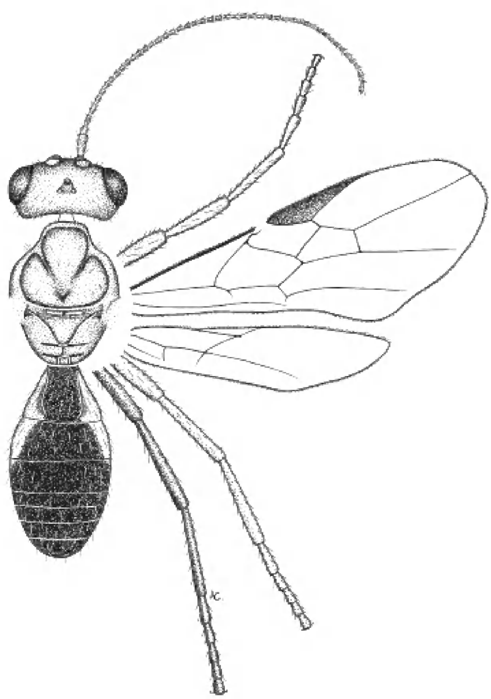
PROCEEDINGS OF THE ROYAL SOCIETY OF QUEENSLAND



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We wish to acknowledge the assistance of the many professionals who gave their time as anonymous referees.

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COVER ILLUSTRATION: Taxonomic illustration of *Diachasmimorpha tryoni* (parasitoid of fruit flies). Provided by Amy Carmichael.

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The Royal Society of Queensland Inc.

REPORT OF COUNCIL, 2007 and 2008

The past two years have been quiet for the Society but busy ones for the country and state in which we live. The election late in 2007 of a new Commonwealth government led by Prime Minister Kevin Rudd poses new hope for science and technology given the governments focus on an 'education revolution' during the campaign. In Queensland the promotion of Anna Bligh to Premier resulted in a small shake up in departments but did not see a substantial expansion of programs to deliver the Smart State agenda, given the larger domestic priorities of infrastructure for water, roads, health and industry linked to the growing economy. Major departmental changes included the formation of Biosecurity Queensland as a business unit in the Department of Primary Industries and Fisheries and the creation of a Minister for Sustainability, Climate Change and Innovation. This ministry includes the Environmental Protection Agency as well as the Office of Climate Change. This office oversees the Queensland Climate Change Centre of Excellence.

The proceedings remain the key focus of the committee. Improving access to the proceedings has been a key strategy in recent years, recent volumes are now accessible via several online subscription services and the full abstract list will soon be available via the Queensland museum online directory. The financial returns copyright access both within Australia and from abroad have become a growing source of revenue for the Society.

The Royal Societies of Australia constitution was adopted in Canberra early in 2008; however, the RSQ declined membership at this time, due to committee concerns over the direction of the proposed work program and the time requirements on the member societies. The RSQ will monitor this association and reassess it position in the future.

The Society would like to acknowledge the hard work of our outgoing editor; Dr Julie Robins, and her editorial team. The RSQ again thanks the Department of Primary Industries and Fisheries for its continued support.

Craig Walton
President

FLORISTIC DIVERSITY OF POPLAR BOX WOODLANDS IN SOUTHERN QUEENSLAND AND CHANGES OVER A 20-YEAR PERIOD

JIAN WANG, TERESA J. EYRE AND V. JOHN NELDNER

Wang, J., Eyre, T.J. & Neldner, V.J. 2008: Floristic diversity of poplar box woodlands in southern Queensland and changes over a 20-year period. *Proceedings of the Royal Society of Queensland*, 114: 1 - 12. Brisbane. ISSN 0080-469X.

Plant species richness data were collected from 60 poplar box (*Eucalyptus populnea* F.Muell.) woodland sites in fragmented landscapes in the southern Brigalow Belt, Queensland. A total of 335 vascular plant species (299 native species and 36 exotic species) were recorded. Native species grouped into five life forms (tree, shrub, vine, forb and graminoid) were surveyed and total species richness and composition results compared with those reported during an earlier south central Queensland study by Neldner (1984). Although forbs (34% of total native species) and graminoids (27% of total native species) remained the major life forms over the past two decades, there was a significant decline in the number of graminoid species in the current study. Buffel grass (*Cenchrus ciliaris* L.), velvety tree pear (*Opuntia tomentosa* Salm-Dyck), Mayne's pest (*Verbena aristigera* S.Moore), purpletop (*Verbena bonariensis* L.), common verbena (*Verbena officinalis* L.) and soft roly-poly (*Salsola kali* L.) were among newly recorded exotic species, that have become common in the poplar box woodlands of southern Queensland. Verbenaceae (three *Verbena* species) and Chenopodiaceae (one *Salsola* species) were also newly recorded families of exotic species.

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Poplar box (*Eucalyptus populnea* F.Muell.) is an Australian endemic species. It occurs in eastern Australia, extending from near Mackay in coastal central Queensland to Leeton in southwest of New South Wales (Beeston et al., 1980). Beeston et al. (1980) described poplar box woodland communities into seven broad categories: *E. populnea* with a grassy lower layer; *E. populnea* with a shrubby lower layer; *E. populnea* with other *Eucalyptus* species co-dominant; *E. populnea* with *Acacia aneura*; *E. populnea* with *A. harpophylla* and *Casuarina* species; *E. populnea* with *Callitris glaucophylla*; and a group of miscellaneous communities in which *E. populnea* is a minor species.

In southern Queensland, poplar box woodland is one of the most extensive vegetation communities of both the Brigalow Belt Bioregion and Mulga Lands Bioregion, as identified by Sattler & Williams (1999). The broad vegetation group of *E. populnea* and *E. melanophloia* woodlands as defined by Wilson et al. (2002) had a pre-clearing distribution of 129,522 km^2 in Queensland with 78,550 km^2 occurring in the Brigalow Belt, 24,466 km^2 in the Mulga Lands, 20,182 km^2 in the Desert Uplands, 2,767 km^2 in the Southeast Queensland, 2,245 km^2 in the Einasleigh Uplands, 1,174 km^2 in the New England Tableland, and 903 km^2 in the Channel Country bioregions. Only 48% of the total pre-clearing area of this broad vegetation group was classified as remnant in 1999 (Wilson et al., 2002).

The vegetation of the Brigalow Belt Bioregion in southern Queensland has experienced severe land clearing (Environmental Protection Agency, 2003). Pre-clearing, poplar box woodland was relatively extensive in the bioregion, but has been rapidly contracting, particularly since 1990 (Young et al., 1999; Environmental Protection Agency, 2003). Only 42% of the Brigalow Belt Bioregion remained as remnant vegetation in 2003 (Accad et al., 2006). As a consequence of broad scale clearing, more than 50% of extant poplar box remnants are less than 10 ha in size, and 35% are between 10 and 100 ha throughout the bioregion (Queensland Herbarium, 2005). Currently, poplar box woodlands occur in a range of fragmented landscapes, from extensively cleared to relatively undisturbed, as a result of rapid and recent landscape changes associated with agricultural and pastoral land uses (Sattler & Williams, 1999). Habitat destruction and fragmentation are the major factors leading to the loss of biodiversity (Saunders et al., 1991; Department of the Environment, Sport and Territories, 1995, 1996; Young et al., 1996).

Recently, there has been a greater awareness of and an increasing interest in understanding the biodiversity conservation and landscape ecology within the fragmented poplar box remnant woodlands in southern Queensland (Ludwig et al., 2000; Franks, 2002; Eyre et al., in review). This has been facilitated by a previous lack of knowledge regarding the biodiversity of semi-arid woodlands in southern Queensland, and a need for relevant data to inform native vegetation management. In response to this, a large project on remnant vegetation condition that aimed to provide quantitative information on the ecological thresholds for native vegetation management in southern Queensland in a fragmented landscape was initiated (Chilcott et al., 2005). The detailed floristic survey data reported in this paper was a component of this larger project. Consequently, one of the aims of this paper was to report on the floristic diversity of the fragmented poplar box ecosystems in the southern Brigalow Belt Bioregion. We were also motivated to report on floristic change over time, given the broadscale clearing and modification to the landscape in the southern Brigalow Belt Bioregion. Unfortunately, long-term monitoring data to report on floristic change is rare in the region. Therefore, we compared the results from this study with the only published study reporting the floristics of the poplar box woodlands in Queensland (Neldner, 1984).

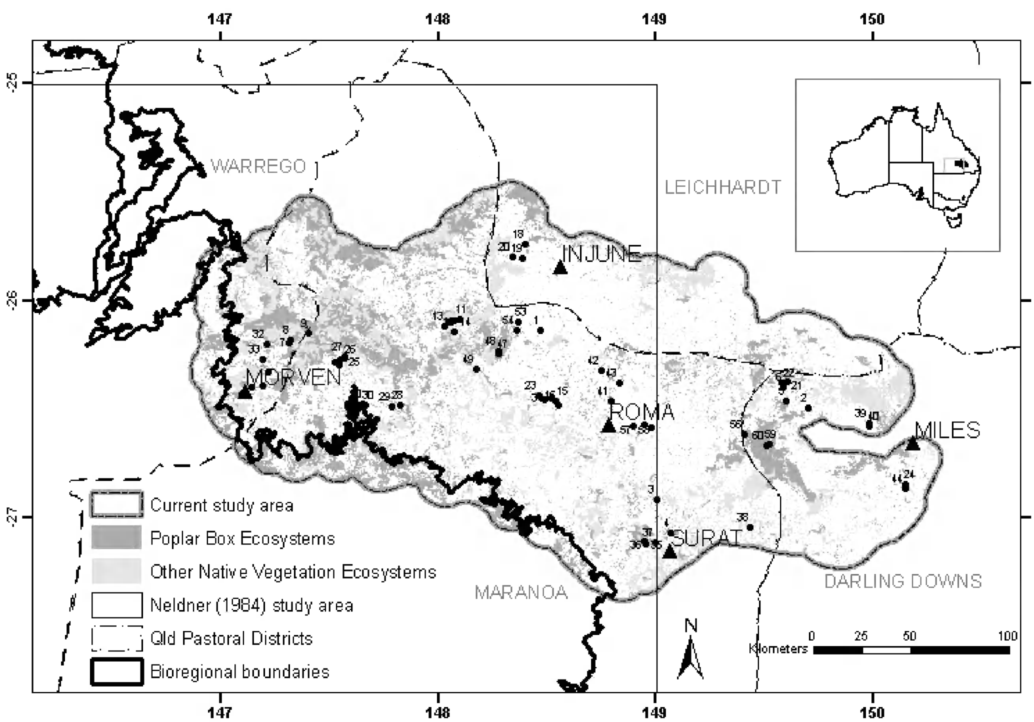

FIG. 1. Distribution of poplar box (dark grey) and other native vegetation (light grey) ecosystems in the study area and the locations of the 60 sampling sites. The Neldner (1984) study area covered all areas south of 25°00 latitude and west of 149°00' longitude. Four Queensland Pastoral Districts and the bioregional boundaries of the Brigalow Belt (east), Mulga Lands (south west) and Mitchell Grass Downs (north west corner) are also shown.

STUDY AREA AND METHODS

A broad vegetation survey, incorporating 22.2 million ha across the Brigalow Belt, Mulga Lands and Mitchell Grass Downs bioregions (Fig. 1), was conducted between 1970 and 1978 by Neldner (1984). The study by Neldner (1984) used the land system mapping completed by the CSIRO and Queensland Department of Primary Industries, and described and mapped poplar box woodlands under one broad vegetation group, *E. populnea* and *E. melanophloia* dominated associations, which included 22 floristic associations. While *E. populnea* could be present in all of the floristic associations, all but five were dominated by *E. populnea*. Within the *E. populnea* and *E. melanophloia* dominated associations, Neldner (1984) identified a total of 364 plant species (332 native species and 32 exotic species). This list was based on the species collected or observed in field-based survey sites as well as Queensland Herbarium specimens previously collected from the study area. Hence, the species list of Neldner (1984) was compiled from data collected over a number of years.

The current study area was within the southern Brigalow Belt Bioregion, Queensland. It incorporated 4.5 million ha, extending from Injune in the north to Surat in the south, and Morven in the west to Miles in the east (25°44'-27°07'S, 147°09'-150°09'E) (Fig. 1). The study area contained five plant communities described by Beeston et al. (1980), and 12 floristic associations as described by Neldner (1984), and eight Regional Ecosystems (REs) in which poplar box was either the dominant or co-dominant species (Young et al., 1999). More than half of the study area (west from Roma, east from Morven) overlapped with the study area of south central Queensland floristic survey (i.e. Neldner (1984) had 149°00'E as its eastern boundary). Within the study area, poplar box ecosystems were mapped using the Queensland Herbarium 1:100,000 regional ecosystem mapping (Queensland Herbarium, 2005).

Sixty sites were selected according to accessibility and their representation of variation in poplar box remnant patch size, shape and level of isolation. Of the 60 sites in the present study, 15 were east of the Neldner (1984) study area (Fig. 1). Variation in management intent was also sampled, with sites being located within freehold, travelling stock route, conservation reserve and forest reserve tenures (Table 1). Information on latitude/longitude, precipitation and temperature for each site is also given in Table 1. Latitude and longitude were recorded from a global positioning system at the start of each plot. Raw annual precipitation and temperature data between 1/1/1957 to 8/10/2003 for each month were downloaded from the SILO Patched Point Dataset (http://www.nrm.qld.gov.au/silo). Two values were obtained from this data; total annual precipitation averaged over a 46-year period and total precipitation for the year of the study (November 2002 to October 2003). The Patched Point Dataset combines original Bureau of Meteorology measurements from a meteorological station with interpolated data for any record gaps (Jeffrey et al., 2001). Records were obtained from the nearest stations to each of the sites.

All sites were located in four Queensland Pastoral Districts (QPD), as mapped by the former Survey Office of the Department of Natural Resources, Mines and Energy (Fig. 1). These included the Darling Downs (12 sites), Leichhardt (three sites), Maranoa (38 sites), and Warrego (seven sites). Knowledge of the QPD is important as they are used by the Queensland Herbarium to assign the distribution of Queensland plant specimens.

Field-work was conducted from November 2002 to October 2003. At each site a 100 m x 50 m plot was marked out at least 50 m from the remnant edge. Vascular species were assessed in the tallest, mid and ground layers. The tallest layer is also called the overstorey, and the mid and ground layers the understorey (Specht & Specht, 1993, 1994, 1999). Life forms in this study included trees, shrubs (woody species usually 1.5-4 m in height and generally multi-stemmed, including mistletoe), vines, forbs (all herbaceous species including ferns and non-woody climbers) and graminoids (mainly in the Poaceae, Cyperaceae and Juncaceae families). The tallest and mid layers were composed of tree, vine and shrub species while the ground layer consisted of forb and graminoid species. The assemblages of all species in and immediately surrounding the plot were recorded and the numbers of species at each site were collated. Nomenclature used in this study follows that of Henderson (2002). When identification to species level was not possible, the specimen was identified to genus or family level.

The Sorensen coefficient, based on presence-absence data, was used to measure similarity (Pielou, 1984) between the results obtained by Neldner (1984) from the poplar box woodlands in south central Queensland and the results obtained from the current study.

TABLE 1. Description of study sites. Numbering refers to FIG. 1; Broadly defined tenure are: freehold (FH), lands lease (LL), national park (NP), reserve (RE), state forest (SF), stock route (SR).

No.	Site id_alias	Nearest_town	Tenure	Regional Ecosystem	Coordinates	Precipitation (mm)		Mean Tempeature (°C)	
						Mean annual	Study period	Max.	Min.
1	AL01	Injune/Roma	FH	11.3.2	26° 08' S, 148° 29' E	548	416	27.1	12.0
2	BOG01	Jackson	RE	11.3.2	26° 30' S, 148° 42' E	579	529	27.2	12.5
3	CAR01	Surat	SR	11.3.2	26° 55' S, 149° 01' E	565	474	27.9	13.0
4	CAR02	Surat	SR	11.3.2	27° 04' S, 149° 05' E	548	529	27.8	13.0
5	CD01	Jackson	FH	11.5.1a	26° 28' S, 149° 36' E	594	547	26.9	12.3
6	CD02	Jackson	RE	11.3.2	26° 24' S, 149° 36' E	610	560	26.6	12.1
7	CHR01	Morven	NP	11.3.2	26° 12' S, 147° 19' E	552	420	26.3	11.4
8	CHR02	Morven	NP	11.3.2	26° 11' S, 147° 20' E	542	410	26.6	11.6
9	CHR03	Morven	NP	11.10.11	26° 09' S, 147° 24' E	576	437	26.0	11.1
10	CL02	Mitchell	FH	11.5.13	26° 06' S, 148° 03' E	581	486	26.5	11.4
11	CL03	Mitchell	LL	11.3.2	26° 05' S, 148° 06' E	592	493	26.3	11.3
12	CL04	Mitchell	LL	11.3.2	26° 08' S, 148° 05' E	568	469	26.7	11.6
13	CL05	Mitchell	LL	11.5.13	26° 07' S, 148° 02' E	581	486	26.5	11.4
14	CL06	Mitchell	LL	11.10.11	26° 06' S, 148° 05' E	592	493	26.3	11.3
15	DSR01	Roma	SR	11.3.2	26° 28' S, 148° 33' E	534	428	27.6	12.5
16	DSR02	Roma	SR	11.3.2	26° 29' S, 148° 34' E	534	429	27.7	12.6
17	DSR03	Roma	SR	11.3.2	26° 27' S, 148° 32' E	534	428	27.6	12.5
18	GLN01	Injune	LL	11.3.2	25° 44' S, 148° 25' E	581	551	27.1	12.0
19	GLN02	Injune	FH	11.3.2	25° 48' S, 148° 24' E	586	555	27.0	11.9
20	GLN03	Injune	FH	11.9.7	25° 48' S, 148° 21' E	576	544	27.0	11.9
21	GUL01	Jackson	FH	11.3.2	26° 22' S, 149° 37' E	625	567	26.4	11.9
22	GUL02	Jackson	FH	11.3.18	26° 23' S, 149° 35' E	610	560	26.6	12.1
23	LR01	Mitchell/Roma	FH	11.9.7	26° 26' S, 148° 28' E	539	434	27.2	12.1
24	LSR01	Condamine/Miles	SR	11.3.2	26° 51' S, 150° 09' E	614	553	27.1	12.5
25	ML01	Mungallala/Morven	LL	11.3.2	26° 16' S, 147° 34' E	540	399	26.8	11.6
26	ML02	Mungallala/Morven	LL	11.3.2	26° 16' S, 147° 33' E	540	399	26.8	11.6
27	ML03	Mungallala/Morven	LL	11.10.11	26° 15' S, 147° 35' E	540	396	26.9	11.7
28	MSR01	Mungallala/Mitchell	SR	11.10.11	26° 29' S, 147° 50' E	511	332	27.6	12.2
29	MSR02	Mungallala/Mitchell	SR	11.5.13	26° 29' S, 147° 48' E	513	330	27.4	12.0
30	MSR03	Mungallala/Mitchell	SR	11.9.10	26° 29' S, 147° 40' E	520	358	26.9	11.7

31	MTM01	Morven	LL	11.9.10	26° 20' S, 147° 13' E	510	395	27.1	12.1
32	MTM02	Morven	LL	11.10.11	26° 12' S, 147° 13' E	518	398	27.0	11.9
33	MTM03	Morven	LL	11.9.10	26° 16' S, 147° 12' E	505	391	27.2	12.1
34	MYR01	Roma	LL	11.3.2	26° 27' S, 148° 30' E	532	430	27.5	12.4
35	NEW01	Surat	SF	11.3.2	27° 07' S, 148° 58' E	557	491	27.8	13.0
36	NEW02	Surat	SF	11.3.2	27° 06' S, 148° 57' E	557	491	27.8	13.0
37	NEW03	Surat	LL	11.3.18	27° 07' S, 149° 01' E	553	510	27.9	13.0
38	PIA01	Yuleba/Surat	LL	11.4.7	27° 03' S, 149° 27' E	540	512	27.5	12.8
39	PL01	Drillham/Miles	LL	11.3.2	26° 34' S, 149° 59' E	606	**620**	26.7	12.3
40	PL02	Drillham/Miles	SR	11.3.2	26° 35' S, 150° 00' E	602	**629**	26.8	12.3
41	RSR01	Roma	SR	11.9.7	26° 28' S, 148° 48' E	550	426	27.7	12.7
42	RSR02	Roma	SR	11.10.11	26° 19' S, 148° 45' E	540	418	27.6	12.6
43	TSR01	Roma	SR	11.3.2	26° 23' S, 148° 50' E	546	440	27.5	12.6
44	TWP01	Condamine/Miles	RE	11.3.2	26° 52' S, 150° 09' E	614	553	27.1	12.5
45	UMB01	Mungallala/Morven	LL	11.9.10	26° 18' S, 147° 33' E	532	391	26.9	11.7
46	UMB02	Mungallala/Morven	LL	11.9.10	26° 17' S, 147° 32' E	532	391	26.9	11.7
47	WAL01	Mitchell	SF	11.3.2	26° 15' S, 148° 17' E	551	451	26.9	11.8
48	WAL02	Mitchell	SF	11.10.11	26° 14' S, 148° 17' E	551	451	26.9	11.8
49	WAL03	Mitchell	RE	11.3.2	26° 19' S, 148° 11' E	537	439	27.2	12.0
50	WAR01	Mungallala/Mitchell	SR	11.9.10	26° 28' S, 147° 40' E	516	346	27.2	12.0
51	WAR02	Morven	SR	11.9.10	26° 24' S, 147° 12' E	517	389	27.1	12.1
52	WAR03	Morven	SR	11.3.2	26° 24' S, 147° 09' E	517	380	27.2	12.2
53	WN01	Injune/Roma	LL	11.3.2	26° 06' S, 148° 23' E	552	438	27.2	12.0
54	WN02	Injune/Roma	LL	11.9.7	26° 08' S, 148° 22' E	549	447	27.1	11.9
55	WSR01	Roma	RE	11.5.13	26° 34' S, 148° 57' E	533	483	27.7	12.8
56	WSR02	Yuleba	SR	11.3.2	26° 37' S, 149° 25' E	591	**613**	27.6	12.8
57	WSR03	Roma	SR	11.5.13	26° 35' S, 148° 54' E	544	486	27.7	12.8
58	WSR04	Roma	SR	11.9.7	26° 35' S, 148° 59' E	539	479	27.7	12.8
59	YUL01	Yuleba/Jackson	SF	11.3.2	26° 40' S, 149° 32' E	574	528	27.3	12.6
60	YUL02	Yuleba/Jackson	SF	11.3.2	26° 40' S, 149° 31' E	581	554	27.4	12.7

TABLE 2. Plant species newly recorded for Queensland Pastoral Districts.

Scientific Name	Common Name	Origin	Habit	Location and/or Tenure	Comment
Acacia jucunda	No common name	native	tree	Mt. Maria, Land Lease	New record for Warrego. The most western distribution for this species.
Alectryon diversifolius	Scrub Boonaree, Holly Bush	native	shrub	Chesterton Range National Park	New record for Warrego.
Atriplex spinibractea	No common name	native	herb	Myrnong (Stock Route), Land Lease	New record for Maranoa. Uncommon wher it is recorded.
Bidens pilosa	Cobbler's Pegs	exotic	herb	Roma (Stock Route), State Reserve and Land Lease	New record for Maranoa. Common at sites.
Capillipedium spicigerum	Scented Top	native	grass	Roma (Stock Route), Reserve	New record for Maranoa. Widespread species.
Chrysocephalum sp.	No common name	native	herb	Chesterton Range National Park	New species (to be formally named).
Dendrophthoe vitellina	No common name	native	shrub	Mungullala (Stock Route), State Reserve	New record for Warrego.
Dipteracanthus australasicus subsp. *corynothecus*	No common name	native	herb	Chesterton Range National Park	New record for Warrego. Endemic to Queensland.
Eclipta prostrata	White Eclipta	native	herb	Mt. Maria, Land Lease	New record for Warrego. Widespread species.
Eremophila debilis	Winter Apple	native	shrub	Chesterton Range National Park	New record for Warrego.
Evolvulus alsinoides var. villosicalyx	Tropical Speedwell	native	herb	Gullugimbi, Free Hold	New record for Darling Downs.
Exocarpos cupressiformis	Native Cherry, Cherry Ballart	native	tree	Chesterton Range National Park	New record for Maranoa and Warrego. Widespread species.
Flindersia maculosa	Leopardwood, Leopard Tree	native	tree	Jackson, Reserve	New record for Darling Downs.
Opuntia aurantiaca	Tiger Pear	exotic	shrub	Yulba, Land Lease; Mungullala (Stock Route), State Reserve; Newington, State Forest and Land Lease; Surat (Stock Route), State Reserve; Roma (Stock Route), State Reserve	New record for Maranoa. Common at sites.
Opuntia stricta	Spiny Pest Pear	exotic	shrub	Most sites	New record for Leichhardt and Maranoa. Common at sites
Opuntia tomentosa	Velvety Tree Pear	exotic	tree	Most sites	New record for Darling Downs and Maranoa. Common at sites.
Paspalum dilatatum	Paspalum	exotic	grass	Roma (Stock Route), State Reserve	New record for Maranoa.
Sporobolus elongatus	Slender Rat's Tail Grass	native	grass	Roma (Stock Route), State Reserve and Land Lease	New record for Maranoa.
Themeda quadrivalvis	Grader Grass	exotic	grass	Roma , Blythe Camp & Water Reserve	New record for Maranoa.
Zinnia peruviana	Wild Zinnia	exotic	herb	Claravale, Land Lease	New record for Maranoa.

RESULTS

SPECIES RICHNESS AND NOTEWORTHY PLANTS

In total, 335 vascular plant species (299 or 89% native species and 36 or 11% exotic species) were enumerated from all current study sites. A full species list with their life forms, origin and occurrence in each site are given in the Appendix.

No rare and threatened species listed under Queensland State Legislation (*Nature Conservation Act 1992* or *Environmental Protection and Biodiversity Conservation Act 1999*) were recorded. However, one new species, *Chrysocephalum* sp. (to be formally named), and 19 new QPD distributional records (12 native species and seven exotic species) for the study area were made (Table 2). The new species was recorded from only one site in Chesterton Range National Park and was uncommon. Most new records of native species were common at sites where they were recorded. However, species such as *Atriplex spinibractea* and *Dipteracanthus australasicus* subsp. *corynothecus* were only encountered occasionally. The new records of exotic species were also common where they were recorded except *Zinnia peruviana,* which was recorded from only one site. Neldner (1984) recorded *Melaleuca groveana*, *Ptilotus blakeanus* and *Vittadinia decora* as three rare species from the poplar box woodlands in south central Queensland. None of these were recorded in the current study.

NATIVE SPECIES

The number of native species within life forms recorded during the current study versus that recorded during the south central Queensland study (Neldner, 1984) is shown in Fig. 2. While the number of forb and shrub species did not differ greatly between the studies, there were more tree and vine species, but less graminoid species recorded in the current study.

TREE

Fifteen percent of the total native species were trees. They belonged to 29 genera within 19 families. Twenty species were recorded from 10% of sites. Poplar box was the only species recorded from all 60 sites. Other common tree species recorded were (number of sites in brackets): *Eremophila mitchellii* (51), *Geijera parviflora* (38), *Callitris glaucophylla* (31), *Alectryon oleifolius* subsp. *elongatus* (24), *Atalaya hemiglauca* (23), *Eucalyptus melanophloia* (21), *Acacia excelsa* subsp. *excelsa* (19), *Capparis loranthifolia* (19), *Acacia harpophylla* (14), *Acacia jucunda* (12), *Casuarina cristata* (9), *Citrus glauca* (9), *Grevillea striata* (9), *Acacia salicina* (8), *Brachychiton populneus* subsp. *trilobus* (8), *Notelaea microcarpa* var. *microcarpa* (8), *Acacia pendula* (7), *Eucalyptus chloroclada* (7) and *Acacia crassa* subsp. *crassa* (6).

Twenty-five species were recorded in less than 10% of sites. Among these, two species were recorded in five sites, six species were recorded in four sites, five species were recorded in three sites, seven species were recorded in two sites and five species were recorded in one site only.

Neldner (1984) recorded 34 tree species belonging to 16 genera within 13 families in the poplar box woodlands of south central Queensland. The Sorensen Similarity Indices (ISS) between the current study and the south central Queensland study were 75, 67 and 56 at the family, genus and species levels respectively.

SHRUB

Sixty-five species or 22% of the total natives were shrub species that belonged to 35 genera in 21 families. Eighteen species were recorded in six or more sites. They were: *Maireana microphylla* (36), *Sclerolaena birchii* (36), *Abutilon oxycarpum* (31), *Eremophila deserti* (27), *Enchylaena tomentosa* var. *tomentosa* (26), *Sida subspicata* (22), *Solanum parvifolium* (20), *Dodonaea viscosa* subsp. *spatulata* (17), *Apophyllum anomalum* (14), *Capparis lasiantha* (14), *Rhagodia parabolica* (14), *Hibiscus sturtii* var. *sturtii* (14), *Eremophila debilis* (10), *Maytenus cunninghamii* (9), *Sida rohlenae* subsp. *rohlenae* (9), *Carissa ovata* (7), *Sida trichopoda* (7) and *Myoporum acuminatum* (6).

Forty-seven species were recorded in five or fewer sites. Among these, four species were recorded in five sites, six species were recorded in four sites, six

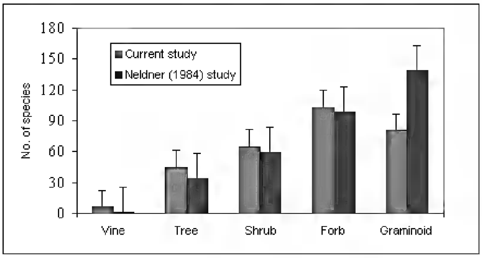

FIG. 2. The number of native species in each life form (standard error bar exhibited) recorded in the current study and Neldner (1984) study.

species were recorded in three sites, 13 species were recorded in two sites and 18 species were recorded in one site only.

Neldner (1984) recorded 59 shrubs in 25 genera of 16 families. The ISS among the families, genera and species between the two studies was 76, 57 and 38 respectively. The relatively low similarity at the species level suggests that a significant difference in species diversity exists between the two studies.

VINE

Six species or 2% of the total natives were vines that belonged to three genera in three families. *Jasminum didymum* subsp. *lineare* and *Parsonsia eucalyptophylla* were recorded in 18 and 12 sites respectively and were the most common vine species. The other four species were recorded in one separate site.

The only vine species recorded previously in south central Queensland was *P. eucalyptophylla* (Neldner 1984). The ISS between the two studies was 50 at the genus level and 29 at the species level.

FORB

Forbs were the major component of species richness in the current study. A total of 103 species or 34% of the total natives were recorded. They belong to 64 genera in 30 families. Thirty-nine were in six or more sites. *Brunoniella australis* was recorded in 49 sites and was the most widespread forb species. Other species recorded in 20 or more sites included *Boerhavia dominii* (37), *Lomandra multiflora* subsp. *multiflora* (33), *Desmodium varians* (32), *Einadia hastata* (27), *Rostellularia adscendens* var. *adscendens* (27), *Glycine clandestina* var. *sericea* (25), *Chamaesyce drummondii* (21), *Einadia nutans* subsp. *nutans* (20) and *Trianthema triquetra* (20).

Sixty-four forb species were recorded in five or fewer sites. Among these, four species were recorded in five sites, eight species were recorded in four sites, 10 species were recorded in three sites, 17 species were recorded in two sites and 25 species were recorded in one site only.

Neldner (1984) recorded a total of 99 species in 66 genera of 27 families. Although at the family and genus level the ISS of 60 and 55 was reasonable, the similarity at the species level (ISS = 35) was much lower indicating a reasonable difference exists in forb species diversity between the two studies.

GRAMINOID

Eighty species or 27% of the total natives were graminoids. They belonged to the Poaceae (73 species in 33 genera), Cyperaceae (six species in two genera) and Juncaceae (one species in one genus) families. Twenty-seven species were recorded in more than six sites. Thirteen species were recorded in more than 20 sites, including *Cyperus gracilis* (46), *Bothriochloa decipiens* var. *decipiens* (43), *Cymbopogon refractus* (43), *Eragrostis lacunaria* (35), *Chloris ventricosa* (35), *Aristida ramosa* (32), *Enteropogon acicularis* (30), *Paspalidium gracile* (30), *Enneapogon lindleyanus* (29), *Aristida caput-medusae* (26), *Aristida jerichoensis* var. *subspinulifera* (26), *Themeda triandra* (25) and *Chloris divaricata* (23).

Fifty-three graminoid species were recorded in less than six sites. Among these, four species were recorded in five sites, nine species were recorded in four sites, nine species were recorded in three sites, nine species were recorded in two sites and 22 species were recorded in one site only.

Graminoids were the major component of species richness in the poplar box woodlands of south central Queensland. Neldner (1984) recorded a total of 139 species that belonged to the Poaceae (129 species, 42 genera) and Cyperaceae (10 species, four genera) families. Of the Poaceae, 62 species from 27 genera were recorded in the current study. The ISS between the two studies were 72 and 61 at the genus and species levels respectively.

EXOTIC SPECIES

Exotic species were mainly found in the ground layer. However, velvety tree pear (*Opunia tomentosa* Salm-Dyck) was also recorded in the tallest and mid layers. Zero to nine exotic species were recorded per site.

Among the exotic plants recorded, buffel grass (*Cenchrus ciliaris* L), Mayne's pest (*Verbena aristigera* S.Moore), soft roly-poly (*Salsola kali* L.), velvety tree pear, spiny pest pear (*O. stricta* (Haw.) Haw.) and tiger pear (*O. aurantiaca* Lindl.) were the most abundant (i.e. cover within sample plots) and frequent (i.e. number of sites recorded) species.

Buffel grass, Mayne's pest and soft roly-poly, were recorded in 21, 24 and 26 sites respectively, being the most abundant and widely distributed species. Although the three *Opuntia* species were recorded in 23 plots, their average ground cover was less than 1%.

Neldner (1984) recorded 32 exotics from 25 genera in nine families. High similarity at the family level (ISS = 91) was recorded between the two studies. In contrast, the similarities for genera (ISS = 35) and species (ISS = 26) were both very low.

DISCUSSION

The field component of the current study surveyed flora assemblages within 60 plots of 0.5-hectare size. This meant that a total sample area of 30 hectares was assessed throughout the study region. Consequently, like most ecological field studies, the sampled area only represented a small proportion of the vegetation of poplar box woodlands, thus potentially limiting the representativeness and adequacy of the results. Furthermore, prior to and during the first few months of the survey, the study area experienced an exceptional drought. Rainfall received at the majority of the sites (n=57) over the sampling period was less than average (Table 1). The dry conditions were one of the major contributors to high levels of dieback at all sites (Wylie et al., 2005). Timing of sampling is a key factor in sampling design, with the season of sampling having a significant effect on the species richness captured (Neldner et. al., 2004). It is likely that the drought conditions during the sampling period significantly reduced the species richness, particularly ground layer short-lived (e.g. annual) forbs and graminoids, which have rapid responses to good seasons.

For native tree species, all families recorded in south central Queensland by Neldner (1984) were present in the current study, except for those within the family of Fabaceae. The family had only one species, *Erythrina vespertilio*, recorded previously. Although once widely but sparsely distributed, it was not recorded in the current study, possibly due to land clearing and habitat fragmentation. An additional 11 tree species were also not recorded in the current study. Some tree species were recorded by previous mapping studies in categories (Beeston et al., 1980) or associations (Neldner, 1984) or REs (Sattler & Williams, 1999) were not sampled during this study. For example, *Acacia blakei* var. *blakei* and *A. julifera* subsp. *curvinervia*, which occur predominantly in sandstone areas, *Hakea tephrosperma*, which occurs on western sandridges and dunes, *Acacia aneura* var. *aneura*, which is mainly found in mulga land and *A. omalophylla*, which is restricted to heavy clay soils. Specimens of *Eucalyptus intertexta, E. microcarpa, Acacia maranoensis, A. microsperma* and *Hakea ivoryi* are stored in the Queensland Herbarium, collected from poplar box woodlands in the study area, but were not recorded in the current study. *Eucalyptus conica* was recorded by Neldner (1984) as occurring in the poplar box woodlands, but this was a misidentification of the species according to the Queensland Herbarium current database.

Seven families of tree species that were not previously recorded in south central Queensland were found in the current study. They were Celastraceae (one species), Euphorbiaceae (one species), Meliaceae (one species), Oleaceae (one species), Pittosporaceae (one species), Santalaceae (two species) and Sterculiaceae (two species). No tree species from these families was dominant or co-dominant. However, *Brachychiton populneus* subsp. *trilobus* and *Notelaea microcarpa* var. *microcarpa* were widespread (found from six or more sites) in the poplar box woodlands of the current study. Other widespread species that were not previously recorded included, *Alectryon oleifolius* subsp. *elongatus*, *Acacia jucunda*, *Citrus glauca*, *Grevillea striata* and *Acacia crassa* subsp. *crassa*.

More tree and vine species were recorded in the current study as compared with Neldner (1984). The reasons for this observation could be: (i) that more species, especially those common ones such as *Angophora leiocarpa*, *Brachychiton populneus* subsp. *trilobus*, *B. rupestris*, *Corymbia tessellaris*, *Pandorea pandorana*, *Alphitonia excelsa*, *Canthium odoratum*, *Citrus glauca*, *Elaeodendron australe* var. *integrifolium*, *Exocarpos cupressiformis*, *Notelaea microcarpa* var. *microcarpa*, *Grevillea striata*, *Hakea lorea* subsp. *lorea*, *Owenia acidula*, *Petalostigma pubescens*, and *Santalum lanceolatum*, have established in the poplar box woodlands of southern Queensland over the past twenty years; (ii) some species, such as *Eucalyptus thozetiana*, *E. crebra*, *E. crebra* x *E. populnea*, *Corymbia clarksoniana* and *Pittosporum angustifolium*, were only recorded from one site in the current study and can be relatively uncommon in the poplar box woodlands, therefore they were not encountered and consequently recorded during the previous survey; (iii) some species, i.e. *Acacia jucunda, A. crassa* subsp. *crassa*, are naturally distributed in the eastern region of southern Queensland, and therefore were not included in the study area of south central Queensland.

The relatively high ISS for species and genera of Poaceae suggests that, although there was large variation in graminoid species richness, the composition of graminoid species and their genera was relatively similar between the two studies. Those genera not recorded in the current study, i.e. *Amphipogon*, *Brachyachne*, *Dactyloctenium*, *Elytrophorus*, *Eriachne*, *Iseilema*, *Monachather*, *Neurachne*, *Oxychloris* and *Paractaenum,* were mainly found in the west of south central Queensland.

Eleven species of Poaceae in the current study were not recorded previously by Neldner (1984). *Aristida queenslandica* var. *dissimilis*, *Arundinella nepalensis*, *Capillipedium spicigerum*, *Chrysopogon fallax*, *Dichelachne crinita*, *Echinopogon ovatus* var. *ovatus*, *Entolasia stricta* and *Sporobolus elongatus* were in the eastern part of the current study area. Three species, *Enneapogon cylindricus*, *Thellungia advena* and *Sporobolus creber*, were probably newly recorded in the poplar box woodlands because of their relatively wide distribution in southern Queensland (Henderson, 2002).

For the species of Cyperaceae, comparison between the two studies showed only three were recorded for both. As all Cyperaceae species recorded have a wide distribution in the poplar box woodlands of southern Queensland, it is unclear why the similarity was so low. One species in the Juncaceae was found from separate sites and was recorded only in the eastern part of the current study.

The reasons for reduced graminoid species richness recorded in the current study compared with that of Neldner (1984) could be explained by: (i) the smaller study area of the current study; (ii) the exceptional drought prior to and during the first few months of the survey period as experienced by the current study; (iii) the natural geographic distribution of many species was not included in the current study area; (iv) land clearing over the past 20 years resulting in microhabitat change. Certainly, the much lower similarities of native forb and shrub species between the two studies suggests that the ground and mid layers of the poplar box woodlands have been at least partially modified over the last 20 years; and (v) weed invasion.

The comparison of exotic species between the two studies revealed very low similarities as well. Although all families recorded in the south central Queensland study were present in the current study, nine genera including nine species were recorded in both studies. The previously recorded exotics were mostly annual or short-lived perennial forbs and graminoids (82%), i.e. *Acanthospermum hispidum*, *Alopecurus geniculatus*, *Arctotheca calendula*, *Calendula arvensis*, *Centaurium spicatum*, *Cichorium intybus*, *Echinochloa colona*, *E. crus-galli*, *Sisymbrium thellungii*. It is unlikely that these exotic species disappeared over the last 20 years. However, there is some evidence to suggest that the distribution of some species (e.g. *Alopecurus geniculatus, Calendula arvensis*) has decreased greatly in the poplar box woodlands of the study area.

The most significant finding of the current study was a number of newly recorded exotic species in the poplar box woodlands of southern Queensland. Verbenaceae (three species) and Chenopodiaceae (one species), as newly recorded families, were among the most common exotic species. Other common exotic species included buffel grass and velvety tree pear. It is clear that these common exotic species occur not only in the poplar box woodlands but also other vegetation types and REs of the study area over the past two decades (Fensham, 1998; Franks, 2002). While buffel grass can invade areas of remnant vegetation, the spread of buffel grass has been greatly increased by being actively sown after tree clearing operations. All other newly recorded exotics were localised and infrequent.

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LITERATURE CITED

ACCAD, A., NELDNER, V.J., WILSON, B.A. & NIEHUS, R.E. 2006. Remnant Vegetation in Queensland: Analysis of Remnant Vegetation 1997-1999-2000-2001-2003, including Regional Ecosystem Information. Queensland Herbarium, Environmental Protection Agency, Brisbane.

BEESTON, G., PURDIE, R., WALKER, P. & PICKARD, J. 1980. Plant communities of the poplar box (*Eucalyptus populnea*) lands of eastern Australia. Australian Rangeland Journal 2: 1-16.

CHILCOTT, C.R., TAYLOR, D. EYRE, T. & YOUNG, A. 2005. Ecological thresholds for native vegetation in southern Queensland. Final Report to Land and Water Australia. Queensland Department of Natural Resources and Mines, Brisbane.

DEPARTMENT OF THE ENVIRONMENT, SPORT & TERRITORIES. 1995. Native Vegetation Clearance, Habitat Loss and Biodiversity Decline. Biodiversity Series, Paper No. 6. Biodiversity Unit, Canberra.

DEPARTMENT OF THE ENVIRONMENT, SPORT & TERRITORIES. 1996. The National Strategy for the Conservation of Australia's Biological Diversity Commonwealth. Department of the Environment, Sport & Territories, Canberra.

ENVIRONMENTAL PROTECTION AGENCY. 2003. State of The Environment Queensland. Environmental Protection Agency, Brisbane.

EYRE, T.J., WANG, J., VENZ, M.F., & CHILCOTT, C. (in review). The response of buffel grass *Pennisetum ciliare* to local and landscape scale variables and the impact on biodiversity values in south-west Queensland. Submitted to Austral Ecology.

FENSHAM, R.J. 1998. The grassy vegetation of the Darling Downs, southeastern Queensland, Australia. Floristics and grazing effects. Biological Conservation 84: 301-310.

FRANKS, A.J. 2002. The ecological consequences of Buffel *Grass Cenchrus* ciliaris establishment within remnant vegetation of Queensland. Pacific Conservation Biology 8: 99-107.

HENDERSON, R. J. F. 2002. Names and Distribution of Queensland Plants, Algae and Lichens. Queensland Herbarium, Environmental Protection Agency, Brisbane.

JEFFREY, S.J., CARTER, J.O., MOODIE, K.M & BESWICK, A.R. 2001. Using spatial interpolation to construct a comprehensive archive of Australian climate data, Environmental Modelling and Software Vol 16/4: 309-330.

LUDWIG, J.A., EAGER, R.W., LIEDLOFF, A.C., McCOSKER, J.C., HANNAH, D., THURGATE, N.Y., WOINARSKI, J.C.Z. & CATTERALL, C.P. 2000. Clearing and grazing impacts on vegetation patch structures and fauna counts in eucalypt woodland, Central Queensland. Pacific Conservation Biology 6: 254–272.

NELDNER, V.J. 1984. Vegetation survey of Queensland - South Central Queensland. Queensland Botany Bulletin No.3. Queensland Department of Primary Industries, Brisbane.

NELDNER, V.J., KIRKWOOD, A.B. & COLLYER, B.S. 2004. Optimum time for sampling floristic diversity in tropical eucalypt woodlands of northern Queensland. The Rangeland Journal 26: 190-203.

PIELOU, E.C. 1984. The Interpretation of Ecological Data: A Primer on Classification and Ordination. Wiley: New York.

QUEENSLAND HERBARIUM. 2005. Survey and Mapping of 2003 Remnant Vegetation Communities and Regional Ecosystems of Queensland, Version 5.0, Environmental Protection Agency, Brisbane.

SATTLER, P.S. & WILLIAMS, R.D. 1999. The Conservation Status of Queensland Bioregional Ecosystems. Environmental Protection Agency: Brisbane.

SAUNDERS, D.A., HOBBS, R.J. & MARGULES, C.R. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology 5: 18-32.

SPECHT, A. & SPECHT, R.L. 1993. Species richness and canopy production of Australian plant communities. Biodiversity and Conservation 2: 152-167.

SPECHT, A. & SPECHT, R.L. 1994. Biodiversity of overstorey trees in relation to canopy productivity and stand density in the climatic gradient from warm temperate to tropical Australia. Biodiversity Letters 2: 39-45.

SPECHT, A. & SPECHT, R.L. 1999. Structure, Growth and Biodiversity of Australian Plant Communities. (Oxford University Press: Oxford).

WILSON, B.A., NELDNER, V.J. & ACCAD, A. 2002. The extent and status of remnant vegetation in Queensland and its implications for statewide vegetation management and legislation. The Rangeland Journal 24: 6-35.

WYLIE, R., DEBUSE, V. & HARDAKER, T. 2005. Tree decline in *Eucalyptus populnea* (Poplar box) remnants in southern Queensland. Department of Primary Industries, Brisbane

YOUNG, A.G., BOYLE, T. & BROWN, A.H.D. 1996. The population genetic consequences of habitat fragmentation for plants. Trends in Ecology and Evolution II: 413-418.

YOUNG, P.A.R., WILSON, B.A., McCOSKER, J.C., FENSHAM, R.J., MORGAN, G. & TAYLOR, P.M. 1999. Brigalow Belt. In: The Conservation Status of Queensland Bioregional Ecosystems, (eds P. S. Sattler & R. D. Williams), 11/1-11/81. Environmental Protection Agency, Brisbane.

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MORPHOLOGICAL AND MOLECULAR IDENTIFICATION OF FUNGAL ENDOPHYTES FROM ROOTS OF *DENDROBIUM SPECIOSUM*

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We have isolated fungal endophytes from roots of *Dendrobium speciosum*, a common epiphytic orchid in southern Queensland rainforests and used morphological criteria and molecular techniques to identify these fungi. Morphological analysis of the cultures obtained demonstrated a variety of non-mycorrhizal deuteromycetes present in plant roots as well as a putative mycorrhizal *Tulasnella*-like fungus. Molecular techniques were useful in identifying four non-sporulating deuteromycete fungi. The wide variety of endophytes isolated further highlights the importance of rainforest plants as reservoirs of fungal biodiversity. □ *Dendrobium speciosum*, Deuteromycetes, fungal endophytes, rainforest plants, *Tulasnella*.

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Fungal endophytes are fungi that live inside plant tissues causing no detriment to the host. It has only been recently that the fungal endophytes of the world's tropical and subtropical flora have begun to be documented (Arnold et al., 2000). The discovery that rainforest tree species can harbour dozens of unique fungal endophyte species suggest that these organisms constitute a large proportion of global fungal biodiversity (Arnold et al., 2001, Hawksworth, 2001).

There are three major groups of fungal endophytes in plants. The family Orchidaceae contain mainly basidiomycetous fungi. The grasses are commonly colonised by fungi within the genus *Acremonium* or from the order Hypocreales (ergot-forming fungi). In woody plants there is a vast diversity of fungal endophyte species but the majority appear to be asexually reproducing (and often not spore forming) members of the ascomycete group of fungi (Redlin and Carris, 1996). Hyde (2001) has recently stated that the ascomycetes of Australia are poorly known while McKenzie (2001) has outlined that Australasia is a vast storehouse of unknown fungi anamorphi or asexually reproducing ascomycetes. The latter author pinpoints Australasian rainforests and its outlying islands as priority sites for mycological investigation.

The rainforests of South East Queensland have a high plant diversity (Williams, 1987) and likely a correspondingly diverse endophyte mycoflora. To date these ecosystems have been little focussed on from a fungal endophyte perspective. As these ecosystems are under threat from clearing for agriculture and urbanisation and other human-based disturbances it is paramount that the fungal endophyte communites of these regions is fully documented before it is irrevocably lost.

The aim of this project is to identify the endophytic fungi of roots of *Dendrobium speciosum* (Smith) a common epiphytic orchid species in southern Queensland rainforests. Fungi will be identified by morphological features or by molecular sequencing of nuclear rDNA. Molecular techniques have previously been shown to be useful in identifying orchid endophytic fungi as they are objective and do not rely on fungal cultures forming sporulating structures (Taylor & Bruns, 1997, 1999; Bougoure & Dearnaley, 2005; Dearnaley & Le Brocque, 2006).

MATERIALS AND METHODS

ISOLATION OF FUNGI FROM ORCHID ROOTS

Roots were sampled from four *D. speciosum* plants growing in Redwood Park near Toowoomba (Fig. 1). Roots were washed in tap water before surface sterilization via immersion in 96% ethanol and flaming. Root sections were incubated on potato dextrose agar containing 15mg/ml tetracycline and streptomycin for 3-4 weeks at 25°C in the dark. Fungal isolates were sub-cultured to ensure purity and then processed as per below.

FIG. 1. *Dendrobium speciosum* plant – note the mass of aerial roots at the plant base. Bar = approximately 6cm.

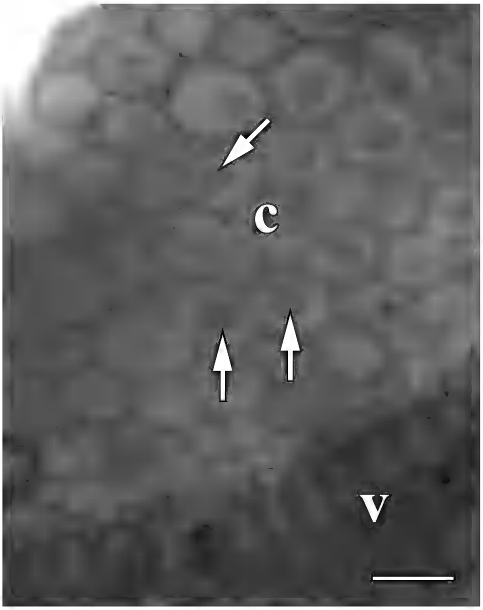

FIG. 2. Cross section of root of *D. speciosum* plant. Note fungal colonization was clearly present in the cortex (c, arrows). (v) = velamen layer , bar = approximately 90µm.

MORPHOLOGICAL AND MOLECULAR IDENTIFICATION OF ORCHID FUNGI

Sporulating fungi were identified on the basis of colony colour and spore morphology using Barnett and Hunter (1998) and Ellis (1976).

We attempted to identify five non-sporulating isolates via PCR, cloning and sequencing using the methods outlined in Dearnaley and Le Brocque (2006). In brief, genomic DNA was extracted from pure cultures of the isolated fungi. ITS rDNA was amplified with ITS1F and ITS4 primers and transformed into *E. coli*. Recombinant plasmids were isolated via blue-white selection and fungal ITS inserts sequenced using T7 primer at the Australian Genome Research Facility. Sequences were compared with fungal ITS sequences in GenBank using BLAST searches.

RESULTS

Fungal colonization was only obvious in roots taken from the interface between orchids and their host tree. When hand sections were microscopically viewed, fungal coils were found in the cortex layer of these roots (Fig. 2). A number of fungal genera were isolated from plants (Table 1) with most isolates of each genus being similar to each other in colony colour and conidial structure. A slow growing and difficult to subculture white mycelial fungus was isolated from plant 3 (Table 1). On the basis of the mycelial colour and shape of the probasidia formed, this fungus was identified tentatively as a *Tulasnella* sp. (Warcup & Talbot 1967). DNA-ITS sequences were obtained for four of the five non-sporulating fungi (one of the fungal ITS amplicon extracts failed to ligate). The non-sporulating fungus isolated from plant 1 had close identity to *Phaeoacremonium rubrigenum* (98% over 436 bp and 99% over 405 bp). The first of the two non-sporulating fungi from plant 2 had identity to *Chaetomium nigricolor* (95% over 528 bp) and a *Paecilomyces* sp. (93% over 548 bp). The second non-sporulating fungus from Plant 2 had identity to an uncultured soil fungus (99% over 583) and a *Fusarium* sp. (99% over 570 bp). The non-sporulating fungus isolated from plant 4 had identity to a *Penicillium* sp. (98% over 357 bp) and an endophytic fungus originally isolated from *Epacris pulchella* (96% over 372 bp).

TABLE 1. Fungal endophyte genera isolated from three of the four *D. speciosum* plants.

Fungal genera isolated	Number of isolates obtained		
	Plant no. 1	Plant no. 2	Plant no. 3
Epicoccum nigrum	-	4	-
Fusarium	3	3	-
Nigrospora	1	1	-
Phialophora	1	-	-
Trichoderma	1	5	-
Tulasnella sp.	-	-	1
Unidentified yeast	2	2	-

TABLE 2. Closest two matches from BLAST searches of ITS sequences amplified from non-sporulating fungi isolated from three of the four *D. speciosum* plants. Included are the deposited accession codes, the two closest GenBank matches and accession codes, sequence identity and overlap of each match.

Plant No.	GenBank accession code	Closest species match	Accession code	Sequence identity (%)	Sequence overlap (bp)
1	EF152422	*Phaeoacremonium rubrigenum*	AB278173.1	98	436
		Phaeoacremonium rubrigenum	AF197978	99	405
2	EF152423	*Chaetomium nigricolor*	AJ458185.1	95	528
		Paecilomyces sp.	DQ191963.1	93	548
2	EF152424	Uncultured soil fungus	DQ420794.1	99	583
		Fusarium sp.	DQ166549.1	99	570
4	EF152425	*Penicillium* sp.	AY354257.1	98	357
		Epacris pulchella root fungus	AY627832.1	96	372

DISCUSSION

There are only a few reports of studies on Australian rainforest endophytes eg. Frohlich, Hyde and Petrini (2000) and Markovina et al. (2005). Significantly, many of these studies have used traditional morphological methods to identify isolated endophytes which raises the possibility that some fungi may have been misidentified or overlooked. Guo et al. (2000) highlights the value of using DNA sequence analysis in the identification of rainforest endophytes – in particular non-sporulating fungal species. The molecular identification of a *Phaeacremonium* sp., a *Penicillium* sp. and a fungus with identity to *Chaetomium*/*Paecilomyces* demonstrates the usefulness of this approach to fully documenting the fungal endophytic community of *D. speciosum*.

Molecular studies of orchid endophytic fungi have typically focused on terrestrial orchid species (eg. Taylor & Bruns, 1997; 1999; Bougoure et al., 2005; Bougoure & Dearnaley, 2005; Dearnaley & Le Brocque, 2006). Recently, molecular studies of fungi from some epiphytic orchids have been carried out in Ecuador (Suarez et al., 2006), Puerto Rico (Otero et al., 2002; 2004), and Singapore (Ma et al., 2003). The main endophytes isolated included the basidiomycete genera, *Tulasnella* and *Ceratobasidium* but ascomycete genera such as *Fusarium* and *Trichoderma* were also identified. This is, to our knowledge, the first published account of molecular identification of endophytic fungi from an Australian epiphytic orchid.

Orchids rely on mycorrhizal fungi to provide inorganic nutrients throughout their life cycle. Orchid mycorrhizal fungi can essentially be divided into two groups. Photosynthetic orchids typically contain heterobasidiomycete fungi (i.e members of the so called *Rhizoctonia* complex) (Warcup, 1981; Perkins et al., 1995; Bougoure et al., 2005). Non-photosynthetic orchids or myco-heterotrophic species are typically colonised by homobasidiomycetes with fungal genera including *Russula*, *Thelephora* and

Coprinus (Taylor & Bruns, 1997; 1999; Bougoure & Dearnaley, 2005; Dearnaley & Le Brocque, 2006; Yamoto et al., 2005).

To date all mycorrhizal fungi isolated from Australian *Dendrobium* spp. belong to the heterobasidiomycete group, Tulasnellaceae. Warcup & Talbot (1967) isolated *Tulasnella calospora* from a *Dendrobium* sp. (probably *Dendrobium speciosum*) from Binna Burra in SE Queensland. The same authors isolated *Tulasnella aysmmetrica* from *Dendrobium tetragonum* from Coen in Nth QLD (Warcup & Talbot, 1971) and *Tulasnella irregularis* from *Dendrobium dicuphum* near Darwin (Warcup & Talbot, 1980). These results support the identification of the slow-growing, difficult to culture, white isolate in this study as a *Tulsanella* sp.

The majority of endophytes isolated here via both morphological and molecular approaches are saprophytic deuteromycete fungi (Barnett & Hunter, 1998) and not mycorrhizal fungi. The infrequency of isolating the *Tulasnella*-like fungus probably relates to the low level of mycorrhizal colonisation in *D. speciosum* roots. While terrestrial orchid species can often be heavily colonized with mycorrhizal fungi (Bougoure et al., 2005), epiphytic orchids have been shown to have low levels of fungal colonization (Hadley & Williamson, 1972) and thus we may not have sampled enough roots to obtain a large number of isolates of the mycorrhizal partner of *D. speciosum*.

In summary we have identified the fungal endophytes inhabiting roots of the epiphytic orchid *D. speciosum*. Using both morphological and molecular approaches we have documented a range of fungal species residing in the roots of the orchid, the majority of which are non-mycorrhizal deuteromycetes. Such a large variety of endophytes from a small plant sample size illustrates the importance of rainforest plants as reservoirs of fungal biodiversity. This study provides impetus for further studies of the fungal endophytes in South East Queensland rainforest plants.

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LITERATURE CITED

ARNOLD, A.E., MAYNARD, Z., GILBERT, G.S., COLEY, P.D. & KURSAR, T.A. 2000. Are tropical endophytes hyperdiverse? Ecology Letters 3: 267-274.

ARNOLD, A.E., MAYNARD, Z. & GILBERT, G.S. 2001. Fungal endophytes in dicotyledonous neotropical trees: patterns of abundance and diversity. Mycological Research 105: 1502-1507.

BARNETT, H.L. & HUNTER, B.B. 1998. Illustrated genera of imperfect fungi, 4th edition. (The American Phytopathological Society: Minnesota, USA).

BOUGOURE, J.J., & DEARNALEY, J.D.W. 2005. The fungal endophytes of *Dipodium variegatum* (Orchidaceae). Australasian Mycologist 24: 15-19.

BOUGOURE, J.J., BOUGOURE, D.S., CAIRNEY, J.W.G., & DEARNALEY, J.D.W. 2005. ITS-RFLP and sequence analysis of endophytes from *Acianthus*, *Caladenia* and *Pterostylis* (Orchidaceae) in south eastern Queensland. Mycological Research 109: 452-460.

DEARNALEY, J.D.W. & LE BROCQUE, A.F. 2006. Molecular identification of the primary root fungal endophytes of *Dipodium hamiltonianum* (Orchidaceae). Australian Journal of Botany.

HADLEY, G. & WILLIAMSON, B. (1972). Features of mycorrhizal infection in some Malayan orchids. New Phytologist 71: 1111-1118.

HAWKSWORTH, D.L. 2001. The magnitude of fungal diversity: the 1.5 million species estimate revisited. Mycological Research 105: 1422-1432.

HYDE, K.D. 2001. Non-lichenised Australian ascomycetes. Australian Systematic Botany 14: 357-375.

FROHLICH, J., HYDE, K.D. & PETRINI, O. 2000. Endophytic fungi associated with palms. Mycological Research 104: 1202-1212.

GUO, L.D., HYDE, K.D. & LIEW, E.C.Y. 2000. Identification of endophytic fungi from *Livistona chinensis* based on morphology and rDNA sequences. New Phytologist 147: 617-630.

MA, M., TAN, T.K. & WONG, S.M. 2003. Identification and molecular phylogeny of *Epulorhiza* isolates from tropical orchids. Mycological Research 107: 1041-1049.

MARKOVINA, A.-L., PITT, J.I., HOCKING, A.D., CARTER, D.A. & MCGEE, P.A. 2005. Diversity of the *Trichocomaceae* in the Katandra nature reserve, central coast, NSW, Australia. Mycological Research 109: 964-973.

MCKENZIE, E.H.C. 2001. Fungi anamorphici in Australasia. Australian Systematic Botany. 14: 485-500.

OTERO, J.T., ACKERMAN, J.D. & BAYMAN, P. 2002. Diversity and host specificity of endophytic *Rhizoctonia*-like fungi from tropical orchids. American Journal of Botany 89: 1852-1858.

OTERO, J.T., ACKERMAN, J.D. & BAYMAN, P. 2004. Differences in mycorrhizal preferences between two tropical orchids. Molecular Ecology 13: 2393-2404.

PERKINS, A.J., MASUHARA, G. & McGEE, P.A. 1995. Specificity of the associations between *Microtis parviflora* (Orchidaceae) and its mycorrhizal fungi. Australian Journal of Botany 43: 85-91.

REDLIN, S.C. & CARRIS, L.M. 1996. Endophytic fungi in grasses and woody plants: systematics, ecology and evolution. (The American Phytopathological Society: Minnesota, USA).

SUAREZ, J.P., WEISS, M., ABELE, A., GARNICA, S., OBERWINKLER, F., KOTTKE, I. 2006. Diverse tulasnelloid fungi form mycorrhizas with epiphytic orchids in an Andean cloud forest. Mycological Research 110: 1257-1270.

TAYLOR, D.L. & BRUNS, T.D. 1997. Independent, specialized invasions of ectomycorrhizal mutualism by two nonphotosynthetic orchids. PNAS 94, 4510-4515.

TAYLOR, D.L. & BRUNS, T.D. 1999. Population, habitat and genetic correlates of mycorrhizal specialization in the 'cheating' orchids *Corallorhiza maculata* and *C. mertensiana*. Molecular Ecology 8: 1719-1732, 1999.

WARCUP, J.H. 1981. The mycorrhizal relationships of Australian orchids. New Phytologist 87: 371-381.

WARCUP, J.H. & TALBOT, P.H.B. 1967. Perfect states of *Rhizoctonias* associated with orchids. I. New Phytologist 66: 631-641.

WARCUP, J.H. & TALBOT, P.H.B. 1971. Perfect states of *Rhizoctonias* associated with orchids. II. New Phytologist 70: 35-40.

WARCUP, J.H. & TALBOT, P.H.B. 1980. Perfect states of *Rhizoctonias* associated with orchids. III. New Phytologist. 86: 267-272.

WILLIAMS, K.A.W. 1987. Native Plants of Queensland. Volume 3. (Keith A.W. Williams, North Ipswich, Queensland).

YAMOTO, M., YAGAME, T., SUZUKI, A. & IWASE, K. 2005. Isolation and identification of mycorrhizal fungi associating with an achlorophyllous plant, *Epipogium roseum* (Orchidaceae). Mycoscience 46: 73-77.

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AN INTERDISCIPLINARY APPROACH FOR UNDERSTANDING AND MANAGING A SUB-TROPICAL COASTAL WETLAND ECOSYSTEM: NATIVE DOG CREEK, SOUTHEAST QUEENSLAND, AUSTRALIA.

JULIE M. ANOROV, PAT E.R. DALE, BERNIE POWELL AND MARGARET GREENWAY

Anorov, J.M., Dale, P.E.R., Powell, B., & Greenway, M. 2008: An interdisciplinary approach for understanding and managing a sub-tropical coastal wetland ecosystem: native dog creek, southeast Queensland, Australia. *Proceedings of the Royal Society of Queensland,* 114 19-32. Brisbane. ISSN 0080-469X.

Coastal wetlands in sub-tropical Australia are increasingly under pressures from population growth and development. To understand and manage the complex systems sustainably requires the integration of knowledge from many disciplines about processes and how these operate. The research takes an interdisciplinary approach to understanding a coastal wetland in sub-tropical south-east Queensland and how it has been impacted by management activities. It starts with a conceptual model and explores this in five discrete but interrelated studies: stratigraphy, pollen analysis, climate and meteorology, soil chemistry (acid sulfate soils assessment), and more recent land use changes. The historical development of the area is outlined using long-term information from sediment cores and pollen analysis as well as more recent history from documents relating to European settlement and aerial photographs for the recent past. Climatic and soils data elucidate the effects of weather variability on the system and are used to assess the impact of drainage works on the flood plain and especially on acid sulfate soils. It concludes that human activities in the area, particularly in the last half of the 20th century, have led to rapid changes. The major issues are salinisation from tidal intrusion into ditched areas and the oxidation of acid sulfate soils resulting from disturbance of the substrate for development-related purposes. Management recommendations include restoring the hydrology and managing land use.

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INTRODUCTION

The importance of coastal wetlands is widely recognised. In Australia over 80% of the population live within 50 km of the coast. Coastal wetlands are under considerable development pressure and there have been significant wetland losses (Saintilan & Williams, 2000; Department of Environment and Heritage, Australia, 1996). To avoid the long term degradation of low-lying coastal environments due to development activities, it is critically important to provide relevant and robust scientific information to decision makers on the likely hazards and risks associated with climate change. Sea level rise and the disturbance of coastal acid sulfate soils are particularly relevant. Both issues, if inappropriately managed, have the potential to adversely impact on biodiversity and water quality. The importance of this is reflected in environmental planning policies (for example, Queensland Government, 2002).

It is difficult to manage coastal wetlands sustainably, as these are complex systems and management needs knowledge of processes from many disciplines, each with its own approach. Integrating knowledge and methods from several disciplines is an interdisciplinary approach defined by Klein (1990) as a process of solving a problem that is too broad or complex to be dealt with adequately by a single discipline or profession. It is thus suited to analysing complex environmental problems, such as understanding wetland ecosystem processes and their management. This paper reports an application of the

interdisciplinary approach to an estuarine system in sub-tropical Australia. The aim is to investigate the factors affecting ecosystem evolution in both the long and short term, using a conceptual model adapted from Maltby et al. (1994). After introducing the model there are five discrete, but interrelated, studies that have been detailed individually in Anorov (2004). First, a geologic/geomorphic investigation provides a framework for understanding how the wetlands evolved during the Holocene Epoch. Second, a palynological study enhances the geological research, examining the directions of ecosystem change evident in the pollen record over some 6000 years. Third, climate and meteorology were linked to hydrology, essential for understanding the risks of the fourth study of acid sulfate soils. Finally, historical research identified the extent of the impact of human activities on the ecosystems. The conceptual model guides the research components. It can aid understanding of the ecosystems as well as potentially informing management about some of the consequences of modifying the wetland system.

MATERIALS AND METHODS

STUDY AREA.

The location of the study area is shown in Fig. 1. It is approximately 1km^2 of the lower Native Dog Creek sub-catchment (27° 41' S, 153 ° 15' E), an ephemeral stream, within the lower Logan River, that joins Moreton Bay some 40 km south of Brisbane. The climate is sub-tropical humid with a summer rainfall maximum. The mean annual rainfall is around 1200 mm. Temperatures range from a mean monthly maximum in July of 21.3°C to 29.6°C in January. The tides are semi-diurnal with an annual range of approximately 2.5 m. The area is underlain by acid sulfate soils (ASS) (Smith et al., 2000). There are four major wetland vegetation types, ranging from freshwater communities of *Melaleuca quinquenervia* (Cav.) ST Blake and *Casuarina glauca* Sieber ex Sprengel above the highest tides, to the intertidal vegetation with saltmarsh towards the landward edge (*Sporobolus virginicus,* (L. Kunth) and *Sarcocornia quinqueflora* (Bunge ex Ung.-Stern)) and with mangroves closer to the tidal source (mainly *Avicennia marina* (Forsk) but with some *Aegiceras corniculatum* (L.) Blanco).

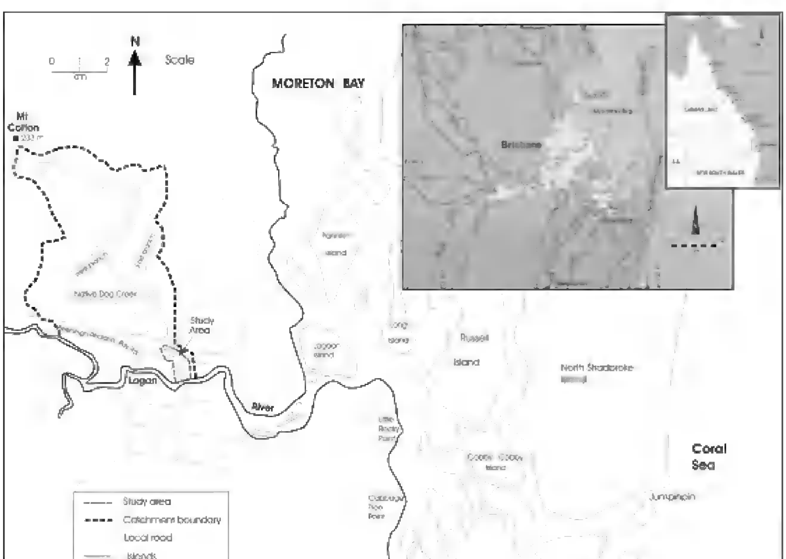

FIG. 1. Location of study area, Native Dog Creek Catchment.

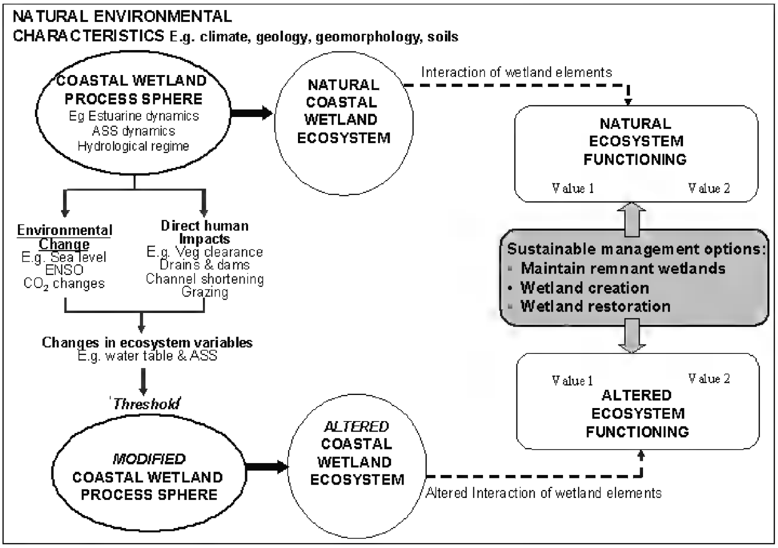

FIG. 2. Conceptual model of interdisciplinary research.

European settlement in the Logan River catchment and associated land clearing since the mid 19th century has resulted in the destruction of 99% of Eucalypt forest on the alluvial flats and 85% of freshwater *Melaleuca* forests in the catchment (Society for Growing Australian Plants, 2002). It is estimated that about 23 % of the intertidal wetland vegetation has been lost (Anorov, 2004).

METHODS

A conceptual model was modified from Maltby et al. (1994) to show the interactions of factors that influence ecosystem functioning, both from natural processes and anthropogenic ones (Fig. 2). The present research is in the context of the model. The range of disciplines and methods used in this research is shown in Table 1. For some of the research, as indicated in Table 1, published reports and data were consulted and secondary data used: for example for the meteorological information and historical aspects of land use. Primary data (used for stratigraphic modelling, pollen and acid sulfate soil analysis) was obtained from two transects within the study area, with additional field observations to capture elevation data. Elevation data was related to the Australian Height Datum (AHD), with an accuracy of 0.5 cm. Soil and sediment samples were taken from six bore holes up to 18 m deep along one of the two transects that extended several hundred metres from the intertidal wetlands to the upland (Fig. 3). There were two drill holes each in the *Melaleuca* swamp close to Native Dog Creek, in the backplain and on the intertidal flats.

Acid sulfate soils sampling and laboratory analysis was undertaken in accordance with Ahern et al. (1998). Radiocarbon dating was carried out in accordance with Gupta and Polach (1985). Pollen processing methods used were developed by Dr Mike Macphail specifically for Holocene estuarine sediments and are outlined in Anorov (2004). Pollen taxa were grouped according to their ecology to facilitate identification of past depositional environments and their relative abundance formed the basis for palaeoenvironmental interpretation. Water quality measures in the field were made using standard meters. Aerial photographs were used to map land use changes.

The research began by examining the geological/ geomorphological history of the area and similar estuarine environments in eastern Australia and the processes that influenced the evolution of the Logan River floodplain and its coastal tributary, Native Dog Creek. This provided a contextual and practical framework upon which to examine supporting palynological, hydrological, pedological, and more recent historical data.

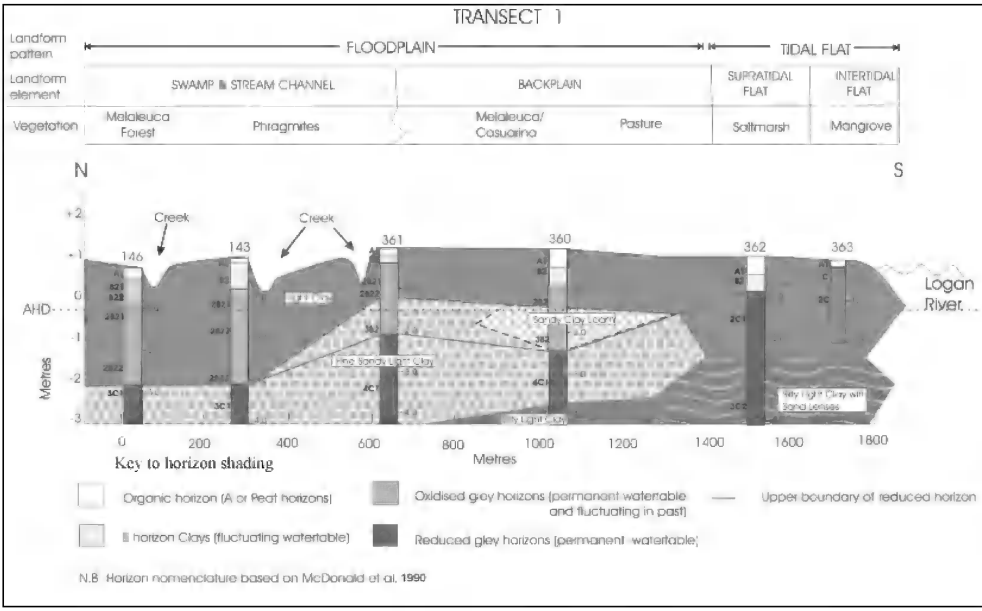

FIG. 3. Stratigraphic cross section of study area showing landform patterns and elements, vegetation and soil morphological data.

The following sections summarise the model and the main findings from each component and show how they relate to the model of wetland characteristics and processes.

RESULTS

THE CONCEPTUAL MODEL

The conceptual model shown in Fig. 2 represents a holistic understanding of the coastal wetland environment and of the impact of human-induced changes upon that environment. It is briefly described below and then applied to the results in the discussion.

The model embodies important information and understanding from many relevant disciplines, as indicated in the following route through it. First there is the framework of *natural environmental characteristics,* such as climate, geology, geomorphology and soils. This is the context in which coastal wetland processes operate to create the *coastal wetland process sphere*, comprising dynamic physical, chemical and biological processes. This results in the development of a *natural coastal wetland ecosystem,* its landscapes and associated ecosystem functions.

Ecosystems associated with estuaries and their floodplains evolve naturally in response to processes and events at different time scales: daily (tides), seasonally (river flow), inter-annually (drought periods), extreme events (flood), and at a millennial scale (sea level change). Interactions of the various elements of the natural wetland ecosystem lead to a unique pattern of *ecosystem functioning*, which establishes specific *values* such as land and water quality, and habitat creation. These values are relevant to human, plant and animal communities.

If the *natural coastal wetland ecosystem* is subjected to human activities, *thresholds,* above which the system no longer functions as a natural one, may be exceeded. This leads to a *modified coastal wetland process sphere.* An *altered coastal wetland ecosystem* develops with new and distinctive charactertistics, which in turn leads to *altered ecosystem functioning*. To mitigate effects of pressures from, for example coastal development, *sustainable management options* are needed, based on an understanding of the model system.

TABLE 1. Methods and interrelated disciplines used to reconstruct the history of Native Dog Creek and its catchment.

Related discipline/s	Information	Information source	Methods (details in Anorov, 2004)
Geology/geomorphological history			
Geology	Age of depositional environment, sediment accumulation rates	Intact gastropod & bivalve shells	Radiocarbon dating
History Geography	Geomorphological history of the general area	Published research	Description & interpretation
Vegetation history to present			
Palynology	Vegetation history	Samples extracted from cores	Pollen analysis, descriptive statistics & modelling
Botany	Present vegetation	Published literature & local field survey	Description & interpretation
Ecology Geography	Relationship of vegetation to elevation	Vegetation & elevation survey	Quantitative descriptive statistics & qualitative interpretation
Climate, meteorology and hydrology			
Meteorology	Meteorological history	Published data. Bureau of Meteorology	Descriptive statistics & interpretation
Hydrology	Hydrological history	Piezometers, creek levels from field monitoring	Descriptive statistics & interpretation
Surveying	Elevation	Field survey	Description & modelling
Pedology & chemistry of soils			
Pedology/ Soil Science	Substrate (soil & sediment morphology)	Logging of substrate cores in field, particle size analysis	Description, interpretation & Modelling
Chemistry	Soil & water chemistry (including Acid Sulfate Soils)	Sampled in field; tested & analysed in field and laboratory	Descriptive statistics & modelling
Recent land use history and human modification			
History	Recent land use history & environmental condition (since 1826)	Historical records: survey plans, photographs, topographic maps, aerial photos	Description & interpretation

The following sections trace the path through the model for the study area, for its important aspects.

GEOLOGICAL/GEOMORPHOLOGICAL HISTORY

The *natural environmental characteristics* of the area are based on its geological and geomorphological history. The coastal bedrock topography of the area north of the Logan River at Carbrook is largely composed of the weakly metamorphosed Neranleigh-Fernvale Beds that extend to the river mouth (Beckmann, 1967). These beds constrain the Logan River to the north and have limited the extent of the flood plain. The early geomorphology evolved as a result of sea level fluctuations and changing estuarine and fluvial regimes during the late Pleistocene and Holocene periods. It consisted of four major phases: Late Pleistocene; Holocene Transgression; Estuary Fill; and Floodplain Development (see Table 2). The history is preserved in sediments that were deposited in response to Holocene sea level rise under a mesotidal, tide-dominated regime. The Logan River system and its Native Dog Creek sub-catchment have evolved from an infilling estuary since the peak of the Holocene transgression 6500 yrs before present (Table 2).

Changes in sea level influenced the nature of the Logan estuary and the environment in which Native Dog Creek developed. In turn, the connection between Holocene coastal sediments and the formation of sedimentary pyrite strongly influenced the soil properties within the study area. The potential oxidation of pyrite and the subsequent release of sulfuric acid into streams and estuaries related to inappropriate development render these coastal ecosystems vulnerable to environmental degradation if mismanaged. This aspect is examined later.

TABLE 2. Summary of stratigraphy as it affects the study area (adapted from Anorov 2004).

Phase	Time (BP)	Mean Sea Level	Event	Lower Logan River & Native Dog Creek area
FLOODPLAIN DEVELOPMENT	Present		Contemporary sea level rise 1 mm/yr during past 40 years	
		< 0.5 m		
	1 000			River extends across newly created surface, excavating the top of estuary fill
	2 000			
ESTUARY FILL	3-4 000		Sea level begins to fall to present levels.	Development of Logan deltaic plain
	6- 6 500	+1 to 1.5m	Sea level Stillstand -	Estuarine infilling of Moreton Bay commences
HOLOCENE TRANSGRESSION	10 000	-25 m	Rapid sea invasion of incised river valleys	
LATE PLEISTOCENEP	18 000	-130 m	Sea level Lowstand –	Shoreline about 50 km east of Moreton Island
	30 000	-48 m	Several oscillations in sea level	Logan River adjusts to new base level as sea level falls

POLLEN ANALYSIS (VEGETATION HISTORY)

The development of geomorphic features that control the extent of freshwater input, drainage and salinity has influenced the mid-late Holocene vegetation history of the area. Pollen analysis, when considered together with the geomorphic evolution of coastal sedimentary sequences, can make useful contributions to clarifying details of past processes and succession and to the understanding of the evolution of the landscape and the *coastal wetland process sphere* (Fig. 2). In the present study, pollen analysis provided valuable information about rates of ecological change within the study area since sea level stabilised 6500 years before present. An example of the pollen record is shown in Fig. 4 for what is currently a freshwater *Melaleuca* forest. In response to the progradation of the present shoreline after sea level stabilised, the fossil pollen record at the *Melaleuca* forest site showed changes from mangroves and saltmarsh to freshwater wetlands between the early-mid Holocene and the late Holocene, a change that took around 800 years. The estimate of dates was based on the results of radiocarbon dating. In other pollen cores there was evidence of pine tree pollen in the recent past, indicative of introduced species following European settlement. That change has occurred over 170 years.

CLIMATE, METEOROLOGY AND HYDROLOGY

Climate is part of the *natural environmental characteristics* and climate and meteorological processes are part of the *coastal wetland process sphere* shown in Fig. 2. Superimposed on geological processes and sea level changes they help to further explain landscape and ecosystem changes (interaction of wetland elements, Fig. 2). Apart from inferences from stratigraphic and pollen analysis there are no very long-term records for climate variables for the area. The closest recording station, about 10km to the west at Beenleigh, has 130 years of rainfall data. These data showed the periodicity and variability of annual precipitation for the area (Fig. 5). Historically, the region has experienced periods of prolonged wet and dry conditions of 5-20 years duration. These have implications both for the hydrological and acid sulfate soil processes in the *coastal wetland process* sphere (Fig. 2).

In the recent past, the 10-year records from the Logan City Water Treatment station (8 km west of the study area) indicate that the most likely period of moisture deficit, based on mean values, is during the eight months from July to February and that an excess of rainfall over evaporation, on average, occurs only in May (Fig. 6).

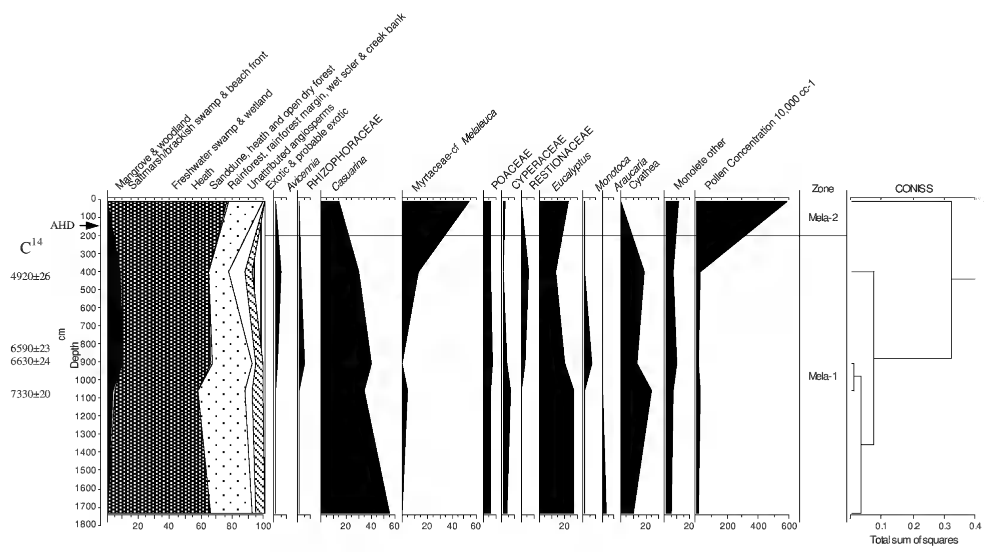

FIG. 4. Summary pollen record of *Melaleuca* wetlands. The x axis shows the percent of total pollen for each of the plant types displayed; the hierarchy on the right is result of a cluster analysis.

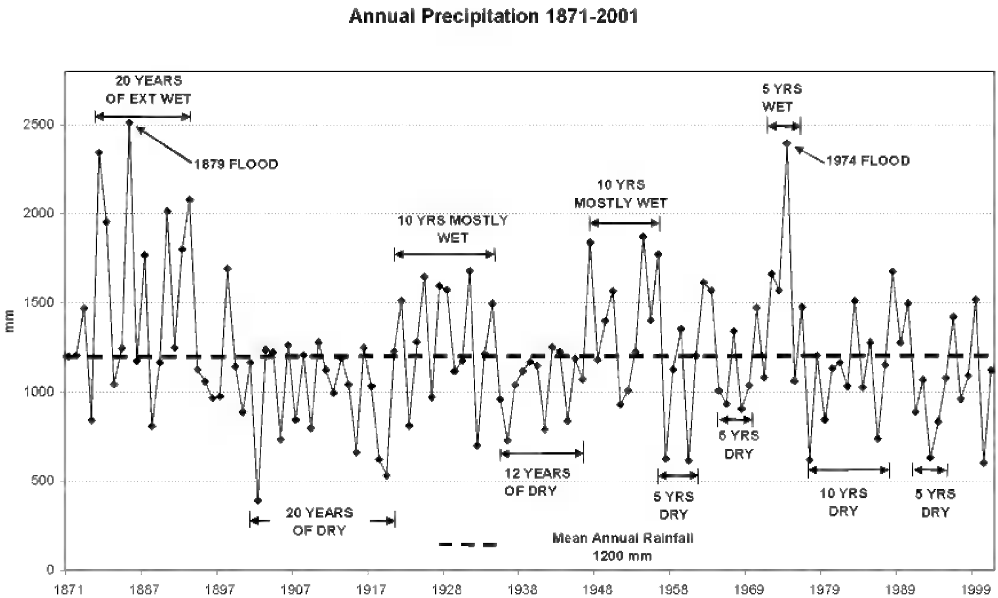

FIG. 5. 130 years of annual rainfall data for Beenleigh Post Office (10km from study area).

The area is also subject to drought. Between 1992 and 2002 the creek completely dried out during five dry periods and there were four flood events when the wetland was inundated for periods of two to nine months as shown in Fig. 7 (M. Greenway (pers. comm.). Four to five days of heavy rain during January 2001 flooded the *Melaleuca* wetland and nearby *Eucalyptus* forest and these habitats remained flooded for approximately two months (personal observation).

The lower reaches of Native Dog Creek are tidal, though its tidal limit is dynamic and thus salinity is variable. Electrical conductivity (EC) of the creek water in the vicinity of the *Melaleuca* wetland was measured on eight separate occasions between June 2000 and October 2002. The minimum and maximum EC values during this period were 0.3 and 26.0 mS/cm respectively, with a mean of 8.89. Previous studies have shown that, when the creek is flowing, salinity and conductivity levels are generally low (Bradley, 1996; Richards, 1998). However, during extreme high water spring tides, saline waters extend a considerable distance into the *Melaleuca* wetland of the study area. Extreme spring tides combined with localised flooding of the Logan River, force saline waters upstream beyond the Beenleigh-Redland Bay Road (Fig. 1) (Greenway & Kordas, 1994). Saline incursions over extended periods may lead to the decline and death of freshwater species.

PEDOLOGY AND CHEMISTRY OF SOILS

The *natural environmental characteristic* of Humic Gley soils are dominant in the area, using the Great Soil Group classification of Stace et al. (1968). According to the Australian Soil Classification system (Isbell, 1998) all soils in the area are either sulfidic or sulfuric Hydrosols, with the exception of the profiles located within the seasonally dry bed of Native Dog Creek in the *Melaleuca* wetland. Those were

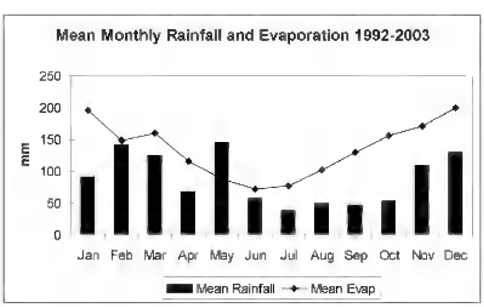

FIG. 6. Mean monthly rainfall and mean monthly evaporation, 1992-2003, Logan City.

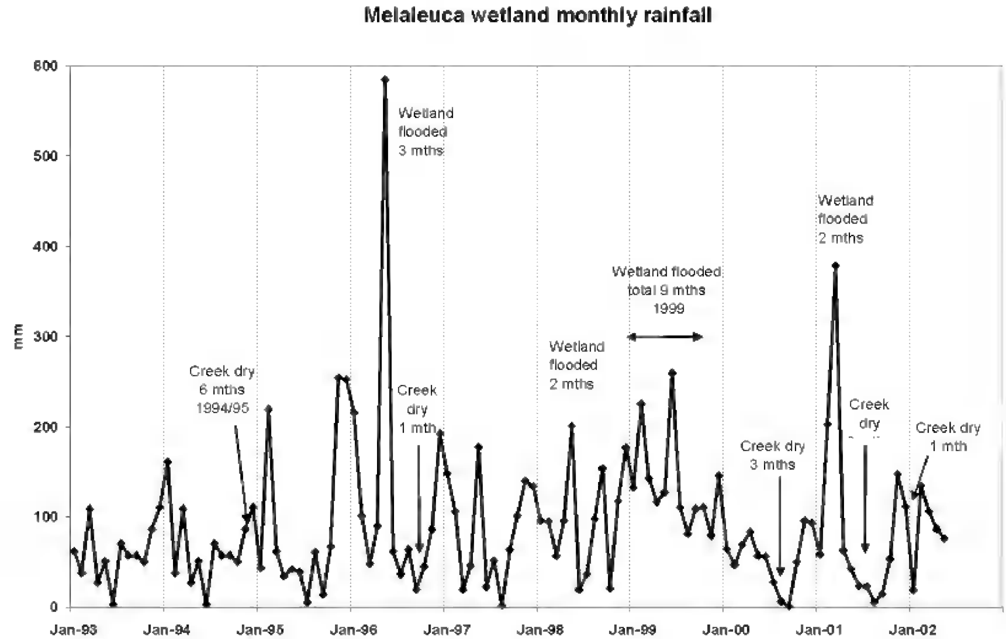

FIG. 7. *Melaleuca* wetland: 10 years of wet and dry periods, Native Dog Creek.

classified as Organosols due to the very high organic carbon content of the peat, with sulfidic subsoils. All soil forms in the wetland are acid sulfate soils as a result of the study area's geomorphic evolution. The original depositional environment of the study area was estuarine, and included sediments that were typical of central basin and fluvial delta environments - environments that were ideal for the accumulation of pyrite. As the estuary infilled, the landward part of the embayment was progressively isolated from estuarine conditions until freshwater/brackish conditions dominated and *Melaleuca* and *Casuarina* wetlands were established. It was during this phase that sulfide oxidation was likely to have occurred, the consequence of which is still evident by the enriched sulfate levels of the ancient soil pore water.

The soils that are not regularly tidally inundated on the Spring tides (that is, those with *Casuarina* and *Melaleuca* vegetation) are typical acid sulfate soils with sulfuric horizons overlying a sulfidic subsoil (Isbell 1998). Table 3 shows some characteristics for those wetlands near the surface and at more than 2.5 m deep. This summarises the distribution and concentration of both actual and potential acid sulfate soils within the study area and assists in identifying areas that display extreme sulfide content.

The study, based on two transects, found that the alternation of excessively wet and dry conditions over 130 years (as shown in Fig. 5), combined with high organic carbon levels and variations in micro-topography, provided ideal conditions for the re-formation of pyrite in the stream channel and other low points within the *Melaleuca* wetlands.

Another important factor in the acidification process (*coastal wetland process sphere*) is the moisture balance of the soil profile. Lin & Melville (1993) suggested that upward movement of solutes occurs in response to the evaporation of water from the capillary fringe (the saturated zone of the soil profile above the water table). In the study area a moisture deficit is likely to occur, on average, for up to eight months of the year (from July to February, Fig. 6) and, even in the stream bed, drought conditions (during early 2001) led to low pH (e.g., 2.88) and high EC values (e.g., 23.9 mS/cm) in the remnant pools, accompanied by heavy deposits of iron floc. However there was also a large rain event later in January 2001, and, after this, quantities of iron and aluminium that greatly exceeded ANZECC (2000) Water Quality

TABLE 3. Soil pore water chemical characteristics at 2 sites in the Native Dog Creek wetlands (adapted from Anorov, 2004).

Vegetation		*Casuarina*		*Melaleuca*	
Depth (m)		2.8	1.3	3.3	1.5
Acid Sulfate status		PASS	AASS	PASS	AASS
Standard Water Analysis					
pH		4.1	4.1	6	4.6
Conductivity	mS/cm	15	19	15	14
Aluminum	mg/L	0.1	81	0.1	22
Iron	mg/L	440	250	150	3.3
Chloride	mg/L	4800	6400	4400	4600
Chloride:Sulfate ratio		2.6	5.8	2.2	5.7

PASS - Potential Acid Sulfate Soils
AASS - Actual Acid Sulfate Soils

Guidelines were released from the soil into the flooded *Melaleuca* forest (see Fig. 3 for location of *Melaleuca* wetland/swamp). Richards (1998) reported similar observations for this wetland. The groundwater was also strongly acidic with elevated concentrations of soluble iron, aluminium and manganese.

Acid and aluminium affect *natural ecosystem functioning* and can cause severe gill and skin damage in exposed fish causing death, or, under sub-lethal conditions, increasing susceptibility to fungal diseases such as epizootic ulcerative syndrome (Sammut et al., 1999). The effects of estuarine acidification can occur at all trophic levels and cause short- and long-term environmental degradation (Sammut, 1998). To avoid such problems, any disturbance of these areas requires prudent and effective management strategies (*sustainable management options*) that include detailed elevation and acid sulfate soil investigations.

The influence of geomorphic and climate processes, local meteorological events, hydrology and soils is expressed in the existing wetland vegetation as an expression of the *natural coastal wetland ecosystem* (Fig. 2). This has been described earlier, but is augmented by examining the recent land use history and *direct* and *indirect human impacts.* This is summarised in the following paragraphs.

RECENT LAND USE HISTORY

Analysing historical records of the local area provided valuable insights into the environmental changes that followed the introduction of European land management practices more than 170 years ago. However, combining historical data with field assessment of the disturbed *Melaleuca* area, revealed that the impact of human activities on this section of the study area had occurred at a rapid rate, possibly exceeding the *threshold* at which the natural system can function, at least in the short-term, as evidenced by dieback observed in the field during 2001-2004 and on the 1995 aerial photograph (mapped in Fig. 8).

HUMAN MODIFICATION OF THE AREA

A chronology of change in the study area was derived from aerial photographs taken between 1944 and 1995, followed by site inspection in 2002 (Anorov, 2004). It has also highlighted the impact of human activities, reflecting the development of this part of Queensland and the demands for services. The 1944 and 1995 maps from the photographs are shown in Fig. 8. The most notable changes (apart from clearing vegetation) have been related to the hydrology, with channel shortening of Native Dog Creek, ditching of the area, and the construction of a golf course with many ponds. Based on aerial photograph interpretation, the development of the golf course in 1989 included the removal of several creek meanders so that by 1990, the original length of the creek had been more than halved. This led to the incursion of saline water into a section of the freshwater *Melaleuca* wetlands identified as '*Melaleuca* dieback' in Fig. 8.

An assessment of the soils, in the '*Melaleuca* dieback' area confirmed the presence of acid sulfate soils throughout the profile (Anorov, 2004). The results

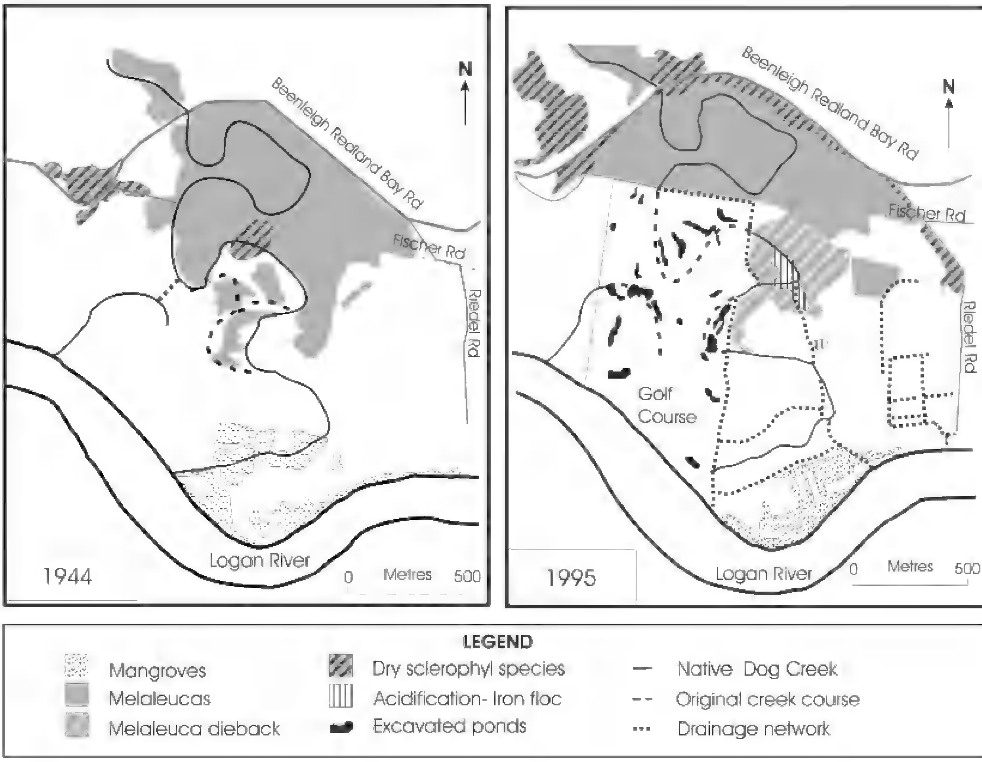

FIG. 8. Changes mapped from aerial photographs 1944 and 1995, Native Dog Creek, Logan River (adapted from Anorov, 2004).

of soil pH before and after field peroxide oxidation are shown in Fig. 9. The greatest reduction in pH_{FOX} occurred at the surface, at 0.75 m (where H_2S_2 odour was detected) and below 2.0 m.

Field observations indicated that this area is irregularly inundated with saline tidal water from Native Dog Creek via low points in the creek bank that appear to have been trampled by cattle. These factors, combined with a fluctuating water table, are likely to have influenced subsoil oxidation. The change in hydrological conditions from freshwater to saline conditions resulted in the progressive decline in health and ultimately, the death of this section of *Melaleuca* trees. The dead trees became unstable, falling haphazardly and creating a hummocky microrelief. The hummocks were occupied by *Sporobolus virginicus* or, at slightly lower elevations, there were bare patches (acidic salt scalds) showing salt efflorescence and coated in iron floc. The processes of salinisation and acidification, followed by vegetation dieback, has resulted in an *altered coastal wetland ecosystem*.

DISCUSSION

APPLICATION OF THE BIO-GEOMORPHIC MODEL

The model in Fig. 2 has exemplified the ways in which coastal wetland ecosystems function and how these respond to both natural and anthropogenic processes and pressures. *Natural environmental characteristics* were shown to have provided the context in which the landscape has evolved. Of particular importance in the study area are climate and sea level changes during the Holocene. The *coastal wetland process sphere*, for the Native Dog Creek study area is dominated by its climate and hydrology. Important processes include the formation of acid sulfate soil. Together with its

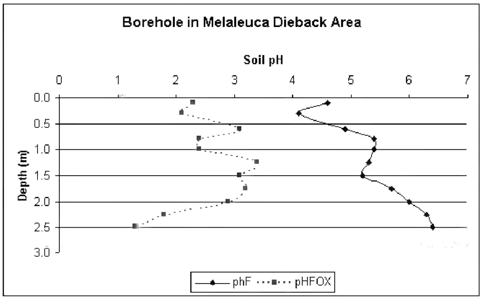

FIG. 9. A comparison of field (pHf) and after field oxidation (pH_{FOX}) down the soil profile in the *Melaleuca* dieback area.

geomorphology and plant succession the *natural coastal wetland ecosystem* landscapes and associated *natural ecosystem functioning* have developed.

In the more recent past, a variety of human activities have affected the development of the system leading to a *modified coastal wetland process sphere* with alterations of important wetland characteristics. Given sufficient time and depending on the magnitude of modification, an *altered wetland ecosystem* forms and develops new and distinctive structural and functional characteristics. This study identified an altered hydrological regime (drainage and stream channel shortening). The change in hydrodynamic conditions, from freshwater to saline conditions and, especially within the former freshwater systems, resulted in the progressive decline in health, and ultimately, the death of a section of the Melaleuca wetlands (Fig. 8). As well there have been chemical transformations of soil and water (acid sulfate soils). These are the key human-induced changes to the coastal lowlands of Native Dog Creek that have disrupted their equilibrium. To minimise these negative impacts, sustainable management options are needed to maintain the natural wetland ecosystems and to restore ecosystem health.

Based on the outcomes of research, management options can be determined. For Native Dog Creek recommendations for the restoration of the wetlands include actions to:

- Re-instate the meanders to mimic the original creek morphology. This would reduce salt water intrusion by shifting the tidal limit seawards thereby providing greater opportunity for the former freshwater wetlands to once again experience extended periods of inundation due to seasonal flooding.
- Avoid any further disturbance of Acid Sulfate Soils.
- Neutralise any existing acidity through the application of lime.
- Remove cattle from the freshwater backswamps and backplains of NDC to minimise erosion of creek banks due to trampling.

In future, the land use planning process should assess the risk of disturbing acid sulfate environments and ensure that effective environment management plans are in place to mitigate impacts of any disturbance.

EVALUATION OF THE RESEARCH

The strength of the research lies in its interdisciplinary nature, integrating the morphostratigraphic, hydrologic, pedogenic and vegetation history of the coastal lowlands of Native Dog Creek to clarify its dynamic and complex history in the context of a model that reflects that dynamism (Anorov, 2004). It should be recognised that altered hydrological regimes, introduced animal and plant species, acidification and salinisation and various land uses are all components and conditions that need to be considered in any management strategy.

The research has contributed valuable information in several areas. It has integrated pollen analysis with stratigraphic modelling to provide an enhanced understanding of long-term processes; it has also shown that pollen analysis reflects the advent of European settlement, with the introduction of exotic plants; it has provided important insights into rates of natural ecological change in response to evolutionary changes in the physical environment that will serve as a reference for comparison with rates of change imposed on the existing coastal wetland ecosystem within the last 170 years. An important outcome from the broader pollen study has been the compilation of a pollen reference collection for estuarine south east Queensland, a region that previously lacked such information.

FURTHER RESEARCH

Issues that warrant further research include: vegetation dynamics from the late Holocene to the present-day, by high resolution pollen analysis and radiocarbon dating, to provide an enhanced understanding of the effects of post-European land practices and activities on the natural coastal wetland ecosystem; an accurate reconstruction of the palaeoenvironment using diatom analysis to indicate palaeosalinity levels and integrated with pollen analysis and geomorphic research. For example, Tibby (1996) found that the use of diatom analysis to investigate changing salinity patterns in the Tuross Lake system (south eastern New South Wales) was a powerful tool in elucidating the cause of some changes in the pollen record by indicating the relative importance of influences such as geomorphic change and climate. This is particularly important as the climate change issue becomes more acute.

CONCLUSIONS

The research reported here has significance at both the local level and more generally. At the local level its value has been in developing an understanding of the changes that have occurred in the past in the study area. As well it has developed an appreciation of the interaction of many factors, each the focus of different areas of research, including natural processes and events and the impacts of human activities. It was concluded that these wetlands are particularly vulnerable to sea level changes and inappropriate land use. This research found that the greatest risk to the environment from human activities was from the disturbance of acid sulfate soils and specific management strategies were suggested to mitigate such impacts.

More generally, this interdisciplinary study has incorporated a range of processes and methods, from several perspectives, into a conceptual model that could be expected to apply broadly to many coastal wetland environments. Based on the findings of, and integration between the various areas of the research, it is suggested that future coastal management strategies should be intimately linked to a knowledge of their past. It is also vitally important to investigate the hydrological status of coastal tidal creeks (and rivers) in detail, especially as modifications to coastal creeks can result in problems associated with saltwater incursion and wetland drainage of the coastal floodplain. Hydrological modification of coastal tributaries is an important management consideration, particularly as acid sulfate soils are known to exist in many coastal settings in Australia and represent a significant environmental hazard if mismanaged.

The natural environment is continually adapting to altered hydrological conditions. It is apparent that human induced changes over the past 170 years in the study area have occurred at a rate that exceeds rates of change normally experienced in natural systems. Hence the current environment is experiencing degradation through both decline in health (as indicated by *Melaleuca* die-back observed in the field) and loss of indigenous plant species. The development and implementation of sustainable management options must be informed by robust and relevant scientific information, if ecosystems and the services they provide are to be sustainable.

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LITERATURE CITED

AHERN, C. R., AHERN, M.A. & POWELL, B. 1998. Guidelines for sampling and analysis of lowland acid sulfate soils (ASS) in Queensland. QASSIT, Dept Natural Resources, Indooroopilly.

ANOROV, J.M. 2004. Integrated study of coastal wetland characteristics and geomorphic processes in a south east Queensland catchment. (PhD thesis, 231 pp. Griffith University: Nathan, Queensland, Australia.).

ANZECC Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000. The Water Quality Guidelines) and Australian Guidelines for Water Quality. http://www.deh.gov.au/water/quality/nwqms/

BECKMANN, G.G. 1967. Soils and land use in the Beenleigh-Brisbane area, south eastern Qld. Soils and land Use Series No. 50 (CSIRO publishing: Australia).

BRADLEY, R. 1996. Plant-water relations of a subtropical riparian Melaleuca wetland. (Griffith University: Nathan, Queensland, Australia).

DEPARTMENT OF ENVIRONMENT AND HERITAGE 1996. Australia: State of the Environment Report 1996 (Theme Report). (Canberra, Australia).

GREENWAY, M. & KORDAS, G. 1994. An Ecological Assessment of the Carbrook Wetlands, Logan City: their significance, threats and future management. (East Logan Wildlife Preservation Society, Logan City Council and Australian Nature Conservation Agency).

GUPTA, S.K. & POLACH, H.A. 1985. Radiocarbon Dating Practices at ANU, Handbook, Radiocarbon Dating Laboratory, Research School of Pacific Studies, Australian National University, Canberra, Australia.

ISBELL, R.F. 1998. The Australian Soil Classification. (CSIRO Publishing: Australia).

KLEIN, J.T. 1990. Interdisciplinarity: history, theory, and practice. (Wayne State University Press: Detroit).

LIN, C. & MELVILLE, M.D. 1993. Control of soil acidification by fluvial sedimentation in an estuarine floodplain, eastern Australia. Sedimentary Geology 85: 271-84.

MALTBY, E.D., HOGAN, D.V., IMMERZI, C.P., TELLAM J.H. & VAN DER PEIJL, M.J. 1994. Building a new approach to the investigation and assessment of wetland ecosystem functioning. Pp. 637-659. In Mitsch, W.J. (ed) Global Wetlands: Old World and New. (Elsevier Science B.V.: Amsterdam, Netherlands).

MCDONALD, R.C., ISBELL, R.F., SPEIGHT, J.G., WALKER, J. & HOPKINS, M.S. 1990. Australian Soil and Land Survey - Field Handbook. 2nd ed., (Inkata Press: Melbourne, Australia).

QUEENSLAND GOVERNMENT, 2002. State Planning Policy 2/02, Planning and Managing Development Involving Acid Sulfate Soils. (Queensland Department of Local Government and Planning).

RICHARDS, R.G. 1998. The effects of drought, flood and saltwater intrusion on water quality in a potential acid sulphate soil area. (Honours Thesis, Griffith University: Brisbane.).

SAINTILAN, N. & WILLIAMS, R. 2000. The Decline of Saltmarshes in Southeast Australia: Results of Recent Survey. Wetlands (Australia) 18: 49-54.

SAMMUT, J. 1998. Associations between acid sulfae soils, estuarine acidification, and gill and skin lesions in estuarine and freshwater fish. (PhD Thesis, School of Geography, Faculty of Science and Technology. University of New South Wales: Sydney).

SAMMUT, J., CALLINAN, R. & DOVE, R. 1999. A brief review of the Aquatic Impacts of Acid Sulfate Soils. (Acid sulfate soils and their management in coastal Queensland: Forum and Technical Papers, Brisbane 21-23 April, Dept Natural Resources: Queensland).

SMITH, C.D., MALCOLM, D., ADAM, J., MANDERS, J. & HALL, I. 2000. Acid Sulfate Soil Mapping in south east Queensland. Acid Sulfate Soils: Environmental Issues, Assessment and Management. (Technical Papers. 20-22 June, 2000, Brisbane, Dept Natural Resources: Indooroopilly, Queensland).

SOCIETY FOR GROWING AUSTRALIAN PLANTS. 2002. Mangroves to mountains: a field guide to the native plant of the Albert and Logan River Catchments. (Copyright Publishing , Brisbane, Australia.)

STACE, H.C.T., HUBBLE, G.D., BREWER, R., NORTHCOTE, K., SLEEMAN,J.R., MULCAHEY, M.J.& HALLSWORTH, R.G. 1968. A Handbook of Australian Soils. (Rellim Technical Publications: Glenside, South Australia).

TIBBY, J. 1996. A Mid- to Late-Holocene Diatom and Pollen Palaeoecology of the Tuross Lake System, South Coast, New South Wales. (Monash Publications in Geography, No. 46: Victoria).

AUTHOR PROFILE

Julie Anorov was a PhD student at Griffith University when the research was carried out. She is now Assistant Director, Coastal Water Quality Section, Department of the Environment and Water Resources, ACT.

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Bernie Powell is a Principal Scientist with the Department of Natural Resources, Mines and Water (Queensland) with expertise in acid sulfate soils.

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Emeritus Professor Elizabeth MORRIS EXLEY

Elizabeth Morris Exley
1927-2007

Elizabeth Morris Exley was born in Brisbane in 1927, the first child of Arthur Eric John Exley and Elizabeth Francis Morris. Her primary education was at Rainworth State School and from 1941 to 1944 she attended Brisbane Girls' Grammar School, she retained many friends from her school days. Elizabeth completed her B.Sc. at the University of Queensland in 1948, joined the University as a Demonstrator in Zoology and Entomology, and gained B.Sc. Honours in 1950, her research topic was larvae of Trypetidae (fruit flies). She continued to work in the Department until 1952 when she was awarded a fellowship at Imperial College, University of London. Here Elizabeth continued her study of fruit fly larvae, and received a Diploma of Imperial College in 1954.

On her return to Brisbane that year Elizabeth joined the Queensland Department of Agriculture as an entomologist, but she could not see a future in the Government Department at that time. Following the award of an M.Sc. from the University of Queensland for further studies on fruit flies, Elizabeth rejoined the UQ Entomology Department in 1958 as a tutor and later lecturer. She remained in the Department until her retirement as Associate Professor in 1992.

Initially her research involved the systematics of ants. However her interest in native bees was inspired by Professor Charles Michener, a world authority on bees from the University of Kansas, who was visiting Queensland. Elizabeth realised how little was known of the native bee fauna of Australia. Michener encouraged her to study the systematics of the tiny bees in the family Colletidae, sub-family Euryglossinae, an endemic Australian group. Their study was to become her life's work and she received her Doctorate in 1968 for her taxonomic thesis on the Euryglossinae. For many years Elizabeth made regular collecting trips, particularly in northern Australia, and her students and research assistants often travelled with her. Her bees were most common in the tropics, where they collected nectar and pollen in blossom in the tops of trees. To reach them she had special insect nets made, with handles several meters long, which were supported in a leather harness. Collecting trips were fun, they were also hard work – out in the sun collecting from blossoms all day, the nets were heavy and awkward, and swinging them often resulted in sore back and shoulders and bruised legs. The evenings were spent sorting and storing the day's catch. The many thousands of bees of all families collected on these trips, and by her students, are stored in the University of Queensland Insect Collection, they are a significant resource for bee researchers both in Australia and internationally.

There were also visits to Universities, Museums and bee researchers and collections in many countries, including several to the hub of the bee research world, Michener's laboratories and the Snow Entomological Museum in Kansas, and to the Natural History Museum in London and Hope collections in Oxford, both of which hold many Australian bee types. In the 1980s her research extended into insect pollination of crops such as lychee, macadamia, pigeon pea and custard apple, some of this work in collaboration with CSIRO. Elizabeth was a pioneer of research into Australian bees, and she was a role model for women in an era when many organisations, including government departments, discriminated against women scientists, no matter how talented.

After her retirement in 1992 the work on the systematics of the Euryglossinae continued. She has collected, described and named more than 230 new species, with another publication still in review. Her death is a great loss to bee research and to entomology in general.

Elizabeth was also a teacher, she enjoyed lecturing and talking with students, and made a significant contribution to the education of entomologists in Australia. Her undergraduate teaching was mainly in insect systematics and insect morphology.

She passionately believed in the importance of systematics as a basic part of entomology studies. Her standards were high and the courses of lectures and practicals were demanding, lectures were packed with information and practicals were very busy. Undergraduates majoring in entomology finished their degrees with a thorough grounding in both systematics and morphology. As a lecturer she was liked and respected by the students.

Although most of Elizabeth's research involved the Euryglossinae her postgraduate students studied many different groups, including other bee families, wasps, butterflies, flies, beetles and spiders. As a supervisor she guided rather than directed. She was generous with her time, always ready to listen and discuss, forthright with her opinions and usually considerate of feelings, and meticulous in checking detail. She was also concerned for the welfare of her own and others' students. Her postgraduate students are now in the midst of, or retired from, careers in Government departments, Museums and Universities and private industry, in science, policy and administration.

Elizabeth was a Life Member of the Queensland Entomological Society, which she joined in 1948 and an Honorary Life Member of the Australian Entomological Society, which she joined when it was established in August 1965, and a member of the Queensland Naturalists and the Royal Society of Queensland.

Elizabeth has left a huge body of information on Australia's rich bee fauna, from her own work and that of her students. She maintained her belief in the importance of systematics, and passed it on to her rigorously trained post-graduate students, some of whom, in turn will pass it on to their students. Her undergraduate and post graduate students have contributed significantly to entomology in Australia and overseas. Entomologists and other colleagues will remember her fondly and with admiration for her dedication to research and education in her chosen field.

The final word from Emeritus Professor Charles Michener, who started and encouraged Elizabeth on her journey with bees. He said 'People in the bee community will remember her into the indefinite future'. I think that sentiment also applies to the wider entomological and naturalist community.

Judith King

Marion Mary SPECHT née GILLIES

Marion Specht
1928-2007

Marion Specht was the talented daughter of a Queensland government architect, William Gillies. Her primary schooling was at East Brisbane State School, her secondary at Brisbane Girls' Grammar, and her tertiary education was at the University of Queensland. She was in good company at Girls' Grammar, with her classmates including the later Professors Elizabeth Exley and June Halliday. For her BSc Honours in 1950-51 she studied the invertebrate mangrove fauna at Myora on North Stradbroke Island. Her knowledge and understanding of the mangrove invertebrate fauna became formidable, and extended to an Australia-wide survey in 1975 (Saenger et al. 1975).

She married Raymond Specht in 1952 and moved to South Australia, and later Victoria, where she continued to develop her scientific interests. She taught undergraduate zoology at the Universities of Queensland, Adelaide and Melbourne, and actively participated in and supported her husband's research. Her original work included the ecology of soil invertebrates in the Ninety-Mile Desert of South Australia (Edmonds and Specht, 1981), a terrestrial interest she continued with further journal articles and book chapters on a range of topics in invertebrate ecology. Her 1962 compilation of the plant ecological literature in Australia since Hooker and Leichhardt was a major contribution to the 1974 *Conservation of Major Plant Communities in Australia and Papua New Guinea* (Specht et al. 1974).

When Ray was appointed Professor of Botany at the University of Queensland in 1966 they returned to Queensland. After moving to Brisbane, Ray, with Marion's support, introduced the *Web of Life*, which applied the 'Inquiry Method' of teaching senior biology, in Queensland. In the late 1960s, Marion was coopted as one of the pilot teachers of the *Web of Life* Biology program at Brisbane Girls Grammar School. She subsequently became the Australian Academy of Science liaison officer for the *Web of Life* in Queensland for 15 years, helping organise two training courses in the University of Queensland, and travelling throughout Queensland to support *Web of Life* teachers.

She was very committed to the support of women, in particular their spirit of intellectual inquiry. She initially joined the YWCA in Adelaide and Melbourne, and later the Australian Federation of University Women (AFUW member since 1980 and member of National Council 1992-94), the University of Queensland Alumni Association, the Lyceum Club, and the Women's College (Standing Committee and Council) at the University of Queensland. She became Queensland President, Australian President and International Vice-President of the Lyceum Club (a club for women *interested in the arts, sciences and social concerns, and in the pursuit of lifelong learning*).

Marion Specht was by education and inclination a biological scientist, but like many women of her generation, her professional career was modified by family responsibilities. Her contribution to her husband's successful career and research output was immeasurable, but her contribution to science, education, and the position of educated women was also substantial.

Edmonds, S.J., and Specht, M.M. (1981) Dark Island heathland, South Australia: Faunal rhythms. pp. 15-27. In: *Ecosystems of the World*. Vol. 9B *Heathlands and Related Shrublands. Analytical Studies*. Elsevier Scientific Publishing Company, Amsterdam.

Saenger, P. Specht, M.M., Specht, R.L. and Chapman, V.J. (1977) Mangal and coastal salt marsh communities in Australasia. pp. 293-345. In: *Ecosystems of the World.* Vol. 1 *Wet Coastal Ecosystems*. Elsevier Scientific Publishing Company, Amsterdam.

Specht, R.L., Roe, E.M. and Boughton, V.H. (eds) (1974) Conservation of major plant communities in Australia and Papua New Guinea. *Aust. J. Botany Suppl*. No. 7, Melbourne.

Alison Specht

GUIDE TO AUTHORS

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6. Biographical Memoirs - A maximum of 1000 words. Memoirs should summarise the contributions of a person to the advancement of natural sciences in Queensland. Memoirs can be of living or deceased persons. Where possible a photograph of the person should be included.
7. Book Reviews – Book reviews will be included on relevant books which are not more than 2 years old. They are to be a maximum of 500 words and should summarise the content of the book and its relevance to the Proceedings' readers.

All manuscripts will be subject to peer review. The *Proceedings* acts to highlight research and researchers relevant to Queensland. To further this, an 'Author Information Box' will appear at the end of each paper. It will contain brief details of the authors and the overall research project in which the published work has been carried out. This is not an acknowledgement, but rather provides readers with an outline of the research teams or groups responsible for the work. It can be up to a maximum of 100 words in length.

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1. The author, or at least one of the authors, must be a financial member of the Society.
2. Authors should submit 3 copies of their manuscript typed on A4 paper, single sided, wide margins, double spaced and every page (including the title page) numbered.
3. Manuscripts, in general, should be organised as follows: Title page (title, names and addresses of authors); ABSTRACT (300 words maximum); INTRODUCTION; MATERIALS AND METHODS (including study area); RESULTS; DISCUSSION; ACKNOWLEDGEMENTS; LITERATURE CITED; AUTHOR PROFILE (100 words maximum).
4. Titles and subtitles should be uppercase, in bold, on a separate line, without indentation. Paragraphs should be separated by one line with no indentation.
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   Periodicals:

   COMITA, G.W. 1968. Oxygen consumption in *Diaptomus*. Limnology and Oceanography 13: 51-57.

   WENG, H.T., MATHER, P.B. & CAPRA, M.F. 1994. Assessment of genetic differentiation in trumpeter whiting (*Sillago maculata* Quoy & Gaimard) populations in Moreton Bay. Proceedings of the Royal Society of Queensland 104: 11-17.

   Books and other:

   BRODY, S. 1945. Bioenergetics and Growth. (Reinhold Publishing Corp. New York).

   UNDERWOOD, A.J. & CHAPMAN, M.G. (eds), Coastal Marine Ecology of Temperate Australia. (University of New South Wales Press Ltd. Sydney).

   JONES, A.R. 1995. Sandy beaches. Pp. 136-151. In Underwood, A.J. & Chapman, M.G. (eds), Coastal Marine Ecology of Temperate Australia. (University of New South Wales Press Ltd. Sydney).
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7. Accuracy in calculations, figures, tables, names, quotations, references etc. is the complete responsibility of the author(s).
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