riparian strips by as little as 10 m can affect the birds that utilise the habitat. Four species of frogs (46 animals) were detected in the study. No frog species were found more commonly in the wide sites, although the seven Southern Brown Tree Frogs were seen only in the narrow sites. We suggest habitat features besides strip width might be more important in determining presence of frogs in riparian vegetation. (*The Victorian Naturalist* **121** (6), 2004, 288-292)

Introduction
Trees are planted in agricultural landscapes to lower water tables and reduce soil salinisation, provide shade and windbreaks for stock and, if planted in riparian zones, filter surface water by trapping sediment and stripping nutrients (Gore *et al.* 1995). As well, revegetation is thought to provide habitat for fauna, and if revegetated strips link larger blocks of natural habitats, then wildlife can use them as corridors. Often such plantings are fenced and this can keep stock out of the waterway and hence lead to improvements in waterway condition (Department of Natural Resources and Environment 2002). Bennett (2000) has noted that whilst tree planting has been extensive in rural Australia over the last 15 years, only 2% of plantings have had as their main purpose conservation of flora and fauna. Nonetheless, most proponents of revegetation will state biodiversity conservation is an important consequence even if it is not the main purpose of such habitat improvement (Bennett *et al.* 2000).

The Dundas Tablelands in south-western Victoria have been extensively cleared of native vegetation but large-scale revegetation programs have been undertaken

[1] School of Ecology and Environment, Deakin University, Warrnambool, Victoria 3280. Current address: Department Sustainability and Environment, Alexandra, Victoria 3714
[2] School of Ecology and Environment, Deakin University, Warrnambool, Victoria 3280. Current address: Office of the Pro Vice-Chancellor (Rural and Regional), Deakin University, Warrnambool, Victoria 3280

recently on private land. Given the importance revegetation might have for biodiversity conservation, we posed the question: is it better to have wider rather than narrower strips of revegetation planted in riparian sites? Landholders must balance any improvements wide blocks might confer in terms of land, water and biodiversity improvements against added costs and loss of potentially productive land. Birds and frogs were selected for study as they both have been used as indicators of the effects of habitat alteration and restoration activities (Jansen and Robertson 2001; Burbrink *et al.* 1998; Hazell *et al.* 2001).

Methods

The study was conducted in the Dundas Tablelands, in the Upper Glenelg River Catchment, some 35 km north of Hamilton in south-western Victoria. Mottled duplex soils predominate, with yellow sodic duplex soils the most common soil type in the valleys cut into the Tablelands (Land Conservation Council 1979). Landforms consist of Palaeozoic and Tertiary rocks capped by laterites of late Tertiary age. Most of the Tablelands comprise undulating to rolling hills dissected by deep V shaped stream valleys, exposing different marine and glacial sediments, trachyte, granodiorite and metamorphic rocks (Land Conservation Council 1979, Glenelg-Hopkins Catchment Management Authority 2000). Climate is a Mediterranean type characterized by hot, dry summers and cool, wet winters. Average rainfall is 650-700 mm per annum (Land Conservation Council 1979). Sites were selected following discussions with the Glenelg Hopkins Catchment Management Authority and were deemed to have similar soils, geology and climate (Merritt 2002). All sites were on private land, the revegetated strips were at least 200 m long, were fenced to prevent access by stock, and ran alongside permanent or ephemeral waterways. Revegetation of all sites took place between 14 and 15 years before the study. The sites were either classified as wide (> 20 m width) or narrow (< 10 m) and had a similar upper canopy of eucalypts (*Eucalyptus aromaphloia*, *E. ovata*, *E. camaldulensis* and *E. goniocalyx*) with native shrubs (e.g. *Melaleuca* spp., *Acacia* spp., *Calistemon* spp., *Casuarina cunninghamiana*, *Hakea* spp. and *Leptospermum* spp.) and a ground cover of native and pasture grasses. Ten sites (five wide, five narrow) were examined. Vegetation structure was examined in terms of the number of times vegetation touched 10 cm sections of a ranging pole. Floristic data were collected on the species present at each site.

The sites were surveyed for 15 minute periods in early morning and late afternoon during Autumn 2002. Birds were observed and identified by sight or sound (Simpson and Day 1999), their activity and numbers recorded. Frogs were sought under logs and rocks and identified using Hero *et al.* (1991), which was also used to identify calls. Standard areas were surveyed to ensure comparability between wide and narrow sites. If there was uncertainty if a bird call originated from an animal outside this standard area, it was ignored. Wind speed, cloud cover and ambient temperature were assessed.

The Dundas Tablelands originally supported an open woodland dominated by *E. camaldulensis, E. melliodora, E.ovata, E. lanceolata* and *E. viminalis* with *Allocasuarina verticilliata* a common understorey shrub. Native grasses would have formed a ground cover. Since European settlement, there has been extensive clearing of the Glenelg catchment. Exotic pasture now covers 68% of the catchment, and remnant forest and woodland cover only 28% of the area, being especially confined to the steeper sites in the Grampians and Dundas Ranges (Glenelg Hopkins Catchment Management Authority 2000). Some 13 frog species and 230 bird species have been recorded from south-western Victoria (Land Conservation Council 1979) although few detailed surveys of the study area have been carried out. Certain native birds (e.g. Sulphur-crested Cockatoo *Cacatua galerita* and Long-billed Corella *C. tenuirostris*) are thought to have increased in numbers since the land was settled by Europeans (Emison *et al.* 1987).

Bird species recorded were classified into five broad foraging guilds (where birds search or forage for food on particular substrates) based on both our observations and also Simpson and Day (1999). Birds were also classified into nesting guilds based on their preferred nest sites (Simpson and Day 1999). The numbers of birds detected in the wide and narrow strips were compared statistically using Chi-square tests.

Results

The narrow and wide sites had similar vegetation structure with the wider sites having more upper canopy vegetation and the narrow sites more ground cover (Fig. 1). A floristics classification dendrogram (Merritt 2002) indicated that only small differences in plant species composition existed between sites, although overall the narrow sites had more species in common with each other than with the wide sites and vice-versa. However, floristic differences between wide and narrow sites were only minor and unlikely to have a major impact on the differences in frequency of use of the sites by the fauna.

Birds

Some 43 species of birds were detected during the study. Only three species of introduced birds were found (European Goldfinch *Carduelis carduelis*, Common Blackbird *Turdus merula* and Common Starling *Sturnus vulgaris*, and they constituted only 63 sightings compared with 5012 sightings of native birds (from 40 species). Three of the native species were considered abundant in that they were seen in more than 40% of all transects, seven were detected in 20-40% of transects, 11 in 5-20% of transects and 22 were detected in fewer than 5% of the transects. Thirteen species accounted for 78% of birds seen (Table 1). The numbers of 13 bird species seen in the narrow sites were significantly different for each species from the number seen in the wide sites ($p < 0.05$) (Chi Square test). For most species, more birds were present in the wider sites; however, four of the species were more commonly detected in the narrow sites (Red-rumped Parrot, White-plumed Honeyeater, Welcome Swallow and Long-billed Corella).

The narrow sites had fewer bird species recorded (33 species) in total than the wide sites (39). The mean species richness of birds in the wide sites (26.2) was significantly greater than the mean species richness of birds (20.8) in the narrow sites (Students t test, $p = 0.015$). We were interested to see if the different width sites had different communities of birds as measured by their foraging and nesting guilds. The most common foraging guild in the study were the ground feeders (e.g. Sulphur-

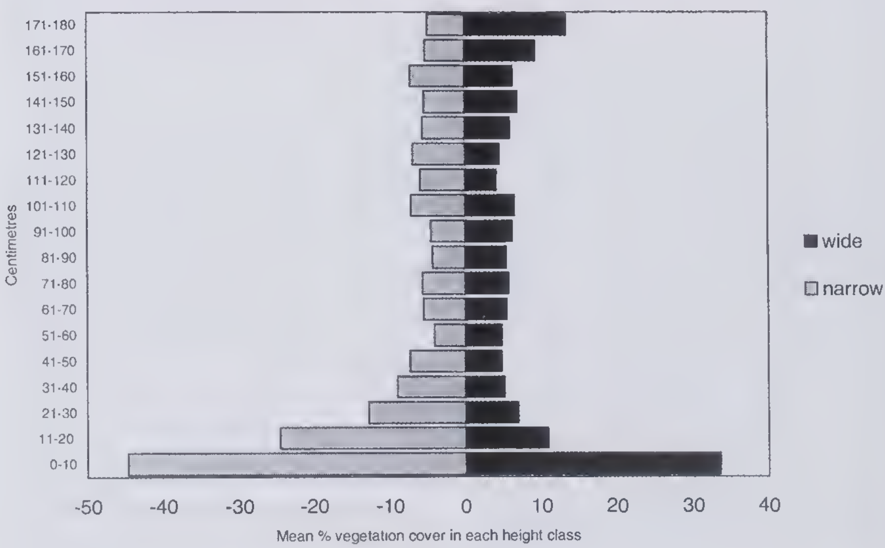

Fig. 1. Vegetation structure profile for the narrow and wide sites

Table 1. Numbers of the thirteen most commonly seen birds observed in the wide and narrow transects. All showed significant differences in the number of observations between the narrow and wide sites ($p < 0.05$).

Species	Wide transects	Narrow transects
Superb Fairy-wren *Malurus cyaneus*	339	267
Crimson Rosella *Platycerus elegans*	320	196
Striated Thornbill *Acanthiza lineata*	260	129
New Holland Honeyeater *Phylidonyris novaehollandiae*	271	42
Red-rumped Parrot *Psephotus haematonotus*	108	200
Australian Magpie *Gymnorhina tibicen*	194	113
Yellow-rumped Thornbill *Acanthiza chrysorrhoa*	270	14
White-plumed Honeyeater *Lichenostomus penicillatus*	95	191
Welcome Swallow *Hirundo neoxena*	57	227
Red-browed Finch *Neochmia temporalis*	213	59
Suphur-crested Cockatoo *Cacatua galerita*	123	114
Grey Fantail *Rhipidura fuliginosa*	194	24
Long-billed Corella *Cacatua tenuirostris*	91	120

crested Cockatoo, Red-rumped Parrot and Australian Magpie). then (in order) foliage, aerial, water and trunk foragers. The largest difference in observations between wide and narrow sites were for the water foragers such as White-faced Heron, Little Pied Cormorant and Australian Shelduck; however, this and all other foraging guilds showed no significant differences in frequency of occurrence or abundance. Birds were also classified as to their nesting guild (Simpson and Day 1999). Canopy nesters (e.g. Ravens and Magpies) were the most common in the narrow sites whilst hollow-nesting species (e.g. Red-rumped Parrot, Sulphur-crested Cockatoo and Striated Pardalote) occurred most frequently in the wide sites.

Frogs

Four species of frog were detected during the study: Common Spadefoot Toad *Neobatrachus sudelli* (34 animals detected), Southern Brown Tree Frog *Litoria ewingi* (7), Southern Toadlet *Pseudophryne semimarmorata* (4) and the Common Froglet (*Ranidella signifera*) (1). All *L. ewingi* were found in narrow sites; this was the only species for which a significant difference in preference for site type was found ($p < 0.05$).

Discussion

Other studies have also found a small number of species account for most birds seen in revegetated areas; for example, we found 13 species accounted for 78% of birds sighted whilst Ryan (1993) working in northern Victoria found eight (of the 50 bird species detected) accounted for more than 75% of all birds observed (Ryan 1993). Of the 13 most abundant species in our study, eight species are generalist species associated with edge habitats, typically using the revegetated sites for shelter and nesting and the open pasture for foraging (Kitchener *et al.* 1982, Loyn 1985, Ryan 2000). Such species include the Australian Magpie and the Superb Fairy-wren. Other species typically reported in revegetated sites include generalist species that use a range of natural and disturbed habitats and are capable of movements to sites to exploit variably-available resources such as nectar and fruit (Ryan 2000).

Only three of the 43 species detected in the survey were introduced species and of 5075 total bird sightings, only 63 were of introduced species. Loyn (1985) also found few introduced species in remnant forest systems in south-eastern Australia.

The differences in floristics, structure, location and geology between study sites were minor. Thus, differences in fauna observed between wide and narrow sites could legitimately be contributed mainly to the width of the sites *per se*. We found that increasing the width of revegetated riparian strips, even by 10m, can have an effect on the birds that use the sites. The wide sites have more species (and more birds) using the ground and shrub layers for nesting. The wide sites offer more safety from the threat of predation and disturbance associated with edges (Major *et al.* 1999).

The four species more commonly detected in the narrow sites are tolerant of disturbance and are edge specialists (Simpson and Day 1999). Most of the differences between sites, however, were for birds favouring the wider sites that offered more protection from the possible deleterious effects of edges. These included such species as Crimson Rosella, Red-rumped Parrot, Common Bronzewing, Superb Fairy-wren, Striated Thornbill, Yellow-rumped Thornbill, Red Wattlebird, New Holland Honeyeater, Flame Robin, Grey Fantail, Willie Wagtail, Australian Magpie and Red-browed Finch.

The wider sites did not seem to confer an advantage for frogs. Other factors for example, connectivity by streams, presence of logs and other structural features that offer protection might be more important than habitat width alone. For example, Burbink *et al.* (1998) found the habitat heterogeneity of a site was a better predictor of frog diversity and presence than habitat width.

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An observation of predation by a Water Rat *Hydromys chrysogaster* on a Feral Pigeon *Columba livia*

Michael J. Murphy[1]

Abstract
The Water Rat *Hydromys chrysogaster* is an active aquatic predator taking a range of invertebrate and vertebrate prey. Most reports of avian prey are of waterbirds such as ducks, waterhens and grebes. Methods of taking avian prey include scavenging of carrion, taking of inactive birds from roosts or nests, and capture of alert, active birds. This short paper describes the hunting skills employed by a Water Rat observed capturing a Feral Pigeon *Columba livia* that was drinking at a billabong on the Murrumbidgee River at Wagga Wagga, New South Wales. (*The Victorian Naturalist* **121** (6), 2004, 293-295)

Introduction

The Water Rat *Hydromys chrysogaster* is a large, aquatic native rodent widely distributed in Australia and New Guinea and found in habitats ranging from slow inland rivers and mountain streams to coastal mangrove swamps and sheltered ocean beaches (Watts and Aslin 1981; Flannery 1995; Olsen 1995). The species has been described as an active and opportunistic predator, foraging in the water and adjacent vegetation and taking a wide range of prey including crustaceans, molluscs, aquatic insects, fishes, frogs, turtles, lizards, small mammals, birds and birds' eggs (Troughton 1957; Watts and Aslin 1981; Olsen 1995).

Woollard *et al.* (1978) studied the diet and foraging ecology of the Water Rat in a freshwater swamp at Griffith, in southern New South Wales, and found avian remains in the gut contents of 8% of the rats examined. Avian species which have been documented as prey are predominantly waterfowl (ducks, waterhens, grebes and darters), but also include domestic poultry, shearwaters and small passerines (McNally 1960; Woollard *et al.* 1978; Watts and Aslin 1981). The present paper reports on a previously undocumented avian prey species for the Water Rat and describes the mode of capture employed. Common and scientific names referred to in the text follow Christidis and Boles (1994) for birds, McDowall (1996) for fishes and Menkhorst and Knight (2001) for mammals.

[1]144 Beryl Street, Coffs Harbour, NSW, 2450

Observation and locality details

The following observation was made in October 1995 at Wollundry Lagoon, Wagga Wagga (35°07'S 147°22'E), on the south-west slopes of southern New South Wales. Wollundry Lagoon is a permanent billabong of the Murrumbidgee River and is located in parkland within the Wagga Wagga urban area. A narrow band of mature River Red Gum *Eucalyptus camaldulensis* has been retained around the shore of the lagoon and provides a source of woody debris in the lagoon. Water Rats can be readily observed at any time of the day but particularly in the late afternoon and evening from vantage points on the bank or from the Beckwith Street bridge that crosses the lagoon.

Feral Pigeons *Columba livia* nest in numbers under the Beckwith Street bridge and use fallen branches emerging from the water as drinking perches. At the time of the observation pigeons were regularly using an emergent fallen branch which had been in place for at least three years, situated within five metres of the bridge and approximately equidistant from either shore.

In the late afternoon (full daylight) of 7 October 1995 the author was positioned on the Beckwith Street bridge to observe Water Rats in the lagoon. A single Water Rat was observed approaching, swimming on the water surface and following the line of the right bank under overhanging trees. Two adult pigeons flew into view from under the bridge, landed on the emergent branch noted above and began to drink. When the Water Rat reached a point on the shore opposite the pigeons it dived beneath the water surface, swam out of sight underwater for approximately six metres and emerged at the pigeons' location. The Water Rat immediately grappled one of the pigeons from below (while the other flew off), and then swam along the surface of the water to the left shore of the billabong, using its jaws to hold the struggling, flapping bird firmly at the neck or shoulder. The Water Rat stayed hidden in vegetation on the left bank for approximately two minutes, and then re-emerged in the open, swimming along the line of the left bank with the now motionless pigeon held in its jaws, until it disappeared into an area of dense reeds. The Water Rat was not observed again and it was presumed it had a burrow or sheltered feeding site located within the reeds.

Additional feeding events observed by the author at Wollundry Lagoon include a Water Rat seen wrestling in the water with a Carp *Cyprinus carpio* about 40-50 cm in length, and another Water Rat seen dragging a dead (road-killed) adult Common Brushtail Possum *Trichosurus vulpecula* down the bank from the roadside and into the water. A Water Rat was also observed at Wollundry Lagoon swimming on the water's surface away from an Australian Pelican *Pelecanus conspicillatus*, which was swimming in close pursuit and making repeated (unsuccessful) attempts to capture it in its bill.

Discussion

The Water Rat has been described as probably the only Australian rodent to be seen at all frequently by human observers (Watts and Aslin 1981). Nevertheless, documented observations of vertebrate prey capture events by the Water Rat are relatively rare. Inclusion of birds in the Water Rat's diet can be through scavenging of carrion, taking of inactive birds from nests or roosts, or by capture of alert, active birds. Woollard *et al.* (1978) noted that the Water Rat included fresh carrion in its diet, including waterfowl freshly shot by hunters. Troughton (1957) and Watts and Aslin (1981) cited FC Morse's observation at the Macquarie Marshes (New South Wales) of a swimming Water Rat dragging a full-grown Eurasian Coot *Fulica atra* which had apparently been freshly killed by a bite severing the spine at the head. Woollard *et al.* (1978) cited Eade's observation of a Water Rat capturing a full-sized Musk Duck *Biziura lobata* by surprise, grabbing the tail of the bird and hanging on until the frantic bird exhausted itself, and then apparently severing its neck. Woollard *et al.* (1978) also quoted a personal communication from DL Serventy describing Water Rats taking adult Short-tailed Shearwaters *Puffinus tenuirostris* from nesting burrows, while McNally (1960) reported that young shearwaters also were taken. Watts and Aslin (1981) noted that Water Rats have been seen to kill ducks and poultry. Fraser *et al.* (1989) suggested that water rats seize ducklings in the water from below and raid birds' nests for eggs and nestlings.

The observation documented in this paper illustrates the complexity of hunting behaviour employed in the capture of a non-aquatic bird by day. It is considered likely that the event observed was not an isolated occurrence. Feral pigeons had been roosting under the Beckwith Street bridge at Wollundry Lagoon, and utilising the same emergent branch as a drinking perch, for several years prior to this observation. The efficiency of the successful predation behaviour observed suggested that the method may have been perfected over a number of attempts.

The major components of the Water Rat's diet are generally described to be molluscs, crustaceans, aquatic insects and fish, with other taxa such as birds taken only occasionally (Troughton 1957; Harris pers. comm. in Woollard *et al.* 1978; Watts and Aslin 1981; Olsen 1995). By considering both the frequency of occurrence and the relative size of the prey item, Woollard *et al.* (1978) concluded that fishes were the most important prey item (in terms of size and constancy), with insects also of major importance (particularly in spring), and that birds made up a substantial part of the diet by virtue of their size, although they were of secondary importance through lack of constancy: in short, birds were taken only seldom but were significant in terms of nutritive value.

Woollard *et al.* (1978) found a number of dietary differences between immature and mature water rats, with younger animals taking fewer crustaceans, birds and large fish and more spiders, plants and small fish than mature animals. Avian prey occurred approximately twice as often in mature rats. In addition, most of the immature rats found to have eaten birds were young animals likely to have been fed by an adult mother, with older, independent immature rats feeding on birds only very occasionally (Woollard *et al.* 1978). This age-related difference is likely to be a reflection of the combination of hunting skill and strength necessary for the Water Rat to tackle avian prey.

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In Pursuit of Plants: Experiences of nineteenth & early twentieth century plant collectors

by Philip Short

Publisher: *University of Western Australia Press, 2003. 351 pages, hardcover; colour and black and white photographs. ISBN 1876268980, RRP $54.95*

In Pursuit of Plants is a book of excitement and adventure. There are many 'tall tales and true' from around the world, glimpses into the lives of past plant collectors. The concept of the book arose when the author was driving north along the Stuart Highway to Alice Springs on a collecting trip for his work as a taxonomist with the Northern Territory Herbarium. He stopped in countryside surrounding Coober Pedy to admire the grandeur of Sturt's desert pea, which carpeted the ground. That others had admired the plant before him was evident by footprints encircling the plants and he considered how lucky we are to be able to drive in comfort to such places. He determined to make available to a wider audience both published and unpublished articles and letters containing accounts by early collectors of their experiences when gathering plants. The work would not be parochial but contain accounts of overseas collectors, highlight minor amateur collectors as well as major professional collectors, and include those who primarily gathered plants for scientific naming and study, not just for horticulture.

One story that stays in my mind concerns HO Forbes and his wonderful use of words describing his 'joy' in finding Ant Plants in Java. He had collected a 'galaxy of epiphytic orchids from an erythrina tree' in the centre of which was an Ant Plant. Although he had only touched the bunch momentarily he was instantly covered with a myriad of small ants. He wrote 'I stripped with the haste of desperation, but,

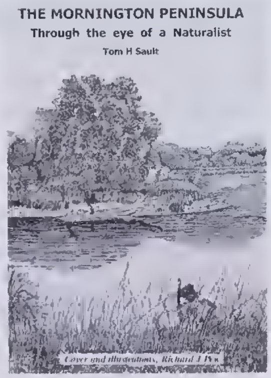
like pepper-dust over me, they were writhing and twisting their envenomed jaws in my skin, each little abdomen spitefully quivering with every thrust it made'. Luckily Mr Forbes had some 'boys' he could send higher into the trees to collect more specimens of the ant plants and carry them to a place where he could examine the plants with comfort and without disturbing the ants!

Not all of the servants were as amenable as those of Forbes. JRT Vogel complained of the need for more servants but that he could not manage the two he had. He stated: 'An African servant will not listen to orders, but will do everything out of his own head, and if his taste does not agree with his master's, the master he thinks must comply with his. If I say to the cook, 'This must not be dressed so', he answers quietly, 'That is how I like it'; and if my servant, contrary to my directions, goes out for the whole evening, he says coolly, 'When you have got your meal, you have nothing more to do with me." Times do not seem to have changed with regard to what many employers expect from their employees!

The book is, in essence, a compilation of short stories so can be read in any order. Accounts of expeditions to Africa, Asia, Australia, New Zealand, Europe, and North, Central and South America are described. Visits by Hooker, Milne and Seeman to various oceanic islands also are described. Stories include horrendous tales of torture, escapes and recapture as well as the mundane accounts of drying and transporting specimens and making lists and descriptions of plants. At times the author detours from the strictly botanical and includes items from other natural history fields, such as, geology. Imagine collecting geological samples from the back of a camel. The reasons for collecting plants also was investigated. It was not only the lure of travel and adventure that attracted collectors but more practical reasons, such as the supplementation of a family income or freedom from the cares of a household.

This book has something to interest everyone, not only the professional and amateur botanists but also those interested in travel, natural history, art, human relationships and times now lost in history. The book is illustrated with photographs of a number of fantastic drawings and paintings made by the collectors, with portraits of some of the collectors and photographs by the author of some of the plants mentioned. It is well worth the $54.95 and if you, like me, have a friend or two who thinks the study of plants is boring, buy them this book. Once they begin to read it, they will never look at plants as boring again.

Maria Gibson
Biological and Chemical Sciences
Deakin University
221 Burwood Highway
Burwood, Victoria 3125



The Mornington Peninsula Through the eye of a Naturalist

by Tom H Sault. Illustrations by Richard Pew

Publisher: *Trust for Nature (Vic.) Southern Peninsula Tree Preservation Society RRP $19.95*

For anyone with even a minor interest in the Mornington Peninsula, or conservation of any kind, this is a very good read. Written from a conservationist's point of view, all aspects of the Mornington Peninsula have been covered, including Geology, Flora, Fauna, Rock Pools and much more.

This book is written in an easy to read format from the heart and mind of a naturalist with a special interest in the Mornington Peninsula. Drawing on his own extensive experience and local knowledge, the author has incorporated scientific data to describe and explain the beautiful and natural features of the region. In order to truly understand the depth of appreciation the author has for the Peninsula, it is important to get to know the author. The book enables the reader to do this, as a summary of the author's interests and experiences is provided in the initial pages of the book. The author, Tom Sault, has a great love for nature. He joined the Field Naturalists Club of Victoria in the early 1960s and was a member of the Field Naturalists Club Council for 13 years. He has been a member of many other naturalist groups for most of his adult life, and is a life member of the Southern Peninsula Indigenous Flora and Fauna Association and the Southern Peninsula Tree Preservation Society.

A concise map of the Peninsula is provided so that the reader can refer to areas mentioned in the book. Also included are a number of maps showing different walking tracks, encouraging the reader to visit and experience, at first hand, the unique flora and fauna of the region. The greatest diversity of native orchid species on the Peninsula occurs in small isolated areas at Crib Point and Stony Point. The endangered Orange-bellied Parrot, which breeds in southwest Tasmania and winters on the mainland, can be seen in the Yaringa Saltmarsh, where it feeds on the succulent vegetation characteristic of the marsh.

Beautiful line drawings by Richard Pew enhance this book greatly. For example, the gorgeous Chocolate Wattled Bat that roosts in hollow trees and under the roofs of houses, the endangered New Holland Mouse that is restricted to sandy heathland, the Grey-crowned Babbler endangered due to habitat fragmentation, the rare Southern Emu-wren and Powerful Owl and, of course, the beautiful native orchids.

Many photos are included from the author's own collection taken over many years, as well as some great macro photos of rock pool wildlife by Glenise Greenwood. Unfortunately some photos are slightly blurred, but these are few in number. The author's concern for the environment is demonstrated by the use of environmentally friendly inks and recycled paper in the publication of the book. As well, the cover has a special UV resistant coating. This, along with the spiral binding, allows the reader to use the book frequently in the field without damaging it.

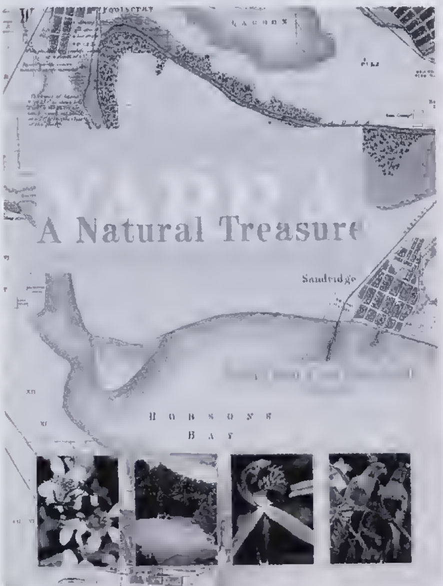
In all, this is a great light read for anyone interested in natural history and for those with a particular interest in the Mornington Peninsula. The book provides visitors with a chance to familiarise themselves with the area and visit places they otherwise would not have known.

Bernadette Sinclair
Deakin University
221 Burwood Hwy, Burwood 3125

The Yarra: A Natural Treasure

by David and Cam Beardsell

Publisher: *Royal Society of Victoria, 1999. 66 pages, paperback; colour photographs. ISBN 0958775850.RRP $17.50*



The Yarra River has an almost emblematic status for Melburnians. It was the prime reason for the location of Melbourne, having been the only reliable, abundant source of potable water at the time of European settlement. The Yarra thus became an important resource for the European settlers, as it had been for Aboriginal people. It continues to be a major natural feature of the city today. So any new publication that focuses attention on the river and aims to increase our appreciation of it is a welcome thing.

The authors of this attractive little volume take as their subject the Yarra River in its course below Yarra Glen. This length they divide into three sections, on the basis of biogeographic differences in the areas through which the river flows. Following the Introduction, each of these sections is dealt with in separate chapters. The book concludes with a list of 'Additional Reading'.

The Introduction provides an overview of land surfaces, vegetation and wildlife, floods, and conservation, relating each to the Yarra River. Each of these themes is then taken up, to some extent, in the chapters that follow. The Introduction also includes tables that serve to present brief detail of plant communities and rare and threatened plant and animal species.

The first section of the river examined here is referred to as the Middle Yarra hills and extends from Yarra Glen to where Diamond Creek joins the Yarra. The natural history components examined in this chapter are predominantly animal, ranging from insects, through reptiles and bats, to birds and fish. The chapter finishes with a couple of paragraphs on Warrandyte's former gold-mining industry.

The middle section of the Yarra flows through the Lower Yarra plains, stretching downstream to the site of the old rock falls, opposite Queen Street in the city. In this chapter both vegetation and wildlife are characterised in their local contexts. Historical sources are employed here, firstly to describe the original vegetation in different parts of the area, and secondly in detailing the wholesale changes made to the river and adjacent landscapes since European settlement.

Coverage of the vegetation in the final section of the book – the estuarine Yarra – is greater than in the previous two sections because, the authors suggest, less has been written on this subject. The final section in this chapter, headed 'Conservation and the future of the Yarra' is perhaps meant to refer to the Yarra as a whole, although this is not apparent from the way it is presented.

The natural history coverage throughout this work is generally slight. This is an A5-sized book of only 66 pages and it contains more than 70 illustrations; this means that there is little space for detailed text. However, the many colour photographs, as well as historical black and white images and a few maps do assist in conveying some of the huge diversity of subject matter that this book seeks to cover.

The lack of references in the form of footnotes or textual parentheses makes for an uninterrupted read but it places greater emphasis on the bibliographic details provided in 'Additional Reading' at the end. Unfortunately, these aspects of the book are not well done. In a number of places (e.g. pp. 36, 37) short quotes are given from historical sources without any indication of where in the source the quote is from; in some cases the source is not even listed at the end of the book.

Given its size and structure, this book can be no more than an introduction to a subject as diverse and wide-ranging as that of the title. However, it serves that role well. There is something in the book for almost all natural historians but perhaps not enough to fully satisfy any given interest.

Gary Presland
History and Philosophy of Science
University of Melbourne
Victoria 3010

Myxomycetes of New Zealand
Fungi of New Zealand Volume 3

by Steven L Stephenson

Publisher: *Fungal Diversity Press, Hong Kong, 2003. ISBN 9628676547. RRP US$50.*

This monograph of the New Zealand myxomycetes, or slime moulds, is a welcome addition to the literature available worldwide. Until now, all reference books on the subject have been written in the northern hemisphere, and very few specimens are cited from New Zealand (or Australia!). But that is about to change, and this book is the start. It is not quite a beginners' book; more for those who have already started on the trail of myxomycetes.

Professor Stephenson, Research Professor at the University of Arkansas, USA, is well qualified to write this volume. He has travelled extensively worldwide, studying the ecology and distribution of myxomycetes.

The book starts with an abstract written in both English and the Maori language. Then the introduction explains the aim of the book, followed by the life cycle of a myxomycete. Occurrence and distribution are also very important, as myxomycetes grow from near the snowline to desert areas and most places in between!

A short history of myxomycetes in New Zealand follows – the first was reported in 1855. Then comes a description of the types of fruiting bodies produced and their basic construction. The dichotomous key to the Orders of Myxomycetes is very clearly set out. Within each Order is a general description and keys to the families of the New Zealand species are then included. These keys are a delight to use, very straightforward and 'user friendly'. I found they worked very well when keying out species that are also found in Australia. The species descriptions are precise and cover all aspects necessary to use the keys. The comments for each entry are a further help in comparing similar species.

The illustrations are very clear and well drawn, but not all species are illustrated, which is a bit of a drawback, as is the lack of drawings of spores, some of which have very interesting ornamentation. The colour photographs are a delight and nicely placed at the front of the book to whet your appetite. Perhaps a scale could have been added to each photograph to give an indication of the actual size.

There is a comprehensive glossary of terms used in relation to myxomycetes, and a list of literature cited. The latter draws attention to the fact that many others have been studying myxomycetes for many years and we have quite a bit of catching up to do. The index is unusual in that it combines the species and the epithets in one alphabetical listing, instead of having two separate lists. Very handy for those of us who remember the epithet, but cannot recall the specific name!

Although one is not supposed to tell a book by its cover, this one excites interest, with a panel of Maori art incorporating two fungi – *Entoloma hochstetteri* and *Aseroe rubra* – and a photograph of *Arcyria cinerea* balancing neatly on a piece of decaying wood.

The simplicity of this book makes it a useful reference in the sometimes exacting task of identification. I am delighted to add this volume to my reference books.

Margaret Brims
Western Australian Museum
Locked Bag 104 Bentley Delivery Centre
Bentley, WA 6983

Australian Natural History Medallion 2004

David Lindenmayer

The 2004 Australian Natural History Medallion was awarded to Professor David Lindenmayer for his contributions to ecology and conservation biology, particularly in the modelling and management of forest processes.

By investigating the habitat preferences of vertebrate species and their response to forestry practices, including ecological burning, Dr Lindenmayer recognised the importance of habitat fragmentation as a threatening process and the need for wildlife corridors and retained elements in wood production forests. He has developed protocols for integrated forest use and wildlife conservation, thus assisting ecological sustainability. These advances in landscape restoration, and a recognition of the importance of remnant vegetation, led him to an interest in reintroduction biology. David's research has relied heavily on the development of vertebrate sampling methodology and computer ecological modelling, particularly the use of Geographic Information Systems and Population Viability Analysis.

Over the last twenty years, David Lindenmayer has established and successfully implemented five major multi-disciplinary research themes in landscape ecology, to develop a better understanding of species' response to landscape change. The first was conducted in Victorian montane Ash Forests, concentrating on the impacts of timber harvesting and strategies to mitigate those impacts. It established the importance of retaining coarse woody debris on the forest floor and nesting hollows, and produced important results concerning the conservation of Leadbeater's Possum. Comparison of vertebrate populations in an extensive Radiata Pine plantation and matched sites in eucalypt forest near Tumut revealed new information about the relevance of patch size and demonstrated the importance of riparian vegetation as dispersal routes. The Nanagroe Natural Experiment is planned to sample sites for 20 years, examining woodland remnants and the changes that occur within them when the surrounding landscape is converted from one dominated by grazing to one that contains extensive pine plantations. The fourth theme will investigate the conservation value of restored vegetation on farmlands for biodiversity. The fifth and final one is a large-scale fire experiment examining the response of vertebrates to wildfire and prescribed fire at Jervis Bay in coastal central New South Wales.

David Lindenmayer graduated with a BSc in Zoology from Australian National University (ANU) in 1982 and spent time in field research in diverse habitats: the arid zone, with Leadbeater's Possum, and in the hedgerows of England. Taking a Dip Ed in 1986 from the University of Adelaide, he then taught in primary schools while consulting to a number of wildlife projects. Between 1987 and 1990 he studied the ecology and habitat requirements of Leadbeater's Possum, leading to the conferring of a PhD from ANU. David's academic career has consisted of a number of research fellowships with the Centre for Resource and Environmental Studies at ANU, interspersed with periods as the William Evans Visiting Fellow at the University of Otago and the Bullard Fellowship at Harvard University. He has also held joint Fellowships with the School for Resource Management and Environmental Science and with the Department of Geography. In 2003 he was awarded a DSc from ANU and was appointed to the position of Professor within the Centre for Resource and Environmental Studies in 2004. He supervises many post-graduate students, with 12 PhD and 3 MSc at December 2003.

Throughout his career, David has conducted many consultancy projects on such topics as Aridlands Surveys, Very Fast Train Project, Long-footed Potoroo, Ecotourism, and for silvicultural practices and sustainable use in forestry contexts for government departments in Canberra, New South Wales and Victoria. He has also consulted for the World Bank and for government and industry bodies concerned with forestry in Canada.

David has been a member of the IUCN/SSC Australasian Marsupials and Monotremes Specialist Group and sits on the editorial boards for the journals *Ecological Applications* and *Biological Conservation*. He was referee for the Endangered Species Scientific Subcommittee when it considered the loss of hollow-bearing trees as a threatening process.

David has been involved in over 360 scientific publications including 12 books, 200 refereed papers, more than 40 book chapters, 25 consultancy or government reports and nearly 80 other articles. Overall he was sole author for nearly 20% of these and senior author for about half of them, demonstrating the collaborative nature of his studies. In 1996 his book *Wildlife and Woodchips: Leadbeater's Possum as a test case for sustainable forestry* won the Whitley Award for Conservation Biology. 1999 was a momentous year with Lindenmayer and Possingham being awarded the 1999 Eureka Science Prize for *The risk of extinction: ranking management issues for Leadbeater's Possum* and Burgmann and Lindenmayer winning the Whitley Award for Best Conservation Biology text with *Conservation Biology for the Australian Environment*. His joint paper with Henry Nix 'Ecological principles for the design of wildlife corridors' was selected to appear in a special edition of *Conservation Biology* focusing on landscape processes drawn from papers in the first 30 issues of the journal.

A strong community outreach component is a feature of all of David's research programs. He typically presents 20 - 30 public lectures and seminars per year and writes many articles for popular and semi-popular magazines. He averages a media interview every couple of weeks for regional, state or national radio, television and print. Numerous volunteers have assisted with his work in the Central Highlands of Victoria, and he has forged strong collaborative links with the Earthwatch Institute where volunteers from all over the world come to assist in the large-scale natural experiments in Victoria and New South Wales.

The Mountain Brushtail Possum is in fact two distinct species, *Trichosurus cunninghamii* occurring from Sydney to southern Victoria, and *Trichosurus caninus* a northern species now known as the Short-eared Possum. David Lindenmayer led the group which, in 2002, confirmed ecological and genetic evidence for this new species.

In 2003 *The Bulletin* named David Lindenmayer as Australia's top innovative thinker in Environmental Science. He was nominated for the Australian Natural History Medallion by the Canberra Ornithologists Group, of which he is a member. Dr David Lindenmayer is to be congratulated as a worthy recipient of this prestigious award.

Ian Endersby
56 Looker Road
Montmorency, Victoria 3094

Guidelines for Authors – *The Victorian Naturalist*

Submission of all Manuscripts

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.

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.

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.

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.

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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. Computer-generated figures should be submitted as high-quality TIFF, encapsulated postscript (EPS) or high quality JPG files of at least 600 dpi, separately on disc and not embedded into a MS Word document. Low-resolution JPG files will not be accepted.

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, 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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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 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. (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)

Please submit manuscripts and enquiries to:

The Editor
The Victorian Naturalist
Locked Bag 3, P.O.
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