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Post-fire recruitment of red tingle (*Eucalyptus jacksonii*) and karri (*Eucalyptus diversicolor*) following low-moderate intensity prescribed fires near Walpole, south-west Western Australia

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ABSTRACT

This study examined the emergence and survival of red tingle and karri seedlings following low to moderate intensity fuel reduction burning at two sites near Walpole. Most seedlings emerged on burnt ground created by the combustion of litter and twigs, but some also emerged on the charred surface of fallen logs. Red tingle seedlings were more than twice as common as karri seedlings at both sites during the first spring following burning. The proportion of 1 m^2 sample quadrats containing red tingle seedlings declined from 43 per cent in October 1996 to 5 per cent by March 1998, while the proportion containing karri declined from 43 per cent to 23 per cent over the same period. Few of the surviving seedlings exhibited dynamic growth or appeared likely to develop into saplings. Small gaps created by natural tree fall were no better stocked than areas beneath an intact forest canopy. The presence of red tingle and karri seedlings following low to moderate intensity fires used for fuel reduction may not therefore lead to recruitment of even-aged sapling cohorts of these species.

INTRODUCTION

Forests around Walpole (34° 59' S, 116° 44' E) on the south coast of Western Australia are notable for the presence of several locally endemic eucalypts including red tingle (*Eucalyptus jacksonii* Maiden), yellow tingle (*E. guilfoylei* Maiden), Rates tingle (*E. brevistylis* Brooker) and red flowering gum (*Corymbia ficifolia* (F. Muell) Hill & Johnson, formerly *E. ficifolia*). Red tingle may attain a height of 70 m and stem diameter in excess of 4 m at maturity (Boland *et al.* 1985). Large trees commonly have prominent buttressing on the lower stem. Red tingle occurs in open and tall open forests on well drained granitic soils between the Deep and Bow Rivers within 8 km of the coast (Wardell-Johnson and Coates 1996). Associated trees include yellow tingle, karri (*E. diversicolor* F. Muell.), marri (*Corymbia calophylla* (R. Br.) Hill & Johnson, formerly *E. calophylla*), and less commonly jarrah (*E. marginata* Donn. ex Smith). Forests containing red tingle have been recognized and mapped as distinct associations on forest type maps prepared for the south-west of Western Australia (Bradshaw *et al.* 1997; Mattiske and Havel 1998).

Forests containing red tingle have long attracted interest because of their majestic appearance and restricted occurrence (Fernie and Fernie 1989), and recent scientific studies have also drawn attention to distinctive aspects of their biology and ecology (MacFarlane and Wardell-Johnson 1996; Wardell-Johnson and Coates 1996). The extant area of forest containing red tingle is estimated to be 6129 ha (Anon. 1998), of which 85 per cent is within the Walpole-Nornalup National Park. The Park also contains open forests and woodlands of jarrah, shrublands in swampy terrain, and coastal woodlands on stabilized aeolian dunes (Wardell-Johnson *et al.* 1989).

Fire has an important influence on the management of the Walpole-Nornalup National Park. Karri and tingle forests accumulate a deep organic layer of litter, bark and twigs which may weigh more than 50 t ha^{-1} in stands unburnt for 50 years (Wardell-Johnson 1997). This organic layer becomes dry enough to burn for several months during summer and early autumn and is capable of supporting intense forest fires. High intensity wildfires burnt much of the karri-tingle forest around Walpole in 1937 and 1950/51. Further karri-tingle forest within the Park was burnt by wildfire in January 1987.

Since the early 1970s park managers have used prescribed fire to reduce fuel loadings in strategic areas of the Walpole-Nornalup National Park in order to limit the potential extent and severity of unplanned fires. The current management plan for the Park (Smith *et al.* 1991) specifies three alternative fire regimes for areas of red tingle and karri forest. These are: fire exclusion for the 10-year duration of the plan; prescribed burning at intervals of 10–20 years to provide structural diversity in the forest understorey; and prescribed burning at 6–8 year intervals to limit the accumulation of ground fuels.

Disturbance by fire is an important trigger for regeneration of karri and other tall eucalypts (White and Underwood 1974; Breidahl and Hewett 1995; Florence 1996). The existence of densely stocked regrowth stands of red tingle and karri resulting from the 1937 and 1951

wildfires at Walpole provides clear evidence of the role played by high intensity fire in the regeneration process (Fig. 1). However, little is known about the extent of regeneration that may result from low to moderate intensity fires including those prescribed for fuel reduction. The only formal study of regeneration in red tingle forest is that of Wardell-Johnson (1997), who examined a number of sites one to two years after moderate intensity fire and found that regeneration of red tingle and karri was predominantly of seedling origin rather than from existing advance growth. The extent of regeneration following prescribed fires may be an important consideration in the management of stands in the late-mature and senescent stages of development (Bradshaw and Rayner 1997) where recruitment of a new cohort is desirable. For recruitment to occur, conditions must not only be favourable for seedling establishment but also for progression into subsequent development stages. Recruitment can be affected by the timing and intensity of fires, particularly during the establishment and juvenile stages of development when saplings are fire-sensitive.

Survival and early development of red tingle and karri seedlings were investigated following fuel reduction burning at two sites near Walpole in autumn 1996. This study sought information about the extent of seedling emergence in relation to seedbed conditions and overstorey canopy cover, and the fate of seedlings over the two-year period following burning.



Figure 1. Densely stocked pole stand of red tingle dating from the 1937 wildfire, Walpole Nornalup National Park.

METHODS

Emergence, survival and growth of red tingle and karri seedlings were studied in stands of mature forest at Shedley Drive and Anderson Road, located respectively 6 km west and 13 km east of Walpole. Both sites were at an elevation of about 100 m above sea level. The site at Shedley Drive had last been burnt by prescribed fire in spring 1988, while the Anderson Road site had remained unburnt since a wildfire in 1951. During August 1996 two transects were established at each location, one in an area where the forest canopy was intact (70–80 per cent cover), and the other in a gap up to 50 m in diameter resulting from natural tree fall. Each transect comprised 10 circular quadrats 1 m^2 in area spaced at 10 m intervals. The number of seedlings of each eucalypt species was recorded within quadrats at approximately monthly intervals between August 1996 and March 1997, and then again during June 1997 and March 1998.

The location of individual seedlings was identified with coloured markers in order to allow detailed assessment of emergence and mortality during the course of the study. Seedbed conditions within quadrats were assessed on the basis of the nature of the seedbed and the degree of fuel consumption. Categories of seedbed distinguished in the field were: unburnt mineral soil; burnt ground created by combustion of litter and twigs; ashbed created by combustion of large woody debris; and the charred surface of logs which had fallen prior to the burn. Basal area of overstorey and intermediate trees was determined by measuring the diameter of all trees >5 cm d.b.h.o.b. in a 0.1 ha plot defined by a distance 5 m either side of the transect centre line. The codominant height of overstorey and intermediate trees within each transect was measured with a hypsometer.

Care was taken to examine the distinctive features of cotyledons and juvenile leaves on each species to ensure that seedlings were correctly identified. Seed of known source was germinated and grown at the CALM Research Centre in Manjimup to confirm observations of seedling characteristics made in the field.

RESULTS

Both sites were burnt during dry conditions in early autumn (Table 1). Fuels were ignited with drip torches using an ignition pattern that resulted in low to moderate intensity fire behaviour in mature red tingle-karri forest. Forward rates of fire spread were 15–40 m h^{-1} and flame heights ranged from 0.5 to 2 m, occasionally flaring to 3 m. About 15 per cent of the area of tingle-karri forest within the boundaries of each prescribed burn experienced crown scorch 12 m or more above ground.

The stand at Shedley Drive consisted primarily of mature red tingle and occasional karri, although no karri were present within the sample transects (Table 2). The basal area of red tingle on the transect beneath the intact canopy was 205 m^2 ha^{-1}, with an additional 22 m^2 ha^{-1} of *Allocasuarina decussata* forming a dense intermediate stratum up to 20 m tall. The transect located in the gap had less than half the basal area of the transect beneath the intact canopy and included only a small contribution of *A. decussata*. At Anderson Road the stand comprised scattered mature trees with an intermediate stratum of pole-sized red tingle and karri up to 35 m tall, and *A. decussata* up to 20 m tall. Stocking of red tingle and karri was more than six times greater at Anderson Road than at Shedley Drive, but the combined basal area was substantially lower

TABLE 1

Weather conditions and fuel dryness during prescribed burning of red tingle-karri forest. Maximum air temperature and 3.00 p.m. relative humidity are shown for the sequence of days over which prescribed burning took place at each site. Surface and profile moisture contents were predicted from weather observations at CALM Walpole using the Forest Fire Behaviour Tables for Western Australia (Sneeuwjagt and Peet 1985).

	SHEDLEY DRIVE	ANDERSON ROAD
Date of ignition	6 March 1996	11 March 1996
Duration of burn	3 days	4 days
Soil Dryness Index (mm)	113[a]	123[a]
Surface Moisture Content (%)	17-16-16	26-18-13-13
Profile Moisture Content (%)	36-34-30	39-37-35-33
Maximum temperature (°C)	20-26-32	24-24-28-24
Relative humidity at 3.00 p.m. (%)	67-47-49	81-58-55-47

[a] For operation purposes in Western Australia the Soil Dryness Index is expressed in units of mm x10, making these values 1130 and 1230 respectively.

TABLE 2
Stand characteristics for transects located beneath an intact canopy and in natural tree fall gaps.

	SHEDLEY DRIVE		ANDERSON ROAD	
	CANOPY	GAP	CANOPY	GAP
Basal area (m^2 ha^{-1})				
E. jacksonii	205	84	68	46
E. diversicolor	-	-	24	2
A. decussata	22	3	4	3
Total	227	87	96	51
Stems per ha				
E. jacksonii	60	50	350	280
E. diversicolor	-	-	40	60
A. decussata	290	40	90	160
Total	350	90	480	500
Height (m)				
Overstorey	50	59	44	37
Intermediate	18	35	35	33

owing to the smaller average tree size. Many of the mature trees at Anderson Road were severely damaged as a result of previous wildfires.

Seedlings began to emerge in April 1996 and continued to emerge for a further seven months until late spring. Both red tingle and karri germinated on a variety of seedbeds including burnt ground and the charred surface of fallen logs. The occurrence of seedlings was proportional to the area of each type of seedbed (Table 3), with more than 90 per cent of seedlings emerging on burnt ground. Seedlings were also observed on ashbeds and on unburnt mineral soil but these seedbed types were absent from, or uncommon, in sample quadrats.

Red tingle seedlings were distinguished by their relatively large cotyledons (typically 10–15 mm wide) and elliptic seedling leaves which were opposite, sessile and bright green in colour with prominent veins (Fig. 2). Karri seedlings had smaller cotyledons (<10 mm wide) with a distinct dumbbell (emarginate) shape, and ovate seedling leaves that were opposite and petiolate.

The number of red tingle seedlings peaked in October 1996 at both sites, while karri seedling numbers peaked in September at Anderson Road and in November at Shedley Drive (Fig. 3). Red tingle seedlings were more than twice as common as karri seedlings at both sites, and overall seedling numbers were higher at Anderson Road than at Shedley Drive. In October 1996, 60 per cent of quadrats contained seedlings of one or both species and 43 per cent of quadrats contained one or more red tingle seedlings (Table 4). Forty per cent of quadrats were unstocked with either species. Seedling densities varied considerably

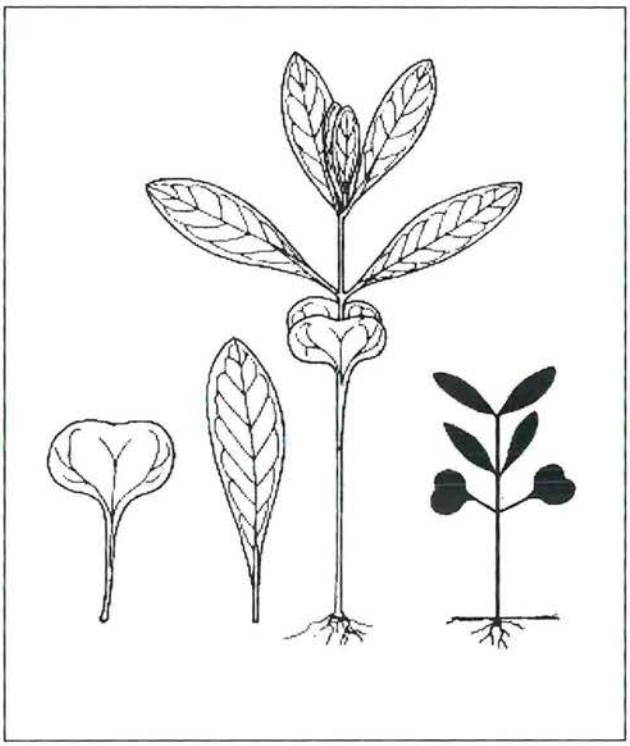


Figure 2. Drawing of a seven-month old red tingle seedling showing the large cotyledons and prominent leaf veins characteristic of this species. The actual height of the specimen was 75 mm.

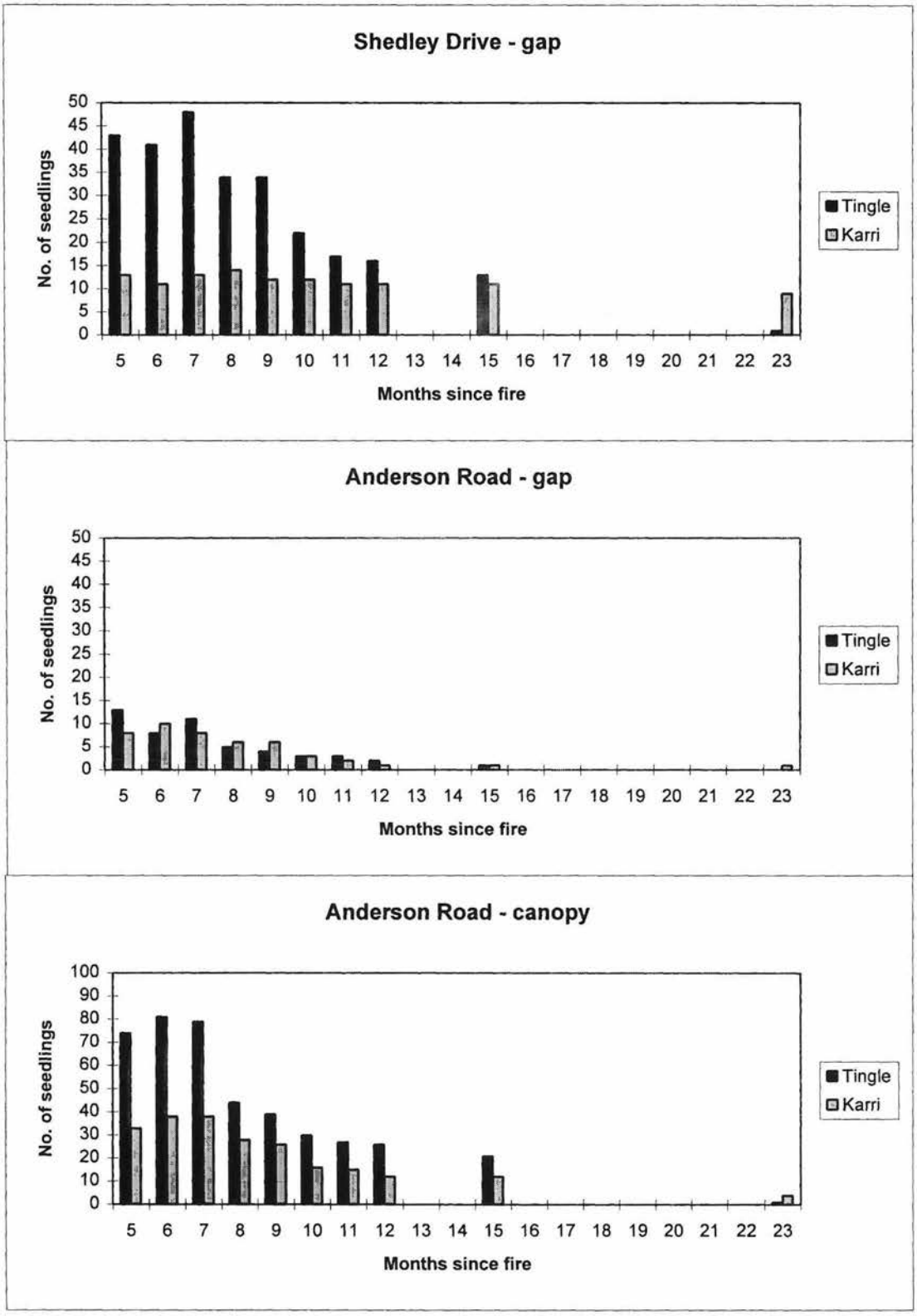


Figure 3. Numbers of red tingle and karri seedlings recorded on transects at Shedley Drive and Anderson Road between August 1996 and March 1998. Each transect comprised 10 m² of sample area. Data for the intact canopy transect at Shedley Drive have not been plotted as only two seedlings were recorded.

TABLE 3
Occurrence of seedlings by seedbed type based on pooled data for forty 1 m² quadrats.

SEEDBED TYPE	PERCENTAGE OF AREA OCCUPIED BY SEEDBED	NUMBER AND (%) OF SEEDLINGS	
		RED TINGLE	KARRI
Burnt	90	134(*96*)	59(*100*)
Old log surface	6	(*4*)	-
Bare ground	4	-	-

TABLE 4
Number of quadrats in each transect containing seedlings in October 1996 and March 1998. Each transect comprised ten 1 m² quadrats.

	SHEDLEY DRIVE				ANDERSON ROAD			
	CANOPY		GAP		CANOPY		GAP	
	1996	1998	1996	1998	1996	1998	1996	1998
Red tingle only	1	0	1	1	4	1	1	0
Karri only	0	0	5	6	0	2	2	1
Both species	0	0	3	0	4	0	3	0
No seedlings	9	10	1	3	2	7	4	9

between quadrats, with the most heavily stocked quadrats containing up to 32 red tingle seedlings per m² and up to 17 karri seedlings per m². Stocking was poorest on the transect beneath the intact forest canopy at Shedley Drive where only one quadrat contained a live seedling in October 1996. Poor stocking on this transect reflected an absence of successful germination and emergence rather than high seedling mortality. The situation was reversed at Anderson Road where the transect beneath the intact forest canopy was more heavily stocked than the transect in the gap.

The number of red tingle seedlings declined progressively from November 1996 to March 1998, so that two years after burning only one red tingle seedling survived at each site (Fig. 3). Both surviving seedlings were about 0.3 m tall in March 1998 and were not exhibiting dynamic growth. Over the same period, the number of karri seedlings declined substantially at Anderson Road, but not at Shedley Drive. The two most dynamic karri seedlings were located together in a quadrat in the gap transect at Shedley Drive. These individuals were respectively 1.3 m and 2.3 m tall in March 1998 and appeared to be growing vigorously and out-competing adjacent understorey shrubs. Seedlings of red tingle and karri exhibiting dynamic growth were observed outside the sample quadrats, commonly on ashbeds beneath relatively open parts of the forest canopy. Most surviving karri seedlings within the quadrats were less than 0.4 m tall and appeared unlikely to remain competitive with the understorey.

DISCUSSION

This study has shown that conditions favourable for the emergence of red tingle and karri seedlings can occur in the first year following a fire of low to moderate intensity in mature forest. The status of the seed crop on mature red tingle and karri trees at the two sites prior to burning is not known, but the emergence of seedlings in 60 per cent of sample quadrats confirms that viable seed was present in the crowns of some mature trees. Evidence from this study, together with the existence of regrowth stands dating from wildfires in 1937 and 1951 and post-logging burns of the early 1970s, strongly suggests that both species carry a crop of seed in most years. The magnitude of the seed crop is likely to vary from year to year in response to a variety of influences including climatic factors, pollinator activity, insect damage and fire (Loneragan 1979; Breidahl and Hewitt 1995).

Seedlings emerged on a range of seedbed types including ashbeds, burnt ground resulting from combustion of the organic litter layer, and the charred surface of fallen logs. Both sites were burnt during dry conditions in autumn and the litter layer was almost entirely consumed, thereby maximizing the area of receptive seedbed prepared.

Burning in spring, or later in autumn, when the litter layer contains more moisture would tend to result in less complete fuel consumption and the retention of a layer of unburnt organic material known as 'duff'. Duff is not considered a receptive seedbed (Breidahl and Hewett 1995) and seedling emergence may therefore be reduced when burning is conducted under more moist fuel conditions. Unfavourable seedbed conditions may have contributed to the low level of seedling emergence beneath the intact canopy at Shedley Drive. Although the fire had removed the organic litter layer and exposed mineral soil, the ground rapidly became covered by a layer of dead *A. decussata* needles cast from the lower canopy following scorch. Ashbed sites are known to favour rapid initial growth of karri and other eucalypts (Hatch 1960; Loneragan and Loneragan 1964; Burrows *et al.* 1990), and probably also favour the growth of red tingle. The lack of ashbeds in the sample quadrats precluded a thorough comparison of growth between seedlings on and off ashbeds.

Seedling mortality during the period from October 1996 to March 1998 was greater for red tingle than for karri. Additional research is needed to determine whether this differential mortality is a consistent feature of the regeneration process in mixed stands of red tingle and karri, or simply a chance event under the particular conditions of this study. The generally high level of mortality experienced by seedlings of both species can probably be attributed primarily to water stress. Rainfall at Walpole was very much below average in the period from March to May 1996, but above average between June to October when the majority of seedlings emerged (Bureau of Meteorology 1996). Average falls were recorded during the first summer after burning (January to March 1997) when seedlings would have begun to experience water stress. Retention of an overstorey has been shown to increase the soil water deficit and level of mortality among jarrah seedlings in the northern jarrah forest (Stoneman *et al.* 1994). Dignan *et al.* (1998) found that an overstorey basal area exceeding 20 m^2 ha^{-1} adversely affected the survival of seedlings three years after sowing in partially cut stands of mountain ash (*Eucalyptus regnans* F. Muell.). They suggested that overstorey basal areas below 20 m^2 ha^{-1} may in fact have a beneficial shelterwood effect on seedlings, at least during the first few years following regeneration.

The effect of retained overstorey on seedling survival is likely also to be important in the context of the present study of mixed red tingle-karri stands. The large sized trees and high basal area typical of mature red tingle-karri stands mean that gaps of at least 3 to 4 ha are needed to reduce overwood competition, and substantially larger gaps may be necessary to eliminate edge effects altogether (Bradshaw 1992). Overstorey basal areas measured on the transects were large by Western Australian standards, particularly at the Shedley Road site. Basal areas for jarrah stands typically range from 20 to 40 m^2 ha^{-1} (Abbott and Loneragan 1986) while mature karri stands may attain basal areas of 50–80 m^2 ha^{-1} (Rayner[1] personal communication). Wardell-Johnson (1997) reported that the average basal area of red tingle in a sample of 30 plots was 48 m^2 ha^{-1}, with a maximum of 106 m^2 ha^{-1}. The Shedley Road site was re-visited in 1998 to check the calculated basal areas, and re-measurement confirmed the values shown in Table 2 for the two quadrats. Large basal areas (129 and 158 m^2 ha^{-1}) were also measured on two circular quadrats, each 0.1 ha in area, established near to the transect beneath the intact forest canopy. Circular quadrats minimize the ratio of perimeter to sample area and thus reduce the chance of error owing to inclusion or exclusion of large trees on the edge of the quadrat. Based on this additional field work we are confident that the basal area values presented in Table 2 are a true reflection of the level of overwood competition at the two study sites.

In conclusion, the presence of red tingle and karri seedlings following low to moderate intensity fires used for fuel reduction may not lead to successful recruitment of even-aged sapling cohorts of these species. While significant numbers of seedlings may emerge during the first year following fire, few of these appear likely to survive and develop into saplings beneath an intact forest canopy or in small gaps caused by isolated tree falls. The scale and intensity of disturbance required for effective recruitment in red tingle-karri forest is a subject worthy of further investigation.

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The terrestrial vertebrate fauna of the Montebello Islands, Western Australia

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[3] Museum of Natural Science, Western Australian Museum, Francis St, Perth, WA 6000.

ABSTRACT

The indigenous terrestrial vertebrate fauna of the Montebello Islands consists of five mammal, 70 bird and 21 reptile species. Three species of exotic mammals occur: Feral Cats and Black Rats were introduced in the 19th Century and the House Mouse was first recorded in 1983. Black Rats have probably been eradicated. Extinctions of the Spectacled Hare-wallaby (Hermite and Trimouille Islands) and the Golden Bandicoot (Hermite Island) are attributed to the exotic mammals. Extinctions of the Black-and-white Fairy-wren and Spinifexbird are attributed to exotic mammals on Hermite Island, but nuclear weapons testing in the 1950s may have been the cause if these species occurred on Trimouille Island in 1950.

INTRODUCTION

The Montebello (previously named Monte Bello) Islands (Fig. 1) lie in 20°21'30" to 20°31'55"S, 115°29'55" to 115°36'30"E and are off the Pilbara coast of Western Australia (WA), about 20 km north of the northern tip of Barrow Island and 80 km north-west of Cape Preston on the adjacent mainland. The closest port is Dampier, about 120 km to the east.

All islands are within Class A Reserve No. 42196, Conservation Park, while the land between high and low water is Class C Reserve 42197, Conservation Park. Both reserves are vested in the Western Australian National Parks and Nature Conservation Authority and managed by the Department of Conservation and Land Management (CALM). Faraday Pearls lease some of the bays under the Fish Resources Management Act and oyster lines are moored in many sheltered bays and inlets. Unofficial island names, currently under consideration as official names, are given in quotation marks.

The Montebellos is an archipelago of about 180 islands, islets and rocks varying in size from Hermite Island (1022 ha) and Trimouille Island (522 ha) to rocks of a few square metres (Fig. 1). Most of the western islands are composed of limestone with low coastal cliffs and occasional pale orange-brown alluvial sand plains and white sand beaches. There are moderately high cliffs on the west coast of Hermite Island, in the southern parts of Trimouille Island, the eastern parts of South East Island and surrounding Karangi Island. The northern islands (North West, Trimouille, South East) and the southernmost substantial island (Ah Chong) have extensive white sand plains and low dunes and beaches between limestone headlands. There are some areas of mangrove, mainly *Avicennia marina* with some *Rhizophora stylosa*, especially on Hermite Island. A fringing coral reef lies to the west and the waters adjacent to the islands have many reefs, shoals and sandbanks.

The islands have a tropical arid climate. The nearest weather station is on Barrow Island, where records have been kept since 1967. Barrow Island has a mean maximum daily temperature of 30.3°C and a mean minimum daily temperature of 21.4°C. The hottest months are February and March with mean maximum daily temperatures of 33.4°C, while the highest temperature recorded is 45.0°C. The coolest month is July with a mean maximum daily temperature of 16.9°C, while the lowest temperature recorded is 6.7°C. Most rain comes from summer tropical cyclones and thunderstorms and autumn and early winter middle level disturbances. The mean annual rainfall is 320.3 mm; the wettest months are June (mean 64.6 mm), March (60.8 mm), February (55.0 mm) and April (48.5 mm). The wettest month on record is 315.6 mm (February) and the highest daily rainfall was 210 mm (June). Drought is common, with all months having records of nil rainfall and 10 per cent of years having rainfall below 154.1 mm. Temperatures at the Montebellos would be slightly less extreme than on the larger Barrow Island, where the weather station is in the centre of the island. Rainfall from thunderstorms may be less than on Barrow, again because of the smaller area of land.

Hill (1955) and Burbidge (1971) have briefly described the vegetation of the islands. Limestone areas are dominated by *Triodia* hummock grassland with scattered low shrubs, while sandy areas have grasses and sedges

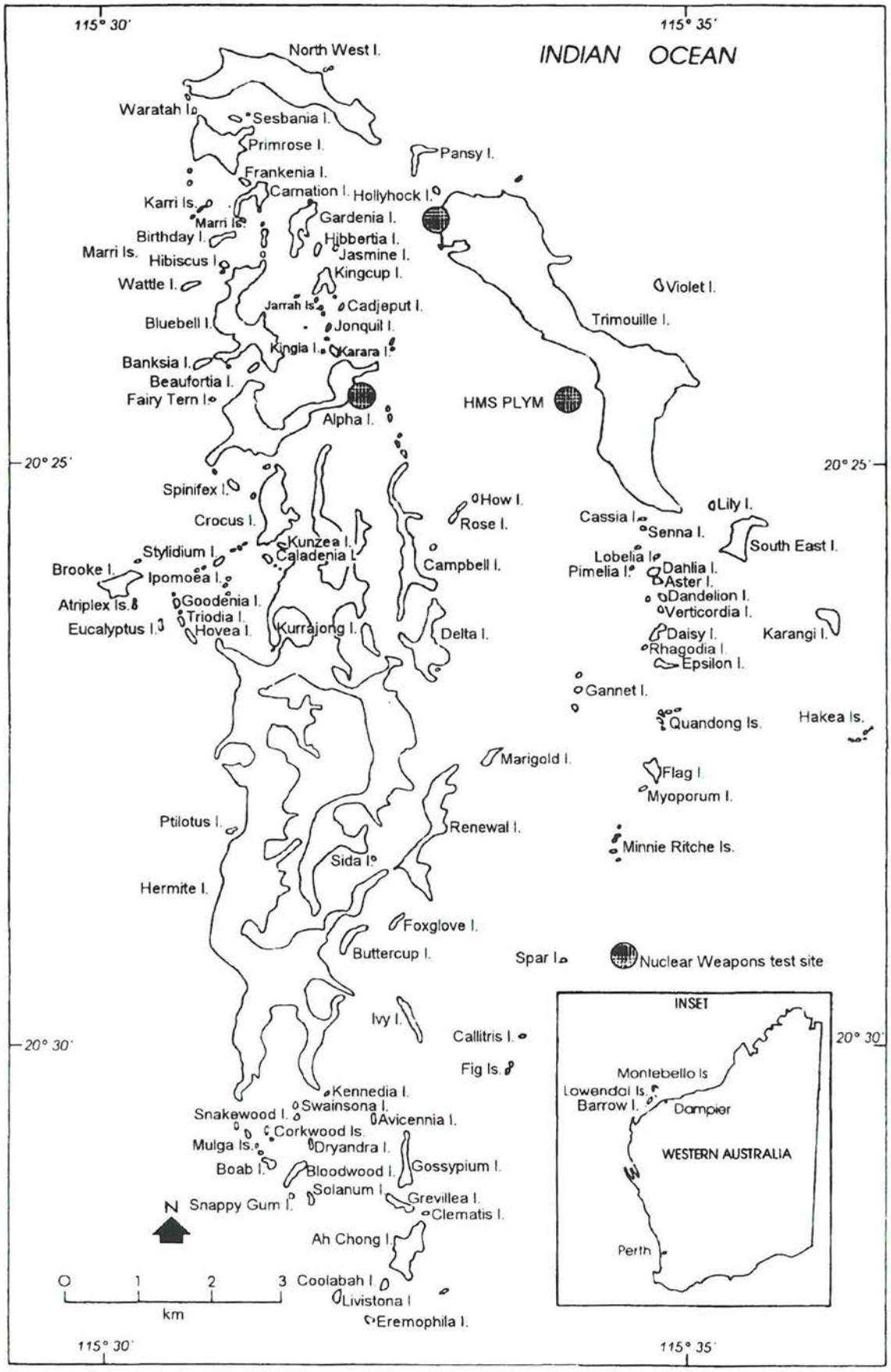


Figure 1. Montebello Islands, Western Australia.

with low shrubs (mainly *Acacia* spp.). Small patches of mangroves occur in sheltered bays, with larger areas in Stephenson Channel, Hermite Island.

In 1952 and 1956, the islands were used by the British as a site for testing atomic weapons (Cooper and Hartley 1979; Australian Ionising Radiation Safety Council (AIRSC) 1983; Cathcart 1994). Three nuclear devices were exploded. The first, in October 1952, was placed below the waterline in a corvette, HMS *Plym*, anchored off Main Beach, Trimouille Island, and resulted in considerable long term contamination of the northern two-thirds of Trimouille. The second and third weapons were exploded on 30 m towers, one at Point Gladstone, at the northern tip of Trimouille Island, and the other near Burgundy Bay on Alpha Island. The Alpha Island nuclear weapon, stated at the time to be 60 kilotons (Kt), was the largest tested anywhere in Australia (AIRSC 1983, Western Radiation Services 1993). However, the actual yield was 98 Kt. Since the test yield broke an assurance made personally by Prime Minister Anthony Eden of the United Kingdom to prime Minister Robert Menzies of Australia that the yield would not exceed 2.5 times that of the 1952 test (thus about 62 Kt), the true yield was concealed until 1984 ('British Nuclear Testing' at http://www.enviroweb.org/issues/nuketesting/hew/Uk/). During the tests the islands were occupied and many kilometres of temporary roads and other facilities were constructed. Structures and considerable amounts of rubbish from this period remain on the islands.

The islands were officially a prohibited area, controlled by the Commonwealth, until 1992, when they were returned to State control and declared a Conservation Park. There is residual, low level radiation from nuclear weapons tests on Trimouille and Alpha Islands. Landings on these islands should be restricted to one hour, there should be no soil disturbance and no metal objects should be handled or removed. Signs are erected providing information about radiation, but may be missing after cyclones. Further information on radiation hazards can be obtained from the Department of Conservation and Land Management, PO Box 835, Karratha, WA 6714, telephone + 8 9143 1488.

There was no Aboriginal occupation of the islands at the time of European exploration. The first European visitors were Thomas Bright and the survivors of the *Tryal*, wrecked on Tryal Rocks in May 1622. Nicholas Baudin named the outer islands in 1801. Phillip Parker King visited in HMS *Mermaid* in 1818 (King 1826) and J. Lort Stokes in HMS *Beagle* in 1840. At this time hydrographic surveys were carried out, and some natural history observations made (Stokes 1846). Thomas Haynes lived on the islands for some years from 1884, experimenting with pearl oyster cultivation, and in his spare time gathered samples of the flora and fauna, which were sent to the British Museum (Montague 1914).

In 1912, P.D. Montague (1914) carried out a biological survey, under the auspices of the Royal Society of London. His collections are in the British Museum. The next visitor who published natural history observations was Keith Sheard, who made a brief visit in August 1950 (Sheard 1950). Frank Hill (1955), who was part of the support party for the first nuclear weapon test, published natural history notes made in 1952. Dominic Serventy and Jock Marshall visited in 1958 to re-examine the natural history following the nuclear explosions (Serventy and Marshall 1964). Harry Butler made some observations in 1966 when an exploratory oil well was drilled on Trimouille Island (Butler 1967). Andrew Burbidge reported on biological survey work in 1970 and 1971, conducted by the then Department of Fisheries and Fauna, the 1971 trip being in association with Harry Butler and West Australian Petroleum (Burbidge 1971). Since then, there have been several visits by CALM staff and others, but little of this information is readily available. Morris (1991) summarized the values of the area and outlined management proposals, as required by the Commonwealth Government before the return to State control.

In 1996, Phase 1 of CALM's *Montebello Renewal* (a 'Western Shield' project) was carried out (Burbidge 1997). Phase 1 was the eradication of the Black Rats (*Rattus rattus*) from the archipelago. Biological survey work preceded this project, being carried out mainly in May-June 1994, and an experimental rat baiting project was conducted in August 1995. Follow up surveys in July 1997 and June 1998 resulted in the collection of more natural history data.

This paper summarizes current information on terrestrial vertebrate animals. Primary responsibility for the sections is Mammals – A.A. Burbidge; Birds – A.A. Burbidge, J.D. Blyth, P.J. Fuller and F.J. Stanley; Reptiles – P.G. Kendrick and L.A. Smith.

MAMMALS

Records of mammals commenced with the visit of HMS *Beagle* in 1840 (Stokes 1846). Montague (1914), Hill (1955), Serventy and Marshall (1964) and Burbidge (1971) also recorded mammal observations.

Isoodon auratus GOLDEN BANDICOOT

Hermite

Recorded on Hermite Island by Montague in 1912 (Montague 1914). Montague found recent remains, including shrivelled skins, and concluded that the species had become locally extinct only recently. He stated 'The cats have evidently been responsible for its extermination' (p. 631) and reported that the skulls corresponded with the Barrow Island subspecies *I. a. barrowensis*. Reported to be absent by Sheard (1950) and subsequent visitors.

[*Bettongia lesueur*] [BOODIE]

Serventy and Marshall (1964) found a lower jaw on Hermite Island in 1958. They postulated that, because of the condition of the bone, the species must have survived on the island until early in the 20th Century. Montague did not locate Boodies in 1912, nor did any other visitors, nor is there any sign of old warrens. Burbidge (1971) suggested that the presence of a single bone was insufficient evidence that the species occurred at the

Montebellos, as it could have been carried from Barrow Island by a Sea-Eagle. Serventy and Marshall were not aware that Boodies occurred on Barrow Island.

Lagorchestes conspicillatus SPECTACLED HARE-WALLABY

Hermite, Trimouille

Montague (1914) found this species on Hermite Island, stating that 'In its habits it is nocturnal, hiding by day amongst the thick *Spinifex*-tufts, and coming out just after sunset to feed upon the bark and young shoots and foliage of various herbs and bushes. It is unlikely that it will exist for many years longer, as it is one of the most defenceless animals that can well be imagined. It is easily dislodged from its hiding-place among the *Spinifex*, from which it often rises in an awkward fashion, tripping up and rolling over before getting away. Though it is able to hop swiftly for a short distance, it rapidly becomes exhausted, and is not difficult to obtain by simply running after it and catching it by the tail. ['*Spinifex*' is now *Triodia*.]

'The breeding-season appears to be during the summer and is possibly dependent upon the rains, for we saw no half-grown specimens, and as the rains the previous summer had failed, they may not have bred at all. It is possible, however, that the cats had accounted for all the young ones' (pp. 630–631) and 'The cats which have been introduced into Hermite Island appear to be breeding rapidly; wherever introduced they soon become exceedingly shy and wary, and grow to a large size. They will, no doubt, in a few years time have accounted for the wallabies, as they have for the bandicoots. If they cannot kill a full-grown wallaby—though I am inclined to believe they do—they make short work of the young ones' (p. 632). No hare-wallabies were seen by Sheard (1950), or by subsequent visitors.

Stokes (1846) stated that this species occurred on Trimouille Island at the time of his 1840 visit, reporting that 'Mr Fitzmaurice having seen plenty of wallaby on the larger islands, a party of us went ashore in the evening...' (p. 212). 'We found that Tremouille [sic] was as scantily supplied with vegetation as Barrow's Island; in one or two places was growing a stunted kind of wood, sufficient for fuel for a small sized ship; but there was no sign of water. The wallaby, which were very numerous, must have got their supply of moisture from the copious dews. They were found lying very close in the wiry prickly grass, allowing us to kick them out, when they went off at speed, affording excellent sport, quite equal to any rabbit shooting; among three guns we managed, in a couple of hours, to *bag* nearly twenty. It was a new kind of wallaby, and has been classed, from a specimen we brought away, as Lagorchester Conspicillata. It had a blunt nose, similar to those at Barrow's Island, and was about the same size, though its colour was lighter, and it had a back exactly like a European hare. The tail tapered away like a rat's, and the flesh was by no means good to eat, tasting very strong; this was the only instance in which we found wallaby at all unpalatable.' (p. 213)

Because Montague found Hare-wallabies only on Hermite Island, he suggested that this might also have been Stokes' locality, as old charts showed the Montebello group as a single island named Trimouille. However, a reading of Stokes shows that he realised this and that he left one of his officers, Fitzmaurice, in a boat to examine the Montebellos and to prepare new hydrographic charts of the area while the *Beagle* went to Barrow Island, so it is most unlikely that he would have made such a mistake. The Natural History Museum, London, has a skull of *L. conspicillatus* from Trimouille Island purchased from John Gould and registered in 1846 (specimen number 1846.4.4.26) (Jenkins[1] personal communication). Although there is no information on collector or date of collection, this is almost certainly the specimen 'brought away' by HMS *Beagle*.

[*Lagorchestes hirsutus*] [MALA, RUFOUS HARE-WALLABY]

Thirty Mala (20 females, 12 with pouch young, and 10 males) were introduced to Trimouille Island on 19 June 1998. These animals came from the 'Mala Paddock', a 1 km² fenced area in the Tanami Desert, Northern Territory and were translocated as part of an approved Translocation Proposal, developed as part of the Mala Recovery Plan. On 8 August 1998, radio-tracking showed that 28 were alive and one was dead; one transmitter was not located (Burbidge *et al.* 1999). Morris[2] (personal communication) located about 20 transmitters during the first week of January 1999; none of these was in mortality mode. In June 1999, radio-tracking and searching located 24 live and one dead Mala with transmitters, plus two additional adult Mala – one that had probably survived from the pouch young introduced in 1998 and one that had been conceived on the Island. The thick vegetation precluded searching for new animals over most of the Island.

Hydromys chrysogaster RAKALI OR WATER-RAT

Hermite, Trimouille, Alpha

Butler (1967, 1970) recorded tracks on Trimouille Island in 1966 and tracks identified as being from this species were found on Hermite Island in 1971 (Burbidge 1971). Morris (personal communication) recorded tracks on Alpha Island in 1983. It has not been reported since, despite extensive searches for it in 1994, and checks of beaches for tracks since.

Rattus rattus BLACK RAT

Most islands

Montague found this introduced species to be very common on many islands during his 1912 visit and attributed its presence to a pearling schooner wrecked about 20 years before his visit. Because of its extensive distribution in 1912, it is likely that this species established earlier than 1890, having escaped from careening and stranded pearling vessels, which were active in the archipelago from the 1840s.

[1] Paula Jenkins, Mammal Group, Department of Zoology, The Natural History Museum, Cromwell Road, London SW7, United Kingdom.

[2] Keith D. Morris, Department of Conservation and Land Management, PO Box 51, Wanneroo, WA 6065

Hill (1955) did not find evidence of rats on Hermite Island during his 1952 visit, although they were relatively common there in 1971 (Burbidge 1971). Between 1994 and 1996 we recorded rats on nearly every island and vegetated islet in the group, except South East and Karangi. They were common on islands as small as Ivy and 'Bloodwood'; but density was much lower on Hermite Island than on many other islands, possibly because of predation by cats. Hill recorded rats on South East Island, but Morris (personal communication) found none in May 1983, so local extinctions and re-invasions have apparently occurred.

Monitoring in 1997 and 1998 suggested that the 1996 rat eradication project, Phase 1 of *Montebello Renewal* (Burbidge 1997), had been successful, although further monitoring will be required before rats can be finally declared absent. Monitoring in 1999 showed evidence of rats on three islands: Hermite (1022 ha), Campbell (47 ha) and Delta (38 ha). The latter two islands were re-baited during winter 1999 and Hermite and adjacent islands were aerially baited in October 1999.

Mus domesticus HOUSE MOUSE
Hermite, Trimouille
Morris (personal communication) found a skull of this species in a Feral Cat scat on Hermite Island in June 1983. The identification of the skull was confirmed by the Western Australian Museum; however, the Museum did not retain the specimen. One volunteer saw an animal he thought was a mouse on Trimouille Island in 1996. In June 1998, P.J. Fuller saw a mouse on Trimouille and we subsequently observed mouse tracks at Cocoa Beach and near Balfour Point. It seems likely that mice numbers were previously kept very low because of predation by rats. Following the good seasons in 1998/1999, a mouse plague seems likely. Mice may occur on other islands in the group.

Vespadelus finlaysoni FINLAYSON'S CAVE-BAT
Hermite, Trimouille, Delta
Collected or observed by Montague (1914), Hill (1955), Butler (1967) and Burbidge (1971) on Hermite and Trimouille Islands. Observed in a cave on Delta Island in 1955 and 1994. A single larger bat, possibly a *Taphozous*, was observed in this cave in 1994, but was not captured.

Felis catus FERAL CAT
Hermite, Trimouille
Montague recorded cats on Hermite Island and he attributed the recent extinction of the Golden Bandicoot to their presence. Sheard (1950) and Hill (1955) also found cats on Hermite, but Burbidge (1971) reported them on Trimouille Island as well. During work between 1994 and 1998, we found cats only on Hermite. People working on the rat eradication project in 1996 repeatedly walked 50 m grids on all the larger islands, so it is most unlikely that we would have missed cat tracks or droppings.

Aerial baiting on Hermite Island in August 1996, using kangaroo meat sausage baits injected with '1080' poison, did not result in any reduction of cat tracks on monitored swept areas.

In June 1999, aerial baiting, using kangaroo meat baits further developed by Dr David Algar (CALMScience Division), eliminated all but four Feral Cats on Hermite island. These were trapped over the next six weeks.

Discussion

Two species of terrestrial, non-volant mammals were recorded at the Montebello Islands in the 19th and early 20th Centuries: *Isoodon auratus* (Hermite Island) and *Lagorchestes conspicillatus* (Hermite and Trimouille Islands); however, both are locally extinct. That the extinctions were caused by Feral Cats and Black Rats there can be little doubt: Burbidge, Williams and Abbott (1997) report a close correlation between the extinction of native mammals on Australian islands and the introduction of exotic mammals. Both species occur on Barrow Island and re-introduction to Hermite Island, once the Feral Cats have been eradicated, is planned.

Finlayson's Cave-bat is moderately common in the archipelago and other bat species may occur as well.

Of the exotic mammals, the Black Rat was most widespread, occurring on almost every island and vegetated islet in the group. Feral Cats, first reported on Hermite by Montague in 1912, are still present there. The only record on Trimouille Island (Burbidge 1971) was of a single animal and it is possible that one animal found its way there from Hermite or was introduced from a boat and has subsequently died. Cats may have found their way to Trimouille before: the local extinction of *Lagorchestes conspicillatus* on Trimouille sometime between 1840 and 1912 could have been caused by cats that subsequently died out, although extirpation owing to rats alone can not be ruled out.

BIRDS

Introduction

Records of birds at the Montebellos commenced with the work of Montague (1914), who visited the islands in 1912. Others to publish information on birds were Sheard (1950), Hill (1955), Serventy and Marshal (1964), Butler (1967), Burbidge (1971) and Abbott (1979, 1982).

We observed birds during our visits between 24 May and 8 June 1994, 14 August and 25 August 1995, 30 May to 2 September 1996, 14 July to 1 August 1997 and 9 June to 1 July 1998. Other records were obtained from CALM files.

Coturnix ypsilophora BROWN QUAIL
Moderately common on Hermite and Trimouille Islands. Occasional deserted clutches of eggs seen on both islands in 1994.

Puffinus pacificus WEDGE-TAILED SHEARWATER
Breeding on Ah Chong (*c.* 1000 pairs), 'Gossypium' (*c.* 100–150 pairs), Alpha (10 pairs), 'Birthday' (40–50 pairs), 'Beaufortia' (2–10 pairs), Brooke (*c.* 200 pairs), Flag (200–300 pairs), Gardenia (*c.* 300 pairs) and South East (*c.* 1700 pairs) Islands. Seen at sea near islands.

Puffinus huttoni HUTTON'S SHEARWATER
Eight mummified specimens were picked up on Trimouille and North West Islands in 1996.

Sula leucogaster BROWN BOOBY
Moderately common. Ones and twos seen in protected waters and adjacent seas.

Phalacrocorax carbo GREAT CORMORANT
Uncommon. Three birds seen in 1996.

Phalacrocorax varius PIED CORMORANT
Moderately common. A colony of 10 to 20 nests with eggs on one of the 'Karri Islands' on 26 June 1996.

Fregata ariel LEAST FRIGATEBIRD
Single female seen at Hermite Island on 17 June 1998.

Pelecanus conspicillatus AUSTRALIAN PELICAN
Moderately common. Small flocks occasionally present in protected bays.

Egretta novaehollandiae WHITE-FACED HERON
Uncommon. Several sightings in 1994 and 1998.

Egretta sacra EASTERN REEF EGRET
Common, mostly grey-phase birds. A single nest on 'Bloodwood' Island on 14 August 1996 had two eggs. On Buttercup Island three unused nests were located in August 1996. Montague (1914) also commented on the preponderance of grey-phase birds.

Ardea alba GREAT EGRET
Recorded by Burbidge (1971).

Butorides striatus STRIATED HERON
Two records. Buttercup Island, 1996 and Brandy Bay, Hermite Island, 1998.

Nycticorax caledonicus NANKEEN NIGHT HERON
Uncommon. Single bird seen in mangroves on Gardenia Island in 1994.

Pandion haliaetus OSPREY
Common. Breeding on numerous islands and islets. Eighteen nests were reported in use during 1996.

Elanus notatus BLACK-SHOULDERED KITE
Moderately common on all larger islands.

Hamirostra melanosterno BLACK-BREASTED BUZZARD
Single bird on Trimouille Island, 1997. Also recorded by Burbidge (1971).

Haliastur sphenurus WHISTLING KITE
Uncommon. Recorded by Burbidge (1971).

Haliastur indus BRAHMINY KITE
Moderately common. Breeding in mangroves on Crocus Island in 1994.

Haliaeetus leucogaster WHITE-BELLIED SEA-EAGLE
Three or four pairs seen in the archipelago each year from 1994 to 1998. Breeding recorded on Hermite (no date, Storr 1984), South East (1994), Trimouille (1985 and 1996), North West (1985), and Brooke (1996, 1997).

Circus assimilis SPOTTED HARRIER
Moderately common. Often seen hunting over larger islands.

Circus approximans SWAMP HARRIER
Uncommon. Recorded on Hermite, Bluebell and Ah Chong Islands. Two or three seen on every visit to Ah Chong in 1996. Both adults and juveniles present. This species is uncommon in the Pilbara and its presence at the Montebellos was unexpected.

Falco peregrinus PEREGRINE FALCON
Uncommon. Single bird on Ah Chong I, 1994.

Falco longipennis AUSTRALIAN HOBBY
Uncommon. Single bird on Ah Chong, 1996.

Falco cenchroides NANKEEN KESTREL
Common, all larger islands.

Limosa lapponica BAR-TAILED GODWIT
Common.

Numenius madagascariensis EASTERN CURLEW
Rare.

Numenius phaeopus WHIMBREL
Moderately common.

Tringa nebularia GREENSHANK
Moderately common.

Actitis hypoleucos COMMON SANDPIPER
Moderately common.

Heteroscelus brevipes GREY-TAILED TATTLER
Common.

Arenaria interpres RUDDY TURNSTONE
Moderately common.

Calidris canutus RED KNOT
Uncommon.

Calidris acuminata SHARP-TAILED SANDPIPER
Uncommon.

Calidris ruficollis RED-NECKED STINT
Moderately common.

Calidris ferruginea CURLEW SANDPIPER
Uncommon.

Esacus neglectus BEACH STONE-CURLEW
Common. About 12 to 15 pairs resident in archipelago between 1994 and 1998. Storr (1984) reported breeding on Trimouille Island but provided no details. We found a scrape ready for eggs on one of the 'Marri Islands' on 15 August 1996.

Haematopus ostralegus PIED OYSTERCATCHER
Common. Present on all beaches and mudflats. Breeding on Alpha 26 May 1983 and 'Renewal' (eggs) on 22 August 1995.

Haematopus fuliginosus SOOTY OYSTERCATCHER
Common; the Montebellos are a minor stronghold for this comparatively uncommon species. Breeding on Bluebell (single egg) on 15 August 1996. Nest was a scrape on beach.

Pluvialis squatarola GREY PLOVER
Uncommon.

Charadrius ruficapillus RED-CAPPED PLOVER
Moderately common

Charadrius leschenaultii GREATER SAND PLOVER
Uncommon.

Charadrius mongolus LESSER SAND PLOVER
Recorded by Montague (1914).

Larus novaehollandiae SILVER GULL
Common. A late summer and autumn breeder. Breeding on Brooke (recent nests, broken eggs on 25 May 1994 and *c.* 200 fledging chicks on 16 March 1997), 'Birthday' (4 old nests 25 May 1994), Gardenia (broken eggs on 31 May 1994), 'Renewal' (single fledgling, 4 June 1994), and South East (1000–1500 birds, three nests with eggs located, 28 May 1994).

Sterna caspia CASPIAN TERN
Common breeding resident. Breeding recorded on Ah Chong, Alpha, Bluebell, Dandelion, Flag, Foxglove, Islet to south of Hermite, Ivy, 'Kunzea', Marri Islands, Primrose and 'Renewal' and Trimouille. Breeding protracted with eggs between late April and August.

Sterna dougallii ROSEATE TERN
Common breeding resident with many thousands of birds present in 1994, 1995, 1996 and 1997. Not present in 1998. Autumn-winter breeder. Breeding recorded on Dahlia, Dandelion, 'Pimelia', 'Myoporum', Gannet, islet to the north of Gannet, 'Fig Islands', and 'Bloodwood'. Colonies from 6 pairs (Dandelion) to more than 2000 ('Bloodwood'). Eggs recorded in May. The colony on 'Bloodwood' Island in 1996 was abandoned by the adults and many dead chicks were found that had been eaten by rats. No breeding colonies located in 1997.

Sterna anaethetus BRIDLED TERN
No birds seen during our visits. Presumably a summer breeder. Evidence of breeding (broken eggs, dead runners, stunted non-flying fledged bird) found during winter trips on Dahlia, 'Gossypium', and South East. Juveniles present on rocky islets south of Hermite on 4 April 1971 (Burbidge 1971). Storr (1984) reported breeding but provided no additional information.

Sterna fuscata SOOTY TERN
Two mummified adults found on South East Island, 28 May 1994.

Sterna nereis FAIRY TERN
Breeding resident. A colony of 315 nests with eggs and six small chicks on 'Fairy Tern Island' on 15 August 1996 and a colony on the same island just commencing egg-laying on 28 June 1998. A colony of about 102 pairs (new scrapes, eggs, small chicks) on 'Hibbertia' Island on 27 July 1997.

Sterna bergii CRESTED TERN
Common. Breeds in some years. Breeding recorded on an islet to the north west of Bluebell (30 pairs, no date), 'Birthday' (70 pairs, 29 May 1994, addled eggs and broken shells), and on Daisy (5000–6000 pairs), Epsilon (*c.* 3500 pairs) on 28 May 1994. In August 1995 the remains of a large colony (estimated to have been about 1500 pairs) was located on Flag Island. Many mummified, partly buried, nearly fledged chicks were seen. This colony was presumably wiped out by Cyclone Bobby which passed near the Montebellos on 24 February 1995. As the eye of the cyclone was unusually slow moving, the severe winds persisted for a much longer period than normal (Bureau of Meteorology[3], Perth, personal communication). No breeding recorded in 1996 or 1997.

Sterna bengalensis LESSER CRESTED TERN
Uncommon. Several pairs observed among a large colony of Crested Terns on Daisy and Epsilon Islands in May 1994 may have been breeding. Because of the presence of large runners, this colony could not be examined closely.

[3] Regional Director, Bureau of Meteorology, PO Box 1370, West Perth, WA 6872.

Anous stolidus COMMON NODDY
Uncommon. Small roosting flocks occasionally seen on outer rocky islands.

Geopelia humeralis BAR-SHOULDERED DOVE
Common. Mainly around mangroves (where it roosts) and feeding among sand dunes. Old nest seen in mangroves at Brandy Bay, Hermite Island, in 1998.

Cuculus pallidus PALLID CUCKOO
Single bird on Hermite I in June 1994.

Cuculus basalis HORSFIELD'S BRONZE-CUCKOO
Recorded by Montague (1914).

Halcyon sancta SACRED KINGFISHER
Uncommon. Mangroves.

Halcyon chloris COLLARED KINGFISHER
Uncommon. Recorded by Montague (1914) and Hill (1955), but no recent reports.

Malurus leucopterus edouardi BLACK-AND-WHITE FAIRY-WREN
Extinct. Recorded on Trimouille Island by Sheard (1950). Not seen before or since.

Lichmera indistincta BROWN HONEYEATER
Common in mangroves.

Epthianura tricolor CRIMSON CHAT
Recorded by Montague (1914).

Pachycephala rufiventris RUFOUS WHISTLER
Recorded by Montague (1914).

Grallina cyanoleuca MAGPIE-LARK
A party of about six birds present for a short time in June 1996.

Rhipidura leucophrys WILLIE WAGTAIL
Uncommon. Three sightings in 1994.

Lalage sueurii WHITE-WINGED TRILLER
Uncommon. Two sightings in 1994.

Artamus leucorhynchus WHITE-BREASTED WOODSWALLOW
Common, especially around mangroves, but also hawking over larger islands.

Anthus novaezeelandiae RICHARD'S PIPIT
Common.

Taeniopygia guttata ZEBRA FINCH
Recorded by Montague (1914) on Trimouille and South East Islands. Geoff Kregor[4] (personal communication) saw 'hundreds' on Hermite Island between 26 and 30 August 1998.

Hirundo neoxena WELCOME SWALLOW
Common.

Cecropis nigricans TREE MARTIN
Common to uncommon in different years. Recorded over larger islands.

Eremiornis carteri SPINIFEXBIRD
Extinct. Recorded on Hermite Island by Montague (1914) and on Trimouille Island by Sheard (1950). Montague erected a new subspecies for the Hermite Island specimens based on 'its smaller size, proportionately larger bill, and in the colour of the head, which is a deeper and richer chestnut-brown.' Not seen by later observers.

Zosterops lutea YELLOW SILVEREYE
Common in mangroves.

Discussion

In all, some 70 species of birds have been recorded in the Montebellos. They comprise 42 sea and shore birds and 28 land birds. The breeding seabirds of the Montebellos have been summarized by Burbidge and Fuller (in press). Among the shorebirds, the relative abundance of Sooty Oystercatchers and Beach Stone-Curlews has been noted above.

Based on our observations between 1994 and 1998, some of the land birds are vagrants or passage migrants: Peregrine Falcon, Australian Hobby, Pallid Cuckoo, Horsefield's Bronze-Cuckoo, Crimson Chat, Rufous Whistler, Magpie-Lark, Willie Wagtail, White-winged Triller, Tree Martin and Zebra Finch. Resident land birds during this period were Brown Quail, Black-shouldered Kite, Spotted Harrier, Nankeen Kestrel, Bar-shouldered Dove, Brown Honeyeater, White-breasted Woodswallow, Richard's Pipit, Welcome Swallow and Yellow Silvereye.

Notable differences between the avifauna of the Montebellos and Barrow Island include the presence at the Montebellos of the Brown Quail and Marsh Harrier and the absence of the Singing Honeyeater, which is common at Barrow Island (Butler 1970; AAB personal observations). Both the Spinifexbird and the Black-and-white Fairy-wren are common breeding residents on Barrow.

Three species of land bird have apparently become locally extinct at the Montebellos. The Black-and-white Fairy-wren was recorded on Trimouille Island by Sheard (1950) but not by Montague in 1912, nor by Hill in 1952 or other later observers. Sheard (*op. cit.*) also recorded this species on Sholl Island, but recent surveys there have failed to locate it (FJS, unpublished). It seems strange that Montague did not record this distinctive species and a concern that Sheard misidentified it must remain.

The Spinifexbird was recorded by Montague in 1912 'principally upon the *Spinifex*-plains [i.e., *Triodia* hummock grassland] of Hermite, where it is common' (p. 634), and by Sheard on Trimouille in 1950. Montague

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visited Trimouille Island but did not record it. The species was not recorded by Hill in 1952, nor by later observers. It seems likely that, on Hermite Island, it was exterminated by the feral cats and/or rats and, on Trimouille Island, if it did occur there, by the atomic weapon test in 1952, which significantly affected most, if not all of the island (see Cathcart 1994).

Johnstone (1990), in commenting on the lack of records of the Mangrove Kingfisher from the Montebellos since 1952, suggested that atomic weapons testing may have destroyed much of their habitat. While the weapons testing did destroy mangroves on Trimouille Island, the larger stands in Stephenson Channel, Hermite Island, were not affected. Montague collected juvenile birds in 1912, so it was a breeding species in 1912. The reasons for its disappearance are unknown.

REPTILES

Montague (1914) was the first to describe the reptile fauna of the Montebello Islands, resulting from collections undertaken between May and August 1912. Hill (1955) made additional collections during the period of British nuclear weapons testing, between August and October 1952. These records, together with those of Butler (1967), collected in 1966 and lodged in the Western Australian Museum, were summarized by Burbidge (1971), who reported the results of collections made from Trimouille, Hermite, Campbell, Alpha, North West, Primrose and Bluebell Islands in 1970.

With the exception of opportunistic collections during brief visits by biologists and others, no further documentation of the reptile fauna of the Montebellos was undertaken until 1994, when CALM staff established 11 pit trap sites on nine islands. This trapping was undertaken prior to the eradication of black rats from the archipelago in 1996. This paper reports the results of those 1994 collections, and summarizes current knowledge of the reptile fauna of the Montebello Islands.

No systematic pit trapping had been undertaken on islands of the Montebello group prior to 1994. In that year, pit trap sites were established at three locations on Hermite, and on Ah Chong, Alpha, Bluebell, Brooke, Crocus, Delta, North West and Primrose Islands. These were open between 22 May and 7 June.

Pit traps were 20 litre ultraviolet-stabilized plastic buckets, with lids, and were placed in sandy habitats where soils were deep enough to sink the traps. Ten pits were placed at each location, in an array of five pairs, with pits from each pair located 5 m apart. Each pair of pits was separated by 15–20 m from adjacent pairs. Pairs of pits were traversed by a single 10 m aluminium fly-wire drift fence. Some pits were placed as close to rocky habitats as possible. When not in use, the pits were capped and buried.

Pit traps were run on two occasions for a minimum of four nights during each period. In addition to pit trapping, searching in litter, soil and under debris was also undertaken. Some night searching was also undertaken at sites on Hermite. Larger reptiles were sometimes captured in Elliott traps.

CHELONIIDAE

Caretta caretta	LOGGERHEAD TURTLE
Chelonia mydas	GREEN TURTLE
Eretmochelys imbracata	HAWKSBILL TURTLE
Natator depressus	FLATBACK TURTLE

Sea turtles are common in waters surrounding the Montebello Islands, and significant sea turtle nesting beaches occur on the Montebellos and nearby island groups. Green turtles (*Chelonia mydas japonica*), hawksbills (*Eretmochelys imbricata*) and flatbacks (*Natator depressa*) are known to nest on the Lowendal Group, while green and flatback turtles nest on Barrow Island. All three species above, and loggerhead turtles (*Caretta caretta*), are known from waters around and near to the Montebello Islands. However, while turtle nesting occurs on islands of the Montebello group, detailed information regarding species and locations is not available. Leatherback turtles (*Dermochelys coriacea*) may also occur in waters surrounding the Montebellos.

GEKKONIDAE

Diplodactylus jeanae
Hermite
Collected from sandplain habitat on Hermite Island, in May 1994.

Gehyra pilbara
Hermite
Known to inhabit the galleries of giant termite mounds throughout the Pilbara, the occurrence of this species on Hermite Island is probably linked to the presence of many large termite mounds. It was not detected on Alpha Island, where termite mounds also occur. Montague (1914) found this species to be common on Hermite. The five specimens identified as *Gehyra australis* in Burbidge (1971) have been re-identified as *G. pilbara*

Gehyra punctata
Trimouille
Collected from Trimouille in 1970 by Burbidge, but not recorded since. Generally an inhabitant of rocky habitats, it may still be present on Hermite and other smaller rocky islands.

Heteronotia binoei
Ah Chong, Alpha, Brooke, Crocus, Hermite, Primrose, Trimouille
A common species readily pit trapped, but also encountered under rocks, litter, logs and debris.

PYGOPODIDAE

Aprasia rostrata rostrata
Hermite
Known from a single specimen collected in 1952, the Hermite subspecies of *A. rostrata* has not been sighted since. Despite pit trapping and intensive hand searching in

soil under litter, rocks and debris, no specimens were caught. However, owing to the cryptic nature of the genus, it is possible that it still occurs on Hermite. Further survey effort will be required before any definitive statement regarding the present status of *A. r. rostrata* can be made. Storr *et al.* (1990) considered the Hermite specimen to be a full species (*A. rostrata*).

Delma borea
Hermite
Collected in 1970, and not seen since.

Delma nasuta
Hermite
Collected in 1970, and not seen since.

Lialis burtonis
Alpha, Hermite
Lialis was recorded in 1952 from the 'Montebello Islands', without a specific island locality. Pit trapped on Alpha and Hermite Islands in 1994.

AGAMIDAE
[*Ctenophorus c. caudicinctus*]
Listed by Hill (1955), with no additional information. No other records of this species have been made on the Montebello group, although it is very common on the adjacent Pilbara coasts and hinterlands. It is possible that this record is erroneous, or that a *C. caudicinctus* individual was inadvertently transported to the Montebellos on one of the vessels supplying the nuclear weapons program from Onslow, and subsequently observed or captured.

Gemmatophora gilberti gilberti
Ah Chong, Hermite
Very common on both Ah Chong and Hermite Islands, particularly behind mangrove areas on the latter, and sandy beaches with rocky cover nearby. Montague (1914) noted that this species was very abundant on Hermite (listed as *Physignathus gilberti*), and was present 'on nearly all the other islands'. The 1994 survey found this species only on Hermite and Ah Chong. This may indicate local extinctions from some of the islands in the group since Montague's visit in 1912, possibly owing to the presence of rats, or the episodic presence of cats.

VARANIDAE
Varanus acanthurus
Hermite
Recorded only from Hermite Island. Appeared to be common around rocky areas, particularly near mangrove or coastal areas.

Varanus gouldii
Alpha, Bluebell, Hermite, Trimouille, tracks on Campbell, Delta, North West, Primrose.
Very common on Trimouille, where black rats appeared to be a major diet item until their eradication in 1996. This species was also relatively common on Alpha and Bluebell Islands. *Varanus gouldii* is uncommon on Hermite, where a specimen was taken by Butler in 1984. Neither specimens nor tracks were recorded on Hermite during the 1994 survey.

Montague noted that *V. gouldii* was abundant 'over the whole Monte Bello Group', and Hill (1955) noted that they were common on Alpha, South East, North West and Trimouille. While the 1994 survey did not visit South East, tracks of *Varanus* sp. were observed on Campbell, Delta, North West and Primrose. While no specimens were secured, the location and nature of the tracks indicated that they were made by *V. gouldii*, or a similar species. Until confirmed otherwise, they are assumed to be *V. gouldii*. This large lizard is capable of swimming between islands of the archipelago.

SCINCIDAE
Ctenotus saxatilis
Ah Chong, Alpha, Bluebell, Brooke, Campbell, Crocus, Delta, Hermite, North West, Primrose, Trimouille
No other species of reptile was found on so many islands as *C. saxatilis*. It was very conspicuous, and was commonly caught in Elliott traps. It is probably present on all islands of reasonable size. Montague (1914) noted that they were common 'on all the larger islands' (listed as *Lygosoma leseurii*).

Glaphyromorphus isolepis
Ah Chong, Alpha, Bluebell, Campbell, Crocus, Delta, Hermite, North West, Trimouille
Almost as widespread as *Ctenotus saxatilis*; the more cryptic nature of this species may have meant that it was not detected in some instances. Montague noted that this species was common only on Hermite (listed as *Lygosoma isolepis*).

Morethia ruficauda exquisita
Hermite
Collected from Hermite Island in 1970 and 1993. This is a highly visible and unmistakable species, and if it were common it would have been recorded during the 1994 survey. It appears to be present at low density.

Lerista bipes
Ah Chong, Alpha, Bluebell, Brooke, Crocus, Delta, East Hermite, Hermite, North West, Trimouille
Common and conspicuous in sandy areas, particularly in beach dunes and near coastal sandplains. Large numbers of this species were pit trapped, and tracks were very common in some areas.

Lerista elegans
Bluebell, Hermite
Although apparently a common species on Hermite, where it was pit trapped on sandy substrates during the 1994 survey, only a single animal was trapped on Bluebell.

Lerista muelleri
Brooke, Hermite
Only two specimens were collected, indicating that this

species is probably uncommon on the Montebellos. This taxon is currently under review by one of the authors (LAS, in prep.). In WA, *L. muelleri* appears to be comprised of up to 15 species. The two specimens collected from the archipelago represent two undescribed species, both of which are widely distributed on the adjacent mainland.

TYPHLOPIDAE

Ramphotyphlops diversus ammodytes
Hermite
Recorded by Montague in 1912, in soil beneath a rock. This species has not been recorded from the Montebellos since.

BOIDAE

Antaresia stimsoni stimsoni STIMSON'S PYTHON
Hermite
Known only from Hermite. It was collected by Montague in 1912 and Butler in 1966, and reported by pearl farm operators in 1991. Observed on Hermite in 1996.

ELAPIDAE

Demansia rufescens
Hermite
Collected during the 1994 survey, and from the inter-tidal zone of Hermite in 1996.

Furina ornata
Hermite
Although the WA Museum collections have only one record of *F. ornata* from the Montebellos (collected in 1981), Hill recorded this species from Hermite in 1952 (listed as *Pseudelaps cristeanus*, and in Burbidge 1971 as *Brachysoma cristeanus*). No records have been obtained since.

HYDROPHIIDAE

Aipysurus laevis
Hydrophis major

Hydrophis ocellatus
A number of sea snake species are likely to occur in waters surrounding the Montebello group. The above three species in the collections of the WA Museum were taken near the Montebellos. Another seven are recorded from waters around Barrow Island: *Acalyptophis peronii, Aipysurus apraefrontalis, A. duboisii, Astrotis stokesii, Emydocephalus annulatus, Hydrophis elegans* and *Hydrophis kingii*. Examination of published distributions (Cogger 1996; Storr *et al.* 1986) indicated that a further three species may also occur in waters surrounding the Montebellos: *Aipysurus eydouxii, Hydrophis ornatus* and *Pelamis platura*. *Ephalophis greyi*, a mangrove specialist, may also occur in the archipelago.

Discussion

Twenty-one species of terrestrial reptile are known to occur on the Montebello Islands. It is immediately apparent that all but one species of reptile (*Gehyra punctata*) known from the Montebellos are present on Hermite Island. Hermite is the largest island in the group, and has by far the greatest shoreline. It has the full range of habitat types present on these islands, including large areas of sandplain, heavily eroded limestone uplands, and the largest areas of mangrove in the archipelago. However, the diversity of habitats alone is probably not sufficient to explain the apparent concentration of species onto this one island. During the 1994 survey, and possibly in the past also, collecting effort was greater on Hermite than elsewhere. Three pit trap sites were established on Hermite, while only one site was placed on other islands. No pit trapping at all was undertaken on Trimouille, despite its large size, owing to both logistical problems in accessing the sites by small boat and potential radioactive contamination of soil. In addition, field workers were accommodated on Hermite, meaning that opportunistic records made around camp contributed to Hermite's species tally.

The species detected are mostly those expected for islands of this size in this area. All but three species are known also from Barrow Island. Of these, one is endemic to the Montebellos (*Aprasia r. rostrata*), and one is a large varanid (Barrow supports *V. giganteus* instead of *V. gouldii*). The last, *Gehyra punctata,* is probably an example of a deletion or omission from the Barrow Island fauna at the time of or following its isolation. Given *G. punctata*'s known habitat preference for rocky areas, it is likely that this species is present but undetected on Hermite.

Aprasia rostrata is a poorly known species with a distribution restricted to the Exmouth Gulf area and Hermite Island. The Hermite subspecies, *A. r. rostrata,* is known only from a single specimen collected in 1952, and has not been recorded since. The presence of feral cats and black rats on the islands lead to fears that this population may have been adversely affected, possibly to extinction, by predation. However, while the recent failure to relocate this species on Hermite Island is discouraging, it is premature to suggest local extinction. *Aprasia* are highly cryptic animals, and further survey effort is required before the conservation status of this species can be determined.

It is certain that further visits to the Montebello group will yield additional records of reptiles. The presence of very large numbers of rats on Trimouille prior to the 1994 survey may have depressed numbers of native fauna to levels where they were not easily detected. The recent eradication of these rats may result in new records for Trimouille in the future. Likewise, more effort on the medium sized islands will undoubtedly result in additional records.

GENERAL DISCUSSION

Four species of native terrestrial mammals (two now extinct) and three species of exotic terrestrial mammals (one hopefully eradicated) have been recorded in the Montebello Islands in modern times. In addition, 21 species of terrestrial reptiles and 70 species of birds have

been recorded. Eight species of seabird have been recorded breeding. Only 10 of the 28 land bird species recorded are considered to be resident. One reptile subspecies (considered by Storr *et al.* 1990 to be a full species), *Aprasia rostrata rostrata*, is endemic to Hermite Island.

The terrestrial fauna of the Montebello Islands has been deleteriously affected by human activities, especially the introduction of Feral Cats and Black Rats in the 19th Century, and the testing of nuclear weapons in the 1950s. It is difficult to be precise about the effect of these disturbances as, although survey data are available from Montague's 1912 visit, there was little additional work until well after the weapons tests. It is clear that both native mammals disappeared before the tests, however, the evidence relating to the disappearance of the Black-and-white Fairy-wren and Spinifexbird is less clear. Both species existed on Hermite in 1912 and Hermite was little affected by the nuclear weapons tests, implicating rats and cats as a cause of local extinction. If either did occur on Trimouille Island, the weapons tests are the most plausible cause of extinction. The endemic legless lizard *Aprasia rostrata rostrata* has not been recorded since 1952, but this could be owing to its cryptic nature, as is probably the case for the lack of records of the blind snake *Ramphotyphlops diversus ammodytes* since 1912.

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The breeding seabirds of Shark Bay, Western Australia

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ABSTRACT

Surveys during May and September 1997 and collation of existing data reveal that 16 species of birds that depend on the ocean for food have been recorded breeding on 42 islands and islets in Shark Bay. Eleven of these are considered to be true seabirds: Wedge-tailed Shearwater, Australian Pelican, Pied Cormorant, Silver Gull, Pacific Gull, Caspian Tern, Crested Tern, Lesser Crested Tern, Roseate Tern, Bridled Tern and Fairy Tern. The other breeding species that depend on the ocean for their food and breed mainly on islands are Eastern Reef Egret, White-bellied Sea-Eagle, Osprey, Pied Oystercatcher and Sooty Oystercatcher. All the true seabirds have tropical or subtropical affinities except the Pacific Gull, which is a temperate species and is at the northern end of its range at Shark Bay. Shark Bay is at the southern edge of the breeding distribution of the Lesser Crested Tern. The other species have widespread distributions and are found along most of the Australian coastline. Pied Cormorants are particularly numerous at Shark Bay and the breeding colonies at Quoin Bluff South on Dirk Hartog Island, Freycinet Island and Pelican Island are the three largest reported in Western Australia. A significant Australian Pelican rookery occurs at Pelican Island. Seabirds breed on most of the smaller islands in Shark Bay, with a few species, such as White-bellied Sea-Eagles, Ospreys and Caspian Terns, breeding in low numbers on the larger islands (Faure, Dirk Hartog, Dorre, Bernier).

INTRODUCTION

The seabirds of Shark Bay are relatively poorly known. Burbidge, Johnstone and Fuller (1996), when reviewing the seabirds of Western Australia (WA), highlighted the Archipelago of the Recherche, Shark Bay islands and islands of the Kimberley coast, in that order, as the most poorly surveyed for seabird breeding.

Most islands in the Shark Bay World Heritage Property are nature reserves, vested in the National Parks and Nature Conservation Authority and managed by the Department of Conservation and Land Management (CALM), however, several of the smaller islets are vacant Crown land. Two of the larger islands, Dirk Hartog and Faure, are pastoral leases. The land tenure of all islands is provided in the Annotated List of Islands below.

ORNITHOLOGICAL HISTORY

Available records of breeding seabird species on islands were briefly summarized by Serventy, Serventy and Warham (1971). T. Carter visited Dirk Hartog Island in 1917 (Carter 1917, 1923), F.L. Whitlock collected eggs and recorded birds on Dirk Hartog Island in 1920 (Whitlock 1921); White 1921), A. Chenery (1928) and E. Ashby (1929) visited Dirk Hartog Island in September–October 1927, J. Gregory (1941) reported on breeding Pied Cormorants and Silver Gulls in May 1938, S. Fowler counted seabirds from the air in 1945 and 1946 (Fowler 1947), D.L. Serventy visited the area in October 1947 (Serventy 1972), G.F. Mees (in Ride *et al.* 1962) provided a comprehensive summary of the birds of Bernier and Dorre Islands from a visit in 1958, G.M. Storr visited several islands in 1965 (Serventy 1972), L.E. Sedgwick (1967, 1968) provided lists of birds from Dirk Hartog Island from a visit in 1967, D.L. Serventy (1972) published information on the colonies of Wedge-tailed Shearwaters of Shark Bay, highlighting the existence of unusual 'white-breasted phase' birds in the populations there and incorporating data collected by a visit by Western Australian Wildlife Authority members H. Hall, A.C. Robinson, N. Beeck, E. Dell and S. Davies on 21 and 22 August 1971, A.A. Burbidge and A.S. George (1978) and B.A. Wells and A.G. Wells (1974) provided some information on the seabirds of Dirk Hartog Island from visits in 1972 and 1973, S.J.J.F. Davies and G.S. Chapman (1975) summarized records from a Royal Australasian Ornithologists' Union Western Australian Group field excursion in 1972, I. Abbott (1977) reported on some birds of Bernier and Dirk Hartog Islands from visits in June and July 1976, M. Howard (1978) published observations on the birds of Bernier Island during a visit in September,

1977, and P.G. Cale (1992) published an annotated list of the birds of Dorre Island from a visit in October 1988. Storr (1985, 1990) provided overviews of the region's birds, including seabirds, but provided little information on abundance. The only previous survey of many of the smaller islands was by K.D. Morris in September 1989 (in the Department of Conservation and Land Management Seabird Breeding Islands Database (CALM SBID), Burbidge and Fuller 1996).

METHODS

We made two visits to almost all of the smaller Shark Bay islands, one in autumn and one in spring. The first visit was from 6 to 13 May 1997, and the second from 16 to 23 September 1997. We used CALM's 7 m research vessel *Caretta* to travel to and between the islands. If weather conditions permitted a landing, one or two persons traversed the whole island searching for evidence of seabird breeding. If a colonial species, such as Pied Cormorant or Crested Tern, was located, a complete nest count was carried out if the birds were on eggs or had very small chicks; if, however, the colony contained large young that might panic and scatter, we made an estimate of the number of breeding pairs from a safe distance. For Silver Gull colonies, where nests are scattered and often well hidden, complete counts were not always possible and we examined a sample of nests to obtain data on stage of breeding, and estimated the total number of breeding pairs. The number of occupied or recently-renovated Wedge-tailed Shearwater burrows was estimated, not counted, and our estimates may not be accurate. We also recorded non-breeding seabirds and other birds on each island.

In this paper we have used a wide definition of seabird. As well as including traditional seabird groups such as shearwaters, gulls and terns (see Ross *et al.* 1995), we have also included Eastern Reef Egret, oystercatchers, Osprey and White-bellied Sea-Eagle (see Burbidge and Fuller 1996).

Published data are included below, as are unpublished data from the CALM SBID and from a recent visit to some islands by R.E. Johnstone (Museum of Natural Science, WA Museum) and others.

ANNOTATED LIST OF ISLANDS

Islands are listed in alphabetical order.

Baudin Island

Location 26°30'55"S, 113°38'56"E. South-western part of Freycinet Sound.
Tenure Nature Reserve 26004.
Description High limestone island with limestone headlands and cliffs, sandy beaches, and varying depths of sand over the limestone. *Spinifex longifolius, Nitraria billardierei* and *Scaevola crassifolia* behind beaches, low heath on uplands, *Nitraria billardierei* shrublands on limestone talus slopes. Alford *et al.* (in prep.) recorded 92 plant species, including nine aliens. Mined for guano.
Breeding seabirds 1997
Silver Gull – May: about 15 pairs present, 6 nests located, ready for eggs or with eggs.
Caspian Tern – September: 2 birds, new scrape.
Previous seabird breeding records
Wedge-tailed Shearwater – 1 September 1965: *c.* 100 (Serventy 1972).
Osprey – old nest present 1997. September 1989: 1 nest (K.D. Morris in CALM SBID).
Silver Gull – September 1989: no data (K.D. Morris in CALM SBID).
Caspian Tern – September 1989: 1 nest (K.D. Morris in CALM SBID).
Crested Tern – September 1989: no data (K.D. Morris in CALM SBID).
Other seabirds present 1997
Pied Cormorant – May: 16. September: *c.* 40.
Pied Oystercatcher – May: 1. September: 1.
Pacific Gull – May: 1. September: 1.
Other birds present 1997
Australian Kestrel – September: 1.
Welcome Swallow – May: common, old nest in cave. September: *c.* 10.
Grey Fantail – May: 1.
Rock Parrot – May: common. September: *c.* 30.
Richard's Pipit – May: common. September: 2.
Silvereye – September: *c.* 12.
Little Woodswallow – May: 6.
Little Crow – May: 1996 nest.
Serventy (1972) reports that G.M. Storr located *c.* 100 Wedge-tailed Shearwater burrows on the south-west face of the island in 1965, but noted that he did not find burrows of this species during a visit in October 1947. We saw no burrows. At the time of our visits a south-facing slope had recently been covered with wind-blown sea grass to a considerable depth and it is possible that this is the area referred to by Storr.

Bernier Island

Location 24°51'S, 113°08'E. With Dorre Island, Bernier Island forms the north-western margin of Shark Bay west of Carnarvon.
Tenure Nature Reserve A24869.
Description A large island of 4267 ha. For a description see Ride *et al.* (1962).
Breeding seabirds 1997 We did not visit this island.
Previous seabird breeding records
Osprey – September 1977: 2 nests (Howard 1977). August 1987: 1 nest (K.D. Morris in CALM SBID).
White-bellied Sea-Eagle – September 1977: 1 nest (Howard 1977).
Pied Oystercatcher – September 1977: 1 nest (Howard 1977).
Pacific Gull – no data (Serventy *et al.* 1971). August 1987: 2 nests (K.D. Morris in CALM SBID).
Silver Gull – June 1976: 1 nest (Abbott 1977).

Brown Inlet (unnamed island)

Location 26°27'22"S, 113°29'24"E. In Brown Inlet, west of Carrarang Homestead.
Tenure Vacant Crown land.
Description Small limestone island, slightly domed and lightly vegetated.
Breeding seabirds 1997
Caspian Tern – September: 1 nest with 2 small chicks.
Silver Gull – September: *c.* 55 birds present, 3 old nests, 3 runners.
Eastern Reef Egret – September: single nest under dense *Nitraria,* with 3 eggs.
Osprey – nest with 2 eggs.
Previous seabird breeding records Nil.
Other seabirds present 1997
Pied Cormorant – September: 8.
Other birds present 1997 Nil.

Charlie Island

Location 26°22'04"S, 113°34'08"E. Freycinet Sound near Carrarang Peninsula.
Tenure Nature Reserve A33828.
Description Limestone plateau with low shrubland of *Nitraria billardierei*. Not mined for guano.
Breeding seabirds 1997
Silver Gull – May: 15 birds present, 2 nests located with eggs. September: 25 birds present, 1 runner, 3 old nests.
Caspian Tern – September: pair with nest with 1 egg.
Previous seabird breeding records
Osprey – May 1997: old nest. September 1989: 1 nest (K.D. Morris in CALM SBID).
Pacific Gull – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
Caspian Tern – September 1989: 1 nest (K.D. Morris in CALM SBID).
Bridled Tern – no data (Storr 1985).
Other seabirds present 1997
Pied Cormorant – May: 25. September: 160.
Osprey – May: 1. September: 1.
Crested Tern – May: 3.
Other birds present 1997
Common Sandpiper – September: 1.
Ruddy Turnstone – September: 2.
Welcome Swallow – May: 2.

Charlie (islet to south-west)

Location 26°23'02"S, 113°31'51"E. Freycinet Sound near Carrarang Peninsula.
Tenure Vacant Crown land.
Description Flat rock with low vegetation.
Breeding seabirds 1997
Silver Gull – September: dead chick, 2 old nests.
Previous seabird breeding records
Pied Cormorant – September 1989: 30 nests (K.D. Morris in CALM SBID).
Other seabirds present 1997
Pied Cormorant – September: 35.
Silver Gull – September: 8.
Other birds present 1997
Ruddy Turnstone – September: 2.
Welcome Swallow – September: 2.
Comments Not visited in May.

Depuch Loop (unnamed islet)

Location 26°31'11"S, 113°35'40"E. Northern end of Depuch Loop on eastern side, north-west of Top Boorabuggatta Well.
Tenure Vacant Crown land.
Description Low rocky islet.
Breeding seabirds 1997
Osprey – September: nest with 2 chicks, 1 egg.
Pied Cormorant – September: 8 empty recently used nests, 1 with large chick.
Silver Gull – September: several old nests, 1 dead runner.
Pied Oystercatcher – September: nest with 2 eggs.
Previous seabird breeding records Nil.
Other birds present 1997
Welcome Swallow – September: 3.
Comments Not visited in May.

Dirk Hartog Island

Location 25°50'S, 113°03'E. A large island of about 62 000 ha which forms the western margin of Denham Sound.
Tenure Pastoral lease.
Description See Burbidge and George (1978).
Breeding seabirds 1997
Pied Cormorant – September: *c.* 600 nests with partially fledged chicks and flying young at Quoin Bluff South. (Colony had not commenced nesting in May.)
Osprey – September: 3 active nests on east coast between Sunday Island and Louisa Bay.
White-bellied Sea-Eagle – September: nest with single large chick at Quoin Bluff South above Pied Cormorant colony.
Previous seabird breeding records
Pied Cormorant – August 1920: 'Two large breeding colonies exist on Dirk Hartog Island – *viz.*, at Quoin Bluff and at another headland to the north, generally known as 'Shag Mia ... I estimated the number of nests (at Quoin Bluff) at over 2500' (Whitlock 1921, p. 175) and 'breeding in a great colony on Quoin Bluff. ... Thousands of young, in various stages of growth were noted. Date, 19th August, 1920' (White 1921, p. 189, reporting Whitlock's visit). September 1927: 'nesting in great numbers on the Quoin Bluff ... young fully fledged (I was there in the third week of September)' (Chenery 1928, p. 225, see also Ashby 1929). No data (Serventy *et al.* 1971; K.D. Morris in CALM SBID). September 1972: *c.* 2500 nests (Burbidge and George 1978). August-September 1973: 'large colony at Quoin Bluff containing an estimated 3000 plus birds'

(Wells and Wells 1974, p. 20). December 1976: numerous old nests (P.J. Fuller and A.A. Burbidge in CALM SBID). All these records, except for Whitlock's 1921 visit, are from Quoin Bluff South. In September we searched the coast northwards from Quoin Bluff to near Sandy Point but found no other colony. The Pied Cormorant colony at Quoin Bluff South, like many other colonies of this species, is located in different areas in different years. In September 1997 the colony was on the north side of the bluff; however, old nests were visible on the south side.
Osprey – September 1972: 'several' nests (Burbidge and George 1978). August-September 1973: 4 nests (Wells and Wells 1974).
White-bellied Sea-Eagle – September 1972: 1 nest (Burbidge and George 1978). August 1973: 1 nest (Wells and Wells 1974). December 1976: 1 nest (P.J. Fuller and A.A. Burbidge in CALM SBID). All these records are from Quoin Bluff South.
Pied Oystercatcher – August 1973: 1 nest (Wells and Wells 1974).
Silver Gull – 'A colony breeds amongst a host of Pied Cormorants at the Quoin Bluff' (Whitlock 1921). No data (Serventy *et al.* 1971; K.D. Morris in CALM SBID). August 1973: no data (Wells and Wells 1974).
Caspian Tern – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID). September 1972: 1 nest at Cape Ransonnet (Burbidge and George 1978).
Fairy Tern – 1920: 'about a week later (after 24 September) several eggs were sent to me from Dirk Hartog; they had been taken from the beach within a mile of the homestead' (Whitlock 1921, p. 173); no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
Bridled Tern – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).

Other seabirds present 1997 Not recorded, as only a small part of the coast was searched.

Other birds present 1997 Not recorded: we landed only at Quoin Bluff South in May and September. For comprehensive lists of birds see Carter (1917, 1923), Whitlock (1921), Sedgwick (1967, 1968), Davies and Chapman (1975), Burbidge and George (1978) and Wells and Wells (1974).

Dorre Island

Location 25°03'S, 113°06'E. With Bernier Island, Dorre Island forms the north-western margin of Shark Bay to the west of Carnarvon.

Tenure Nature Reserve A24869.

Description A large Island of 5163 ha. For a description see Ride *et al.* (1962).

Breeding seabirds 1997 We did not visit this island.

Previous seabird breeding records

Pied Cormorant – August 1977: no data (R.I.T. Prince in CALM SBID); no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
Eastern Reef Egret – August 1978: no data (R.I.T. Prince in CALM SBID).
Osprey – October 1975: no data (R.I.T. Prince in CALM SBID). August 1977: no data (R.I.T. Prince in CALM SBID). October 1988: 2 nests (Cale 1992); no data (K.D. Morris in CALM SBID).
White-bellied Sea-Eagle – December 1973 and August 1978: no data (R.I.T. Prince in CALM SBID); no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
Pied Oystercatcher – October 1988: 1 nest (Cale 1992).
Pacific Gull – October 1975: (R.I.T. Prince in CALM SBID). October 1988: 1 nest (Cale 1992); no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
Silver Gull – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
Caspian Tern – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
Crested Tern – no data (Storr 1985).
Fairy Tern – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).

Double Island

Location 26°24'58"S, 113°37'00"E. Western Freycinet Sound off Carrarang Peninsula.

Tenure: Nature Reserve 26004.

Description: Two limestone plateaux with talus slopes. *Nitraria billardierei* shrubland on slopes and grasses and herbs on plateaux. Probably mined for guano.

Breeding seabirds 1997

Wedge-tailed Shearwater – September: *c.* 160 freshly-excavated nesting burrows.

Previous seabird breeding records

Wedge-tailed Shearwater – October 1947: a 'few' burrows (Serventy 1972). April 1971: *c.* 50 burrows (Serventy 1972). September 1989: 11–100 nests (K.D. Morris in CALM SBID).
Pied Cormorant – old nests present in September 1997; no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
White-bellied Sea-Eagle – no data (K.D. Morris in CALM SBID).
Bridled Tern – no data (Storr 1985; K.D. Morris in CALM SBID).

Other seabirds present 1997

Pied Cormorant – May: 12. September: 15–20.
Silver Gull – September: 10.
Caspian Tern – September: 2.
Crested Tern – September: 2.
Bridled Tern – September: 4.

Other birds present 1997

Welcome Swallow – May: 2.
Little Crow – May: 1.

Comments We did not land in May.

Eagle Island

Location 26°05'41"S, 113°34'31"E. Freycinet Reach, off Eagle Bluff, Peron Peninsula.

Tenure Vacant Crown land.

Description Limestone dome, with low cliffs and a low dune on the south-eastern end, vegetated with a *Nitraria billardierei* shrubland and herbs. Alford *et al.* (in prep.) recorded seven plant species, including three aliens.

Breeding seabirds 1997
Silver Gull – May: *c.* 140 birds present, 32 nests located, ready for eggs or with eggs. September: *c.* 180 birds present, 2 nests with eggs, 4 runners, many old nests.
Caspian Tern – September: nest with 2 eggs.
Previous seabird breeding records
Osprey – September 1989: 1 nest (K.D. Morris in CALM SBID).
Pied Oystercatcher – no data (K.D. Morris in CALM SBID).
Silver Gull – September 1989: 11–100 nests (K.D. Morris in CALM SBID).
Caspian Tern – September 1989: 1 nest (K.D. Morris in CALM SBID).
Other seabirds present 1997
Pied Cormorant – May: 16. September: 240.
Osprey – May: 1.
Other birds present 1997
Rock Parrot – May: 4.
Welcome Swallow – May: 7. September: 10–15.

Eagle Island (islet to south)

Location About 100 m south of Eagle Island.
Tenure Vacant Crown land.
Description Shrubland of *Nitraria billardierei*. Alford *et al.* (in prep.) noted several other species; however, they did not land on the islet.
Breeding seabirds 1997 Nil.
Previous seabird breeding records Nil.
Other seabirds present 1997
Pied Cormorant – May: 15. September: 40.
Silver Gull – May: 2. September: 15.
Other birds present 1997 Nil.

Egg Island

Location 25°54'35"S, 113°09'21"E. In Tetradon Loop, south of Quoin Bluff South, off east coast of Dirk Hartog Island. Also known as Tetradon Island.
Tenure Nature Reserve 26004.
Description Dome-shaped, rock-based with extensive guano and sand, mostly unvegetated, with a few shrubs of *Nitraria billardierei* on north-east corner. Mined for guano.
Breeding seabirds 1997
Silver Gull – May: *c.* 160 birds present, 47 nests located, ready for eggs or with eggs. September: *c.* 180 to 200 birds present, 2 nests with eggs, 3 runners.
Breeding seabirds 1998 (Johnstone[1], personal communication)
Silver Gull – 15 August: *c.* 200 birds present, 32 nests with eggs located, 6 runners.
Previous seabird breeding records
Silver Gull – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
Caspian Tern – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
Crested Tern – many broken eggs found in May 1997, probably bred in spring or summer of 1996.
Bridled Tern – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
Other seabirds present 1997
Pied Cormorant – May: 150. September: 200–220.
Australian Pelican – May: 6.
Pied Oystercatcher – September: 1.
Pacific Gull – May: 1.
Other birds present 1997 Nil.

Faure Island

Location 25°52'S, 113°54'E. Disappointment Reach, north of Petit Point, east-south-east of Monkey Mia.
Tenure Pastoral lease.
Description A large island of 5148 ha, leased for pastoral purposes.
Breeding seabirds 1997 We did not visit this island.
Previous seabird breeding records
Caspian Tern – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).

Freycinet Island

Location 26°24"S, 113°37'E. Western Freycinet Sound off Carrarang Peninsula.
Tenure Nature Reserve 26004.
Description High limestone plateau with talus slopes and a peak at the northern end. Slopes vegetated with *Nitraria billardierei* shrubland, many shrubs showing damage owing to nesting and roosting cormorants. Plateau with herbfields. Mined for guano. Alford *et al.* (in prep.) recorded 34 plant species, six of them aliens.
Breeding seabirds 1997
Wedge-tailed Shearwater – September: *c.* 200 freshly excavated nesting burrows, some nests occupied in daytime.
Pied Cormorant – May: *c.* 1500 nests on western slope towards north end of island, 40 per cent with 1 or 2 eggs and 60 per cent under construction or ready for eggs. Old breeding colony at southern end of island. September: *c.* 1000 birds present, breeding completed.
Silver Gull – May: *c.* 250 birds present, 37 nests located, ready for eggs or with eggs. Estimated total of 80 to 90 nests.
Previous seabird breeding records
Wedge-tailed Shearwater – October 1947: *c.* 50 burrows on western side (Serventy 1972). October 1965: *c.* 500 burrows on southern and western slopes (Serventy 1972). April 1971: *c.* 250 burrows (Serventy *et al.* 1971). September 1989: 100–500 nests (K.D. Morris in CALM SBID).
Pied Cormorant – no data (Serventy *et al.* 1971). September 1989: 500–1000 nests (K.D. Morris in CALM SBID).
Eastern Reef Egret – September 1989: 1 nest (K.D. Morris in CALM SBID).

[1] R.E. Johnstone, Museum of Natural Science, Western Australian Museum, Francis St, Perth WA 6000

Silver Gull – September 1989: 2 nests (K.D. Morris in CALM SBID).
Caspian Tern – September 1989: 1 nest (K.D. Morris in CALM SBID).
Bridled Tern – no data (Serventy *et al.* 1971). September 1989: no data (K.D. Morris in CALM SBID).
Other seabirds present 1997
White-bellied Sea-Eagle – September: 2.
Pied Oystercatcher – September: 2.
Caspian Tern – September: 2.
Other birds present 1997
Australian Kestrel – September: 1.
Banded Land-rail – September: 1 runner.
Common Sandpiper – September: 1.
Ruddy Turnstone – September: 4.
Rock Parrot – May: 10. September: *c.* 35.
Welcome Swallow – May: 8–10. September: common.
Richard's Pipit – September: 2.

Friday Island

Location 26°06'10"S, 113°24'10"E. In Freycinet Reach, off western side of Heirisson Prong and south of causeway to Slope Island.
Tenure Nature Reserve A33829.
Description Limestone plateau with talus slope to north and a small beach on the southern side, *Nitraria billardierei* shrubland on talus, low shrubs and herbs behind beach and no vegetation on plateau. Mined for guano.
Breeding seabirds 1997
Wedge-tailed Shearwater – September: *c.* 65 freshly excavated burrows.
Pied Cormorant – September: 88 nests with young almost ready to fly.
Silver Gull – September: *c.* 120 birds present, 2 nests with eggs, 4 runners, breeding mostly finished.
Previous seabird breeding records
Wedge-tailed Shearwater – September 1965: *c.* 50 nests (Serventy 1972). September 1972: no data (N. Beeck in CALM SBID).
Pied Cormorant – September 1989: 100–500 nests (K.D. Morris in CALM SBID).
Silver Gull – September 1989: 11–100 nests (K.D. Morris in CALM SBID).
Caspian Tern – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
Bridled Tern – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
Other seabirds present 1997
Eastern Reef Egret – September: 2.
Other birds present 1997
Rock Parrot – September: *c.* 10.
Ruddy Turnstone – September: 4.
Red-necked Stint – September: 2.
Comments Not visited in May owing to adverse weather conditions.

Kangaroo Island

Location 26°19'10"S, 113°29'59"E. Boat Haven Loop.
Tenure Vacant Crown land.
Description Low plateau with herbfield on shallow soils and a low dune with *Nitraria billardierei* shrubland, surrounded by low cliffs with *Nitraria billardierei* shrubland. Alford *et al.* (in prep.) recorded 11 plant species, including five aliens. Mined for guano.
Breeding seabirds 1997
Osprey – September: nest with 2 chicks and addled egg.
Pied Oystercatcher – September: pair with 1 runner.
Pacific Gull – September: 2 new nests.
Silver Gull – May: 6 birds present, 1 nest located with single egg. September: 160 birds present, nest with 2 eggs.
Previous seabird breeding records
Osprey – September 1989: 1 nest (K.D. Morris in CALM SBID).
Pacific Gull – September 1989: 4 nests (K.D. Morris in CALM SBID).
Silver Gull – September 1989: 11–100 nests (K.D. Morris in CALM SBID).
Caspian Tern – September 1989: 1 nest (K.D. Morris in CALM SBID).
Other seabirds present 1997
Pied Cormorant – May: 11.
Eastern Reef Egret – September: 2.
Osprey – May: 1.
Pacific Gull – May: 2.
Other birds present 1997
Welcome Swallow – May: 5.

Kangaroo Island (islet to south)

Location 26°20'29"S, 113°30'52"E. Boat Haven Loop.
Tenure Vacant Crown land.
Description Low dome-shaped islet with *Nitraria billardierei* shrubs near edge and herbs or bare sand elsewhere.
Breeding seabirds 1997
Pied Cormorant – May: 63 nests, 37 with eggs and 26 under construction or ready for eggs. September: 10 nests with eggs, 13 nests with unfledged young.
Osprey – September: nest with 1 egg.
Silver Gull – May: 12 birds present, 4 nests located, ready for eggs or with eggs. September: 10–12 birds present, 3 dead chicks and several runners.
Caspian Tern – September: nest with 1 egg.
Previous seabird breeding records Nil.
Other seabirds present 1997
Osprey – May: 1.
Pied Oystercatcher – September: 2.
Other birds present 1997
Rock Parrot – May: 5. September: *c.* 8, nest with chicks under loose limestone slab.
Welcome Swallow – September: *c.* 5.

Koks Island

Location 24°45'03"S, 113°09'34"E. Off northern tip of Bernier Island.
Tenure Nature Reserve A33901.
Description Limestone plateau with surrounding cliffs.
Breeding seabirds 1997 We did not visit this island.
Previous seabird breeding records
Crested Tern – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
Roseate Tern – no data (K.D. Morris in CALM SBID).
Fairy Tern – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).

Lefebre Island

Location 26°13'51"S, 113°30'26"E. Freycinet Sound, north of Carrarang Peninsula and east of Edel Land.
Tenure Vacant Crown land.
Description A rocky island with scanty vegetation.
Breeding seabirds 1997 May: Nil. September: Nil.
Previous seabird breeding records
Wedge-tailed Shearwater – no data (Storr 1985).
Pied Cormorant – no data (K.D. Morris in CALM SBID).
Other seabirds present 1997
Pied Cormorant – May: 80. September: 250–300.
Ruddy Turnstone – September: 2.
Silver Gull – May: 15. September: 20.
Rock Parrot – September: 10.
Other birds present 1997 Nil.

Mary Anne Island

Location 26°29'07"S, 113°41'00"E. Southern Freycinet Sound.
Tenure Nature Reserve 26004.
Description Limestone plateau and talus slopes, *Nitraria billardierei* shrubland on slopes, plateau with grasses and herbs. Mined for guano. Alford *et al.* (in prep.) recorded 16 plant species, including four aliens.
Breeding seabirds 1997
Pied Oystercatcher – September: nest with 1 egg.
Pacific Gull – September: pair with newly constructed nest.
Silver Gull – May: about 90 present, 21 nests located, ready for eggs or with eggs. September: 25 to 30 birds present, 1 nest with 2 eggs plus dead runners.
Roseate Tern – May: 138 nests: 20 new scrapes, 83 with 1 egg, 35 with 2 eggs.
Previous seabird breeding records
Pied Cormorant – no data (Serventy *et al.* 1971).
Osprey – September 1989: 1 nest (K.D. Morris in CALM SBID).
Pied Oystercatcher – September 1989: 2 nests (K.D. Morris in CALM SBID).
Pacific Gull – September 1989: 1 nest (K.D. Morris in CALM SBID).
Silver Gull – September 1989: 9 nests (K.D. Morris in CALM SBID).
Caspian Tern – September 1989: 1 nest (K.D. Morris in CALM SBID).
Crested Tern – no data (Serventy *et al.* 1971).
Bridled Tern – no data (Storr 1985).
Other seabirds present 1997
Pied Cormorant – May: 35. September: *c.* 50.
Caspian Tern – September: 2.
Other birds present 1997
Ruddy Turnstone – September: 20.
Welcome Swallow – September: *c.* 5.

Meade Island

Location 26°00'06"S, 113°11'58"E. About 75 m off east coast of Dirk Hartog Island, adjacent to homestead.
Tenure Vacant Crown land.
Description Low limestone island with small pockets of sand. *Nitraria billardierei* shrubland with halophytes.
Breeding seabirds 1997
Osprey – September: nest with chicks.
Silver Gull – May: *c.* 40 birds present, 3 nests located, 1 with addled egg and 2 new nests. September: *c.* 50 birds present, 4 nests with eggs, 3 runners, breeding almost completed.
Breeding seabirds 1998 (Johnstone, personal communication)
Osprey – 3 August, 15 August: nest with 3 eggs.
Silver Gull – 3 August: 2 nests with eggs, 2 runners. 15 August: 3 nests with eggs.
Crested Tern – 3 August: *c.* 45 runners, *c.* 60 recently fledged birds. 15 August: 50–60 feathered runners, *c.* 50 recently-fledged young.
Lesser Crested Tern – 3 August: 10–15 runners, 1 broken egg. 15 August: 2–3 runners, 6 recently-fledged young.
Previous seabird breeding records
Silver Gull – no data (K.D. Morris in CALM SBID); May 1978: 9 nests (P.J. Fuller and A.A. Burbidge in CALM SBID); February 1985: no data (A.A. Burbidge in CALM SBID).
Crested Tern – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID); September 1972: 1 chick (Burbidge and George 1978).
Roseate Tern – no data (K.D. Morris in CALM SBID). December 1976: 200–300 nests (Burbidge and George 1978).
Fairy Tern – no data (K.D. Morris in CALM SBID).
Other seabirds present 1997
Pied Cormorant – May: 15. September: 25.
Australian Pelican – September: 4.
Osprey – May: 1.
Pied Oystercatcher – September: 2.
Crested Tern – September: 6.
Other birds present 1997
Rock Parrot – May: 2.
Comments May: A recently-dead Feral Cat (*Felis catus*) found on island. Feral cats are abundant on the adjacent Dirk Hartog Island.

North Guana Island

Location 26°32'00"S, 113°41'26"E. Southern Freycinet Sound, west of Salutation Island and north of Baba Head.

Tenure Nature Reserve 26004.
Description Limestone plateau and talus slopes. Slopes vegetated with *Nitraria billardierei* shrubland, grassland on plateau. Alford *et al.* (in prep.) recorded 17 plant species, including three aliens. Plateau mined for guano.
Breeding seabirds 1997
Osprey – September: nest with 1 egg.
Pacific Gull – September: 2 new nests.
Silver Gull – May: 50 birds present, 11 nests located, ready for eggs or with eggs. September: 15 to 20 birds present, old nests seen plus dead runners.
Previous seabird breeding records
Osprey – September 1989: 2 nests (K.D. Morris in CALM SBID).
Bridled Tern – September 1989: 15 nests (K.D. Morris in CALM SBID).
Other seabirds present 1997
Pied Cormorant – May: 8. September: 15.
Osprey – May: 3.
Pied Oystercatcher – September: 1.
Roseate tern – September: 4.
Fairy Tern – September: 6.
Other birds present 1997
Rock Parrot – May: common. September: *c.* 35.
Welcome Swallow – May: 5. September: *c.* 6.
Richard's Pipit – September: 2.

North Guano, islet to west

Location Freycinet Sound, about 150 m west of North Guano Island.
Tenure Vacant Crown land.
Description Rugged limestone rock with *Nitraria billardierei* shrubland. 'Little Guano Rock' of Alford *et al.* (in prep.), who recorded eight plant species.
Breeding seabirds 1997
Roseate Tern – May: 92 nests all with eggs.
Previous seabird breeding records Nil.
Other seabirds present 1997
Pied Cormorant – September: 25.
Silver Gull – September: 2.
Crested Tern – September: 2.
Other birds present 1997 Nil.

North Kangaroo Island

Location 26°17'58"S, 113°30'12"E. Boat Haven Loop.
Tenure Vacant Crown land.
Description Small plateau with *Calandrinia polyandra* herbfield, surrounding low cliffs vegetated with *Nitraria billardierei* shrubs. Alford *et al.* (in prep.) recorded 15 plant species including three aliens. In our September visit most of the island was covered with the introduced Ice Plant (*Mesembryanthemum crystallinum*). Alford *et al.* (in prep.) reported that the island had been mined for guano, but we saw no sign of this.
Breeding seabirds 1997
Fairy Tern – September: 6 nests with eggs.
Previous seabird breeding records Nil.
Other seabirds present 1997
Pied Cormorant – May: 6. September: 5.
Eastern Reef Egret – September: 1.
Osprey – May: 1.
Pied Oystercatcher – September: 1.
Silver Gull – September: 6.
Caspian Tern – September: 2.
Other birds present 1997
Rock Parrot – May: 4. September: 6.
Welcome Swallow – September: *c.* 10.
Richard's Pipit – May: 2.
Comments We did not land in May.

Pelican Island

Location 25°51'13"S, 114°00'49"E. Disappointment Reach, east of Faure Island.
Tenure Nature Reserve 26004.
Description Sand cay on large limestone reef, covered with closed shrubland of *Nitraria billardierei*, some of which shows damage from cormorant colonies. Narrow beaches surround the island.
Breeding seabirds 1997
Pied Cormorant – May: *c.* 1150 nests towards northern tip of island, most were new nests ready for eggs or with up to 4 eggs; about 150 nests towards southern end of colony with large young. Old colonies evident (old nests) in regenerating *Nitraria* towards southern end of island. No birds breeding in September.
Australian Pelican – May: 92 nests on western edge of island towards northern end, all with 1 or 2 eggs. September: 6 three-quarter grown young in crèche, 30–40 adults at island.
Pied Oystercatcher – September: 4 nests with eggs.
Silver Gull – May: about 350 birds present, 42 nests located, ready for eggs or with eggs.
Previous seabird breeding records
Lane and Pearson[2] (personal communication) recorded the following data during a study of pelican biology during the 1970s.
Australian Pelican – 19 May 1974: *c.* 60 pairs on eggs. 10 July 1975*: *c.* 70 pairs on nests. 4 September 1975: *c.* 30 flightless young (out of nest). 20 March 1976*: no nesting. 1 August 1976*: *c.* 20 pairs nesting. 7 October 1976*: no nesting. 4 February 1977*: no nesting. 1 April 1977*: no nesting. 8 August 1977*: a crèche of flightless young, estimated 30–35 birds. 1 March 1978: no nesting. 12 September 1978: *c.* 40 large chicks in crèche, 1 nest with single egg. [* denotes aerial survey.] Lane and Pearson also recorded the following data on other seabirds.
Pied Cormorant – 19 May 1974: several thousand. 10 July 1974: nesting, no estimate made. 1 April 1977: several thousand nesting. 12 September 1978: several thousand nests.
Pied Oystercatcher – 4 September 1975: 'numerous' pairs on eggs.
Pacific Gull – 12 September 1978: 2 nests with eggs.
Caspian Tern – 12 September 1978: 40 nests containing eggs, eggs and chicks, and chicks.

[2] J.A.K.Lane, CALM**Science** Division, Busselton.
G.B.Pearson, CALM**Science** Division, Woodvale.

Other seabirds present 1997
Eastern Reef Egret – May: 1. September: 2 (probably breeding – bird flushed twice from dense vegetation).
White-bellied Sea-Eagle – September: 2.
Pied Oystercatcher – May: 45.
Silver Gull – September: 5.
Other birds present 1997
Grey-tailed Tattler – May: 1.
Bar-tailed Godwit – May: 2. September: 12.
Curlew Sandpiper – September: 4.
Red-necked Stint – September: several on reef.
Wedge-tailed Eagle – September: 1.
White-bellied Woodswallow – September: 7.
Notes Pelican Island is an important Australian Pelican and Pied Cormorant breeding site. Available data show that pelicans nest and lay in late autumn and that most young have left the island by October. The Pied Cormorant colony is one of three large colonies in Shark Bay, the others being at Quoin Bluff South on Dirk Hartog Island and on Freycinet Island. The 1978 record of a colony of Caspian Terns is the only record of colonial nesting of this species in Shark Bay.

Ransonnet Rock

Location 26°09'50"S, 113°12'52"E. In South Passage, off Cape Ransonnet, Dirk Hartog Island.
Tenure Vacant Crown land.
Description Small, unvegetated rock.
Breeding seabirds 1997 May: Nil.
Previous seabird breeding records Nil.
Other seabirds present 1997 May: Nil.
Other birds present 1997 May: Nil.
Comments Not visited in September.

Salutation Island

Location 26°32'S, 113°46'E. Southern Freycinet Sound.
Tenure Nature Reserve 26004.
Description Rocky limestone headlands with sandy beaches, inland areas mainly sand. Inland areas vegetated with low open shrubland of *Acacia rostellifera* over low shrubs, grasses and herbs. Alford *et al.* (in prep.) recorded 109 plant species, 14 of them aliens.
Breeding seabirds 1997
Osprey – September: nest ready for eggs.
Pied Oystercatcher – September: 4 nests with 1 or 2 eggs.
Pacific Gull – September: 3 nests ready for eggs.
Caspian Tern – September: 5 nests all with a single egg.
Previous seabird breeding records
Pied Cormorant – September 1989: 100 nests (K.D. Morris in CALM SBID).
Osprey – August–September 1972: 1 nest with chick (Davies and Chapman 1975).
Pied Oystercatcher – September 1989: 1 nest (K.D. Morris in CALM SBID).
Pacific Gull – August–September 1972: 9 nests with eggs (Davies and Chapman 1975). September 1989: 2 nests (K.D. Morris in CALM SBID).
Silver Gull – September 1989: 11–50 nests (K.D. Morris in CALM SBID).
Caspian Tern – September 1989: 1 nest (K.D. Morris in CALM SBID).
Other seabirds present 1997
Pied Cormorant – May: 10. September: *c.* 90.
Pied Oystercatcher – May: 2.
Pacific Gull – May: 4.
Silver Gull – September: *c.* 25.
Crested Tern – September: 12.
Other birds present 1997
Wedge-tailed Eagle – September: 1.
White-faced Heron – May: 1.
Greenshank – September: 4.
Grey-tailed Tattler – September: 2.
Common Sandpiper – September: 1.
Red-necked Stint – September: 4.
Australian Kestrel – September: 2.
Rock Parrot – September: 6.
Welcome Swallow – May and September: common.
Quail, probably Brown Quail – May: 4. September: 12.
Richard's Pipit – May: common. September: 4.
Willie Wagtail – May: 1.
Singing Honeyeater – September: 3.
Comments Tracks and stick nests of Wopilkara (Greater Stick-nest Rat) *Leporillus conditor* abundant and four animals seen in daylight during the September visit. This species has been introduced as part of the implementation of a recovery plan.

Salutation Island (islet to south)

Location About 100 m off the south-east corner of Salutation Island.
Tenure Nature Reserve 26004.
Description Flat topped rock with sparse vegetation.
Breeding seabirds 1997
Silver Gull – September: 40 birds present, 3 runners.
Previous seabird breeding records
Pied Cormorant – September 1989: 20–50 old nests (K.D. Morris in CALM SBID).
Other seabirds present 1997
Pied Cormorant – September: 80.
Other birds present 1997 Nil.
Comments Not visited in May.

Slope Island

Location 26°05'47"S, 113°24'53"E. Freycinet Reach to east of Heirisson Prong.
Tenure Mining lease.
Description Connected to mainland by causeway in late 1966 or early 1967. Most of the island has been destroyed or severely degraded by the construction of a salt-loading facility. Some remnant *Nitraria billardierei* shrubland on talus slopes. Alford *et al.* (in prep.) recorded four plant species, including one alien.
Breeding seabirds 1997 Nil.
Previous seabird breeding records
Wedge-tailed Shearwater – 1943: no data (Serventy 1972). 28 August 1965: 150–200 breeding pairs (Serventy 1972). April 1971: *c.* 150 pairs (Serventy 1972). February 1980: no data (K. Marshall in CALM SBID).

Bridled Tern – 1917: 'Mr Carter obtained an egg on Slope Island' (Whitlock 1921). February 1980: no data (K. Marshall in CALM SBID).
Other seabirds present 1997
Pied Cormorant – September: 120.
Osprey – September: nest on jetty, with 2 birds in attendance.
Silver Gull – September: 50–60.
Other birds present 1997 Nil.
Comments Not visited in May. We searched for Wedge-tailed Shearwater burrows in September, but located none, although workers at the site told us that some birds still visited the area at night. Rabbits abundant in location where burrows formerly occurred.

Slope Island (island to north)

Location 26°03'28"S, 113°23'51"E. Freycinet Reach, about 4 km north of Slope Island salt loading facility.
Tenure Vacant Crown land.
Description Domed rocky islet with sparse vegetation. Mined for guano.
Breeding seabirds 1997
Wedge-tailed Shearwater – September: 68 freshly excavated burrows.
Silver Gull – May: 160 birds present, 38 nests located, ready for eggs or with eggs. September: *c.* 250 birds present, 3 nests with eggs, 4 runners.
Caspian Tern – September: nest with 2 small chicks.
Crested Tern – May: 410 nests, 34 scrapes, 376 with 1 egg.
Previous seabird breeding records Nil.
Other seabirds present 1997
Pied Cormorant – May: 24. September: *c.* 450.
Australian Pelican – September: 5.
Eastern Reef Egret – September: 1.
Pied Oystercatcher – May: 2.
Other birds present 1997
Ruddy Turnstone – May: 24. September: 14.

Smith Islands (north)

Location 26°35'00"S, 113°43'25"E. Southern Freycinet Sound.
Tenure Vacant Crown land.
Description Bare limestone.
Breeding seabirds 1997 None recorded
Previous seabird breeding records Nil.
Other seabirds present 1997
Pied Cormorant – September: 13.
Silver Gull – September: 4.
Other birds present 1997 Nil.
Comments Strong winds prevented landing in May.

Smith Islands (south)

Location 26°35'00"S, 113°43'25"E. Southern Freycinet Sound.
Tenure Vacant Crown land.
Description Bare limestone.
Breeding seabirds 1997
Eastern Reef Egret – September: nest with 2 eggs.
Osprey – September: nest with chick.
Silver Gull – September: 8–10 birds present, nest with addled egg, plus 2 runners.
Previous seabird breeding records
Osprey – September 1989: 1 nest (K.D. Morris in CALM SBID).
Pied Cormorant – September 1989: 5 nests (K.D. Morris in CALM SBID).
Other seabirds present 1997
Pied Cormorant – September: 15.
Other birds present 1997 Nil.
Comments: Strong winds prevented landing in May.

Smith Rocks

Location 26°05'41"S, 113°24'04"E. Freycinet Reach, off east coast of Heirisson Prong, to south of salt loading causeway.
Tenure Vacant Crown land.
Description Unvegetated rock.
Breeding seabirds 1997 Nil.
Previous seabird breeding records Nil.
Other seabirds present 1997 Nil.
Other birds present 1997 Nil.

South Guano Island

Location 26°32'46"S, 113°41'25"E. Southern Freycinet Sound, west of Salutation Island and north of Baba Head.
Tenure Nature Reserve 26004.
Description 3.717 ha. Limestone plateau with surrounding rugged talus slopes. Tall shrubland of *Nitraria billardierei* on talus, herbfields on plateau. Alford *et al.* (in prep.) recorded 22 plant species, including three aliens. Plateau mined for guano.
Breeding seabirds 1997
Wedge-tailed Shearwater – *c.* 80 freshly excavated burrows on western slopes.
Silver Gull – May: 100 birds present, 12 nests located, ready for eggs or with eggs. September: 35–40 birds present, 2 runners.
Previous seabird breeding records
Wedge-tailed Shearwater – September 1989: 6 nests (K.D. Morris in CALM SBID).
Osprey – old nest present in 1997.
Other seabirds present 1997
Pied Cormorant – May: 25. September: 45.
Eastern Reef Egret – September: 1.
Other birds present 1997
Rock Parrot – May: 6. September: 35.
Australian Kestrel – September: 1.
Welcome Swallow – May: 5.
Richard's Pipit – September: 2.

Three Bays Island

Location 26°33'16"S, 113°38'47"E. South-western Freycinet Sound.
Tenure Nature Reserve 26004.

Description Limestone headlands with low sandy areas and beaches between. Sandy areas have *Spinifex longifolius* and bands of *Nitraria billardierei*. Headlands with low heath of *Atriplex cinerea* and *Sarcostemma viminale*. Alford *et al.* (in prep.) recorded 80 plant species, including 12 aliens. Mined for guano.

Breeding seabirds 1997

Osprey – September: nest with 3 large young.
Pied Oystercatcher – September: pair seen whose behaviour indicated nesting, but nest not located.
Silver Gull – May: 9 nests located, ready for eggs or with eggs, *c.* 40 nests probable. September: breeding finished, several flying juveniles.
Caspian Tern – September: nest with 1 egg.
Crested Tern – May: 4 nests each with single egg on north-west slope of eastern headland. Seven pairs present.

Previous seabird breeding records

Osprey – we saw a nest judged to have been used in 1996. September 1989: 1 nest (K.D. Morris in CALM SBID).
Caspian Tern – September 1989: 2 nests (K.D. Morris in CALM SBID).
Pacific Gull – September 1989: 1 nest (K.D. Morris in CALM SBID).
Silver Gull – September 1989: no data (K.D. Morris in CALM SBID).

Other seabirds present 1997

Pied Cormorant – May: 30. September: *c.* 70.
Osprey – May: 2.
Pacific Gull – September: 2.
Silver Gull – September: *c.* 75.
Crested Tern – September: 33.

Other birds present 1997

Australian Kestrel – September: 1.
Rock Parrot – May: common. September: 6.
Welcome Swallow – May: 6. September: numerous.
Richard's Pipit – September: 2.
Silvereye – September: *c.* 10.

Comments Tracks of a small mammal, presumably *Mus domesticus*, seen behind northern beach. This species was trapped on Three Bays Island in 1989 (Morris[3], personal communication)

Sunday Island

Location 26°07'33"S, 113°14'07"E. Blind Strait, near Dirk Hartog Island.

Tenure Nature Reserve 26004.

Description Low limestone plateau surrounded by cliffs.

Breeding seabirds 1997

Osprey – September; nest with single egg.
Silver Gull – May: *c.* 140 birds present, 15 nests located, ready for eggs or with eggs. September: *c.* 40 birds present, 2 nests with eggs, several runners.
Crested Tern – May: 14 nests, 2 scrapes and 12 with 1 egg. September: 1 three-quarter fledged chick with broken wing.

Breeding seabirds 1998 (Johnstone, personal communication):

Silver Gull – 15 August: 200–300 birds present, 7 nests with eggs, 2 runners.
Bridled Tern – 15 August: old egg under *Nitraria billardierei* shrub.

Previous seabird breeding records

Osprey – no data (K.D. Morris in CALM SBID).
Pacific Gull – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
Caspian Tern – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
Crested Tern – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).
Bridled Tern – no data (Serventy *et al.* 1971; K.D. Morris in CALM SBID).

Other seabirds present 1997

Eastern Reef Egret – September: 2.
Osprey – May: 2.

Other birds present 1997 Nil.

White Island

Location 26°26'39"S, 113°45'42"E. Central Freycinet Sound.

Tenure Nature Reserve 26004.

Description Limestone, steep sides, flat top, scattered *Nitraria billardieri* on slopes, plateau unvegetated, mined for guano. Alford *et al.* (in prep.) recorded 15 plant species, five of them aliens.

Breeding seabirds 1997

Osprey – September: newly lined nest.
Silver Gull – May: 250 birds present, 24 nests located, ready for eggs or with eggs. Colony of about 100 pairs probable. September: 190–200 birds present, runners and flying juveniles.
Caspian Tern – September: nest with 2 eggs.

Previous seabird breeding records

White-bellied Sea-Eagle – no data (Storr 1985).
Osprey – In May 1997 we saw a nest judged to have been used in 1996.

Other seabirds present 1997

Pied Cormorant – May: 250. September: 220.
Bridled Tern – September: *c.* 70 pairs.

Other birds present 1997

Welcome Swallow – May: 5. September: 6.

Wilds Islands

Location 26°27'07"S, 113°36'55"E. Freycinet Sound, north of Giraud Point.

Tenure Nature Reserve 26004.

Description A group of three islands. The largest comprises a plateau with talus slopes, joined by a tombolo to a rugged rock, and the other two are unvegetated rocks. The plateau has been mined for guano and is vegetated with grasses and herbs, the slopes with a shrubland of *Nitraria billardierei*. Alford *et al.* (in prep.) recorded 13 plant species on the plateau and slopes, including five aliens, and nine plant species including three aliens on the vegetated rock.

[3] K.D. Morris, CALMScience Division, CALM, PO Box 51, Wanneroo, WA 6065

Breeding seabirds 1997
Silver Gull – May: 90 birds present, 26 nests located, ready for eggs or with eggs. September: 70 birds present, several flying young.
Previous seabird breeding records
Pied Cormorant – no data (Serventy *et al.* 1971).
September 1989: 100–500 nests (K.D. Morris in CALM SBID).
Silver Gull – September 1989: no data (K.D. Morris in CALM SBID).
Other seabirds present 1997
Pied Cormorant – May: 42.
Other birds present 1997
Rock Parrot – May: 5.

Wilds (islet to south)

Location 26°29'15"S, 113°36'43"E. Freycinet Sound near entrance to Depuch Loop.
Tenure Vacant Crown land.
Description Scattered *Nitraria billardierei* around edges, central parts bare. Alford *et al.* (in prep.) refer to this island as Depuch Island 'North'. Mined for guano.
Breeding seabirds 1997
Silver Gull – May: 30 birds present, 3 nests located, all with eggs.
Crested Tern – May: 13 nests all with 1 egg.
Previous seabird breeding records Nil.
Other seabirds present 1997
Osprey – May: 1.
Pacific Gull – May: 2.
Other birds present 1997
Ruddy Turnstone – May: 3.

Wilds (islet to south-west)

Location 26°29'16"S, 113°34'28"E. Depuch Loop, adjacent to Carrarang Peninsula.
Tenure Vacant Crown land.
Description Limestone boulders and guano; scattered herbs and grasses with some *Nitraria billardierei* shrubs. Alford *et al.* (in prep.) refer to this island as Depuch Island 'South'.
Breeding seabirds 1997
Silver Gull – May: *c.* 45 birds present, 5 nests located with eggs.
Previous seabird breeding records Nil.
Other seabirds present 1997
Pied Cormorant – May: 18. September: 50.
Pacific Gull – May: 3. September: 2.
Silver Gull – September: 2.
Other birds present 1997
Australian Kestrel – September: 1.
Rock Parrot – May: 30–35.
Welcome Swallow – May: 7.

Wilds (islets to west, North Islet)

Location 26°26'42"S, 113°34'15"E. Freycinet Sound, near entrance to Depuch Loop, adjacent to eastern side of Carrarang Peninsula.
Tenure Vacant Crown land.
Description Bare rock.
Breeding seabirds 1997 Nil.
Previous seabird breeding records
Silver Gull – September 1989: 20 nests (K.D. Morris in CALM SBID).
Other seabirds present 1997
Pied Cormorant – September: 25.
Silver Gull – September: 2.
Other birds present Nil.

Wilds (islets to west, South Islet)

Location 26°27'10"S, 113°34'28"E. Freycinet Sound, near entrance to Depuch Loop, adjacent to eastern side of Carrarang Peninsula.
Tenure Vacant Crown land.
Description Low domed rock with grassy plateau and some *Nitraria*. Mined for guano.
Breeding seabirds 1997
Eastern Reef Egret – September: 1 nest with 2 eggs under Osprey nest.
Osprey – September: 1 nest with 1 egg and 2 small chicks.
Silver Gull – September: breeding finished, 3 dead runners.
Caspian Tern – September: 1 nest with 1 egg.
Previous seabird breeding records
Pied Cormorant – September 1989: 50 nests (K.D. Morris in CALM SBID).
Silver Gull – September 1989: 50–100 nests (K.D. Morris in CALM SBID).
Other seabirds present 1997
Pied Cormorant – September: 15.
Pacific Gull – September: 2.
Other birds present
Rock Parrot – September: 15–20.

ANNOTATED LIST OF BREEDING SEABIRDS

Wedge-tailed Shearwater (*Puffinus pacificus*) recorded breeding on Baudin, Charlie, Double, Freycinet, Friday, Lefebre, Slope, Slope (island to N) and South Guano Islands. The largest colony we recorded, of *c.* 200 burrows, was on Freycinet Island. A widespread species breeding from near Perth around the northern coasts of Australia. Shark Bay colonies are much smaller than those in the Houtman Abrolhos (Fuller, Burbidge and Owens 1994) and on some islands off the Pilbara coast. The colony on Slope Island appears now to be effectively destroyed, owing to the construction of the salt loading port. Construction destroyed some, but not all, habitat; however, the causeway to the mainland allowed access to feral animals and this resulted in the Red Fox (*Vulpes vulpes*) predating adults and young, and the European Rabbit (*Oryctolagus cuniculus*) interfering with breeding burrows. Serventy (1972) reported that Shark Bay birds show a variation in plumage unknown elsewhere in WA (a proportion (*c.* 20 per cent) of the birds, instead of being

uniformly dark-plumaged, has white under-parts. This condition was first reported only in the Slope Island colony; however, work in 1965 and 1971 showed that it occurred in other Shark Bay islands as well. Serventy (1972) estimated a total of about 600 breeding pairs in Shark Bay, very similar to our 1997 estimate of 580 (Table 1); however, estimates of numbers of breeding pairs made from estimates of number of active burrows may be inaccurate.

Australian Pelican (*Pelecanus conspicillatus*) recorded breeding on Pelican Island. This is the only Shark Bay colony. In WA, other colonies are found some distance away – in the south-west (Oyster Harbour, Peel Inlet, Mandurah, Penguin Island) and off the Pilbara (Little Rocky Islet being the closest to Shark Bay) and Kimberley coasts. It also occasionally breeds in inland freshwater lakes in the Pilbara and Kimberley.

Pied Cormorant (*Phalacrocorax varius*) recorded breeding on Charlie (islet 2 km SW), Depuch Loop (unnamed islet), Dirk Hartog, Dorre, Double, Freycinet, Friday, Lefebre, Mary Anne, Pelican, Salutation, Salutation (islet to south-west), Smith (South), White and Wilds Islands and Wilds (islets to west, South Islet). Reported breeding on Faure and North Guano Islands and on light beacons 13 and 25 km west of Denham (Gregory 1941; Storr 1985); may breed on additional smaller islands. Shark Bay is a major stronghold for this species with large colonies on Dirk Hartog, Freycinet and Pelican Islands. Fowler (1947) reported numbers of Pied Cormorants seen from the air in October 1945 and July 1946, noting that 'The number of cormorants observed during the first flight was the largest I have seen within a comparable area in Australia' (p. 69). Fowler reported 15 000 to 20 000 birds off the east coast of Dirk Hartog Island between Cape Levillain and Egg Island during the 1945 flight.

Eastern Reef Egret (*Egretta sacra*) recorded breeding on Brown Inlet (unnamed island), Dorre, Freycinet, Salutation, Smith (South) and Wilds (islets to west, south islet) Islands. This widespread species may breed on almost any rock island in Shark Bay.

Osprey (*Pandion haliaetus*) recorded breeding on Baudin, Bernier, Charlie, Depuch Loop (unnamed islet), Dirk Hartog, Dorre, Eagle, Kangaroo, Mary Anne, Meade, North Guano, Salutation, Smith (South), Sunday, Three Bays, White, Wilds Islands, and Wilds (islets to west, south islet). A common species in Shark Bay which may breed on almost any island or islet in the area.

White-bellied Sea-Eagle (*Haliaeetus leucogaster*) recorded breeding on Bernier, Dirk Hartog, Dorre, Double and White Islands. A widespread but not particularly common species. May breed on other Shark Bay islands from time to time.

Pied Oystercatcher (*Haematopus longirostris*) recorded breeding on Bernier, Depuch Loop (unnamed islet), Dirk Hartog, Dorre, Eagle, Mary Anne, Pelican, Salutation and Three Bays Islands. May breed on any island with sandy beaches.

Sooty Oystercatcher (*Haematopus fuliginosus*) recorded breeding on Dorre Island. An uncommon species in Shark Bay.

Silver Gull (*Larus novaehollandiae*) recorded breeding on Baudin, Bernier, Charlie, Charlie (islet to south-west), Depuch Loop (unnamed islet), Dirk Hartog, Dorre, Eagle, Egg, Freycinet, Friday, Kangaroo, Mary Anne, Meade, North Guano, Pelican, Salutation, Salutation (islet to south-west), Slope, island to north, Smith (South), South Guano, Sunday, Three Bays, White, Wilds, Wilds (islet to south), Wilds (islet to south west), Wilds (islets to west, north islet), and Wilds (islets to west, south islet). Very common in Shark Bay. This species is increasing in abundance near centres of human population.

Pacific Gull (*Larus pacificus*) recorded breeding on Bernier, Charlie, Dorre, Kangaroo, Mary Anne, North Guano, Pelican, Salutation, Sunday and Three Bays Islands and on Wilds (islet to south). Probably breeds on other islands. The Pacific Gull is at its northern breeding limit on the west coast at Shark Bay. An unusually large number of breeding pairs (9) recorded on Kangaroo Island.

Caspian Tern (*Sterna caspia*) recorded breeding on Baudin, Charlie, Dirk Hartog, Dorre, Eagle, Egg, Faure, Freycinet, Friday, Kangaroo, Mary Anne, Pelican, Salutation, Slope (island to north), Sunday, Three Bays, White Island and Wilds (islets to west, south islet). Will breed on most islands. Usually a single pair will defend an area around its nest site; however, the species is occasionally colonial, as has been recorded on Pelican Island.

Crested Tern (*Sterna bergii*) recorded breeding on Baudin, Dorre, Egg, Friday, Koks, Mary Anne, Meade, Slope (island to north), Sunday, Three Bays and White Islands. A colonial breeder, often breeding in the same place for several years, then shifting to a new site.

Lesser Crested Tern (*Sterna bengalensis*) recorded breeding on Meade Island (Johnstone, personal communication). The southernmost breeding record for this species in WA.

Roseate Tern (*Sterna dougallii*) recorded breeding on Koks, Mary Anne and Meade Islands, and on North Guano (islet to west). Reasonably common in Shark Bay, but in lower numbers than at the Houtman Abrolhos (Fuller *et al.* 1994) and along the Pilbara coast (CALM SBID). A colonial breeder, but not faithful to breeding site.

Fairy Tern (*Sterna nereis*) recorded breeding on Dirk Hartog, Dorre, Koks, Meade and North Kangaroo Islands. An uncommon species in WA, where it breeds on islands and on beaches on the mainland. A colonial breeder, but not faithful to breeding site.

Bridled Tern (*Sterna anaethetus*) recorded breeding on Charlie, Dirk Hartog, Double, Egg, Freycinet, Friday, Mary Anne, North Guano, Slope, Sunday and White Islands. Returns to the same breeding islands year after year. An abundant species along the Western Australian coast south to near Perth.

DISCUSSION

Our surveys in May and September 1997 located colonies of most species previously known to breed in Shark Bay, located many new colonies and provided estimates of the

minimum total number of breeding pairs for some species (Table 1). An early summer visit would have added data, especially on terns. Bridled Terns, for example, had not started nesting in September. A summer survey of all islands would have been difficult in a small boat because of the strong southerly winds that prevail in Shark Bay from October to April. A helicopter survey was planned, but could not be arranged because of the unavailability in the area of a float-equipped helicopter.

Sixteen species of 'seabirds' have been recorded breeding on 42 islands and islets in Shark Bay. Eleven of the birds are considered to be true seabirds: Wedge-tailed Shearwater, Australian Pelican, Pied Cormorant, Silver Gull, Pacific Gull, Caspian Tern, Crested Tern, Lesser Crested Tern, Roseate Tern, Bridled Tern and Fairy Tern. The other breeding species that depend on the ocean for their food and breed mainly on islands are Eastern Reef Egret, Osprey, White-bellied Sea-Eagle, Pied Oystercatcher and Sooty Oystercatcher. All the true seabirds have tropical or subtropical affinities except the Pacific Gull, which is a temperate species and is at the northern end of its range at Shark Bay. Shark Bay is at the southern edge of the breeding distribution of the Lesser Crested Tern. The other species have widespread distributions and are found along most of the Australian coastline.

Table 1 provides a summary of the breeding data we collected in 1997. Some of the estimates of minimum number of breeding pairs are clearly under-estimates, as our visits did not coincide with peaks of breeding. At the Houtman Abrolhos, Roseate Terns breed in both early summer and autumn, with numbers breeding in summer being much higher (Fuller *et al.* 1994). We recorded autumn breeding at Shark Bay but would have missed any summer breeding. Crested Terns also probably have their peak of breeding in the early summer, again something we would have missed. Caspian Terns have a long breeding season along the Western Australian coast and we probably missed some winter and summer breeding. Visits to the larger islands (Dirk Hartog, Faure, Bernier and Dorre) would have added records, particularly of White-bellied Sea-Eagles, Ospreys and oystercatchers. Counts for Wedge-tailed Shearwater, Pied Cormorant and Australian Pelican are probably near complete.

With only a few hundred breeding pairs, Wedge-tailed Shearwaters are not common in Shark Bay, but the existence of 'white-breasted phase' birds, reported by Serventy (1972) needs further investigation.

Pied Cormorants are particularly numerous at Shark Bay (Table 1). The breeding colonies at Quoin Bluff South on Dirk Hartog Island, Freycinet Island and Pelican Island are the three largest reported in WA (CALM SBID). The large numbers of this species reflect both the large area of protected water within the embayments and the relative abundance of suitable food fish.

The western subspecies of the Pacific Gull, *Larus pacificus georgii*, is found from Shark Bay to Lancelin on the west coast and, on the south coast, from Cape Leeuwin westwards into South Australia. It is a comparatively rare bird, numbering in the thousands (Burbidge *et al.* 1996).

Seabirds breed on most of the smaller islands in Shark Bay, with a few species, such as Caspian Terns, Ospreys and White-bellied Sea-Eagles breeding in low numbers on the larger islands (Faure, Dirk Hartog, Dorre, Bernier).

In summary, Shark Bay is an important seabird breeding area, with numerous small islands providing excellent nesting sites for species such as the Eastern Reef Egret, Osprey, Pacific Gull, Silver Gull, Caspian Tern, Crested Tern, Roseate Tern, Fairy Tern and Bridled Tern. As well, it has the three largest rookeries of Pied Cormorant in WA, has a major Australian Pelican rookery and is the southernmost recorded breeding site for the Lesser Crested Tern in WA.

Table 1. Summary of breeding seabirds recorded in Shark Bay, May and September 1997.

SPECIES	ESTIMATED MINUMUM TOTAL NUMBER OF BREEDING PAIRS	MINIMUM NUMBER OF BREEDING ISLANDS/ISLETS
Wedge-tailed Shearwater, *Puffinus pacificus*	580	5
Pied Cormorant, *Phalacrocorax varius*	3430	7
Australian Pelican, *Pelicanus conspicillatus*	95	1
Osprey, *Pandion haliaetus*	20	16
White-bellied Sea-Eagle, *Haliaeetus leucogaster*	1	1
Pied Oystercatcher, *Haematopus longirostris*	14	7
Pacific Gull, *Larus pacificus*	16	7
Silver Gull, *Larus novaehollandiae*	1000	26
Caspian tern, *Sterna caspia*	11	11
Crested Tern, *Sterna bergii*	441	5
Roseate Tern, *Sterna dougallii*	230	2
Fairy Tern, *Sterna nereis*	3	1

SEABIRD CONSERVATION AND MANAGEMENT

While most of the islands on which seabirds breed are currently reserved for nature conservation, some remain vacant Crown land and should be reserved to aid the protection of the colonies that occur there. Islands that are in need of reservation as nature reserves are: unnamed islet in Brown Inlet west of Carrarang homestead, islet to south-west of Charlie Island, islet in northern end of Depuch Loop, Eagle Island and adjacent islet, Kangaroo Island, islet to south of Kangaroo Island, Lefebre Island, Meade Island, islet to west of North Guano Island, North Kangaroo Island, island to north of Slope Island, Smith Islands and islets near Wilds Islands.

Most of the smaller islands are currently infrequently visited and little management is required. However, many fishers anchor in the lee of these islands and at times land briefly on them. A readily available pamphlet, distributed through CALM offices and fishing tackle outlets, should be made available summarizing the nature conservation values of the islands and outlining procedures to be followed by visitors to prevent disturbance and damage to the seabird colonies. Signs advising of their status as nature reserves have been erected on some islands; these require regular checking and maintenance.

ACKNOWLEDGEMENTS

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A review of the biology and conservation status of the Ngadji, *Pseudomys chapmani* Kitchener, 1980 (Rodentia: Muridae)

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SUMMARY

The Ngadji, *Pseudomys chapmani*, was described in 1980 and recognized as the builder of pebble-mounds in the Pilbara and adjacent regions of Western Australia. At that time its range was thought to have declined substantially and it was declared by the State Minister to be 'fauna that is likely to become extinct or is rare'. Since then, it has been found on many sites associated with development projects, particularly iron ore mining, in the Pilbara. This prompted mining companies to undertake research on Ngadji status and biology. That culminated in a review and subsequent deletion from threatened fauna lists. Much of the new information is located in reports that are not generally available. This paper redresses that situation. While we have not attempted a re-evaluation of the review here, our data support its conclusions and we endorse the recommendations made in it.

Ngadji pebble-mounds can be distinguished from pebble mounds of other sympatric species and only Ngadji construct and maintain them. Ngadji have disappeared from about 35 per cent of their former extent of occurrence (340 000 km^2), mostly in Pilbara coastal ranges and the Gascoyne and Murchison regions. The pattern of decline suggests that foxes may have been instrumental, but cats and stock may have played a part. Fire was probably not important. Mounds probably allow these small rodents to obtain adequate nest insulation in stony, arid uplands, while aspects of mound occupation and the animals' biology enable them to accommodate energetic constraints and a 'boom-bust' life-mode. This life-mode requires pragmatic interpretation of IUCN criteria for establishing their conservation status.

INTRODUCTION

Pseudomys chapmani Kitchener, 1980 was described from four specimens collected at West Angelas, south-east Pilbara region, Western Australia (WA). Seven paratypes already in the Western Australian Museum collection had been obtained during the 1950s at Woodstock, Mt Edgar, and White Springs in the east Pilbara and misidentified as *P. hermannsburgensis*. The Woodstock specimens were dug from a 'mound, with small stones on a stony ridge', those from White Springs were collected 'in stony mounds' and the mice were commonly trapped 'nearby such mounds' at West Angelas (Kitchener 1980).

In WA, naturalists had associated pebble-mounds with mice for many years. Thus Davies (1970) listed '*Leggadina* Stone-Nest Mouse' in the fauna of Mileura Station because 'the old nests – survive on Mt Hale' but he considered it 'probably already extinct'. Ride (1970 p. 154) used 'Pebble Mound Mouse' and 'Sandy Inland Mouse' as alternative common names for *P. hermannsburgensis* noting (p. 152) it 'is widespread and common in the Pilbara and the Centre where it lives in shallow burrows often on stony ridges beneath piles of small pebbles'. Watts and Aslin (1981 p. 191) noted that, in the Pilbara, *P. hermannsburgensis* 'can be found in burrows within termite mounds, as well as in burrows marked by pebble-mounds' but referred to Kitchener (1980) in a footnote (p. 189).

From field experience and observations of a captive mouse housed with pebbles from its mound, Dunlop and Pound (1981) suggested that '*P. chapmani* builds pebble mounds and *P. hermannsburgensis* merely uses these nests in the Pilbara on an opportunistic basis. Thus the common name Pebble-mound Mouse should properly be assigned to *P. chapmani* whereas *P. hermannsburgensis* should be referred to only as the Sandy Inland Mouse.' Other species of mice are now known to build pebble-mounds in Australia (see below) and so *P. chapmani* is called the Western Pebble-mound Mouse (Start and Kitchener 1995) or Ngadji, the Panyjima[1] name for the species. We follow Braithwaite *et al.* (1995) and use Ngadji as the common name and treat it as singular or plural, like Chuditch and sheep.

[1] The Panyjima people are the traditional Aboriginal owners of part of the Hamersley Range where pebble-mounds are common.

Dunlop and Pound (1981) mapped the then known distribution of pebble mounds (Fig. 1). They had no records from coastal areas but showed that mounds were widely distributed through much of the Pilbara, Gascoyne and into the northern Murchison regions of WA (regional terminology is consistent with Thackway and Cresswell 1995). However, they concluded 'from the efforts of workers in the Gascoyne and Murchison districts it now seems probable that the species is extinct in these areas (Davies[2], personal communication) and the remaining populations may be confined to the eastern Pilbara'.

At that time, zoologists were alarmed by the extent of decline and extinction among Australian mammals. The patterns were not well understood but several Western Australian rodents were among the affected species (e.g. Ride 1970; Burbidge and McKenzie 1989; Lee 1995; Smith and Quin 1996). In view of the large, apparent contraction of range noted by Dunlop and Pound, *P. chapmani* was declared in 1983 by the State Minister to be 'fauna that is likely to become extinct or is rare' pursuant to the Western Australian *Wildlife Conservation Act 1950*. It was included in 'Part 2 - Species that are vulnerable' of 'Schedule 1 Listed Species' of the (Commonwealth) *Endangered Species Protection Act* and 'Vulnerable' by ANZECC (1991) but Lee (1995) treated it as 'Insufficiently Known'.

[2] S.J.J.F. Davies, formerly CSIRO, Perth, WA.

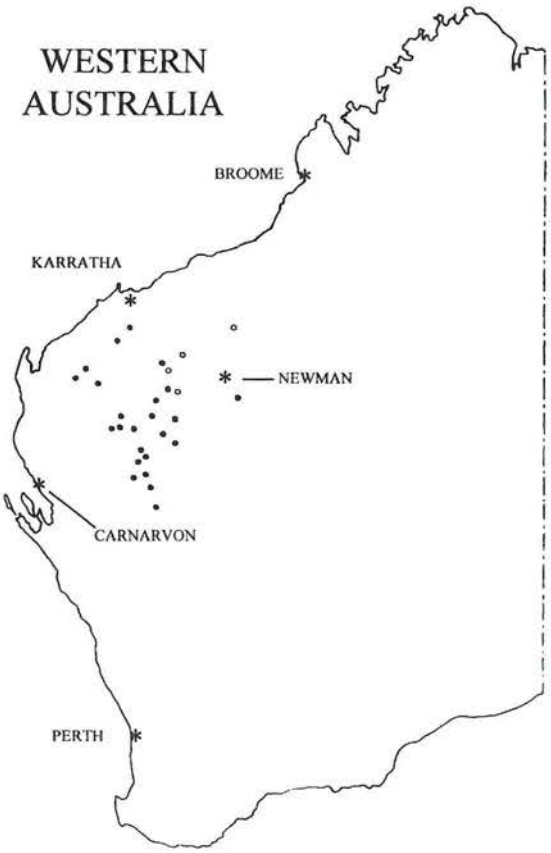


Figure 1. The distribution of pebble mounds known to Dunlop and Pound (1981). • *= abandoned mounds;* o *= containing Ngadji.*

Since 1980, many environmental assessments for proposed development projects have identified Ngadji on land that would be disturbed. The projects have been as diverse as highways, mines and their associated infrastructure (e.g. railways, construction camps and powerlines) and interpretive facilities (e.g. nature trails in national parks). Table 1 lists examples.

The first-generation of Pilbara iron ore mines and their associated infrastructure, including roads, railways and towns, were built between sixteen and eight years before *P. chapmani* was described; for example, Tom Price in 1964, Shay Gap and Pannawonica in 1972 (Anon 1979 p. 96). Nevertheless, much of the impetus and the resources used to acquire better knowledge of Ngadji in recent times have come from the iron ore mining industry. This has been encouraged by modern attitudes and obligations to environmental management, statutory environmental review procedures and the presence of a threatened species on so many second-generation project sites in the Pilbara.

The effects of developments on Ngadji came to the fore in the *Draft Environmental Review and Management Plan* for the Marandoo iron ore mine (O'Brien *et al.* 1992). The Ngadji was mentioned in 165 public responses of which 112 expressed concern about the effect of the project on its conservation status (Hamersley Iron Pty Ltd unpublished data). The proponent, Hamersley Iron (HI), made a commitment to determine the range and distribution of the species (O'Brien *et al.* 1992, p 232). Consequently, surveys of several key areas were conducted and voucher specimens have been lodged in the Western Australian Museum (Piggott 1992b, c, 1994d).

HI also established a detailed monitoring program at Marandoo (e.g. Hamersley Iron 1994) and supported research through The University of Western Australia. This work has focused on mound occupancy, movement patterns and social structure (Anstee 1994, 1996; Anstee and Needham 1997; Anstee *et al.* 1997a).

BHP Pty Ltd accepted commitments to manage and developed management programs for Ngadji at four Pilbara iron ore mine sites, Jimblebar, Yarri, Marillana Creek (Yandi) and Ore Body 18 (Piggott 1993a; Endersby 1994, 1997a, b; BHP Iron Ore and Ecologia 1996; Ecologia 1996a; Anon 1998). Consequent research and monitoring has yielded significant data on individual mice, their movements and mound activity as well as population structure, density and dynamics (e.g. Piggott 1993b, 1994a, b, c; Halpern Glick Maunsell 1997a, b, c, d, 1998c, d). These data are useful to those who have to manage the species at development sites. They also add substantially to knowledge of the biology of an Australian rodent that has adapted to a harsh, arid environment.

Implementation of the program at Marillana Creek (Yandi) mine site yielded information on (among other things) mound distribution and occupancy as well as the structure of the burrows and nest chambers under the mounds (e.g. Ecologia 1996b; Halpern Glick Maunsell

TABLE 1. Examples of Project proposals affected by the presence of. *P. chapmani.* Some projects have many pertinent references. The listed reference is the most detailed or the one that provides good directions to other documents.

PROJECT	TYPE	PROPONENT	REFERENCE
Area "C"	New iron ore mine	BHP	Piggott 1994a
Brockman Detritals	New iron ore mine	HI/CRA	Blandford *et al.* 1990
Burrup Land Use/Mgt Plan	Land use planning	State Government	O'Brien Planning Consultant 1994
Camel Road Heritage Trail	Nature trail	CALM	CALM files
Channar Mine	New iron ore mine	HI/CRA	Ninox 1985, 1986
Exmouth Borefield	Water supply	Water Auth. WA	Muir Environmental 1995
Jimblebar Mine	New iron ore mine	BHP	Ecologia 1996a
Marandoo Mine	New iron ore mine	HI/CRA	O'Brien *et al.* 1992
Mt Bruce Road	New road	Ashburton Shire	Main Roads WA 1995
Mt Whaleback	Mine management	BHP	BHP *in lit.* to CALM
BHP Ore Body 25	New iron ore mine	BHP	Ecologia 1995a
BHP Ore Body 18	New iron ore mine	BHP	Ecologia 1995b
Tom Price North Road	New road	Main Roads WA	Ecologia 1992
Yandicoogina Mine	New iron ore mine	HI/CRA	Hamersley Iron 1995
Yandicoogina Rail	New railway	HI/CRA	Hamersley Iron 1995
Marillana Creek (Yandi) Mines Stages 1 & 2	New iron ore mine	BHP	Ecologia 1996b
Marillana Creek (Yandi) Rail	New railway	BHP	Maunsell *et al.* 1988
Yarrie Mine	New iron ore mine	BHP	Piggott 1994a

1997e, f, 1998a). The latter complemented knowledge of burrow systems that had been obtained at Marandoo (Piggott 1992a).

Translocation offers a management option for Ngadji populations that would be destroyed by development, providing an opportunity to reintroduce them either to sites where they are locally extinct or to rehabilitated mine sites where they once occurred. There have been four experimental translocations. BHP management programs for Jimblebar and Ore Body 18 included translocations of Ngadji that would otherwise have been destroyed and showed that Ngadji can be translocated but the success rate was low (BHP Iron Ore Pty Ltd 1995; Ecologia 1996c, d, e, f; Halpern Glick Maunsell 1997g, 1998b). At Marandoo, no translocated animals are known to have re-established from a pilot translocation carried out on behalf of HI. A little red antechinus (*Dasykaluta rosamondae*, a dasyurid carnivore) was found carrying one of the translocated mice. It was dead. This predator may have killed several of them (Anstee 1995). HI has undertaken subsequent translocation projects using mice which would have been displaced by mining (Anstee unpublished data).

This work, augmented by numerous unpublished records of mounds and mice collected by other workers in the last ten years, has enormously increased knowledge of the species. The Ngadji is clearly much more widespread than Dunlop and Pound (1981) had realized and in many areas it is abundant in suitable habitat. It occurs in at least five large conservation reserves (Table 2).

Start (1996) collated the available information and reviewed the conservation status of the species. He recommended *P. chapmani* be allocated to the IUCN Species Survival Commission (1994) Red List category Lower Risk (Least Concern); no longer be declared by the Western Australian Minister for the Environment to be 'fauna that is likely to become extinct or is rare' and deleted from 'Part 2 - Species that are vulnerable' of 'Schedule 1 Listed Species' of the (Commonwealth) *Endangered Species Protection Act 1992*. These recommendations have been implemented (Western Australian Government Gazette 28 November 1997; Commonwealth Government Gazette 4 November 1998).

Most of the information that was available to Start was unpublished or contained in reports to HI or BHP. Like his review, it is generally unavailable to environmental managers and the scientific community. This is a significant handicap to biologists who are required to prepare environmental reviews and implement management programs involving Ngadji. Furthermore, the information in these documents adds significantly to our knowledge of Australian arid zone rodents. This paper aims to redress that situation. While all the reports we are aware of that contain information relevant to this mission are cited, some additional works are cited in Anon 1998. Finally, while we have not attempted a re-evaluation of Start's (1996) review here, our data support its conclusions and we believe the recommendations made in it were sound.

TABLE 2. The occurrence of *P. chapmani* in Western Australian National Parks and Nature Reserves.

CONSERVATION RESERVE	STATUS
Barlee Range Nature Reserve	Presence confirmed (Appendix 1)
Collier Range National Park	Presence confirmed (Appendix 1)
Karijini National Park	Presence confirmed (Appendix 1)
Millstream-Chichester National Park	Presence confirmed (Appendix 1)
Rudall River National Park	Presence confirmed (Appendix 1)
Carnarvon Range (proposed National Park)	Not surveyed but contains suitable habitat. *P. chapmani* is known from other upland areas of the Little Sandy Desert.
Mungaroona Range Nature Reserve	Not surveyed. Contains suitable habitat and is within its known range.
Cape Range National Park	Probably extinct

ISSUES THAT REQUIRED CLARIFICATION

Before Start (1996) could collate and review the data on Ngadji, he had to clarify several potentially confusing issues. For example, pebble mounds can provide useful evidence of the historical and present distribution of *P. chapmani* because they persist for a long time, even when occupants do not maintain them. Furthermore, occupied, 'active' mounds are readily distinguishable from unoccupied, inactive or 'old' mounds. However, evidence from mounds can only be used reliably if it is certain that *P. chapmani* has built them and, in the case of active mounds, is maintaining them.

Ngadji Mounds

In the Pilbara and adjacent regions, Ngadji pebble-mounds consist of accumulations of remarkably even-sized pebbles which may cover 0.5–9 m^2 (Dunlop and Pound 1981). They may be up to 0.5 m high (Piggott 1992a) but Anstee (1994) reported the mean dimensions of 25 mounds at Mt Bruce as 3.56 x 2.46 m by 0.12 m high with some exceeding 5 m on the longer axis. These are exceptionally large. Long-inactive mounds are usually raised above the ground surface but have a subdued profile and lack the 'topographic' features that characterize the surface of active mounds under which Ngadji are living. The features of active mounds include entrance holes to complex underground burrow systems and nest chambers up to 0.5 m below ground. The external entrances are often at the centre of cones and often blocked by pebbles (e.g. Piggott 1992a; Start and Kitchener 1995; Anstee 1996; Ecologia 1996b; Halpern Glick Maunsell 1998b). There is a published photograph of an active mound in Start and Kitchener (1995). Anstee (1996) gives a comprehensive description of the surface features and both he, Anstee *et al.* (1997b) and Ecologia (1996b), provide diagrams.

In the Pilbara and Little Sandy Desert, pebble mounds are built on slopes, commonly 2°–6°, composed of stony soils that usually have a hamada or surface stone-pavement. The soils are often shallow or skeletal and mounds are sometimes built around boulders or on the edges of exposed patches of bedrock. Typically, they are water run-off sites in a landscape characterized by sharply incised drainage lines. 'Hard spinifex', usually *Triodia basedowii* or *T. wiseana*, dominates the vegetation. *Eucalyptus leucophloea* or *E. gamophylla* are often present but other trees, mallees and a variety of shrubs, notably *Acacia* and *Senna* spp., may be present. The drainage lines support more floristically diverse and structurally complex plant communities that form linear thickets. *Acacia* is usually the dominant genus.

In the Hamersley and Ophthalmia Ranges, pebble mounds are common on the colluvial slopes that lie between massive, steep-sided ridges and their intervening river valleys and basins. These slopes were described and mapped as the Bahada Land Unit by Lorimer (1991). However, there and elsewhere, pebble mounds may also occur on weathered ridge tops and throughout landscapes composed of undulating uplands with a mantle of stony soils, as in parts of the Chichester Range. They do not occur on steep slopes, areas of bulky scree or areas devoid of stony soils and they are rarely present where the linear thickets marking drainage lines are absent.

Even in suitable habitat, pebble-mounds are not randomly scattered throughout the landscape and the density of pebble mounds varies across apparently similar habitat. For example, Piggott (1993b) found densities at Yarrie varied from less than one to three or four per hectare. At Shovelanna Hill in the east Ophthalmia Ranges, densities range from 0.06 to 0.2 mounds per hectare (Endersby 1997b). Furthermore, they are often grouped and frequently built near drainage lines. Endersby (1997b) and Piggott (1993b, at Yarrie) observed that mounds were frequently within 20 m of channels. Similarly, on Mt Bruce, Anstee (1994) found significantly more pebble-mounds within 21 m of the drainage lines than elsewhere (21 m = mean radius of core areas within home ranges, see below).

Large mounds contain many thousands of pebbles that the mice have excavated from the burrows below or gleaned from the surface nearby. Start and Kitchener (1995) reported that the weights of 1600 pebbles taken

from 21 mounds in the Hamersley Range varied from 0.5 to 10 g each with 94 per cent weighing less than 5 g. The mode was in the 1.0–1.5 g size class. Dunlop and Pound (1981) recorded a range of 1.3 to 13.7 g in a sample of 73 pebbles. Figure 2 summarizes data on the weights of 300 pebbles from three Ngadji mounds at 23° 53'S, 120° 30'E, near Savory Creek in the Little Sandy Desert region (A.N. Start unpublished data).

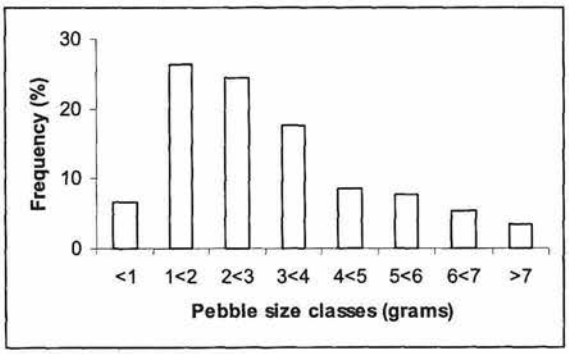


Figure 2. Weight classes (in grams) of pebbles taken from three Ngadji mounds at 23.88°S 120.50°E, near Savory Creek, Little Sandy Desert region, WA. N = 300: Range = 0.4 to 10.1: Mean = 3.06: SD = 1.83. 84% weigh < five grams.

Occasional larger pebbles (which may not all have been added by Ngadji) in samples can distort the impression for a reader who is not familiar with mounds in the field. In reality, Ngadji mounds are remarkable for the uniformity of pebble size. Davies (1986) noted 'the uniformity of their pebbles (is) such that they are used as screenings for concrete making by pastoralists.'

Other Mound Builders

In the upper Murchison, Davies (1986) recorded two types of pebble mounds distinguishable by pebble size. He ascribed one (pebbles weighing 1.5 to 3.8 g) to *P. chapmani* and the other (pebbles weighing 15.5 to 26 g) to 'an unknown larger murid', perhaps *Leporillus*. The large-pebble mounds tended to occur more commonly in the south but there was a broad area of overlap. He mapped (his Fig. 14) the positions of nine small-pebble mounds and five large-pebble mounds in an area approximately 150 x 150 m in a mixed colony on Erong Springs Station (25° 34'S, 116° 39'E).

In many areas stick-nest rats, *Leporillus* spp., incorporated stones in their nests. Stick-nest rats are now presumed extinct on mainland WA and surviving nests are degenerating. Many nests in sheltered caves and breakaways still contain sticks, stones and a black resinous material, 'amberat'. However, stick-nest rats often built in the open where the organic components of their nests have vanished leaving (where they incorporated them) piles of pebbles (Copley 1988).

Copley published photographs of several *Leporillus* pebble-mounds, including one in open mulga woodland in the Western Australian Goldfields (his Fig. 15) and he mapped the distribution of stick nests, distinguishing those containing stones from those that did not. Several sites where stones were incorporated occur within the former distribution of *P. chapmani*. Copley records the size of stones from the nests of *Leporillus* as 2–6 cm in diameter.

Figure 3 summarizes data on the weight of 21 pebbles taken from an old *Leporillus* nest. Their longest axes ranged from 18.5 to 50.0 mm (mean 31.7, SD 7. 7). The nest, which still contained some sticks and 'amberat', was situated in a small breakaway on Mulyajingle Peak (26° 11'S, 116° 07'E) in the Murchison. Although many of the pebbles were smaller than those recorded by Davies (1986), 76 per cent weighed more than 5 g whereas 84 per cent of the pebbles in the samples used to generate Figure 2 weighed less than 5 g. In our experience pebble-mounds derived from old *Leporillus* nests are readily, visually distinguishable in the field from those of Ngadji by the size of the pebbles, even where the former were built in the open.

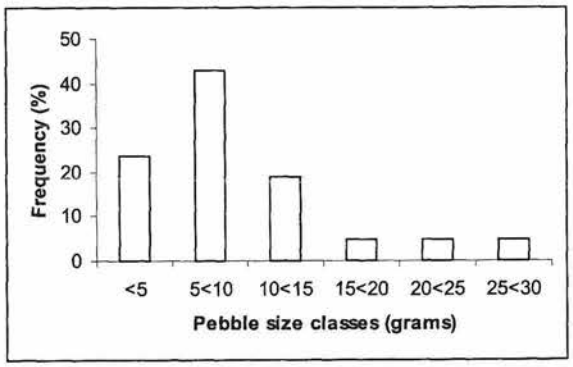


Figure 3. Weight classes (in grams) of pebbles taken from an old Leporillus *nest on Mulyajingle Peak, Murchison region, WA. N = 21: Range 2.8 to 25.1: Mean = 9.36: SD = 5.99. 76% weigh > five grams.*

Malleefowl, *Leipoa ocellata*, may have occurred in the extreme southern portion of the range of *P. chapmani* (compare Blakers *et al.* 1984 with Fig. 2) though Davies (1970) did not record Malleefowl from Mileura. Stones may incidentally be incorporated into Malleefowl mounds and it is possible that, where the organic components of old mounds have disappeared, pebble mounds may remain. Burbidge and Fuller[3] (personal communications) have noted several large pebble mounds, one of which was circular with a central depression, in a mulga community in the Gibson Desert. These may be the remains of Malleefowl mounds. However, pebble mounds derived from Malleefowl mounds are unlikely to be confused with those of Ngadji because the stones would not have been selected for size, apart from the exclusion of very large ones.

Since Dunlop and Pound (1981) discovered that *P. chapmani* builds pebble mounds in the Pilbara region, other species of mound-building mice have been recognized elsewhere in Australia. Ironically, *Pseudomys*

[3] Andrew Burbidge and Phil Fuller, Department of Conservation and Land Management, Western Australia.

patrius was associated with pebble mounds by Stalker who collected it in 1907 (Thomas and Dollman 1909) but it was overlooked by Lee (1995) and largely dismissed in the synonymy of *P. delicatulus* by other authors before van Dyck (1996) and van Dyck and Birch (1996) realized that it is the pebble-mound mouse of eastern Queensland where it occurs from near Townsville to near Gympie. Another, undescribed *Pseudomys* species builds pebble mounds in the Cloncurry - Mt Isa area of north-western Queensland. It is not *P. johnsoni,* as stated in van Dyck (1996) (van Dyck and Birch 1996, and van Dyck[4] personal communication).

Kitchener (1985) described *Pseudomys johnsoni* from specimens taken in 1983. It was known to Kerle (1995) from the Northern Territory in the Davenport and Murchison Ranges south-east of Tennant Creek and in a small area in the Barkly region but it is now known to be widespread and much more common than previously thought (Cole 1996).

Pseudomys calabyi was described as a subspecies of *P. laborifex* by Kitchener and Humphreys (1987) but Lee (1995), Woinarski (1992) and Woinarski *et al.* (1995) treat it as a full species. It has been recorded in association with pebble-mounds in the Northern Territory from Stage III of Kakadu National Park in the valleys of the upper South Alligator and Mary Rivers (Lee 1995). *P. laborifex* has not been reported to build pebble mounds but a pebble-mound mouse that occurs in the Victoria River District, Northern Territory (Woinarski[5] personal communication) and Gardner Range, WA (Coate 1995; A.N. Start, unpublished data) may be *P. laborifex* (Donellan[6] personal communication). Its taxonomic status is currently being studied.

There is an emerging pattern of Australian arid, sub-tropical, savanna uplands with stony surfaces being occupied by one or another of several small, pebble-mound building *Pseudomys* species. The five recognized species are isolated from one another by extensive areas of unsuitable habitat such as sandy deserts.

Because several species of *Pseudomys* build pebble-mounds, we considered the possibility that more than one species of pebble-mound mouse may occur in the Pilbara, Gascoyne, Murchison or Little Sandy Desert regions of WA. However, there is no evidence of this. Specimens of *P. chapmani* in the Western Australian Museum have been collected from almost all areas in which active mounds are recorded (Fig. 4 and Appendix 1). Although uplands containing mounds of pebble-mound mice are patchily distributed, there are few extensive, inhospitable land surfaces, such as sandy deserts, isolating any of the areas in which pebble-mounds occur. Perhaps the most isolated population lived on Cape Range, which is separated from other areas by a sand sheet. However, Baynes and Jones (1993) have identified sub-fossil material from there as *P. chapmani* while Baynes and Bradshaw (1996) have shown that sub-fossil material from coastal hills near Karratha is *P. chapmani*. A sand sheet also isolates the population at Yarrie. Nevertheless, specimens taken there are referable to *P. chapmani* (Cooper[7], personal communication).

Therefore, we assume that *P. chapmani* is the only pebble-mound mouse that occurs or occurred in those areas of the Murchison, Gascoyne, Pilbara and Little Sandy Desert biogeographic regions embraced by the distribution of mounds (Fig. 4 and Appendix 1).

Identifying Ngadji in the Field

Some of our records are based on mice that were trapped and released. Thus, reliability of field identification is an important issue. *P. chapmani* is usually caught near mounds (e.g. Dunlop and Pound 1981; How *et al.* 1991). Its size and/or other features can distinguish it in the hand from all other sympatric murids except *P. hermannsburgensis* (with which it has been confused in the past). Although *P. chapmani* and *P. hermannsburgensis* partition habitat (Halpern Glick Maunsel 1997h; ANS personal observation), there is a broad area of overlap and, at many sites, they can be caught together (e.g. Karijini National Park - Courtenay 1994; Jimblebar - Endersby 1994, Halpern Glick Maunsell 1997h; Ore Body 18 - Halpern Glick Maunsell 1998b; Marillana Creek (Yandi) - Halpern Glick Maunsell 1997e, f, 1998a; Yarri - Halpern Glick Maunsell 1997b, d; Packsaddle/The Governor area – A.N. Start unpublished data).

Kitchener (1980) distinguished '*P. chapmani* from all other species of the genus by a combination of its small size, large auditory bullae and short and broad palatine foramina'. The skull characters are useful for separating museum specimens. However it is not always appropriate, particularly with threatened fauna, to take specimens to access skeletal characters. *P. chapmani* and *P. hermannsburgensis* have similar pelage colour and body dimensions. Kitchener *et al.* (1984) showed that (for museum specimens) pes length plotted against ear length separated them. However, the groupings are contiguous and this ratio is not always adequate. In any case, field measurements on live animals are difficult, subadults confound the problem and Halpern Glick Maunsell (1997b, d) suggest that *P. chapmani* may be sexually dimorphic with discernible differences in field-measured head length.

Cooper (1993) described and illustrated differences in the footpads of the three small *Pseudomys* that occur in the Pilbara, including *P. chapmani*, *P. hermannsburgensis* and the superficially similar *Mus domesticus*. Since then, field workers have been able to identify live *P. chapmani* in the field (e.g. Anstee 1994; Courtenay 1994; Endersby 1994; Piggott 1994a; ANS personal observation). Confirmation of field identifications of animals deposited in the Western Australian Museum has verified the efficacy of the method (e.g. Piggott 1992b, c, 1994a, d; Endersby 1994).

[4] S. van Dyck, Queensland Museum, Brisbane.
[5] J.C.Z. Woinarski, Parks and Wildlife Commission, Darwin.
[6] Steve Donellan, South Australian Museum
[7] Norah Cooper, Western Australian Museum.

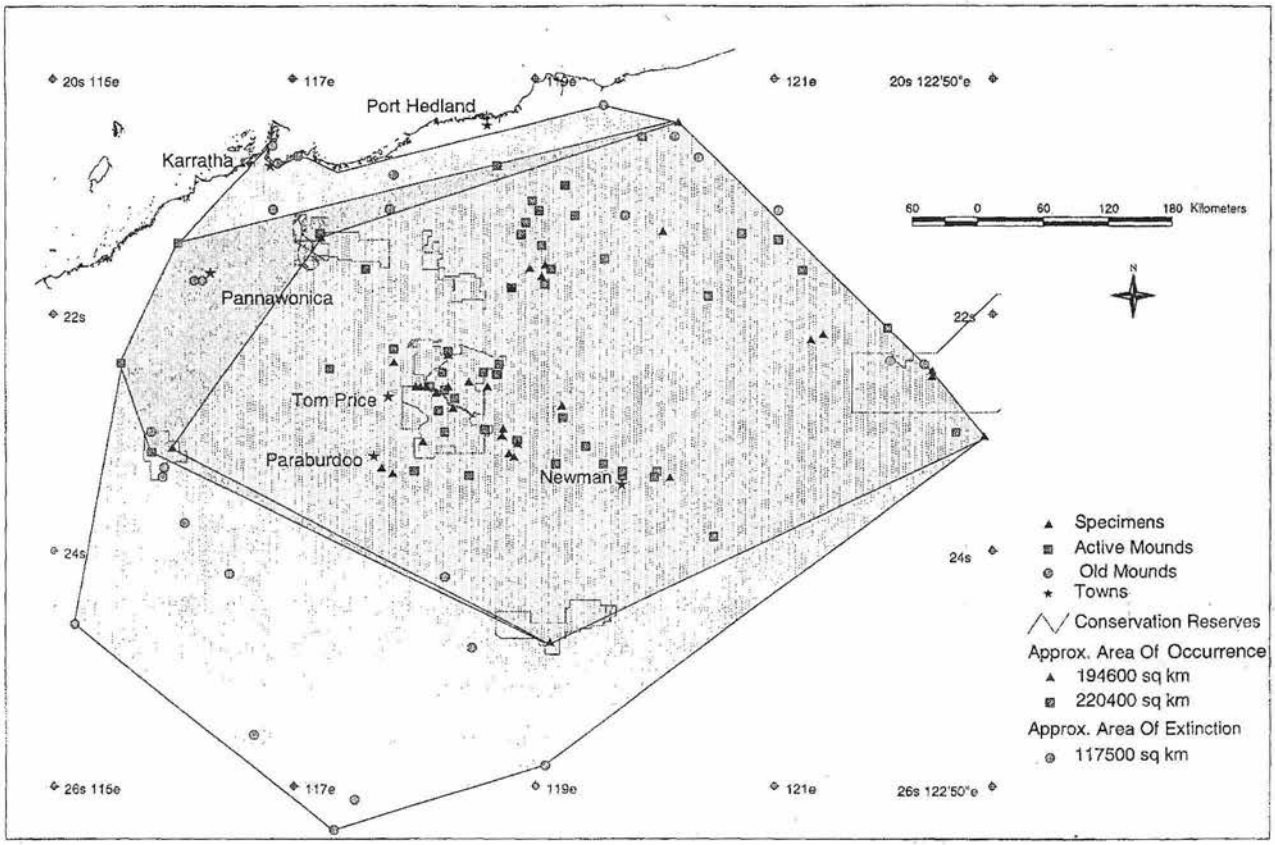


Figure 4. Past and present distribution of P. chapmani. *The figure presents three data sets with point locations for all records and convex polygons linking the peripheral locations in each data set to produce Extent of Occurrence maps (IUCN Species Survival Commission 1994). Note old mounds at one site on Cape Range not shown.*
The polygons depict:
Former Extent of Occurrence based on location of all mounds including old mounds (except one site on Cape Range)
Current Extent of Occurrence based on location of active mounds
Current Extent of Occurrence based on location of specimens

Associating Active Mounds with *P. chapmani*

It is understandable that pebble mounds were attributed to *P. hermannsburgensis* before *P. chapmani* was recognized as a distinct species (e.g. Ride 1970; Watts and Aslin 1981). After all, specimens in the Western Australian Museum identified as *P. hermannsburgensis* had been taken from pebble mounds (Kitchener 1980). Even after that, Dunlop and Pound (1981 p. 2) state '*P. chapmani* builds pebble mounds and *P. hermannsburgensis* merely uses these nests in the Pilbara on an opportunistic basis'. Their assertion that *P. hermannsburgensis* uses the pebble-mounds opportunistically continues to be cited, although not always referenced (e.g. Kitchener 1983; Ecologia 1995a, b, 1996a).

The experience of most workers over the last eight years is that active mounds are reliable indicators of extant Ngadji. Where there are active mounds, *P. chapmani* can invariably be caught, given sufficient effort. Furthermore, we have not been able to locate any original records of *P. hermannsburgensis* occupying pebble-mounds let alone building or maintaining them. A considerable body of circumstantial evidence suggests that they do not do so although they may be caught close by and, at Ore Body 18, four male *P. hermannsburgensis* and one female *P. chapmani* were caught within a flywire hoop erected around an active pebble-mound (Halpern Glick Maunsell 1998b).

Ngadji are not easily trapped and most workers place Elliott traps inside fly-wire fences encircling active mounds (Anstee 1994). This method is particularly useful for catching all the occupants of a mound where the number of mice per mound is to be recorded (e.g. Anstee 1994; Piggott 1994a; Ecologia 1996c; Anstee *et al.* 1997a,b; Halpern Glick Maunsell 1997d, 1998a,) or where all mice are to be removed prior to earthworks commencing (e.g. BHP Iron Ore Pty Ltd 1995; Ecologia 1996b; Halpern Glick Maunsell 1998b).

Other mammals are seldom reported from within the fences. The House Mouse, *Mus domesticus,* has been caught within them at Marillana Creek (Yandi) (Ecologia 1996g), Marandoo (Anstee, unpublished data), Mt Whaleback (Endersby, unpublished data) and Jimblebar, where released House Mice ran straight to burrow openings on the mounds and entered them (Teale[8] personal communication).

A small dasyurid, *Ningaui timealeyi,* was the only other mammal caught within fences at Marillana Creek (Yandi) where 77 *P. chapmani* were recovered from 43 of 65 active mounds. *N. timealeyi* and two other dasyurids, *Dasykaluta rosamondae* and *Sminthopsis* sp. were caught within fences at Marandoo. Courtenay (1994) caught another rodent, *Zyzomys argurus*, at an active mound in Karijini National Park but she was not using encircling fences and there is no evidence that it was using the mound. Piggott (1994e p. 266) observed that 'occasionally other species do "invade" mounds' but gave no supporting evidence.

The House Mice may have been living in burrows beneath pebble-mounds but Ningaui, which are known to shelter in spinifex hummocks (Dunlop 1995), were probably living above ground, albeit within the fences. *D. rosamondae* preys on *P. chapmani* (Anstee 1995) but it is uncertain whether it, or the *Sminthopsis* sp. were sheltering in the Ngadji burrows. In any case, the dasyurids are unlikely to tend them.

P. hermannsburgensis occurs in all these areas but has only once been caught within the fences (Halpern Glick Maunsell 1998b). Indeed, at Jimblebar where there was a trapping grid in addition to traps set at fenced mounds, *P. hermannsburgensis* was sometimes caught more frequently than *P. chapmani* in un-fenced traps on the grid, but was never caught within fences (Roy Teale personal communication).

Over much of the range of *P. hermannsburgensis* (Breed 1995) there are no pebble mounds (e.g. Ride 1970; Dunlop and Pound 1981; Watts and Aslin 1981) suggesting that it does not build them. Furthermore, there are numerous places where old pebble mounds show no signs of being used, even where *P. hermannsburgensis* is still present. This suggests that *P. hermannsburgensis* does not tend mounds abandoned by Ngadji. Similarly, House Mice are often common where pebble-mounds are now abandoned, suggesting that, even if they co-habit mounds with Ngadji, they do not maintain the mounds after the pebble-mound mice have gone.

We conclude that in these areas, only Ngadji build and tend pebble-mounds attributable to small murids.

Classifying Mound Activity

Many of our records are based on the presence of 'active' mounds. Thus the ability to determine whether mounds are still active is crucial. In 1988, Start (unpublished) sprayed non-toxic, water-based paint on pebble mounds to determine whether they were in use: Ngadji moving pebbles expose unpainted surfaces which are easily observed the next day. Several workers have used the method since. It has been useful in identifying occupied mounds and demonstrating that some mounds are used each night while others are used intermittently (see below).

However, visual methods are often used to identify active mounds and several classifications for the level of activity have been developed. Endersby (1994) used four categories, one active and three inactive (indicating different time frames since mounds were abandoned). Studies by Ecologia (1996c, d, e, f, g, h) and Halpern Glick Maunsell (1997d, f, 1998b) for BHP have used Endersby's classification. Piggott (1992d) used three categories, 'active', 'inactive' and 'old' and used the 'paint test' to subdivide 'active' into 'in use' or 'not in use'. Anstee (1994, 1996) developed a visual scoring method to determine the likelihood of *P. chapmani* presence in mounds. It is based on an activity index derived by scoring each of three mound features on a 0–3 scale. His method circumvents the constraints imposed on trap effort by time and resources, and possible errors inherent in the paint test (mice may be deterred by paint and other animals may disturb mounds). Courtenay (1994) used the paint test but distinguished 'movement' (pebbles had been turned so that paint was hidden) from 'activity' (unpainted pebbles appeared on the mound surface).

Because a variety of systems have been used, in this paper we use two categories of activity where we address issues of distribution and decline. They are:

'Active' where it is clear that a mound is being tended and

'Old' where mounds are clearly abandoned.

THE CURRENT STATUS OF *P. CHAPMANI*

Distribution

Figure 4 plots the current and inferred-recent (probably post-European settlement) distribution of *P. chapmani* using pebble mounds, and live animals. The map distinguishes sites at which only old mounds have been recorded (and the species is presumed to be locally extinct) from sites at which Ngadji have been caught or where active mounds have been recorded since 1980 (and the species is extant). The Extent of Occurrence[9] indicated by each data set has been calculated from convex polygons created by joining the peripheral locations (IUCN Species Survival Commission 1994). The plots and area calculations were generated with the GIS package ARCVIEW Version 2.1 (ESRI 1994).

Almost all areas where Ngadji were recorded between 1980 and 1990 have been revisited since then so that data on the presence of Ngadji and active pebble mounds are mostly no more than eight or nine years old. The concentration of records between Tom Price and Newman reflects the extensive occurrence of iron ore deposits in the

[8] Roy Teale, Halpern Glick Maunsell, Perth.

[9] The terms Extent of Occurrence and Area of Occupancy are defined in IUCN SSC (1994).

Hamersley and Opthalmia Ranges and consequently the location of work done by iron ore mining companies. Similarly, the concentration of active mound records south-east of Port Hedland reflects field work by J.N. Dunlop and C. Newland who recorded mounds while inspecting gold mining projects in that area. They did no trapping.

Although Ngadji are common in those two areas, they are not necessarily the areas of greatest abundance. Many of the gaps reflect lack of fieldwork rather than absence of Ngadji. For example, there have been no biological surveys in the Chichester, Collier or Mungaroona ranges. The Ngadji records from Millstream-Chichester, Collier Range, Parry Range and Rudall River National Parks were obtained during brief visits made specifically to search for *P. chapmani* (Piggott 1992b, c, 1994d). Furthermore, pebble-mounds are easily 'missed' where people do not search specifically for them.

Huge areas of potentially suitable habitat have not been examined, particularly in the Chichester Range and the Hamersley Range west of Tom Price. From the air, there appear to be extensive areas of suitable habitat in Mungaroona Range Nature Reserve and many other parts of the Chichester Range (ANS personal observation). However, it should also be noted that there are large areas of unsuitable habitat within the Extent of Occurrence of *P. chapmani* (e.g. alluvial surfaces of the Fortescue River valley, large mulga flats in the south-east Pilbara and sandy surfaces in the Little Sandy Desert).

There is close correspondence between the area from which there are specimens and that where active mounds are known to occur. Inclusion of the large area in the west, where there are no specimens to support records of active mounds, is based on pebble-mound records of Piggott (1994d) in the Parry Range and Dunlop in hills south of the Fortescue River near the North-west Coastal Highway (Dunlop[10] personal communication; and maps held by the Department of Minerals and Energy, Karratha). Neither observer trapped at these sites.

Changes in Distribution

We consider that a population of Ngadji comprises a group of individuals that are readily able to encounter and interact with other members of the population. Discrete populations are separated by landforms that are not normally occupied by Ngadji so that interaction between members of adjacent populations is infrequent to impossible (e.g. sand plains, broad river valleys). No Ngadji populations are known to have disappeared since 1980. Figure 4 shows that the original Extent of Occurrence was about 340 000 km^2. Ngadji still occur in suitable habitat within 220 400 km^2 (65 per cent) of that area. They seem to be extinct within about 13 000 km^2 of the Pilbara's coastal lands and 104 000 km^2 of the upper Murchison, and the Gascoyne, although Coate (1997) has recently reported and published a photograph of active mounds on Mt Phillip Station (24° 24' S 116° 18' E) in the Gascoyne, suggesting that at least one relict population may survive there. However, there is proportionally much less suitable habitat on the Pilbara coast, and areas of the Murchison and Gascoyne from which Ngadji have disappeared than in the uplands of the Pilbara. Thus, the decline in Area of Occupancy is probably substantially less than 35 per cent of the original area.

The status of Ngadji on Cape Range is unclear. They are known from sub-fossil deposits (Baynes and Jones 1993) and mounds have recently been reported (Muir Environmental 1995). Muir considered that one mound may have been active but several others were old (Muir[11] personal communication).

The areas in which Ngadji persist correspond closely with the areas mapped by Beard (1975) as hummock grasslands. This accords well with Ngadji habitat summarized by Start and Kitchener (1995). Even in the eastern Hamersley Range, where Beard maps extensive areas of mulga woodland interspersed with hummock grasslands, the woodlands mostly occupy sites that are low in the landscape, often on extensive clay or loam flats. The intervening uplands are stony ridges, usually dominated by hummock grasses (van Etten 1987). Pebble-mounds are largely absent from the flats (where *P. hermannsburgensis* is commonly caught) but abundant on the uplands (Halpern Glick Maunsell 1997h; A.N. Start, unpublished data). The records from the Collier and Barlee Ranges were also from habitats dominated by spinifex (*Triodia* spp.), although much of the surrounding country carries mulga woodlands.

Beard mapped that portion of the Gascoyne and Murchison from which Ngadji have apparently disappeared as low woodland of mulga (*Acacia aneura*) or scrub of *Acacia* and other species, or low scrub of *Eremophila* and *Senna* species (he used the generic name *Cassia*; for a discussion of *Cassia* and *Senna* see Randell 1988). Hummock grasslands are scarce, even on uplands where shrubs, particularly *Senna* and *Eremophila* species, are common components of the mulga understorey or (on very shallow soils of uplands) the dominant genera. Mabbutt (1963) provides more detail on the land units at Mileura where Davies worked.

In this region, pebble mounds usually occur on the slopes of hills and ridges dominated by *Senna* species (Davies[12] personal communication; Coate 1997). Coate described the terrain where he observed active mounds on Mt Phillip Station as 'flat with gentle slopes'. The mounds were 'close to drainage systems' and the vegetation was 'mainly of *Acacia* species (*Acacia aneura* prominent along the creeks), *Eremophila* species and *Senna* species'.

The coastal Pilbara mostly comprises plains vegetated by a mosaic or mixture of hummock and bunch grasses. On the Abydos Plain, east of Whim Creek, the soils are mostly sandy and on the Roebourne Plain, west of Whim Creek, soils are finer grained clays or loams. These plains do not offer suitable habitat for Ngadji but, in places, there are small ranges on which old pebble-mounds have been recorded. These include hills east of Port Hedland, near

[10] J.N. Dunlop, Department of Minerals and Energy, Karratha, WA.

[11] B.G. Muir, Muir Environmental Consultants. Perth WA.

[12] S.J.J.F. Davies, formerly CSIRO, Perth, WA.

Whim Creek, Wickham, the Burrup Peninsula and hills to the south of Karratha. They carry hummock grasslands and have patches of suitable, stony slopes.

It is difficult to determine when Ngadji disappeared from the upper Murchison, much of the Gascoyne and coastal areas of the Pilbara. In his account of the fauna and flora of Mileura Station in the decade 1960–1969, Davies (1970) wrote 'the old nests – survive on Mt Hale'. Thus it had probably gone from there at least 40 years ago, perhaps much earlier. Piggott (1994d) reported that the owner of Mulgul Station, who had lived his life in the area, still sees old mounds but had not seen any active mounds for 20 or 30 years.

In coastal sites Butler and Butler (1983) caught *P. hermannsburgensis* and reported active mounds on the Burrup Peninsula (they attributed the mounds to *P. hermannsburgensis* despite Kitchener (1980) and Dunlop and Pound (1981) showing that *P. chapmani*, not *P. hermannsburgensis* was the pebble-mound mouse in the Pilbara). However, numerous naturalists and biologists have worked there since and we can find no other reports of active mounds or live Ngadji (e.g. O'Brien Planning Consultants 1994; Kendrick[13] personal communication; ANS personal observations). Mounds in the hills just south of Karratha lacked any surface relief and appeared very old in 1979. Their appearance had changed little by 1995 suggesting that they could have been inactive since the late 1960s and perhaps much earlier (A.N. Start unpublished data).

CAUSES OF THE DECLINE

Smith and Quin (1996) reviewed the patterns and causes of decline and extinction in Australian conilurine rodents. They note that most declines occurred before 1970 and that 69 per cent of 16 Eremaean species (they had insufficient data for the others) have experienced large range contractions. Although they found many univariate correlations between patterns of decline and a variety of factors, they point out that interpretation of univariate associations could result in misleading conclusions. Confounding interactions between various factors have to be taken into account. Dickman *et al.* (1999) demonstrate that densities of many arid Australian rodent populations reflect recent rainfall histories, but that other factors including fire and predation by foxes and cats may modify expected responses to rainfall events.

Rabbits

Declines of conilurine rodents have been most severe where rabbits have been abundant (but there are several interacting factors including rabbit-caused habitat degradation, support of exotic predator populations, etc.). However, rabbits are absent from most of the historic range of Ngadji (compare King 1990 with Fig. 4) and, where present, they probably occupy different habitat to that of Ngadji. For example, rabbits are present in small numbers in the south-east Pilbara and Little Sandy Desert where they occupy mulga flats or claypans, habitats not used by Ngadji (A.N. Start unpublished data).

Foxes

Even where rabbits are scarce or absent, declines of conilurine rodents have been severe where foxes and/or livestock have been abundant and circumstantial evidence suggests foxes may have been instrumental in the local extinction of Ngadji. Foxes were first reported in WA 160 km west of Eucla in 1915. The first bounties on scalps from the Pilbara (Roebourne and Nullagine) were paid in 1931 but foxes were present in the Gascoyne and Murchison some years earlier (Long 1988). Long reported foxes to be common on the upper west and lower north-west (= the Gascoyne and Pilbara) coasts but rare in the Pilbara uplands and now uncommon in the mid-west interior.

King and Smith (1985) present data from bounty returns that indicate fox numbers peaked between 1928 and 1935, soon after they arrived in the Northwest Division (i.e. pastoral areas from the Eighty Mile Beach to the agricultural lands of the Southwest Division, including the whole of the Ngadji's original range). In 1930 about 30 per cent of 11 038 Western Australian bounties were paid on foxes from that Division despite a relatively small human population able to take them.

King and Smith also examined the distribution of foxes in WA. In Figure 5, their data for the area encompassing the Extent of Occurrence of Ngadji is superimposed on the distribution of pebble-mounds. There is a close similarity between the areas where they had numerous fox records, the Murchison and Gascoyne and the Pilbara coast, and the areas where *P. chapmani* has declined. However, they obtained very few fox records from the non-coastal areas of the Pilbara where Ngadji remain widespread and often common. Those they recorded were from:

- Yalleen, Millstream, Coolawanyah, Hooley, Mulga Downs, Roy Hill and Ethel Creek pastoral leases which all lie on the Fortescue River. Foxes may have followed the river valley which supports bunch grass, saltmarsh and riparian woodland communities (Beard 1975) that Ngadji do not occupy.
- Yarrie and Warrawagine pastoral leases on the De Grey River. Again foxes may have followed a large river, but there are extensive areas of sandy soil, which Ngadji do not occupy. They also record foxes from pastoral leases with sandy soils on the Abydos Plain.
- Juna Downs, Sylvania, Prairie Downs, Weelarrana and Turee Creek pastoral leases in the south-east Pilbara where there are extensive areas of mulga woodlands that are similar to the woodlands which cover much of the Gascoyne and upper Murchison country in which fox records have been numerous. Even so, foxes are apparently rare on these pastoral leases now (personal communications from several pastoralists) and pebble mounds have only been recorded on stony uplands carrying hummock grasses that are embedded in the mulga landscape.

[13] Peter Kendrick, Department of Conservation and Land Management, Western Australia.

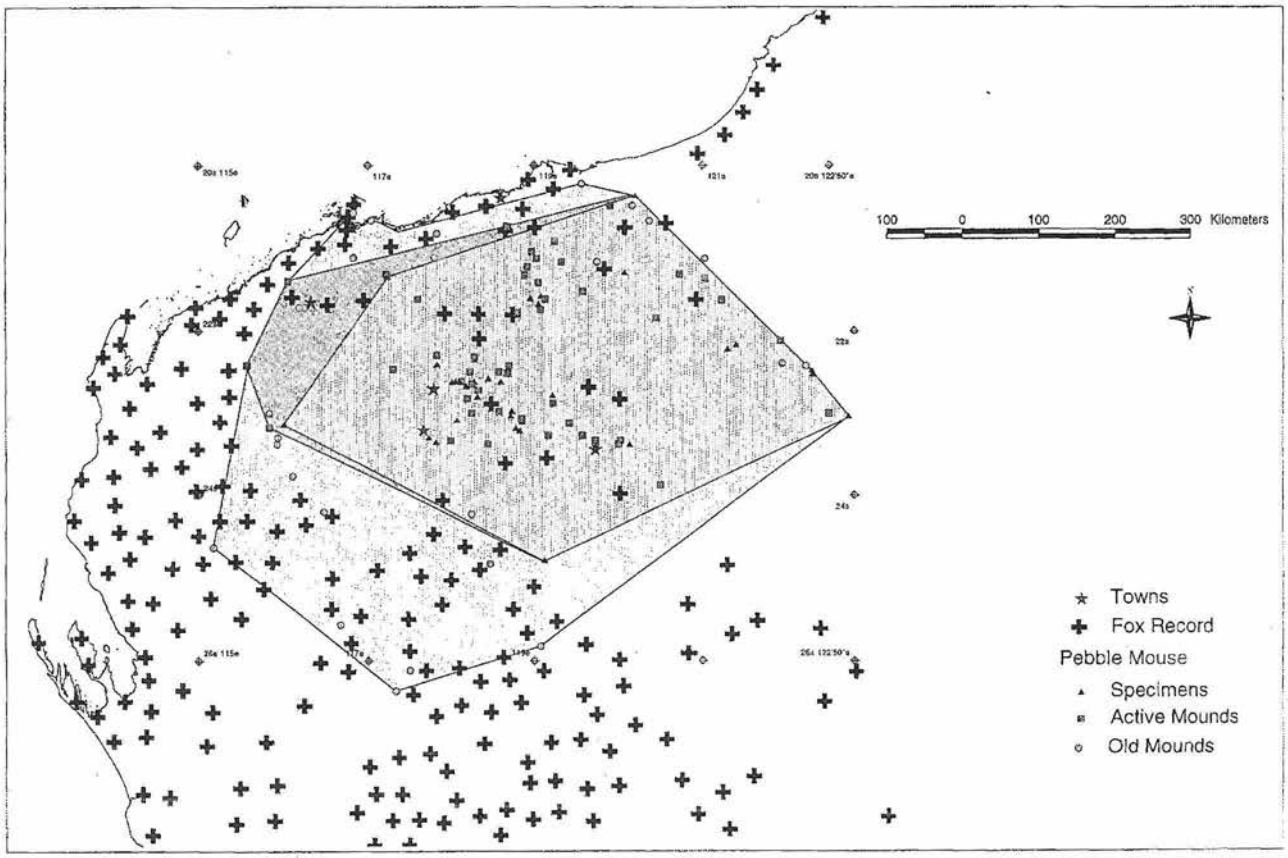


Figure 5. Distribution of foxes in relation to the former and current Extent of Occurrence of P. chapmani. *Data on foxes were obtained from King and Smith (1985). For an explanation of the distribution of* P. chapmani *see Figure 2 caption.*

The fox presence/absence data of King and Smith do not reflect abundance. Anecdotal evidence supports Long's (1988) assertion that foxes are rare in the Pilbara uplands, even on the Fortescue River. Thus, at Millstream (which is on the Fortescue), National Park Rangers did not report any foxes between 1979 and 1988 (Department of Conservation and Land Management files) and none have been seen by the Ranger-in-Charge since then (Geoff Kregor personal communications). Discussions with pastoralists and 'doggers' during those years indicated that foxes were rarely sighted or caught in dingo traps and sightings were memorable (A.N. Start unpublished data). Long-time residents of the Pilbara's inland pastoral areas reported that most of their fox sightings dated back several decades and they rarely see foxes these days (Peter Kendrick personal communication). There have been no reports by rangers of foxes in Karijini National Park during the past 20 years.

Foxes are still common on the Pilbara coast where their predation is the most likely cause of decline or extinction of rock wallaby populations. Kinnear *et al.* (1998) has demonstrated the ability of foxes to depress or eliminate rock wallaby populations. On the Burrup Peninsula and Dolphin Island, rock wallaby (*Petrogale rothschildi*) numbers increased substantially after fox baiting (Kinnear[14] personal communication). On Depuch Island near Whim Creek, there was widespread evidence of foxes eating rock wallabies (*Petrogale lateralis*) in 1962 (Ride 1964). That population of rock wallabies is now extinct.

Cats

Smith and Quin (1996 p. 17) implicated cats as 'the primary agents of decline among the smaller (10–90 g) conilurines and among conilurines of all body sizes in areas where dingoes are abundant and foxes are scarce or absent'. They found that where rabbits and foxes are scarce (but dingoes may be abundant), cat abundance is the best predictor of decline in small conilurine rodents. Cats occur throughout Australia and preceded foxes into many areas (e.g. Burbidge *et al.* 1988; Burbidge and McKenzie 1989; Wilson *et al.* 1992; Smith and Quin 1996). Few environmental factors limit their distribution; they do not have to drink fresh water and they reproduce in all habitats but they are very cryptic and often go unseen (Wilson *et al.* 1992). Martin *et al.* (1996) reported that native rodents were the most frequent item (16 per cent) in the stomachs of cats taken in the pastoral areas of WA. Their sample of 53 cat stomachs was mostly obtained from the Pilbara and Murchison regions in 1992–94. Cat population densities in the current range of Ngadji are unknown but they are certainly present and they have obviously not caused a significant decline in the distribution of Ngadji although they may affect Ngadji population densities and may have caused some local extinctions. The impact that cats may have had in other parts of the former range of Ngadji is not known. They may well have exacerbated the effects of foxes and exotic herbivores in the Murchison and Gascoyne and of foxes on the Pilbara coast.

[14] J.E. Kinnear, Department of Conservation and Land Management, Perth.

Livestock and Other Exotic Herbivores

With the exception of locations in the Little Sandy Desert, the historic range of Ngadji lies within the pastoral zone. However, a substantial portion of their range in the Pilbara is in uplands which, being of little pastoral value, have remained vacant Crown land or been reserved, often for national park or nature reserve. Where Ngadji occur on pastoral leases, their usual habitat of upland, run-off sites with shallow, stony soils supporting 'hard' spinifex is generally avoided by cattle and sheep. Goats are absent and donkeys occur sporadically. Where they are present, donkeys, like stock, usually seek more hospitable and productive sites. Therefore, there is little disturbance of Ngadji habitat by exotic herbivores in the Pilbara.

However, in the mulgalands of the Gascoyne and northern Murchison, exotic herbivores have not avoided Ngadji habitats. Stocking rates with sheep and/or cattle have been very high in relation to the carrying capacity, and degradation of the country is widespread and sometimes very severe (see Hobbs and Hopkins 1990 for an overview). Furthermore, goats have been numerous through much of the area (Wilson *et al.* 1992) and have exacerbated the degradation of the land and vegetation.

Fire

Fire is often thought to affect the status of mammals in arid Australia (e.g. Burbidge and McKenzie 1989). Much of the debate has focused on changes in fire patterns since the pattern of Aboriginal peoples' occupation of the land, and consequently their burning practices, have changed. However, there is little information on fire responses by arid Australian rodents (Sutherland and Dickman 1999). The spinifex habitats of Ngadji in the Pilbara are fire-prone and probably burn frequently because the spinifex hummocks provide excellent fuel. Lightning and Aboriginal people lit fires before European settlement but the frequency, intensity and spatial extent of fires in the Pilbara have probably changed since Aboriginal people left the land (e.g. Start *et al.* 1991). Pastoralists and the managers of Crown reserves including national parks and nature reserves have assumed responsibility for fire management while large areas that remain vacant Crown land are effectively unmanaged. Yet Ngadji persist in their spinifex habitats across tenure types and mounds are still actively tended after fires have removed surrounding vegetation (Halpern Glick Maunsell 1998c; A. N. Start unpublished data).

In November 1997 a wild fire burnt some or all of the vegetation (dominated by hummock grass) on nine of ten monitoring plots and two research plots at Yarrie. The research plots (on which 65 per cent and 95 per cent respectively of the vegetation was destroyed) were monitored about five weeks after the fire. Mound activity was lower than in previous summers and, unusually, no females were breeding. However, Table 6 shows that the estimated total population of mice was higher than it had been through 1996 and early 1997 (Halpern Glick Maunsell 1998c). It is difficult to determine the significance of the quantitative shift in relation to fire because the bait in traps may have been more than usually attractive after the fire when food may have been scarce. Nevertheless it is clear that a relatively dense population coped well with the initial post-fire period.

Western Australian mulga woodlands without spinifex or other highly flammable understorey species are relatively infrequently burnt (Start 1986; van Leeuwen *et al.* 1995). However, this is the habitat that covers most of the country from which Ngadji have disappeared in the Gascoyne and Murchison. As Ngadji have persisted in the more fire-prone habitat it seems unlikely that fire has been a significant, causative factor in their decline.

CONCLUSION

We conclude that circumstantial evidence suggests the areas from which Ngadji have disappeared correspond well with areas where foxes have been abundant and/or widespread. Except on the Pilbara's coastal hills, it also corresponds with the habitats grazed by livestock and feral herbivores. The latter process may have exacerbated fox predation by allowing 'hyperpredation' (Smith and Quin 1996). The effect of cat predation is unknown, but it may have exacerbated the effects of foxes and ungulates. Fire has probably not been a significant causative factor.

MOUND OCCUPATION

Since Ngadji expend considerable amounts of energy building and tending pebble mounds on stony uplands, the mound must confer an advantage not used by or not available to species living in other parts of the same landscape. A plausible hypothesis proposes that the mound insulates nests from extremes of temperature where frosts and very high temperatures are common and shallow stony soils prohibit deep burrows (Anstee 1994 in Appendix 4). There has been only one study comparing temperatures outside the nests with those inside. Piggott (1994a) reported nest temperatures fluctuating between 19°C and 25°C while surface temperatures varied from 6°C to 36°C over a 24-hour period in August.

Pebbles are an appropriate material from which to build the mounds because:

- they are abundant in Ngadji habitat
- their mass and hardness makes them more resistant to wind and water erosion than soil
- organic materials would be a liability in fire-prone hummock grasslands and pieces small enough for the mice to carry would be susceptible to erosion and decay
- wind-blown sand and dust is trapped between the pebbles adding to their insulating effectiveness at no additional energetic cost to the mice. Spaces between pebbles below the near-surface layers are usually filled by sand or soil particles (A.N. Start unpublished data).

However, construction of a new mound by each individual or pair entering a population would be energetically and temporally expensive if not prohibitive and new mounds are rarely observed. Endersby (unpublished data) noted two new mounds at Jimblebar in 1994 but has seen none since then. Where mound activity has been monitored for several years at Yarrie (since 1993) and at Marillana Creek (Yandi) (since 1995) no new mounds have been recorded and we are not aware of new mounds being recorded anywhere else except where mice have been enclosed with piles of pebbles.

Communal construction and occupation of mounds by successive generations of mice would be an energetically economical strategy for animals that live under huge pebble-mounds.

There is evidence that successive generations of Ngadji occupy mounds. Some mounds are known to have been active for over 20 years (A.N. Start, unpublished data), much longer than the expected life span of small Australian murids (Predavec 1997). Furthermore, at many sites most mounds are active. For example, at Yarrie, 232 (77 per cent) of 300 mounds were active (Piggott 1993b). This is more likely to reflect long-term occupation of mounds by successive generations than recent colonization or population expansion because:

- there are some inactive mounds with very subdued profiles that have probably not been used for several decades. They indicate that Ngadji have been at the site for at least that long
- almost all active mounds observed in 1993 are still tended by Ngadji. (We have no data on whether the untended mounds have been abandoned altogether.)
- no new mounds have been observed on monitored plots despite times when the number of ngadji in the population has increased (e.g. at Yarrie and Marillana Creek (Yandi), Table 6).

Ngadji often live gregariously. Although it is common to catch only one mouse from a mound, multiples are frequent (Table 3) and the occupants of a mound may comprise adults of both sexes as well as juveniles (e.g. Anstee *et al.* 1997b). Twenty-five were taken from one mound surrounded by fly-wire at Jimblebar (Ecologia 1996c): however, that is exceptional. Data are available from 192 active mounds that were encircled with fly wire and trapped. A total of 424 mice were trapped at 145 (75.5 per cent) of them to give a mean of 2.92 mice per occupied mound. Figure 6 shows the distribution of mouse numbers per mound.

Observations on captive colonies provide further evidence that Ngadji can live and reproduce when many animals cohabit. Thus, young have been born and raised in a colony of 15 adults at the Perth Zoo (Bradley[15], personal communication). CALM[16] held two captive colonies in which several mice were housed amicably and bred in large terraria part filled with pebbles. In one, following collapse of part of a burrow, the mice transferred three litters of

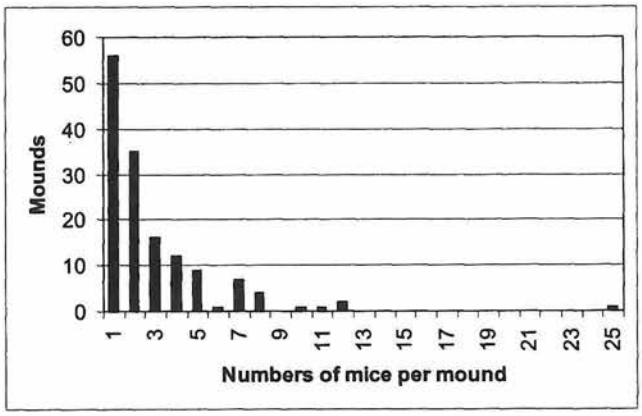


Figure 6. Numbers of mice per mound caught within fly wire fences erected around 192 active pebble-mounds. Data compiled from Anstee (unpublished data), Ecologia (1996b,c,i), Halpern Glick Maunsel (1997b,c,d,e,f, 1998a,b) and Piggott (1992a).

infants that had been born 'underground' into a depression that they constructed in the surface pebbles. Thereafter, all three mothers and an adult male spent their days asleep in a huddle over the infants.

The number of Ngadji occupying a mound fluctuates with time. Table 4 illustrates changes in the number of mice caught at mounds over longer periods. This could be explained by nomadic movement of mice between mounds or by fluctuations in the number of animals in the population. The latter seems more likely because there is evidence that individuals have a home mound to which they return regularly. Halpern Glick Maunsell (1997a, c, 1998c) captured one male Ngadji at the same mound three times over a period of 16.5 months between August 1996 and December 1997. Anstee (1994) and Anstee *et al.* (1997b), found that radio-collared animals always returned to the same home-mound for the day. Core areas around home-mounds were used by residents but not by mice from neighbouring home-mounds. However, mice from several home-mounds shared home ranges beyond their core areas.

At Anstee's study area, surplus mounds (that did not have daytime occupants) were frequently visited during the night and mice from more than one home-mound would visit the same surplus mounds. The visitors would enter burrows and move pebbles on the mounds. Collective tending of surplus mounds may explain why it is common to catch no mice at some apparently active mounds and why several studies have found that some mounds are used each night while others are used intermittently (Piggott 1994a; Chapman 1995; Ecologia 1996i; Halpern Glick Maunsell 1997c, e, f, 1998a, d).

REPRODUCTION

Table 5 contains data on the reproduction of Ngadji. Pregnant Ngadji have been recorded in every month except January and April. There is no evidence that pregnancies do not occur in January and April; rather data on

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[16] The Western Australian Department of Conservation and Land Management.

TABLE 3. Numbers of *P. chapmani* trapped within fences encircling active mounds. Only data from sites at which more than 40 mice were trapped are included.

LOCATION	ACTIVE MOUNDS TRAPPED (WITH MICE)[a]	NUMBER OF MICE PER MOUND (2/14=2 MICE IN EACH OF 14 MOUNDS)	TOTAL MICE CAUGHT (MEAN)[b]	REFERENCE
Jimblebar	10 (8, 80 %)	0/2, 1/2, 2/1, 5/1, 7/1, 8/1, 10/1, 25/1	59 (7.4)	Ecologia 1996c
Mt Bruce	32[c] (25, 78 %)	0/7, 1/7, 2/5, 3/1, 4/1, 5/3, 6/1, 7/2, 8/2,11/1, 12/2	110 (4.4)	Anstee unpublished
Marillana Creek (Yandi)	72 (52, 72 %)	0/22, 1/30, 2/14, 3/2, 4/2, 5/1	77 (1.5)	Ecologia 1996b
Yarri 1	9 (9, 100 %)	2/1, 3/1, 4/4, 5/1, 7/1, 8/1	41 (4.6)	HGM[d] 1997d
Yarri 2	17 (13, 76 %)	0/4, 1/1, 2/3, 3/6, 5/1, 7/2	44 (2.7)	HGM 1998c

[a] Numbers in parentheses = active mounds containing at least one mouse.
[b] Numbers in parentheses = mean number of mice per mound in mounds containing at least one mouse.
[c] Anstee actually trapped at 16 active mounds but re-trapped some at 3 or 9 month intervals to give 32 mound-trap sessions (see Table 4).
[d] HGM = Halpern Glick Maunsel.

TABLE 4. Variation with time in the number of *P. chapmani* trapped at two adjacent study sites, Mt Bruce (MB) and Marandoo (M). nt = not trapped. (Anstee unpublished data.)

MOUND NUMBER	MICE CAUGHT			
	JULY 1994	SEPT 1994	JULY 1995	SEPT 1995
MB 02	6	2	3	5
MB 03	12	12	11	7
MB 20	4	7	0	1
MB 14	0	2	nt	nt
MB 19	5	0	nt	nt
M 10	nt	nt	1	0
M 12	nt	nt	1	0
M 13	nt	nt	5	0
M 14	nt	nt	0	2
M 20	nt	nt	8	1

reproductive status are lacking for those months. Lactating females and juvenile mice have been recorded in February and March, suggesting pregnancies occur in January. Similarly, lactating females and juveniles in May suggest pregnancies occur in April.

Some data on pregnancy frequency and age-at-onset were obtained from four Ngadji recaptured while monitoring experimental translocations at Jimblebar.

- An adult female, pregnant on 18 September 1995, gave birth to 4 young. It was in early pregnancy when recaptured in mid December 1995 (Ecologia 1996d).
- An adult female, pregnant on 9 September 1995, was again pregnant on 10 November 1995 (Ecologia 1996d).
- A juvenile female (8.4 g; adults weigh about 12 g (range 10–15 g) - Start and Kitchener 1995), caught on 11 September 1995, was pregnant on 9 December 1995 (Ecologia 1996d).
- A juvenile female (weight not recorded) on 12 December 1995 was considered adult, but was not pregnant on 25 February 1996. It was pregnant on 2 May 1996 (Ecologia 1996f).

Although the data are scant, they suggest that *P. chapmani* commonly produces up to four young per litter; like other *Pseudomys* species they have four nipples. Females are capable of breeding soon after maturing and they are capable of producing litters at approximately two to three month intervals.

TABLE 5. Summary of the reproductive records for female *P. chapmani*. Figures in parentheses under 'Lactating' = number of young in litters. Numbers in superscript identify references.[1] A.N. Start (unpublished), [2] Anstee 1994, [3] Dunlop and Pound 1981, [4] Dunlop and Sawle 1980, [5] Ecologia 1996b, [6] Ecologia 1996c, [7] Ecologia 1996d, [8] Ecologia 1996f, [9] Ecologia 1996i, [10] Piggott 1992a, [11] Piggott 1994a, [12] Piggott 1994c [13] Halpern Glick Maunsell (HGM) 1997b, [14] HGM 1997d, [15] HGM 1997e, [16] HGM 1997f, [17] HGM 1998a, [18] HGM 1998b, [19] HGM 1998c.

MONTH	PREGNANT	LACTATING	JUVENILE
January			
February	P [1, 5]	L (4) [5]	J [5]
March	P [5]	L (2) [5]	J [5]
April			
May	P [1, 3, 8, 10,]	L (4) [1,] (4) [3]	J [1, 3, 4, 8, 10]
June	P [12, 14, 16]		J [1, 9, 14]
July	P [2, 14, 16]	L [2, 14]	J [16]
August	P [11, 13]	L [13]	J [11, 13]
September	P [6, 7]	L (1) [1,] (4) [7, 6]	J [2, 6]
October	P [7]		
November	P [11, 12, 13, 15]	L [13]	J [11]
December	P [7, 13, 18, 19]	L [13, 17]	J [7, 13, 17]

TABLE 6. Changes in the estimated density (numbers of mice per hectare) of Ngadji populations at Yarrie and at Marillana Creek (Yandi) (derived from data presented by Halpern Glick Maunsel 1998a and 1998c.). Note that there had been a relatively good season prior to winter 1997 and that vegetation at the Yarri plots was burnt in a wildfire about 5 weeks prior to the summer 1997/8 trapping session.

	WINTER 1996	SUMMER 1996/97	WINTER 1997	SUMMER 1997/98
Yarri	3.4	4.0	8.2	12.1
Marillana Creek (Yandi)	2.0	1.7	3.4	1.9

POPULATION DYNAMICS

The 'boom or bust' life strategy is common among Australian conilurine rodents of the arid zone. Predavec (1994) and Dickman *et al.* (1999) have reviewed the available data. Fluctuations in density of many arid Australian rodent populations are often (but not always) correlated with rainfall patterns. During times of low productivity, rodents are present in very low numbers and some species may be restricted to more favourable refuges.

Like other small rodents of Australian deserts, population density of *P. chapmani* probably fluctuates by several orders of magnitude in response to resource availability, which is influenced by erratic rainfall patterns. The species is obviously capable of persisting in a very inhospitable environment through prolonged periods of drought and it apparently has the ability to increase rapidly in good times. However, there are few reliable data.

The period during which the Ecologia study took place at Jimblebar was one of sustained good rainfall. Although the sample size is too small to test statistically, trap success rates increased three-fold in six months (Ecologia 1996f). Other data have been obtained at Yarrie and Marillana Creek (Yandi) (Table 6; Halpern Glick Maunsel 1998a, 1998c). The trends at both locations were similar except at Yarri in Summer 1997/98 when there was a substantial increase in the number of mice caught despite a reduction in the level of mound activity in the area and little rain after winter 1997. This apparent anomaly at Yarrie may be explained by wildfire that burnt most of the vegetation about five weeks prior to the trapping session. If the fire had reduced food availability, the attractiveness of bait may have been enhanced.

Ngadji may be able to spread from refugia in good times; one was trapped on a mulga flat at least 2 km from the nearest known mound, during a good season (A.N. Start unpublished data). The very similar *P. hermannsburgensis* has been recorded moving 14 km in a straight line in less than two weeks, and several other small mammals of the Australian arid zone have been recorded moving several kilometres (Dickman *et al.* 1995).

Reliance on mounds, which are energetically expensive to construct and are occupied by many generations, could impose a severe constraint on the 'boom or bust' strategy for Ngadji. However, there appear to be two methods by which they can overcome the problem. Firstly, in times of resource abundance, expanding populations can

presumably occupy and breed in the surplus mounds which had no resident mice but were used intermittently by residents of other mounds. Indeed the intermittent use of surplus mounds while a population is at low ebb would ensure they remain habitable in readiness for expanding numbers when good seasons arrive. Secondly, increasing the number of mice inhabiting the available mounds probably accommodates a substantial proportion of an increasing population. This may explain variation in the number of home-mound occupants from one to twenty-five animals while there is still a lack of new pebble-mounds.

Implications for Monitoring Ngadji Populations and Assessing their Conservation Status

Besides the increased trap success rates recorded by Ecologia (1996f) and the data obtained at Yarrie and Marillana Creek (Yandi) by Halpern Glick Maunsel (1998a, c; summarized in Table 6), there are no quantitative data on population fluctuations for *P. chapmani*. Other monitoring programs at Marandoo, Yarrie and Marillana Creek (Yandi) are based on mound activity. They detect local extinction and identify population fluctuations accommodated by abandoning or re-occupying mounds. This may account for the change in rate of occupation sometimes reported (e.g. Chapman 1995). Monitoring mound activity will not necessarily detect population fluctuations that are accommodated by the strategies we suggest. However, long-term trapping grids established at Yarri and Marillana Creek (Yandi) since June 1996 may yield some quantitative data (Mark Endersby, unpublished data).

Consideration of the conservation status of Ngadji, like other small arid-zone rodents, should take natural fluctuations in population size into account. Normal fluctuations associated with climatic variables would make it very difficult to use population size to ascertain changes in their long-term conservation status except where they are demonstrated to fail to respond to good seasons. Local extinction is then likely to be evident. These factors have implications for the applicability to Australia's arid zone rodents of some of the criteria established by the IUCN Species Survival Commission (1994) to assess the conservation status of animals. Many of the criteria depend on change to population numbers over substantial time frames. For example:

> 'A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium term future, as defined by any of the following criteria (A to E).
> A. Population reduction in the form of either of the following:
> 1. An observed, estimated, inferred or suspected reduction of at least 20 per cent over the last 10 years or three generations, which ever is longer, based on (and specifying) any of the following: [direct observation, etc]
> 2. A reduction of at least 20 per cent, projected or suspected to be met within the next 10 years or three generations, which ever is the longer, based on (and specifying) any of the following:' [direct observation, etc].

Identical criteria apply to the Critically Endangered and Endangered categories except that the population reductions are 80 per cent and 50 per cent respectively. Criteria B and C also provide for use of population reduction, but in conjunction with other factors.

Population is defined as 'the total number of mature individuals of the taxon – expressed as numbers of mature individuals only' (IUCN Species Survival Commission, 1994; definitions p. 11).

Thus, these criteria are biologically inappropriate to many Australian arid zone rodents, including Ngadji, which regularly and naturally experience substantial population fluctuations in response to environmental conditions. In conservation terms, significant declines in breeding potential of these species would be caused by local extinctions contracting the Area of Occupancy. For this reason Start (1996) interpreted 'population reduction' in terms of discrete populations in his review of the Ngadji's conservation status. We concur with that approach and consider that his conclusions and recommendations were sound.

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APPENDIX 1. Location data for *Pseudomys chapmani*. Latitude and longitude are expressed as decimal degrees. Source details are available from the corresponding author.

LOCATION	LAT	LONG	SPECIMEN	ACTIVE MOUNDS	OLD MOUNDS
Abydos, near 28 Mile Camp	21.33	118.88	n	y	y
Barlee Range Nature Reserve	23.13	116.00	y	y	y
Barlee Range RN, south end	23.38	115.92	n	n	y
Barlee Range RN, south end	23.30	115.93	n	n	y
Barlee Range NR, west side	23.17	115.83	n	y	y
Barlee Range NR, north end	23.00	115.83	n	n	y
Boundary Ridge	23.03	118.72	y	y	y
Broadhurst Range, north-west of	22.12	121.93	n	y	y
Brockman Mine	22.30	117.83	n	y	y
Burrup Peninsula	20.58	116.83	n	n	y
Burrup Peninsula	20.58	116.83	n	n	y
Callawa Plateau	20.58	120.87	n	n	y
Cane River Station	22.05	115.62	n	n	y
Channar	23.30	117.73	y	y	y
Chichester Range	21.35	117.23	y	y	y
Cobra Station	24.20	116.47	n	n	y
Collier Range	24.78	119.12	y	y	y
Cookes Hill	20.75	118.68	n	y	y
Croydon	21.12	117.80	n	n	y
Deepdale	21.72	116.18	n	n	y
Dinner Hill	22.62	118.28	y	y	y
Edmund Station	23.77	116.10	n	n	y
Erong Springs Station	25.57	116.67	n	n	y
Fortescue Bridge, south of	21.40	116.05	n	y	y
Fortescue Falls	22.50	118.57	n	y	y
Galteemore Mining Centre	21.85	120.45	n	y	y
Giles Point	23.27	119.17	n	y	y
Gregory Range	22.22	121.30	y	y	y
Gregory Range	22.17	121.40	y	y	y
Jimblebar – Mt Wheelarra	23.38	120.13	y	y	y
Joffre Falls	22.35	118.28	y	y	y
Judal (Mt Hale), near Mileura	26.12	117.50	n	n	y
Karijini NP, Ranger HQ	22.58	118.45	y	y	y
Karratha	20.73	116.87	n	n	y
Karratha	20.73	116.87	n	n	y
Kennedy Range, east of	24.63	115.18	n	n	y
Kenneth Range, Mt Vernon	24.23	118.25	n	n	y
Marandoo	22.62	118.12	n	y	y
Marandoo	22.62	118.01	y	y	y
Marandoo	22.67	118.18	y	y	y
Marandoo	22.62	118.10	y	y	y
Marble Bar	21.17	119.75	n	n	y
McCamey's Monster	23.38	120.00	y	y	y
McKay Range	23.03	122.73	y	y	y
McKay Range	23.00	122.50	n	y	y
McPhee Mining Centre	21.05	118.97	n	y	y
Miles Hill	22.43	122.23	n	n	y
Mileura Station	26.37	117.33	n	n	y
Mindi Spring	22.80	118.32	y	y	y
Mt Anketel	20.67	117.04	n	n	y
Mt Barricade	22.82	118.20	n	y	y
Mt Bilroth	21.62	117.60	n	y	y
Mt Brockman	22.47	117.30	n	y	y
Mt Bruce	22.62	118.05	y	y	y
Mt Bruce	22.62	118.13	n	y	y
Mt Channar	23.33	118.00	n	y	y
Mt Edgar	21.30	120.07	y	y	y
Mt Hanwright	22.32	118.28	n	y	y
Mt Herbert	21.32	117.22	n	y	y
Mt Howieson	22.65	118.25	n	y	y
Mt Howieson, south-east of	22.72	118.33	n	y	y

Mt Leake, near	25.83	119.08	n	n	y
Mt Maguire	23.35	117.82	y	y	y
Mt Meharry	22.98	118.58	n	y	y
Mt Newdegate, near	21.13	121.03	n	n	y
Mt Newman	23.27	119.57	n	y	y
Mt Trevarthon	23.00	118.25	n	y	y
Mt Vigors	22.50	118.23	n	y	y
Mt Webber, Fibre Queen Mine	21.62	119.13	n	y	y
Mt Whaleback – Newman	23.33	119.73	y	y	y
Mt Windell	22.62	118.60	y	y	y
Mulgul Station	24.83	118.47	n	n	y
Munjina Gorge	22.43	118.70	n	y	y
Munjina Gorge, south of	22.52	118.68	n	y	y
Newman, Ore Body 25	23.37	119.73	n	y	y
Nimingarra Hill	20.50	119.90	n	y	y
North Pole, north of	20.92	119.25	n	y	y
North Pole, south of	21.17	119.33	n	y	y
Oakover River	21.37	121.03	n	y	y
Packsaddle	22.97	118.73	y	y	y
Pannawonica, Mesa J,	21.72	116.25	n	n	y
Pardoo Quarry	20.23	119.57	n	n	y
Parry Range	22.42	115.57	n	y	y
Pincunah Hill, south-east of	21.23	118.92	n	y	y
Rhodes Ridge	23.12	119.42	n	y	y
Rio Tinto Gorge	22.41	117.83	y	y	y
Ripon Hills	21.32	121.03	n	y	y
Rooney Creek	22.53	122.30	y	y	y
Rooney Creek	22.48	122.30	y	y	y
Savory Creek	23.88	120.50	n	y	y
Shay Gap	20.50	120.17	n	n	y
Shovelanna Hill	23.33	120.02	y	y	y
Split Rock	21.53	119.58	n	y	y
Strelly Gorge	21.13	119.03	n	y	y
Table Top Hill	22.40	121.95	n	n	y
Tambourah	21.75	119.08	n	y	y
between Tambourah/Woodstock	21.42	119.05	n	y	y
The Governor	23.07	118.85	n	y	y
The Governor, south of	23.08	118.87	y	y	y
The Governor, south of	23.10	118.85	y	y	y
Turee Creek h/s, 35 km ne	23.37	118.45	n	y	y
Weeli Wolli Creek	22.88	119.23	n	y	y
West Angelas	23.18	118.78	y	y	y
West Angelas	23.21	118.82	y	y	y
Whim Creek	20.83	117.83	n	n	y
White QuartzHill	20.68	120.37	n	n	y
White Springs	21.78	118.80	y	y	y
White Springs	21.78	118.80	n	y	y
Woodstock	21.61	118.95	y	y	y
Woodstock	21.58	119.08	y	y	y
Woodstock	21.68	119.05	y	y	y
Woodie Woodie Mine	21.63	121.23	n	y	y
Yandicoogina	22.78	119.22	y	y	y
Yarrie Plateau	20.37	120.20	y	y	y
Zebra Hill, north of	21.12	116.83	n	n	y

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Report on the history of the arrival of the feral cat population in Western Australia

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SUMMARY

This investigation was commissioned by the CALMScience Division of the Western Australian Department of Conservation and Land Management with a view to understanding the spread of the feral cat population across the continent. It has been proposed that cats arrived in Western Australia via Dutch shipwrecks on the west coast in the 17th and 18th centuries; with Macassan trepangers on the north and north-west coasts; or overland from the east coast. This report examines the evidence for each of these possibilities, and considers others. Oral evidence from Aboriginal people suggests that the arrival of the cat pre-dates the arrival of both foxes and rabbits by some margin. Aboriginal people have also claimed that cats came from the west, which would tend to point toward the ships of the Dutch and/or other Europeans as the source of cats. With the exception of Matthew Flinders' *Investigator*, however, no definite evidence for cats on board vessels making landfall on the Western Australian coast until 1826 has been uncovered. Furthermore, a thorough examination of the available sources has revealed no evidence of cats being carried on board Macassan praus.

INTRODUCTION

This report sets out the discoveries made in relation to the question of when and how feral cats (*Felis catus*, Linn. 1758) first arrived in Western Australia (WA).

METHODS

Material relating to the history of feral cats was located through extensive searches of library catalogues, article databases and the internet, as well as bibliographies of relevant monographs and articles, and research notes at the Battye Library, Perth, WA. This research has been confined to published sources in the English language.

OVERVIEW OF CURRENT KNOWLEDGE OF THE HISTORY OF CATS IN AUSTRALIA

The domestic cat (*Felis catus* Linn. 1758) is believed to be descended primarily from the wild cat of Africa and extreme south-western Asia (*F. sylvestris libyca*). It was domesticated in Egypt around 4000 years ago, and introduced into Europe around 2000 years ago, where some interbreeding occurred with the wild subspecies *F. sylvestris silvestris* (Nowak 1991). It is known that cats accompanied the first British settlers in Australia, and that they were established over the greater part, and perhaps all, of the Australian continent by the end of the nineteenth century. The first record of a feral cat in the Northern Territory was by one Mr Winnecke, who in 1883 saw a cat near the Queensland border, on what is now Tobermorey Station (Johnson 1991). Long (1988) notes that in WA, feral cats were recorded at Lake Prinsep between 1890 and 1896, and at Lake Darlot (north of Leonora) in 1894. In 1891, Wells reported a cat in the northern part of the Victoria Desert, approximately 400 miles from any European settlement (Finlayson 1961). Cats were reported in the north-west of South Australia by J. Carruthers in 1892 (Johnson 1991), and Long (1988) and Johnson (1991) both refer to D.W. Carnegie's 1897 report of meeting two Aboriginal women who had caught a black domestic cat in the Winnecke Hills, around 500 km west of Alice Springs. Long also notes the first recorded reports of cats on islands off the Western Australian coast: Monte Bello Is. 1912, Dirk Hartog Is. 1917, Bernier Is. 1906–07 (but absent in 1959), Pelsart Is. 1913. Historian Eric Rolls tells of how when Arthur Mason was sent by the West Australian Under-Secretary For Lands to look for rabbits in unmapped country east of Kalgoorlie in 1896, he reported that west of Eucla, there were more traces of domestic cats than rabbits (Rolls 1969, p.153). As the century drew to a close, cats were seen as a potential solution to the problem posed by rabbits, and they were deliberately released, sometimes in large numbers. For example, 200 cats from Adelaide were released between Eyre Patch and Mt Ragged on the south coast of WA in 1899, on the orders of the Colonial Secretary (Long 1988).

There remains, however, some uncertainty as to when and how cats first arrived on the continent, and several

authors have sought to explain how cats came to be found in areas remote from the frontier of white settlement. Several authors have proposed that the cats arrived via Macassans, who collected trepang (Holothurioidea) in the shallow waters on the coasts of the Kimberley, Arnhem Land and the Gulf of Carpentaria from the eighteenth century, and possibly earlier (Underhill 1987; Johnson 1991; McKinnon 1991). In 1965 Fred Russ, then owner of Gibb River Station in the Kimberley, told A.J. Marshall, who was on a Monash University expedition to the area, 'there was a faint possibility that, long before the white man came, Malays had traded domestic cats to the coastal populations of Aboriginals' (Marshall 1966, p.172). Others have proposed that cats were often carried on board European ships in the seventeenth and eighteenth centuries as pets and for rodent control, and as evidence for the number of cats likely to be carried on a ship several cite the example of Captain Cook, who left 20 cats on Tahiti, as well as some on the islands Ulietea and Huaheine, in 1774 (see for example Fitzgerald 1990; Newsome 1991; Strahan 1995; original reference to be found in Beaglehole 1961, p.412). Strahan also notes that Banks' *Endeavour* journal lists 'catts' aboard in 1768 at the crossing into the Atlantic (Beaglehole 1962, p.174), although none are mentioned ashore at Endeavour River where the ship was careened for repairs. With reference to New Zealand, Fitzgerald (1990, p.335) also gives other examples of cats on board eighteenth-century European ships, noting, however, that despite ostensibly being introduced in the 1770s, 'cats apparently did not become feral until at least 50 years later' (notwithstanding which, by the 1830s they were reputedly valued by the Maori as food and for their skins). With regard to the Australian population of feral cats, several authors thus point to Dutch shipwrecks on the west coast of Australia as a likely early source for the feral cat population (Finlayson 1935; Burbidge *et al.* 1988; Johnson 1991; Newsome 1991; Burbidge in O'Neill 1994; Strahan 1995). Other authors mention neither of these theories, asserting merely that cats spread rapidly when introduced by British settlers, particularly when released in large numbers to control rabbits (Davies and Prentice 1980; Serventy 1980; Lever 1985, 1994). Paul Wagner, in the Department of Biological Sciences at Macquarie University, is in the final stages of writing up a thesis on the history of feral cats in Australia. This research has so far revealed no evidence of a Dutch or Portuguese origin for Australian cats, nor any confirmed archaeological evidence for the pre-European presence of cats, although a link with Sulawesi has been suggested (Wagner 1999 personal communication).

ARCHAEOLOGICAL SOURCES (TERRESTRIAL)

The only reference to cats found in an archaeological context in WA occurred in a report on the contents of 'Thylacine Hole', in the Nullarbor region. This cave is an animal trap, with a near-vertical entrance shaft 0.9 m to 1.8 m in diameter and 12 m deep. On the cave floor were found a large amount of owl-pellet deposit, as well as the

> carcasses, skeletons and scattered bones of animals which had died in the cave. These included snakes, lizards, birds, murids, bats, a cat, dogs (?dingoes), rabbits, possums, kangaroos, wallabies, thylacines, native cats, a wombat, and a Tasmanian devil (Lowry and Lowry 1967, p.26).

The Thylacine (Geological Survey of Western Australia Specimen F 6364) in the cave was radiocarbon dated to 3280 ± 90 years B.P., and a dog (presumably a dingo; Geological Survey of Western Australia Specimen F 6343) found in the cave to 2200 ± 96 years B.P. (Lowry and Merrilees 1969, p.15). However, the presence of rabbits indicates that not all of the specimens in the cave are of such great antiquity, and the cat has apparently not been radiocarbon dated.

ABORIGINAL SOURCES

With the exception of two references treated in the section on Macassans (below), the earliest of the direct references to Aboriginal perceptions of the arrival of cats in Australia comes from Fred Russ of Gibb River station, who reported to A.J. Marshall in 1965 that 'forty years ago tribal Aborigines told him that cats were native to the area' (Marshall 1966, p.172). In the most thorough study of Aboriginal knowledge of desert mammals to date, carried out from 1982–85, Andrew Burbidge, Ken Johnson, Phillip Fuller and R. Southgate visited many Aboriginal communities throughout the central deserts and surrounding regions, talking to groups of older people and showing them skins of desert mammals in an attempt to establish the historical distribution and population change for the various species. They found that '[a]ll people questioned regarded cats as always being present. Some indicated that they moved into central Australia from the west' (Burbidge *et al.* 1988, p.32). The researchers also noted that cats were a 'favoured food item'. In a later discussion with Graeme O'Neill, Andrew Burbidge compared this with the Aboriginal knowledge of the arrival of other feral animals:

> When we talked to Aborigines about feral animals we got a pretty consistent picture that foxes, rabbits and camels had arrived quite recently ... But they said cats had been present for a long time – many Aborigines regarded them as part of the native fauna. (O'Neill 1994, p.49)

Johnson (1991, p.45) repeated these findings, including the idea that the cats came from the west, and added a reference to a personal communication from Bryan Walsh about an Aboriginal man in the Nhulunbuy area (of the NT) 'who was the keeper or owner of a feral cat dreaming and became most indignant when doubt was cast by a European on its veracity'. However, this incorporation of the cat into Aboriginal totemic systems does not necessarily signify great antiquity – in Groote Eylandt, for example, the totemic system has been modified by the introduction of the Ship totem, as a result of contact with Macassan trepangers (Worsley 1955).

There is perhaps some evidence for the incorporation of the cat into Aboriginal mythology in two myths collected from the Murngin (Wulamba) people of north-east Arnhem Land by W.L. Warner in the 1930s (Warner 1958). These myths, 'Pussy Cat and the Milky Way', and 'Pussy Cat and Crow', see Pussy Cat involved in the creation of star constellations. In the first myth, Warner has placed 'native wild cat' in brackets after the first use of the term 'pussy cat', which perhaps indicates that this was Warner's interpretation of the Aboriginal use of 'pussy cat' (or one of the Aboriginal derivations of the term, such as *puutji* in the Luritja and Pintupi languages). Vincent Serventy recalls that in the 1950s, Aboriginal people in the central desert region referred to feral cats as 'pussycat' (Serventy 1980). It is therefore intriguing that in the myths related by Warner, the use of the term 'pussy cat' – rather than 'native cat' or just 'cat' – is retained, but still assumed to refer to 'native cats'. This is particularly so as the only 'native cat' found in the area is *Santanellus hallucatus*, the Northern Quoll, which is significantly smaller than a cat (Cronin 1991, p.18), apart from their other differences. Warner provides no untranslated version of the myths, so this ambiguity is impossible to resolve. No cats appear in the extensive lists of camp names, sacred names, country names, totems or sign language given by Warner, and nor do they make an appearance in myths with important ritual significance. However, even if it could be confirmed that these myths in fact relate to *Felis catus*, this would still give no definite indication as to the timing of the cats' arrival.

It is interesting to note that in hypothesizing the disappearance of many species of small desert mammals, Burbidge and Fuller (1979) reported that when Aborigines of the Warburton region were questioned 'as to the reasons for the disappearance of the native mammals they often told [Burbidge and Fuller] it was due to predation by cats.' However, the research of Burbidge *et al.* from 1982–85 apparently elicited no similar response (Burbidge *et al.* 1988).

In addition to Carnegie's 1897 report of Aboriginal women in the Winnecke Hills having killed cats for food, in 1900 the *Illustrated handbook of WA* included a reference to cats as an Aboriginal food item (Aytoun 1900). Finlayson (1935) made a similar observation during field work in the central desert region in the early 1930s, as did Thompson (1985) for the east coast of Arnhem Land in 1933. More recently, references have been made to the inclusion of cats in the Aboriginal diet in the central deserts (Finlayson 1961; Serventy 1980; Burbidge *et al.* 1988); Arnhem Land (Meehan 1977); and the Western Desert region (Greenway 1972). However, given the apparent rapidity with which cats were incorporated into the Maori diet in New Zealand (Fitzgerald 1990), and the similarly rapid inclusion of European foods in the Aboriginal diet following the British invasion, even evidence which points to a relatively early inclusion of cats in the diet of some Aboriginal groups would not necessarily indicate that cats had been present in the region for a long time. Furthermore, other studies of Aboriginal diets have omitted cats as a food item: the published work of the Australian-American Expedition to Arnhem Land in the late 1950s does not refer to cats (Mountford 1960); nor do they appear in Sara Meagher's study of the traditional diet of Aboriginal groups in the south-west of WA, which includes a survey of both the archaeological evidence and written accounts of contemporary white observers between 1831 and 1884 (Meagher 1973, 1974–75).

Burbidge *et al.* (1988) list the names given to cats in eight Aboriginal dialects. Of these, several (such as *anngthathaka*, *nyarapingi*, and *nyumpunypa*) appear novel, while others appear derivative or imitative. For example, *wilyka*, which is common to four of the dialects, could be derivative of the English 'wild cat', and *miiyawu* (common to three of the dialects) would appear to be imitative of the noise made by cats. A linguist would be able to draw more firm conclusions on this matter. However, Finlayson (1935) claimed that it 'is significant that the cat affords the single example of a non-indigenous mammal which has had a Luritja name applied to it', concluding that this may be taken as evidence that the cats had been in the centre of Australia long before white people.

SOURCES ON MACASSANS

Overview

'Macassans' is a term usually taken to refer to those people from present-day Indonesia, who from the eighteenth century, and possibly earlier, came annually to the northern coasts of Australia to collect trepang – edible holothurians – which were processed in Australia before being taken back to island South-East Asia for sale to the Chinese. The trepangers visited two parts of the northern Australian coast: an area they called Marege', which extended from Melville Island, across the coast of Arnhem Land to the Wellesley Islands in the Gulf of Carpentaria; and a section of the Kimberley coast of WA which they called Kaya Jawa, extending from the east side of Napier Broome Bay south-west to Cape Leveque. It is well-documented that on several occasions, Macassans took Aboriginal people back to Macassar, some of whom stayed for years, or perhaps even their entire lives. No reference to cats was found in any of the sources consulted, with the exception of two Aboriginal sources. In order to ascertain whether any older trends, which may have fallen through the gaps in the written record, continued to the present day, Australian Customs and Coastwatch were contacted and asked whether Indonesian fishers or illegal immigrant vessels carried cats. Both denied having seen or heard of cats on board either type of vessel, although poultry were seen on the former.

Records

Macknight (1986) notes that there exists an exceptionally 'complete and detailed' documentary record for trade in Indonesian Archipelago in the sixteenth and seventeenth centuries, referring in particular to the 'exhaustive and well-informed' account of trade in the

region by Cornelius Speelman in 1670, as well as the accounts of Tomé Pires (early sixteenth century) and Godhino de Erédia (early seventeenth century). From its inception in 1602, the VOC (Nederlandse Verenigde Oost-Indische Compagnie, commonly known as the Dutch East India Company) also kept detailed records, some of which are now held in the Public Records Office in the Hague, and others in Jakarta. Few of the original sources have been translated and published, but surveys of the material have been carried out by many contemporary authors, on whose work I have drawn. Macknight has also drawn on material held in the South Australian Archives, relating to Macassans at Marege' from the 1870s to 1900s. Macassarese and Bugis sources, although worked on extensively by A.A. Cense, J. Noorduyn and local scholars, have not yielded any information on Macassan trepanging in Australia (Macknight 1976). Ronald and Catherine Berndt have recorded descriptions of the Macassans given to them by Aboriginal people in Arnhem Land during field work there in 1946–47 and 1949–50. Contemporary descriptions of the Macassans at work in Australia can be obtained from the journal of Matthew Flinders, who encountered a fleet of praus (Macassan sailing vessels) on the Arnhem Land coast in 1803, and various nineteenth- and early twentieth-century works by authors based in Australia and South-East Asia.

Commencement of Visits

There has been some debate over when the Macassan trepanging began. The earliest date so far has been provided by Ronald and Catherine Berndt (1947, 1954), who estimated that visits by Macassans would probably have commenced some time in the early sixteenth century, to account for the level of influence they achieved on Aboriginal cultures. In his 1969 University of London PhD thesis, 'Late prehistoric changes in Aboriginal culture in Kimberley, Western Australia', Ian Crawford concluded that visits by Macassans commenced some time between 1669 and 1763 (Morwood and Hobbs 1997, p.198). Macknight (1976) initially suggested between 1650 and 1750, but most likely not before 1675. However, on the basis of documentary and archaeological sources, he later brought this estimate forward, placing the commencement of the industry in the 1710s–1720s without, however, ruling out earlier irregular visits (Macknight 1986). Carbon dating of charcoal from Macassan trepang-boiling fireplaces returned a date of around 800 years before present, but Macknight and subsequent authors have challenged this date, citing problems with the dating of mangrove wood, and the need for an oceanic reservoir correction factor. The first reliable record of Macassan trepanging in Australia dates from 1754: in 1751, the Dutch resident of Timor wrote to the authorities in Batavia about a Chinese trader who had set out from Timor to search for turtle-horn on 'the large sand-plate behind Rotti'. After seven days at sea, the trader reached a land to the south, inhabited by people matching the description of Australian Aboriginals. The VOC directors in Amsterdam, upon hearing of the incident, asked for more information about the Southland, to which authorities in Batavia responded: 'The Southland which is in the Southeast of Timor not far from thence is made now and then from Timor and Makassar, but produces so far [as] we know nothing but trepang, being dried jelly-fish, and wax' (Macknight 1976, p.95).

There is, however, a Macassarese legend with a possible basis in fact, relating to an early Macassarese voyage to Australia. In 1667, after the Macassarese were defeated by the Dutch, it is said that a few praus escaped and ultimately reached the Gulf of Carpentaria. Various landforms and places in the area were named after the leaders of the party, who eventually returned to Macassar, taking with them the first cargo of trepang (Macknight 1976). The significance of the tale lies in the continued use by Macassans of the place-names given in the legend.

Port of Origin

Most of the Macassan praus, and the trepang collectors on them, were Macassarese, a distinct linguistic group occupying the far south-west of the island of Sulawesi (Celebes), and Macassar (or Makassar, now Ujung Pandang), was the port of origin for most voyages to Arnhem Land (Macknight 1976). However, some voyages were also carried out by Bugis craft, and references to crew including a 'papua' or native of New Guinea, Javanese and Seramese also exist (Macknight 1976). Praus also came from areas other than Macassar. Of 13 praus observed by G.W. Earl in Port Essington in 1840, 11 came from Macassar, two 'small' ones from the island of Sumbawa, and one belonged to the Bajau, who are described by Earl as 'without any fixed home, living constantly on board their prahus, numbers of which congregate among the small islands near the southern coasts of Celebes' (Earl 1846, p.65).

Elsewhere, Earl also writes that the Bajau visited Kaya Jawa more often than Marege' (Macknight 1976). Macknight notes in his 1986 paper that '[t]he position in Western Australia is much more complex than in the Northern Territory since there is good written evidence for contact with the lesser Sunda Islands' (1986, p.71), although he neglects to give a source for this evidence. In discussing the history of the trepang industry in the Kimberley, Morwood and Hobbs (1997) claim that 'Makassarese, Bugise, Butonese and Bajau people, from islands such as Sulawesi, Madura, Flores, Timor and Roti' visited the northern coast to collect marine resources including trepang, although the Macassarese dominated the enterprise in both areas prior to 1900 (Morwood and Hobbs 1997).

Route

Pterological and micropore studies of minerals in pottery sherds excavated from a trepanging site at Tamarinda on the Kimberley coast suggested that the sherds originated in Kei Island or Flores, whereas similar analysis of sherds from Arnhem Land suggested a Sulawesi origin. Subsequent analysis of sherds from other Kimberley sites

indicated a similar origin to that of the Tamarinda samples (Burns 1990). These results imply that a different route was taken by Macassans visiting the Arnhem Land coast to those visiting the Kimberley coast, with the voyage to Marege' proceeding via the north-east end of Timor, and praus bound for Kaya Jawa often passing Flores, and between Timor and Roti. Mulvaney (1966) also notes that some praus took this latter route. Macknight describes the route to Marege' in some detail:

> From Macassar it lay around the southwest corner of Celebes [Sulawesi], down past Salayar and then southeast towards Timor and the islands fronting it. Dugout fishing canoes were often obtained from the island of Tanahjampea, which was passed on the way. The anchorage on the south of this island is still known as Labuan Marege' (1976, pp.33–34).

He also notes that praus passing around the north-east-end of Timor sometimes stopped to take on fresh water, and to collect 'spare parts' in the form of bamboo and rattan from the neighbouring island of Kisar. In a later work, Macknight (1986) discerned from Dutch archives that in the late seventeenth century, praus on their way to Marege' stopped first at the island of Bonerate. Taking a linguistic perspective on the issue, M.J. Walsh (1986, p.47) has produced a map (based on J. Urry's calculation of 'Macassan' influence on languages at Port Keats) showing possible routes taken by Macassarese and Buginese which resulted in loan words in the Murinypata language.

The crossing from Timor to Melville Island usually took four days, and the entire one-way journey from Macassar 10–15 days (Macknight 1976). Praus were occasionally caught in storms and wrecked; Macknight (1976) provides a table showing that on average one or two praus were wrecked or went missing every year on the voyage to Marege' between 1881 and 1900.

Life on Board and in Australia

The most extensive work so far on Aboriginal traditions relating to the Macassans was carried out in Arnhem Land by the Berndts in the late 1940s. The Macassans are seen by the Aboriginal people in an historic context, as opposed to pre-Macassan visitors, called the *Bainii, or Baijini*, who in Aboriginal mythology appear after the peopling of the land, but still contemporaneous with some dreamtime Ancestral Beings. In Aboriginal myths, the Macassans established more or less permanent settlements on the coast, built houses on stilts, planted tamarind trees and coconut palms, and manufactured knives, cloth, sails and pottery. They also 'kept fowls (*gerauwul*), tied to the posts of their huts by one leg, around which a ring was fastened: and in the praus they brought cats (*miu*) as well' (Berndt and Berndt 1954, p.43). This word for cat is similar to the Macassarese word (see below), although both are clearly imitative of the noise made by cats. The Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS) library catalogue also lists a publication by Peter White (White 1968), which is annotated as referring to 'Arnhem Land and Macassan influence on art, myth, ceremonial; introduction of tamarind and bamboo, domestic fowls and cats'. The inclusion of fowls alongside cats arouses the suspicion that this work quite probably refers back to the Berndts. However, attempts to view this publication, categorized by AIATSIS as 'restricted use', have not been successful. In an apparent change of mind, White later declared that 'there is no certain record of animal introductions by Macassans', and indeed with the exception of the dingo, 'no definite evidence for the introduction of animals into Australia in the prehistoric period' (White 1971, pp.188–189). In a still more recent publication, *A prehistory of Australia, New Guinea and Sahul*, White makes no mention of cats, except to note that feral cats now exist (White and O'Connell 1982).

The Aboriginal evidence cannot be ignored, however it must be treated with some caution. Although the reference to fowls is verified to some extent by other sources, including European ones, the assertion that the Macassans made pottery in Australia out of termite mound clay has been challenged by Mulvaney (1966) and Macknight (1972), on the grounds that it would be unusual for pottery to be made on a trepanging expedition; the absence of archaeological evidence of pottery wheels, paddles, kilns and so on; the difficulty of making any pottery from termite mounds; and microscopic examination of sherds which has revealed the presence of volcanic minerals not found in northern Australia. Subsequent analysis of pottery sherds has placed their origin in Sulawesi and Flores or Kei Island (see above). Mulvaney (1966) and Macknight (1972, 1976) also challenge the Aboriginal assertion that the Macassans set up semi-permanent settlements.

The Berndts divide Macassan trepanging into two distinct periods: the first lasting from the sixteenth century to the 1820s, and the second, characterized by more fractious relations between the Macassans and Aboriginal people (as well as Europeans, in the latter part of the period), from the 1820s to the end of the industry in 1907, when the visits were prohibited by the Commonwealth Government. It is possible that, although there is no documentary or archaeological evidence for contact beginning before the eighteenth century (with the exception of the equivocal carbon dating mentioned above), if such earlier contact did occur, the building of semi-permanent settlements, and the transportation of cats, may have been two of the differences between the undocumented early period, and the way the industry operated in the later period. Alternately, the inclusion of cats in the Aboriginal myths may be explained with reference to the way in which the latter are constructed. Kenneth Maddock has analysed Aboriginal myths relating to both Captain Cook and the Macassans, in order to test the relationship between myth and history as it has occurred in Australia. He suggests that the value of the stories 'lies less in enabling the past to be reconstructed as in giving a 'reading' of an Aboriginal sense of themselves, or of their past, in relation to the outside world' (Maddock 1988, p.21). If the inclusion of cats in Aboriginal tradition is interpreted in this way, it could be seen to represent

evidence that cats were regarded as something which arrived from 'outside', contemporaneously with that other major 'outside' influence, the Macassans, but not necessarily arriving on board their praus. Unless cats are regarded as a later embellishment of the myths, these stories would therefore indicate that cats arrived prior to the British invasion, most likely via early explorers or shipwrecks.

Of those non-Aboriginal authors who had contact with the Macassans, and wrote of conditions aboard their praus, none mention cats. The earliest reference consulted – *The Suma Oriental of Tomé Pires* – (*c.*1515), refers to the praus of the traders and pirates of the islands of Macassar, but makes no mention of either trepang or cats. Nearly three hundred years later Flinders (1966), meeting with a fleet of Macassan praus on 17 February 1803, recorded conditions on the praus in more detail: 'They carry a month's water, in joints of bamboo; and their food is rice, cocoa nuts, and dried fish, with a few fowls for the chiefs' (Flinders 1966, p.231). A similar description is given by Peter Good, the Gardener on board Flinders' voyage (Good 1981). King (1827), who encountered a fleet of Macassan praus at Coepang (now Kupang) in Timor in 1818, similarly makes no mention of cats, and nor does J. Crawfurd (1820), in his extensive *History of the Indian Archipelago* (written subsequent to a nine-year stay in the region from 1808). Earl, observing Macassan praus in Port Essington in 1840 referred to poultry on board the vessels, but not cats (Earl 1846, p.65).

A.R. Wallace, a naturalist who spent several years in the archipelago, arriving back in England with 310 species of mammals in 1862, wrote an extensive work on the archipelago that was published in 1869. The only species of *Felis* mentioned in the work is *F. megalotis*, 'a tiger cat, said to be peculiar to Timor, where it exists only in the interior, and is very rare' (Wallace 1869, p.208). In the only reference discovered so far in the non-Aboriginal Asian literature to carnivores of any description being transported, Wallace mentions that the Malay civet, *Viverra tangalunga*, a species relatively common throughout the archipelago, was

> made captive by the Malays, who procure civet from it ... an animal very restless and untamable, and therefore likely to escape. This view is rendered still more probable by what Antonio de Morga tells us was the custom in the Philippines in 1602. He says that 'the natives of Mindanao carry about civet-cats in cages, and sell them in the islands; and they take the civet from them, and let them go again' (Wallace 1869, p.392).

In his survey of the mammals of the south-west Pacific and Moluccan Islands, Tim Flannery (1995) notes that the palm civet (*Paradoxurus hermaphroditus*) was possibly introduced to the North Moluccas to help control rodents. Nowak (1991, p.1154) refers to this animal being carried by people from island to island for use as a rat catcher – a practice probably accounting for its presence on Sulawesi and Timor. Flannery also notes that although *Felis catus* is found on 'most larger islands in the region', its exact distribution is unclear. It is possible, therefore, that historically, civets have largely replaced cats for rodent control in the region, which would explain the paucity of reference to cats (on land and on boats) in the historical sources.

In describing his travels throughout the region, including a detailed description of a voyage on a 'native prau' (in which he travelled from Macassar to the Aru Islands over 14 days in December 1856), Wallace refers to almost every species of domestic animal, including dogs, but not to domestic cats. Nor do they appear in his description of the bustling trade centre of Dobbo, in the Aru Islands. In a more recent work by Alfred Searcy (1909), who was stationed at Port Darwin as sub-collector of Customs for 14 years from June 1882, there is still no mention of cats, although Searcy is clearly interested in the fauna of the region, speculating that 'the animal from which the dingo has sprung' may have come from Chinese stock, via Portuguese traders (an hypothesis which we now know to be untrue). As a customs officer, Searcy regularly boarded praus, and it is unlikely that he would have overlooked the presence of cats on them (particularly as his first vessel, the cutter *Flying Cloud*, was itself infested with rats and cockroaches). The only published manifest for a Macassan prau was taken by Macknight (1976) from South Australian archives, for a prau departing for Marege' in 1886. Cats are not included in the list.

Language

The tendency for several Aboriginal linguistic groups to use imitative names for 'cat' (see above) could make it difficult to distinguish whether they borrowed Macassan names: the regular Macassarese word for 'cat' is *miong* (Cense 1979), and forms given by nineteenth-century travellers include *miaò* for South Sulawesi and *miau* for Bajau (Wallace 1869), and *meyung* for both Macassar and Bugis dialects and *maioh* for a Roti dialect (Crawfurd 1820). Furthermore, even if such a link could be established, it would not necessarily indicate that the cats arrived on board the Macassan praus, merely that they appeared in the area contemporaneously. In an article which appeared in *Aboriginal History* in 1981, Alan Walker and R. David Zorc offered a list of words recognizably 'borrowed' from Macassarese and other Austronesian languages by Aboriginal speakers of Yolngu-Matha, who live mainly in north-eastern Arnhem Land. It is perhaps pertinent that the list contained the words for pig, sheep/goat, buffalo, horse, dog, prawn, mudcrab, and jellyfish, but not cat. Although the list is not fully comprehensive, the authors were assisted by 11 Yolngu-Matha speakers, and it would be surprising if the word for cat was inadvertently overlooked.

Conclusion

No reference to cats was found in any of the sources relating to Macassans, with the exception of two references to Aboriginal traditions, which must not necessarily be taken to mean that the Macassans were the source of the cats. Although there is always the potential that as a commonplace their presence was overlooked, that they

travelled only occasionally on praus, or that they accompanied Macassans only in the very early stages of the industry, the overwhelming absence of cats in the historical sources relating to Macassans makes it very unlikely that they were introduced from Sulawesi or other Indonesian islands by Macassan trepangers (although it is possible that they may have been introduced from Batavia [Jakarta] or other ports by European vessels).

OTHER POTENTIAL SOURCES OF CATS: THE BAIJINI, ARABS, CHINESE AND PORTUGUESE

Several authors have pointed to the possibility of people other than the Dutch, French, English and Macassans landing on Australian soil. Most of these proposals are based on much conjecture and relatively little evidence, and can therefore not be pinpointed with any certainty as the source of feral cats in Australia. In the interests of comprehensiveness, however, I have provided a brief survey of the available evidence.

Several references occur in the literature to accidental 'drift voyages' from Timor and other islands in the archipelago. As well as the case of the Chinese trader who sailed and drifted his way from Timor to Australia, referred to in the Dutch records of 1751 (see above), Erédia, writing in the 1600s, recorded several examples of native and Portuguese craft, as well as a Chinese junk, being blown southward of various islands by the north-west monsoon. Similarly, in the 1840s, G.W. Earl noted that nearly every Timorese village mourned the loss of praus blown to the south-east (Mulvaney 1975). The Berndts (1954) also refer to Aboriginal stories of 'spirit canoes' – sometimes containing people – which were blown onto Arnhem Land shores, and Colin Jack-Hinton (1989, p.41) proposes that 'drift voyages have almost as great an antiquity as the populations of Timor, Tanimbar and the Aru Islands'. On a different note, Walker and Zorc (1981, p.109) refer to 'Philippine Lanaw pirates (who apparently operated off the coast of northern Australia)'.

The same Arnhem Land Aboriginal song cycles that refer to the Macassans also refer to a group of people called the *Baijini, or Bainii*, a light-skinned people who arrived before the Macassans. The *Baijini* were said to have built stone houses, cultivated the land, made cloth and collected trepang. The presence of *Baijini* women is an important feature of the tales, and possibly points to the Bajau as the source of the myths: among the Bajau – sea nomads based around the islands south of Sulawesi – it was usual for women to travel on praus along with the men (Berndt and Berndt 1954). Pires, writing in 1512–15, refers to these people – whom he portrays as pirates based in the islands around Macassar – and in particular their taking women to sea (Pires c.1515). However, the Aboriginal tradition does not refer to the *Baijini* bringing cats.

Jack-Hinton (1989) has surveyed other possible early contacts with Australia. He notes that Chinese trade with south-east Asia can be dated to at least the third century AD, and that in the first three decades of the fifteenth century Admiral Ch'eng Ho travelled – with a large entourage – to Indonesia, Ceylon, India the Persian Gulf and the east coast of Africa. Similarly, Muslim traders had been active in the archipelago since the eighth century AD. It is possible that either a Chinese junk or Arab dhow made a landfall in Australia – by design or accident – at some time. However, there is no documentary evidence that this occurred, and very little archaeological evidence: in 1879, a carved figure of the Taoist immortal Shou Lao, tentatively dated to the fourteenth century, was found buried in the roots of a Banyan tree; and during World War II, a soldier in the Wessel Islands discovered several coins near the island's only fresh water spring: three Dutch coins dated from 1690 to 1784, and five coins from Kilwa, Tanzania, dated between the thirteenth and late fifteenth centuries.

There have also been several works dealing with likely Portuguese voyages to Australia. One of these voyages, possibly undertaken in 1599 or 1600, is referred to in a vague account by Erédia and on a map dated 1602, discovered in the Brazilian National Library in 1946, which shows a voyage from Timor, south to '*Ouro*' ('Isle of Gold', possibly a point on the Western Australian Coast near Brunswick and Collier bays), then north to Flores, south to Ashmore Reef and Cartier Island, then north again to Sawu (Ward 1987). This 'voyage', however, has been dismissed by McIntyre (1982) as a fantasy on the part of Erédia. It is also conceivable that Gomes de Sequeira, in 1525, and Cristavão de Mendonça, in 1521, landed on Australian shores, although the latter voyage was ignored by contemporary chroniclers, (possibly owing to a policy of secrecy resulting from Spanish-Portuguese rivalry). There is, however, another more certain source which suggests that the Portuguese knew of the Australian continent: on the maps which appeared out of the Dieppe school of cartography between 1536 and 1566, a Portuguese discovery, 'Java-la-grande', was marked as a land mass in about the same position, and about the same size, as Australia. A further possible piece of evidence for Portuguese landing in Australia is the so-called 'Mahogany Ship': a wreck in the sand hills behind the beach about halfway between present-day Port Fairy and Warrnambool. This wreck, which was first reported by sealers in 1836, and 25 Europeans subsequently, was regarded by the Aboriginal people as having always been there. The remaining descriptions of the ship fit those of a Portuguese caravel, although the remains of the wreck were buried by a sandstorm in 1890 and have never been recovered (Ward 1987). In spite of much conjecture on the subject, none of the available evidence points unequivocally to a Portuguese landing on Australian shores, and scholars such as W.A.R. Richardson (1989) remain unconvinced that any European contact with Australia occurred before the early seventeenth century.

EUROPEAN SOURCES

Overview

The first recorded European voyage to the southern continent was instigated by the director of the Dutch Factory at Bantam, Jan Willemsz Verschoor, who sent Willem Jansz in the *Duyfken* to 'Nova Guinea, and other east- and south-lands' (Schilder 1989, p.72). Unfortunately, the log of this voyage has been lost. However, much Dutch contact with the coast resulted from Frederick Brouwer's discovery in 1610 of a fast route to the East Indies, which took advantage of the westerly winds between lat. 35° and 45°S before setting a northerly course for the Indies. The route was officially adopted by the VOC in 1616. As longitude was estimated at the time by distance travelled, the error by the end of the Indian Ocean crossing was often great, and several Dutch trading vessels thus came across the Southland: some landed, some turned immediately to the North, some were wrecked. The VOC Resolution of 1616 also included an article stating that 'the koopman, schipper and stuyrman of the ships that call into any other place than Tafelbaey (unless in an emergency) whereby delaying their voyage, will have to pay an amends of six hundred guilders to the profits of the Company' (Green 1977, p.4). However, by no means all vessels stopped at Table Bay (one of the bays at the Cape of Good Hope). For example, all Dutch vessels sent on voyages of exploration sailed from the Indies, (with the exception of de Vlamingh, who sailed from the Netherlands), and the Englishman William Dampier sailed via the Philippines and other Asian islands in 1688, and in 1699 via Brazil. Many of the early journals and other relevant documents have been lost, and for some voyages the only known documents are charts or maps, or a reference in VOC correspondence or instructions. A list of all known non-Macassan vessels making landfall on the Western Australian coast, with details of ports of departure and available sources, *inter alia*, is given below.

Cats (and Dogs) in European Tradition, and European Sources

As no record of cats aboard ships could be found in the available journals or manifests (with one exception, detailed below), other sources were surveyed in order to ascertain the likelihood that cats were on the ships, without their presence being recorded. A survey of the indexes of the *Mariner's Mirror*, journal of the London-based Society for Nautical Research, revealed great variation in superstition relating to cats on board ships. In 1911 (1:319), 'A' suggested that 'A black cat is proverbially lucky on board ship', whereas in 1913 (3:317), 'R.M.N.' regarded cats as 'taboo' afloat, but lucky when left on shore in fishers' houses. More recently, in 1959, Edgar K. Thompson asked why Charles Darwin, in the journal of his voyage on HMS *Beagle*, wrote on 20 December 1831: 'The sailors declare that there is somebody on shore keeping a black cat under a tub, which it stands to reason must keep us in harbour' (45:82). In reply (45:347), Henning Henningsen observed that this statement would seem to imply that a cat gave favourable winds, but in Danish superstition, the opposite is the case. Quoting from Jens Kamp, *Danske Folkeminder* (Odense, 1877, p.203), he writes:

> When a skipper wants a favourable and good wind he should have no cat onboard [sic]. Old sailors often tell about how contrary the wind used to be, when such an animal was found onboard [sic]. But if they threw the cat into the sea it would help immediately.

In 1987 (73:202) Andrew T. Lloyd wrote to the *Mariner's Mirror* calling for evidence by which to quantify the truth of the statement that ships carry cats: in particular he asked whether all or some sailing ships carried cats and why; whether the custom declined with the advent of steam, and whether any particular variety or sex was preferred. Unfortunately, no informative response was published.

There is perhaps some reason to suspect that the Dutch may have carried dogs on board their ships rather than cats. Masselman (1963, p.13) relates the legend of the founding of Amsterdam by a shipwrecked Viking, a Frisian and his dog, who went out in the Frisian's fishing boat and were driven by a storm to shore at the present site of Amsterdam:

> From this modest beginning, with two men and a dog, Amsterdam, according to the legend, grew [footnote: Jan Mens, *Amsterdam: paradijs der herinnering* (Amsterdam, 1947)]. Of the three, only the dog gained a lasting place in history - it became a tradition for all ships to carry a dog on board. Eventually the dog became a symbol of ownership, and no vessel could be considered abandoned so long as the animal was still on board.

Although Masselman does not mention dogs (or cats) again, it is clear that the Dutch maintained some tradition of dogs on board their boats, with a particular kind of dog, the Keeshond, being kept as a watchdog on river and canal vessels (Perry *et al.* 1996). This dog was very popular until the late seventeenth century, when it fell from favour through its association with the Patriot Party and in particular its leader, Cornelius 'Kees' de Gyzelaar (who had a Keeshond as his constant companion), who failed in a revolt against the reigning House of Orange. Of the 290 illustrations in a collection of sixteenth–nineteenth century maritime prints by the Dutch masters, 15 depict dogs (although, perhaps significantly, they are all on jetties or foreshores), but none show cats (de Groot and Vorstman 1980).

On further consideration, cats appear remarkably absent from Dutch records. In an attempt to establish whether cats were prevalent at Cape Town, and where these cats may have originated, the first volume of the journal of Jan Van Riebeeck, covering the years 1651–1656, was read. The journal begins with Riebeeck preparing to depart from the Netherlands on 14th December 1651 with a fleet to establish a refreshment

station – Cape Town – at Table Bay, on the Cape of Good Hope. The fleet departed on the 24th December 1651 from Texel, and arrived at the Cape on the 7th April 1652. The journal then covers Riebeeck's day-to-day management of the station: construction of a fort, creation of gardens, and dealings with the 'natives'. However, not once in this journal does Riebeeck refer to cats; mention is made of all manner of domestic animals – including dogs – and to predatory wildlife, but the only 'cats' noted by Riebeeck are civet-cats, which are looked on as both a potential economic resource:

> It is definite, at any rate, that there are civet-cats here, but how abundant they are, time will have to show. If one had people with knowledge of taking the civet from the cats, one could even keep civet-cats for the Hon. Company (Riebeeck 1952, p.38).

and as a nuisance to people and livestock:

> Last night a civet-cat entered the Commander's room, and after much trouble it was caught and killed. These cats abound here to such an extent that it is difficult to protect pigeons, ducks or fowls against them (Riebeeck 1952, p.318).

If cats were, however, usually carried on Dutch ships (for which there is apparently no evidence), it is possible that they may have arrived at the Cape with earlier Dutch navigators who put in to Table Bay, or with Dutch shipwrecks at Table Bay (such as that of the *Mauritius*, which foundered at the Cape in 1643, or the *Haerlem*, which was stranded in Table Bay in March 1647, the survivors living there for a whole year). They may also have arrived with navigators from other nations who put in at the Cape (such as Englishmen Shillinge and Fitzherbert in 1620, and their countryman Captain Johnson in 1622). Certainly by the early nineteenth century there were feral black cats at the Cape. In *The Cat: Past and Present*, M. Champfleury quotes from the 1824 *Histoire Naturelle des Mammifères* of Fréderic Cuvier, of 'a black Cape cat':

> The Cape cat had the eyes and the disposition of the common domestic cat. It had been tamed, and left to itself on board the vessel that brought it to Europe; like the domestic cat it made war on rats, with all the more success on account of its size and strength. ... Only for its repugnance to being lifted up, or even touched, it might have been taken for a domestic cat (Champfleury 1885, p.176).

Cats do not appear in published examples of provisions and cargoes of VOC vessels. Bruijn *et al.* have published a list of victuals specified by the Heren XVII for all Chambers of the VOC as of 12 December 1695, as amended by resolutions adopted in 1702, 1706, 1712, 1713 and 1724. The list includes '4 live fullsize sows or 12 young pigs for large ships of 145 ft length, for smaller ships less' (amended in 1731 to specify hogs instead of sows – 18 for ships or 160 ft and 12 for ships of 130 ft), and '40 hens for a large ship, fewer for smaller ships', as well as quantities of utility articles such as candles (Bruijn *et al.* 1979:I pp.217–218). Cats are not mentioned. Bruijn *et al.* also provide, by way of example, lists of two cargoes of outward-bound East Indiamen, which also omit cats (1979, pp.219–222).

Several sources also refer generally to life and conditions on board Dutch East Indiamen (Boxer 1963; Bruijn *et al.* 1979, pp.157–161), the vessels of the French explorers (Taillemite 1990), and English shipping from the seventeenth to nineteenth centuries (Thrower 1972). None mention cats. We know, however, that cats were aboard the *Endeavour* 1768–1771 (Beaglehole 1962, pp.175–176), and the *Resolution* 1772–1775 (Beaglehole 1961, p.135n, 412). There is also definite evidence that some English and French voyagers carried dogs on board their ships, as they are recorded in the journals of Dampier (in 1687), D'Entrecasteaux, Vancouver, Baudin (in 1803) and King, as well as Banks' *Endeavour* Journal. They also appear on the *'Spyall'* (fictionalized *Investigator*) in Matthew Flinders' story *Trim* (Flinders 1977).

Trim is Matthew Flinders' story of his favourite cat: a black and white male which was born on board the *Reliance*, in between the Cape of Good Hope and Botany Bay, in 1799. Trim was 'a favourite with everybody on board', and '[b]eing brought up amongst sailors, his manner acquired a peculiarity of cast which rendered them as different from those of other cats' (Flinders 1977, p.7). Trim learned to swim, and had 'no dread of water'. As well as entertaining the crew and providing companionship for Flinders, however, Trim was clearly on board to catch 'the enemies of king and country' – rats. His catching was by no means confined to the ship, however. As Flinders euphemistically puts it:

> Trim, besides his other voyages, completed the tour of the globe. Many and curious are the observations which he made in various branches of science, particularly in the natural history of small quadrupeds, birds, and flying fish, for which he had much taste (Flinders 1977, p.21).

Trim, however, proved somewhat unsuited to long periods at sea: 'In the Gulf of Carpentaria, from the unhealthiness of the climate, the want of his usual fresh food ... this worthy creature became almost grey, lost much of weight, and seemed to be threatened with a premature old age' (Flinders 1977, p.26). Does this perhaps suggest that cats would be unlikely to earn their keep during long VOC voyages from the Netherlands to the Indies, with scarce fresh food? We also discover that there were several dogs on board the *Investigator*, as well as at least one other cat – 'Van, a Dutch cat on board'. This last reference is intriguing, but equivocal as to whether Van was a Dutch *ship's* cat, or a Dutch breed or type of cat. Perhaps the most important implication of the tale of Trim, however, is its demonstration that even where cats are present, they are not always mentioned in the journals of a voyage: in Flinders' *A voyage to Terra Australis*, neither Trim nor any other cats on board are mentioned once. Even in the dramatic shipwreck of the *Porpoise*, Trim is absent from the official account, while Flinders' story tells us that he survived, making it to shore with the crew and spending two months marooned with the survivors. Trim is also absent from gardener Peter Good's journal of the voyage (Good 1981).

Trim is also not the only cat known to have survived a shipwreck, one also surviving the wreck of the HMS *Pandora* in 1791 (although its subsequent fate is unclear). The *Pandora* was the Royal Navy warship sent to the South Pacific to capture the *Bounty* mutineers. In case the *Bounty* was found, the *Pandora* was heavily laden on this voyage with additional crew, stores and fittings. After leaving England in November 1790 and rounding Cape Horn, the *Pandora* arrived at Tahiti in March 1791, subsequent to which nearly four months were spent searching the Cook, Union, Samoan and Society Islands for the mutineers, some of whom they found. They never found the *Bounty*, however, and on 29 August 1791, the *Pandora* was homeward bound via Torres Strait when she hit a part of the Great Barrier Reef and sank at what is now known as Pandora Entrance, approximately 5 km to the north-west of Moulter Cay on the outer Great Barrier Reef, about 120 km east of Cape York (Queensland Museum 1999). The cat was found sitting in the cross-trees, just above the waves, and was rescued by a boat the day after the wrecking, subsequent to which the cat disappears from the records (Gesner 1999). The 99 survivors spent three days on Escape Cay before setting out for the Dutch East Indies in the ship's boats, arriving in Timor after 16 days.

American merchant vessels, of which one, the *Rapid*, was wrecked off WA's Point Cloates in 1811, were also known to carry both cats and dogs: Joan Druett tells how in early nineteenth-century America, Captain's wife Mary Rowland claimed that 'it says in our laws that we must carry cats', and Jack Russell terriers were 'particularly popular' as they were such good ratters (Druett 1998, p.143). Dogs were also recommended by Robert Stevens, a nineteenth-century authority on sea-freight who wrote the popular *On the Stowage of Ships and their Cargoes,* which was reprinted at least nine times between 1859 and 1894. Under the heading of 'Vermin' in this work, Stevens writes:

> When numerous, rats will attack the common English domestic cat, and if unsuccessful in destroying it, will much diminish its usefulness. At Milford, in 1857, a cat was taken on board the guano-laden Dutch ship *Konign der Nederlanden*, in the evening; the next morning nothing was to be seen but her skin and bones. The ring-tailed malay cats, being very strong, can more easily secure rats, with which they feed their young. Bull-terriers are considered preferable to domestic cats, but they cannot follow vermin so easily; to be of service they should weigh 8 to 14 lbs, over that they are unwieldy (pp.776–777).

In a posting to the SUB-ARCH listserv (SUB-ARCH@asu.edu) on 12 July 1999, Research Associate Professor Warren C. Riess, of the History and Marine Sciences Darling Marine Centre of the University of Maine, wrote that the Maine Coon Cat – a large breed of brown cat with a bushy ringed tail – is descended from the Asian cats used on ships (although there are conflicting ideas as to this breed's origin, see Frew 1997). No other reference to large Asian cats on ships has been uncovered.

Stevens also referred to the presence of cats in maritime law, claiming that in a rule laid down by Roccus (to which no further reference could be found), 'if mice eat the cargo ... the master must make good the loss, because he is guilty of a fault. Yet if he had cats on board his ship, he shall be excused' (p.777). From 1750, at least, this 'rule' was, however, a fallacy. In that year English law established that damage to cargo caused by rats was not a 'peril of the sea' by which a master could be excused from liability for the damage, and the master could therefore be held responsible, notwithstanding the presence of cats. Stevens claims that in Europe, however, the master was apparently not liable for such damage in the first place (thereby reducing, perhaps, the historical incentive to carry cats?) From Stevens we also learn that cats and dogs were not the only animals used to combat vermin – in 1866, the *Victoria*, embarking from Ceylon with a cargo of coffee, was equipped with 'two cats and two Cingalese ferrets' (p.779). In addition to animals, Stevens considered trapping and fumigation as means by which to combat rats, with the latter in particular being regarded as a standard and necessary procedure, and in fact appearing in several of the journals of voyages in the list below. Phillip King, on the other hand, dealt with vermin by totally submerging the *Mermaid* at Port Jackson for 'several days' (King 1827, p.345).

Maritime Archaeology

A search of the Western Australian Maritime Museum's Artefact Database (which has nearly 25 000 records listed) using the keyword 'cat' returned no relevant records, and of the 645 bone artefacts recovered and catalogued from all shipwrecks on the WA coast (disregarding the 99 entries relating to manufactured bone items such as buttons and combs), none have been identified as cat bones. Several bones have been identified as rat and rabbit, as well as seal, sheep, cow, etc. However, there are still many bones broadly described as 'mammal', or just as 'bones'. Jeremy Green, Head of the Maritime Archaeology Department of the Western Australian Maritime Museum, has not found references to cats in VOC records, nor their remains on any of the wreck sites he has worked on (Green 1999 personal communication).

An enquiry to the SUB-ARCH listserv (SUB-ARCH@asu.edu) about whether cat bones have been retrieved from wreck sites elicited a response from John Broadwater, Manager MONITOR National Marine Sanctuary, whose team located the skull of an immature cat (which had, perhaps significantly, been gnawed by rats) on the *Betsy*, a British transport (ex-collier) sunk at Yorktown, Virginia in 1781. A similar enquiry to the sea-site list (sea-site-request@mailbase.ac.uk) returned an earlier find: Jon Adams of the Centre for Maritime Archaeology at the University of Southampton reported that a cat fibula was found on the *Sea Venture* (1609) in Bermuda. This was possibly a pet travelling with the English colonists bound for Jamestown, Virginia, or may have been a ship's cat. The faunal analysis on both wrecks was done by Dr Philip Armitage, who may be able to offer further information on the prevalence of cat remains on shipwreck sites.

Voyages

A list of known and possible landings or shipwrecks of non-Macassan vessels on the northern and western coasts of Australia, from Cape York to Cape Nuyts, to 1826 appears below with information relating to port of departure, date of departure, ports of call en route, availability of journal or other documents, and other relevant details relating to the voyage. A list of all VOC vessels bound for Batavia may be found in Bruijn *et al.* (1979), *Dutch-Asiatic shipping in the 17th and 18th centuries,* vol. 2. *Outward-bound voyages from the Netherlands to Asia and the Cape (1595–1794).* In the list below, details of type, chamber, departure date and stopovers for outgoing VOC ships from Europe have been taken or confirmed from this source. The list below does not include Macassan voyages, which are dealt with above. All primary source material relating to each voyage, which has been published in English, has been read, the only exceptions (to the best of my knowledge) being George Vancouver's journal (which, aside from being very long, is very well indexed) and the English translation of Labillardière's *Relation du voyage à la recherche de la Pérouse*, which was located too late for it to be included in this study. Some archival material has been translated and extracts included in publications, which are listed under 'references' in the entries below. These sources have all been read for mention of cats.

Other archival material is available in WA, but examination of it would require the skills of someone fluent in old Dutch, as it has not been translated. For example, the 1624/29, 1631/34, 1636–1637, 1640/41–1644/45, 1656/57, 1661, 1663, and 1666/67–1682 volumes of the *Dagh-register gehouden int Casteel Batavia vant passerende daer ter plaetse als over geheel Nederlandts-India* (Journals kept in Batavia Castle of all that goes on there and in the whole of the Dutch East Indies) have been published and are held at the University of Western Australia. These journals, which contain a daily account of incidents and events, could be worth examining for the presence of cats. The *Generale Missiven van Gouverneurs-General en Raden aan Heren XVII*, or 'General Missives' have also been published in an 11-volume set (Coolhaas 1960–1997), although as these contain more general information relevant to political, military and commercial matters, they are unlikely to contain references to cats. Other Dutch archival material is also available in WA on microfilm (See RN 816, Battye Library, Perth), particularly for years surrounding the wrecking of the *Vergulde Draeck* and the *Batavia*. These records include copies of Resolutions, *Overgekomen Brieven en Papieren* (Letters and Papers Received), notes, and requisitions. The *Overgekomen Brieven* often include *comnsumptierekeningen* (provisions accounts) in which masters had to account for the consumption of their ships' provisions (Bruijn *et al.* 1979). These could thus potentially contain reference to cats, if they were usually carried, and on any particular voyage their loss would have increased the depredations of rats. Detailed lists of equipment carried on board the VOC vessels would once have been found in the archives of the *department van de equipage*, although much of the material which was recorded in this archive in 1683 has since been lost (Bruijn *et al.* 1979: I, p.196). John Landwehr (1991) provides Algemeen Rijksarchief (repository in The Hague) locations for examples of several types of these documents, including a 'Ship's inventory', but no published examples of these have been uncovered.

Marchant (1982) provides extensive lists of archival material held by the French Archives Nationales, Bibliothèque du Service Historique de la Marine, and Bibliothèque Nationale Département des Manuscrits, relating to the French expeditions to Australia. Records from the Baudin Expedition are also available in the Battye Library private archives, as are the papers of Paul Gaimard, French surgeon and naturalist on board the *Uranie*.

With regard to Dutch ports, it should be noted that Texel, Wielingen and Rammekens are the roads, or anchorages, from which the ships departed. Their home port was determined by their chamber. Upon leaving their home port, ships would be taken unladen to the roads, where they would be loaded with small barges called lighters, of which 18 to 20 were required for the provisioning of one East Indiaman. The crew were taken to the boat when loading of goods and provisions was complete, except for valuables, which were loaded last of all.

In the list of voyages given below, for some Dutch vessels there is no record of a stop at the Cape. This information is taken from Bruijn *et al.*, who either provide dates for the stay at the Cape, signify that the vessel ran past the Cape with the words 'no call', or leave the entry blank, where there is no record of a call or otherwise. The resolution of 1616, which instituted fines for all masters who delayed their voyage by stopping at any place other than the Cape makes it likely, however, that these vessels did put in at the Cape, but the stop was not recorded (a situation more likely prior to the establishment of a refreshment station there in 1652).

The list below, although comprehensive, cannot be regarded as entirely complete. For Dutch voyages, Heeres (1899, p.55n.) comments, rather cryptically, that 'in the year 1628 certain other Dutch vessels sighted or touched at the west-coast of Australia on their outward voyage to India [sic]', with references given to 'Leupe, *Zuidland*, p.58; my edition of the Daily Register of Batavia, p.341'. As these publications are both in Dutch, this lead was not pursued. A similar comment, with reference to the year 1629, appears on p.62. From 1798, sealers, whalers and other vessels increasingly sailed to the south coast of WA. These voyages were not often recorded, although evidence of their presence was found by several nineteenth-century navigators: King (1827, pp.121, 131) records that a 'merchant brig', the *San Antonio* visited Oyster Harbour in 1820, and that an American sealer was brought into Oyster Harbour for careening in 1822 (1827, p.225). D'Urville (1987, p.31) met with a party of whalers in the same area in 1826. Mostly departing from Port Jackson, these voyages should not be ignored as a potential source of cats, particularly in light of the case of Anchor Island in New Zealand, where sealers are believed to have liberated cats in 1792 (Fitzgerald 1990, p.339).

Known and possible landings or shipwrecks of non-Macassan vessels on the northern and western coasts of Australia, from Cape York to Cape Nuyts, to 1826.

• Note on nomenclature: All names of ports are contemporary ones. Their present-day names are as follows: Ambonia = Ambon; Bantam = Banten; Batavia = Jakarta; Bouton = Butung; Coepang = Kupang, Timor; Pulo Condore = Con Son Islands; Jesus-Maria Is. = Rambutyo, St. John's Island = one of the islands of present-day Hong Kong S.A.R., Vendola Is. = Nuana Is.

• Notes on categories: 'Captain' = the name most commonly associated with the voyage, be it the skipper, merchant, expedition commander, etc.; 'Date of landfall' = date of landing in Australia (or sighting of land, where landing not confirmed); 'Point of arrival in Australia' = point of first landing (or where land was first sighted, if landing not confirmed) in Australia, or in WA where prior Australian landfalls had been made.

Name of vessel	*Duyfken*
Name of Captain	W. Jansz
Type of vessel	VOC *jacht*
Port of departure	Dutch Factory, Bantam
Date of departure	18 November 1605
Date of landfall	
Places visited en route	Banda, Aru Is., New Guinea
Point of arrival in Australia	12°15'S 141°47'E, west coast of Cape York Peninsula
Wrecked or landed	Landings made with boat.
Other landings, if any	Several along west coast of Cape York Peninsula, as far south as Cape Keerweer, 13°40'S, 141°31'E.
Available primary sources	Chart only.
References	Heeres 1899; Robert 1973; Sigmond and Zuiderbaan 1979.
Comments	No journal has survived.

Name of vessel	*Eendracht*
Name of Captain	D. Hartog
Type of vessel	VOC *retourschip* – Amsterdam Chamber
Port of departure	Texel
Date of departure	23 January 1616
Date of landfall	25 October 1616
Places visited en route	Maio Is. (21 February–4 March); Cape Lopez (27 March–11 May); Cape of Good Hope 5 August–27 August
Point of arrival in Australia	Dirk Hartog Island (27°S)
Wrecked or landed	Landed with boat.
Other landings, if any	
Available primary sources	Correspondence (published in Heeres 1899, p.8–9), chart (H. Gerritsz.), pewter plate.
References	Major 1859; Heeres 1899; Robert 1973; Sigmond and Zuiderbaan 1979.
Comments	No reference to cats in correspondence.

Name of vessel	*Mauritius*
Name of Captain	W. Jansz
Type of vessel	VOC *retourschip* – Amsterdam Chamber
Port of departure	Texel
Date of departure	4 January 1618
Date of landfall	31 July 1618
Places visited en route	Cape of Good Hope
Point of arrival in Australia	22°S
Wrecked or landed	Landed with boat.
Other landings, if any	
Available primary sources	Correspondence (published in Heeres 1899, p.12).
References	Major 1859; Heeres 1899; Sigmond and Zuiderbaan 1979.
Comments	No mention of cats in correspondence

Name of vessel	*Dordrecht*
Name of Captain	F. de Houtman / J. Dedel
Type of vessel	VOC *retourschip* – Amsterdam Chamber
Port of departure	Texel
Date of departure	28 December 1618
Date of landfall	
Places visited en route	Cape of Good Hope (17 May – 8 June)
Point of arrival in Australia	32°30'S
Wrecked or landed	
Other landings, if any	
Available primary sources	Correspondence (published in Heeres 1899, pp.14–17).
References	Major 1859; Heeres 1899.
Comments	Saw, named Houtman's Abrolhos. Bad weather prevented landing. No cats mentioned.

Name of vessel	*Tryall*
Name of Captain	J Brooke
Type of vessel	English East India Company
Port of departure	Plymouth
Date of departure	4 September 1621
Date of landfall	24 May 1622
Places visited en route	Cape of Good Hope
Point of arrival in Australia	Trial Rocks, *c* 42 km north of Barrow Island.
Wrecked or landed	Wrecked.
Other landings, if any	
Available primary sources	East India Company Correspondence (some published in Green 1977 and Henderson 1980. More is available on microfilm in WA); artefacts held by Western Australian Maritime Museum.
References	Green 1977; Henderson 1980.
Comments	Published correspondence contains no reference to cats. The *Tryall*'s skiff, carrying ten people, may have visited the Montebello Is., and the longboat, carrying 36 people, searched the Montebello Is. for water before heading north to Batavia. Both the skiff and longboat reached Batavia. 93 people perished on the wreck. The distance of this wreck from the mainland makes it a highly improbable source of feral cats.

Name of vessel	*Leeuwin*
Name of Captain	?
Type of vessel	VOC *retourschip* – Amsterdam Chamber
Port of departure	Texel
Date of departure	20 April 1621
Date of landfall	?
Places visited en route	Gulf of Guinea
Point of arrival in Australia	35°S
Wrecked or landed	Not wrecked.
Other landings, if any	
Available primary sources	Charts only.
References	Major 1859; Heeres 1899; Sigmond and Zuiderbaan 1979.
Comments	Named Cape Leeuwin. Little is known of this voyage.

Name of vessel	*'t Wapen van Hoorn*
Name of Captain	?
Type of vessel	VOC *fluijt* – Hoorn chamber
Port of departure	Texel
Date of departure	26 December 1621
Date of landfall	22 July 1622
Places visited en route	?
Point of arrival in Australia	32°03'S 115°44'E
Wrecked or landed	Stranded.
Other landings, if any	
Available primary sources	Correspondence (published in Heeres 1899, p.17–20).
References	Heeres 1899; Henderson 1980; Western Australian Maritime Museum Shipwreck database.
Comments	No reference to cats in correspondence.

Name of vessel	*Pera*
Name of Captain	J. Carstensz
Type of vessel	VOC *jacht*
Port of departure	Ambonia
Date of departure	21 January 1623 (with *Arnhem*, below)
Date of landfall	12 April 1623
Places visited en route	Aru Is., south coast of New Guinea
Point of arrival in Australia	11°45'S – west coast of Cape York Peninsula. First landing made somewhere between the Coleman and Holroyd Rivers.
Wrecked or landed	Landed with boat.
Other landings, if any	Several landings along this coast to 17°03'S.
Available primary sources	Journal, 'Note on Natives and Nature' (both the latter, and an extract from the former, translated and published in Robert 1973), charts.
References	Robert 1973.
Comments	Journal extract read, no reference to cats found.

Name of vessel	*Arnhem*
Name of Captain	D. Melisz then W. van Colster
Type of vessel	VOC *jacht*
Port of departure	Ambonia
Date of departure	21 January 1623 (with *Pera*, above)
Date of landfall	12 April 1623
Places visited en route	Aru Is., south coast of New Guinea.
Point of arrival in Australia	11°45'S – west coast of Cape York Peninsula.
Wrecked or landed	Presumably landed with boat to collect water and wood.
Other landings, if any	Probably made along west coast of Cape York Peninsula to 17°28'S, also Groote Eylandt, Marchinbar Is.
Available primary sources	Charts, journal of *Pera*, VOC correspondence (translated and published in Heeres 1899 and Robert 1973).
References	Heeres 1899; Robert 1973.
Comments	As the journal of this voyage has been lost, landings cannot be confirmed. No reference to cats in correspondence.

Name of vessel	unknown
Name of Captain	unknown
Type of vessel	VOC (?)
Port of departure	unknown
Date of departure	unknown
Date of landfall	16?? (?)
Places visited en route	unknown
Point of arrival in Australia	Victoria Harbour, near Esperance (?)
Wrecked or landed	Wrecked and refloated.
Other landings, if any	unknown
Available primary sources	none
References	Henderson 1980; Western Australian Maritime Museum Shipwrecks Database.
Comments	No wreck found; report based on Aboriginal legend and a rock inscription on shore.

Name of vessel	*Vergulde Zeepard*
Name of Captain	F. Thijszoon / P. Nuyts commander
Type of vessel	VOC *retourschip* – Zeeland Chamber
Port of departure	Wielingen
Date of departure	22 May 1626
Date of landfall	26 January 1627
Places visited en route	Reprovisioned in Sierra Leone, June.
Point of arrival in Australia	37.5°S
Wrecked or landed	Landed with boat.
Other landings, if any	Probable, between Cape Leeuwin and Nuyts Archipelago.
Available primary sources	Chart (journal lost).
References	Major 1859; Heeres 1899; Schilder 1976.
Comments	Little is known of this voyage. According to Bruijn *et al.* (1979), there were six passengers on this voyage.

Name of vessel	*Vianen*
Name of Captain	G. de Witt
Type of vessel	VOC
Port of departure	Batavia
Date of departure	14 January 1628
Date of landfall	February 1628
Places visited en route	none
Point of arrival in Australia	Approx 21°S – exact location unknown.
Wrecked or landed	Stranded on a reef – approximately 20 tonnes of pepper and a quantity of copper were thrown overboard in order to refloat the vessel.
Other landings, if any	
Available primary sources	Correspondence (published in Heeres 1899, p. 54); chart.
References	Heeres 1899; Schilder 1979; Henderson 1980.
Comments	After refloating, de Witt charted approximately 50 *mijlen* (approximately 320 km) of the north-west coast before sailing, continuously pumping water out of the vessel, to Mauritius where the *Vianen* was repaired. No cats mentioned in published correspondence.

Name of vessel	*Batavia*
Name of Captain	F. Pelsaert
Type of vessel	VOC *retourschip* – Amsterdam Chamber
Port of departure	Texel
Date of departure	28 October 1628
Date of landfall	4 June 1629
Places visited en route	Cape of Good Hope (14 April–22 April)
Point of arrival in Australia	Morning reef, Wallabi group, Abrolhos Is.
Wrecked or landed	Wrecked.
Other landings, if any	Mainland reached with ship's boat where a search conducted for water before proceeding to Java.
Available primary sources	Pelsaert's journal, VOC correspondence.
References	Heeres 1899; Henderson 1980; Drake-Brockman 1995.
Comments	Henderson notes of the voyage of 46 of the survivors to Batavia, that '[d]uring a gale near the mainland coast, in the vicinity of what is now Port Gregory, the yawl had to be abandoned, together with everything else that could be spared, to lighten the sloop.' It is unlikely, however, that any cats would have been taken thus far on the journey, if in fact there were any on the *Batavia* in the first place. Other survivors stayed on the Abrolhos Is. No archaeological evidence of cats on the wreck has been recovered, and no reference to them found in the published material.

Name of vessel	*Sardam*
Name of Captain	F. Pelsaert
Type of vessel	VOC – rescue mission for *Batavia* wreck survivors.
Port of departure	Batavia
Date of departure	15 July 1629
Date of landfall	17 September 1629
Places visited en route	none
Point of arrival in Australia	High Island, Houtman's Abrolhos.
Wrecked or landed	Landed with boat.
Other landings, if any	12 October 1629, skipper of *Sardam* sent in boat with crew to recover wreck items, and are lost. 4 November, smoke columns were seen to the NNE of the Abrolhos, on the mainland - Pelsaert thought it may have been the skipper, although it was as likely to be Aboriginal fires. 16 November, party lands on the mainland, probably around Red Bluff, just south of present-day Kalbarri. Two men – Wouter Loos and Jan Pelgrom – marooned on the mainland here with arms, food and 'goods for barter'.
Available primary sources	Pelsaert's journal, VOC correspondence, letter of Predikant G. Bastiaensz (published in Drake-Brockman 1995: Appendix IV).
References	Henderson 1980; Drake-Brockman 1995.
Comments	In the journal of the *Sardam*, Pelsaert remarks that 'on these islands [the Wallabi group, in Houtman's Abrolhos] there are large numbers of Cats, which are creatures of miraculous form, as big as a hare' (Drake-Brockman 1995, p.235). However, it is clear from Pelsaert's subsequent description that he is in fact using 'Cats' [*Catten*] to refer to wallabies, rather than *Felis catus*. The Predikant's letter also refers to these 'Beasts which they called Cats' (Drake-Brockman 1995, p.267).

Name of vessel	*Klein Amsterdam* and *Wezel*
Name of Captain	G.T. Pool then P. Pieterszoon
Type of vessel	VOC *jachts*
Port of departure	Ambonia
Date of departure	17 April 1636
Date of landfall	13 June 1636
Places visited en route	Banda, New Guinea, Kai and Aru Is.
Point of arrival in Australia	Near the entrance to Dundas Strait, Melville Is.
Wrecked or landed	No landing recorded in journal, but Batavia *Dagh-register* mentions that they landed. Sailed west from point of arrival to Cape van Diemen (on Melville Is.) before heading for Timor.
Other landings, if any	
Available primary sources	Directions, Journal (extract published in Robert 1973)
References	Robert 1973.
Comments	Extract from journal read – no cats mentioned.

Name of vessel	*Heemskerck* and *Zeehaen*
Name of Captain	A. Tasman
Type of vessel	VOC
Port of departure	Batavia
Date of departure	14 August 1642
Date of landfall	1 December 1642
Places visited en route	Mauritius
Point of arrival in Australia	West coast of Tasmania – 42°25'S.
Wrecked or landed	Landed with boat at Frederick Henry Bay.
Other landings, if any	
Available primary sources	Tasman's journal, with manifests, instructions, correspondence, translated and published. A sailor's journal from this voyage is also available in manuscript form at the Algemeen Rijksarchief, The Hague.
References	Heeres 1965; Sharp 1968.
Comments	In Australia, touched only at Tasmania. Journal and manifests read nevertheless, for references to cats, of which none were found.

Name of vessel	*Limmen, Zeemuw, de Braq*
Name of Captain	A. Tasman
Type of vessel	VOC
Port of departure	Batavia
Date of departure	29 January 1644
Date of landfall	
Places visited en route	Banda, Aru, New Guinea.
Point of arrival in Australia	around 10°50'S, on west coast of Cape York Peninsula.
Wrecked or landed	Landings with boat for water and wood presumed.
Other landings, if any	From point of arrival, the expedition sailed around the north and north-west coast of Australia until they were in about 23°S. Landings difficult to confirm, as only chart remains, but Robert (1973) claims landings were likely at least south of the Sir Edward Pellew Group, York Sound or Brunswick Bay.
Available primary sources	Chart, manifests, instructions. Journal lost.
References	Heeres 1965; Sharp 1968; Robert 1973.
Comments	No cats recorded in manifests, or mentioned in instructions.

Name of vessel	*Vergulde Draeck*
Name of Captain	P. Albertsz
Type of vessel	VOC *jacht* – Amsterdam Chamber
Port of departure	Texel
Date of departure	4 October 1655
Date of landfall	28 April 1656
Places visited en route	Cape of Good Hope (9 March–12 March)
Point of arrival in Australia	Reef, 12 km south of Ledge Point (31°16'S), 6 km from mainland.
Wrecked or landed	Wrecked.
Other landings, if any	
Available primary sources	Correspondence and *Dagh-register* entry (published in Heeres 1899, p.75), archaeological artefacts.
References	Green 1973; Sigmond and Zuiderbaan 1979; Henderson 1980.
Comments	Survivors and wreckage reached mainland. Seven men reached Batavia in ship's boat on 7 June 1656. No reference to cats in published material, and no cat bones identified in wreckage.

Name of vessel	*Witte Valke*
Name of Captain	S. Sanders
Type of vessel	VOC *fluijt* – looking for *Vergulde Draeck*
Port of departure	Batavia
Date of departure	8 July 1656
Date of landfall	?
Places visited en route	none
Point of arrival in Australia	
Wrecked or landed	Appleyard and Manford (1979) indicate that the boat landed in Geographe Bay. Other sources state that bad weather prevented a landing.
Other landings, if any	
Available primary sources	Correspondence and journals (summaries of the latter published in Major 1859).
References	Major 1859; Appleyard and Manford 1979; Henderson 1980.
Comments	No reference to cats in published material.

Name of vessel	*Goede Hoop*
Name of Captain	Bakels
Type of vessel	VOC *jacht* – looking for *Vergulde Draeck*
Port of departure	Lying in Straits of Sunda, where joined by the Witte Valke, from Batavia
Date of departure	?/July 1656
Date of landfall	?
Places visited en route	none
Point of arrival in Australia	30.66°S
Wrecked or landed	Landed with boat and a search party sent inland. Three of this party did not return.
Other landings, if any	A second party of eight men, sent in search of the missing three, did not return, and the boat was later seen smashed to pieces on the beach.
Available primary sources	Correspondence and journals (summaries of the latter published in Major 1859).
References	Major 1859; Henderson 1980.
Comments	It is unlikely that cats would have been sent ashore with the search parties – certainly there is no record of this being the case.

Name of vessel	*de Vinck*
Name of Captain	J. Jansz
Type of vessel	VOC *fluijt* – Chamber of Zeeland.
Port of departure	Wielingen
Date of departure	24 December 1656
Date of landfall	8 June 1657
Places visited en route	Cape of Good Hope (19 April–27 April)
Point of arrival in Australia	29°07'S
Wrecked or landed	Bad weather apparently prevented any landings.
Other landings, if any	
Available primary sources	Correspondence and journals (summaries of the latter published in Major 1859)
References	Major 1859.
Comments	Looking for *Vergulde Draeck*. No reference to cats in published material.

Name of vessel	*Waekende Boey*
Name of Captain	S. Volckertszoon
Type of vessel	VOC *fluijt* – looking for *Vergulde Draeck*
Port of departure	Batavia
Date of departure	1 January 1658
Date of landfall	24 February 1658
Places visited en route	none
Point of arrival in Australia	31°20'S
Wrecked or landed	Landed with boat, which returned on the 25 February having found traces of wreckage from the *Vergulde Draeck*.
Other landings, if any	27 February boat sent ashore in 31°14'; 28 February boat sent ashore in 30°40' but unable to land due to rough seas. On the 19 March they sighted Rottnest Island, and a boat was sent to land there, but no good landing place was found on account of the rocks surrounding the island. However, Major (1859, p.85) relates that the steersman on this excursion reported '[t]wo seals were seen there, also one wild cat, and the excrements of other animals.' Heeres (1899, p.79) has translated this section as 'two seals and a wild cat, resembling a civet-cat, but with browner hair'. On the 20 March, a boat was sent to the mainland shore east of Rottnest, where a piece of the mast of the *Draeck* was found, and brought back to the galliot. Several trips to shore in the boat were made on this and subsequent days, until the 23 March, when the boat was damaged on the way to the coast, so that its crew could not return. As the galliot had no spare boats, it could not fetch the men from shore, and finally sailed for Batavia.

	The men left on the coast, led by Abraham Leeman, prepared their boat for open water with seal skins and sailed for Java. Only four men survived the journey.
Available primary sources	Correspondence and journals (summaries of the latter appearing in Major 1859, and an excerpt in Henderson 1980); chart, published in Sigmond and Zuiderbaan 1979; 'Description of the West Coast of the South Land' by S. Volckertszoon (in Major 1859 and Heeres 1899), journal of Abraham Leeman, of the journey of the abandoned boat back to Java (translated and published in de Heer 1963). Original journals are preserved in the Algemeen Rijksarchief at The Hague.
References	Major 1859; Heeres 1899; de Heer 1963; Sigmond and Zuiderbaan 1979; Henderson 1980.
Comments	No reference to cats – other than the 'wild cat' seen on Rottnest – was found in any of the published material. The 'wild cat' sighting is, however, enigmatic: Was it a ship's cat from the *Vergulde Draeck* which was carried over a hundred kilometres on wreckage to the island? Was it put there earlier by one of the voyages, such as that of the *Leeuwin*, for which we have few records? Or was it a quokka, mistakenly described as a cat? The latter is perhaps most likely, especially given that in the *Nijptangh* journal of de Vlamingh's voyage, quokkas are described as 'a kind of rat as big as a common cat' (Major 1859, p.121).

Name of vessel	*Emeloort*
Name of Captain	A. Jonck
Type of vessel	VOC *galliot* – looking for *Vergulde Draeck*
Port of departure	Batavia
Date of departure	1 January 1658
Date of landfall	8 March 1658
Places visited en route	none
Point of arrival in Australia	30°25'S
Wrecked or landed	Landing of boat, with ten men and provisions for several days, on 9 March.
Other landings, if any	Boat sent ashore again at the same location on 10 March, and at 30°25'S some days later.
Available primary sources	VOC Correspondence and journals (summaries of the latter appearing in Major 1859); chart, published in Sigmond and Zuiderbaan 1979. Original journal is preserved in the Algemeen Rijksarchief at The Hague.
References	Major 1859; Sigmond and Zuiderbaan 1979.
Comments	No mention of cats in published correspondence.

Name of vessel	*Elburg*
Name of Captain	J. Peerenboom
Type of vessel	VOC *fluijt*
Port of departure	Texel
Date of departure	14 December 1657
Date of landfall	?
Places visited en route	Cape of Good Hope (13 April–23 April); four weeks at Tristan de Cunha because of calm.
Point of arrival in Australia	33°14'S
Wrecked or landed	Landed in boat with nine men; met with Aboriginal people.
Other landings, if any	
Available primary sources	VOC General Missive 14 December 1658 (Archival, cited in Major 1856); correspondence (published in Heeres 1899, p.81).
References	Major 1856; Heeres 1899.
Comments	No mention of cats in published material associated with this voyage. Four passengers on board.

Name of vessel	*Vliegende Swaan*
Name of Captain	J. van der Wall
Type of vessel	VOC
Port of departure	Ternate
Date of departure	7 December 1677
Date of landfall	?
Places visited en route	
Point of arrival in Australia	Probably Emeriau Pt., around 16°45'S
Wrecked or landed	Landed with boat.
Other landings, if any	Apparently landed several times with boat between point of arrival and mouth of the Exmouth Gulf, where the ship left the coast and headed north-west.
Available primary sources	Chart only (journal lost).
References	Heeres 1899; Robert 1973.
Comments	This encounter with the southland was accidental – the *Vliegende Swaan* was en route from Ternate to Batavia when it was blown to the south.

Name of vessel	*Cygnet*
Name of Captain	W. Dampier
Type of vessel	pirate/trader (English)
Port of departure	Difficult to say, given nature of vessels. The *Cygnet*, initially of London, turned pirate at Nicoya, and first appears in Dampier's narrative at Plata Is., off the west coast of present-day Ecuador.
Date of departure	October 1684 (from Plata Is.)
Date of landfall	5 January 1688
Places visited en route	Many stops in towns on the Pacific coast of Ecuador and Central America, California Is., Guam, Mindanao, Pulo Condore, St John's Island, Piscatores (a small group of islands between Taiwan and mainland China), a group of islands to the east of Taiwan (most likely Sakishima-gunto), Bouton.
Point of arrival in Australia	Buccaneer Archipelago.
Wrecked or landed	Landed with boat.
Other landings, if any	The *Cygnet* was also careened: 'When we had been here about a week, we hal'd our ship into a small sandy cove, at a spring-tide, as far as she would float; and at low water she was left dry, and the sand dry without us near half a mile, for the sea riseth and falleth here about five fathoms. ... All the neep-tides we lay wholly aground, for the sea did not come near us by about a hundred yards. We therefore had time enough to clean our ship's bottom, which we did very well' (Dampier 1937, p.316). The location of this cove is in some doubt, but Marchant argues that Karakatta Bay, which lies at the top end of the western side of King Sound on the mainland, best matches Dampier's description (Marchant 1988, p.113).
Available primary sources	Dampier's journal
References	Dampier 1937; Marchant 1988.
Comments	No cats are mentioned in Dampier's journal, except in describing the animals kept by the Indians of Mangera Island, in the Caribbean: 'Neither have they any sort of beast, but Cats and Dogs' (Dampier 1937, p.90). On departing the Americas, Dampier noted that they 'had a great many Rats aboard, which we could not hinder from eating part of our Maiz' (1937, p.193). Later, when the *Cygnet* arrived at Guam, we discover that there was a dog on board the vessel, but it is only mentioned in being given away: 'We had a delicate large *english* Dog, which the Governour did desire, and had it given him very freely by the Captain, though much against the grain of many of his Men, who had a great value for that Dog' (1937, p.209). Thus bereft, after Guam, of even a large dog to catch rats aboard the *Cygnet*, is it possible that some of the men subsequently found some cats on other islands and brought them abroad? Marchant reproduces an Aboriginal cave painting from Bigge Island in the Kimberley, which shows 'Europeans with buckets of water and game, provisioning ship' (1988, p.119ii). In the left of this picture is a whiskered animal which could conceivably be a large cat, although its humped back makes it more probably a representation of a kangaroo or wallaby.

Name of vessel	*Ridderschap van Holland*
Name of Captain	D. de Lange
Type of vessel	VOC
Port of departure	Wielingen
Date of departure	11 July 1693
Date of landfall	?
Places visited en route	Cape of Good Hope (9 January–5 February)
Point of arrival in Australia	?
Wrecked or landed	Possibly wrecked?
Other landings, if any	
Available primary sources	VOC correspondence
References	Henderson 1980
Comments	This vessel disappeared between the Cape of Good Hope and Batavia. Although it was possibly wrecked on the coast of WA, no wreck has ever been located. It was also rumoured to have been taken by pirates near Madagascar.

Name of vessel	*Geelvink, Nijptangh* and *'t Weseltje*
Name of Captain	W. de Vlamingh
Type of vessel	VOC frigate, hooker and galiot (respectively)
Port of departure	Texel
Date of departure	3 May 1696
Date of landfall	31 December 1696
Places visited en route	Cape of Good Hope, Tristan d'Acunha, St. Paul Is., Amsterdam Is.
Point of arrival in Australia	Rottnest Is.
Wrecked or landed	Landed with boat.
Other landings, if any	Swan River – 86 men taken on an expedition inland, which lasted from 5 January to 7 January; went up river with boats and landed from 10th–12th January. Landed a further eight times (at least) on the mainland – once staying two nights – while sailing north toward

	Dirk Hartog Island, where they also landed, discovering the plate left by Dirk Hartog. One landing also made on the mainland coast to the north of Dirk Hartog Island, to look for water.
Available primary sources	Journals of *Geelvinck* and *Nijptangh* (Schilder 1985); charts published in Schilder 1984; Appendices of Schilder (1985) include: 'Instructions for de Vlamingh and the Broard Council', 'Extract from the Manuscript Journal of the *Nijptangh*', 'Extract from the Manuscript Journal of the *'t Weseltje*', 'Surgeon's journals of the *Geelvinck* and the *Nijptangh*', 'Extract from a Letter from the Lords XVI to the Governor-General and Councillors, 10 November 1695', and several other items of correspondence, 'Extracts from the Resolutions of the Chamber of Amsterdam', 'Muster books of the *Geelvinck*, the *Nijptangh*, and *'t Weseltje* made out at the Cape', 'Nicolaes Witsen's Account of de Vlamingh's voyage'. Schilder (1985) also lists archival sources related to the voyage (pp.228–229).
References	Major 1859; Schilder 1984; Schilder 1985.
Comments	Journals and extracts published in Major (1859) and Schilder (1985) read – no reference made to cats. *Geelvinck* careened at Rottnest Island 2 January 1697. The *Nijptangh* journal, by upper-surgeon Mandrop Torst, also records that on the Island Amsterdam, 4 December 1696, the party 'saw many dead birds under the trees and many holes in the ground and our people caught a small weasel and two grey hares. Thereupon we went back aboard.'

Name of vessel	*Roebuck*
Name of Captain	W. Dampier
Type of vessel	English
Port of departure	the Downs
Date of departure	14 January 1699
Date of landfall	6 August 1699
Places visited en route	Canary Is., Cape Verde Is., Bahia de todos los Santos (Brazil)
Point of arrival in Australia	Shark Bay
Wrecked or landed	Landed with boat.
Other landings, if any	21 August, landed on Rosemary Island in Dampier Archipelago. 31 August landed with boat in Roebuck Bay, where they fought with Aborigines.
Available primary sources	Journal published.
References	Dampier 1981.
Comments	Journal read in its entirety – no mention of cats on ship or land, although their absence was noted: 'flesh have they not, nor any sorte of cattle, not soe much as catt or dog, for, indeed, they have noe occasion of such creatures unless to eat them, for of that food which they have they leave no fragments. They have noe sorte of fowl, neither tame nor wild, for the latter I saw very few in the country, neither did wee see any kind of wilde beast in the country, but the track of one' (Major 1859, p.109).

Name of vessel	*Vossenbosch, D'Waijer* and *Nova Hollandia*
Name of Captain	M. van Delft
Type of vessel	VOC *fluijt, sloop* and *patsjallang*, respectively.
Port of departure	Batavia
Date of departure	23 January 1705
Date of landfall	31 April 1705
Places visited en route	Coepang
Point of arrival in Australia	Shark Bay (Melville Is.)
Wrecked or landed	Landed with boat.
Other landings, if any	Greenhill Is., probably also Cobourg Peninsula.
Available primary sources	No journal has been found, only instructions, a chart and 'A written detail of the discoveries and notable occurrences in the voyage of the fluijt '*Vossenbosch*,' the sloop '*D'Waijer*,' and the *patsjallang* '*Nova Hollandia*' ... ', which has been translated and published in Major (1856, pp.165–173).
References	Major 1856; Robert 1973.
Comments	'Written detail' read – no mention of cats.

Name of vessel	*Zuytdorp*
Name of Captain	M. Wysvilet
Type of vessel	VOC *retourschip* – Zeeland Chamber
Port of departure	Wielingen
Date of departure	1 August 1711
Date of landfall	June 1712
Places visited en route	Sao Thome Is. (13 December–4 January), Annabon, Cape of Good Hope (23 March–22 April)
Point of arrival in Australia	27°11'S, 113°36'E
Wrecked or landed	Wrecked at the base of cliffs.
Other landings, if any	

Available primary sources	Soldiers' roll; soldiers' request book. No cargo or passenger list has survived.
References	Henderson 1980; Playford 1996.
Comments	Survivors reached the top of the cliffs, and it has been suggested that they may have joined Aboriginal society – Playford surveys the evidence (1996, pp.210–232). Aboriginal stories of the wreck, as summarized by Playford (1996, pp.78–79), do not include reference to cats, and no archaeological evidence of cats has been discovered at the site to date.

Name of vessel	*Fortuyn*
Name of Captain	P. Westrik
Type of vessel	VOC *retourschip* – Amsterdam Chamber
Port of departure	Texel
Date of departure	27 September 1723
Date of landfall	1724
Places visited en route	Cape of Good Hope (2 January–18 January)
Point of arrival in Australia	?
Wrecked or landed	?
Other landings, if any	
Available primary sources	
References	Henderson 1980
Comments	This vessel disappeared between the Cape of Good Hope and Batavia. It may have been wrecked along the Western Australian coast, but no wreck has been found. Contemporary evidence suggests that it was more likely to have been wrecked in the vicinity of the Cocos Is.

Name of vessel	*Aagtekerke*
Name of Captain	J. Witboom
Type of vessel	VOC *retourschip* – Zeeland Chamber
Port of departure	Rammekens
Date of departure	27 May 1725
Date of landfall	?
Places visited en route	Benguela (Angola), Cape of Good Hope (3 January–27 January)
Point of arrival in Australia	?
Wrecked or landed	?
Other landings, if any	
Available primary sources	Listing in VOC register of outward shipping.
References	Henderson 1980.
Comments	This vessel was lost between the Cape of Good Hope and Batavia. It may have been wrecked on the Abrolhos: survivors of the wreck of the *Zeewyck* saw relics from an earlier wreck there.

Name of vessel	*Zeewyck*
Name of Captain	J. Steyns
Type of vessel	VOC *retourschip* – Zeeland Chamber
Port of departure	Rammekens
Date of departure	7 November 1726
Date of landfall	9 June 1727
Places visited en route	Cape of Good Hope (26 March–21 April)
Point of arrival in Australia	Half-moon *s*reef, Houtman's Abrolhos.
Wrecked or landed	Wrecked.
Other landings, if any	Survivors reached Gun Is., in the Abrolhos.
Available primary sources	Henderson (1980, p.46) refers to translations of the *Zeewyck* journal of Adriaen Van der Graff, by both C. de Heer and Lous Zuiderbaan, but gives no location for these. Heeres (1899) also refers to this journal, without giving a location for it. Another *Zeewyck* journal may be found in the Royal Library of Belgium, Brussels (cat. 7366). Correspondence relating to the wreck, and subsequent voyage to Batavia, has been excerpted by Major (1859, pp.176–189), from a Dutch publication entitled 'de Houtman's Abrolhos'. Correspondence published in Heeres (1899).
References	Major 1859; Sigmond and Zuiderbaan 1979; Henderson 1980.
Comments	Extract in Major (1859), and correspondence in Heeres (1899) contain no reference to cats, and no cat remains have been identified among the archaeological artefacts. The longboat from the *Zeewyck* was sent with a crew of twelve to Batavia to get help, but disappeared. The remaining survivors built a sloop, the *Sloepie*, from the wreckage of the *Zeewyck*, and sailed for Batavia with water, food and chests of coins salvaged from the wreck. This vessel, with 82 survivors, arrived in the Straits of Sunda 21 April 1728. If there were any cats on board the *Zeewyck*, it is highly unlikely that any would have made it to the mainland, either perishing or being eaten on Gun Island, or taken aboard the *Sloepie*.

Name of vessel	?
Name of Captain	unnamed Chinese trader
Type of vessel	?
Port of departure	Amenoebang, Timor
Date of departure	?/March 1751
Date of landfall	seven days after departure.
Places visited en route	none
Point of arrival in Australia	north-west coast
Wrecked or landed	Landed.
Other landings, if any	
Available primary sources	Letter of the Resident of Timor, Daniel van den Bergh, to the Governor General Jac. Mossel and the Councillors of the East Indies, 20 September 1751 (Excerpted in Robert 1973, p.147).
References	Robert 1973; Macknight 1976.
Comments	This Chinese trader was heading for a sandbank south of Roti to hunt turtles for their shells, but a strong north wind drove him south for a week, when he came upon a low coast where he landed. The Aboriginal people he met invited him to accompany them inland, but he declined and sailed back to Timor. Unsurprisingly, the letter makes no mention of cats, nor does it give any detail as to the type of vessel, or how it landed on the coast.

Name of vessel	*Rijder* and *Buis*
Name of Captain	J. Gonzal
Type of vessel	VOC barques
Port of departure	Batavia
Date of departure	8 February 1756
Date of landfall	17 April 1756
Places visited en route	Banda
Point of arrival in Australia	West coast of far north Cape York Peninsula
Wrecked or landed	Landed with boat.
Other landings, if any	several other landings along west coast of Cape York Peninsula
Available primary sources	No journals, only a report compiled at Batavia by Gerrit de Haan (extract published in Robert 1973, pp.151–163)
References	Robert 1973.
Comments	*Buis*' boat was lost with eight men in about 11°00'S. Report contains no mention of cats.

Name of vessel	*Gros Venture*
Name of Captain	F.A. de St Allouarn
Type of vessel	French
Port of departure	Ile de France (Mauritius)
Date of departure	16 January 1772
Date of landfall	17 March 1772
Places visited en route	Kerguelen Is.
Point of arrival in Australia	Flinders Bay (Cape Leeuwin)
Wrecked or landed	Landed with boat.
Other landings, if any	Shark bay (29 March–6 April)
Available primary sources	Archival only – see Marchant 1982.
References	Marchant 1982.
Comments	

Name of vessel	*Discovery* and *Chatham*
Name of Captain	George Vancouver
Type of vessel	English
Port of departure	Falmouth, England.
Date of departure	1 April 1791
Date of landfall	28 September 1791
Places visited en route	Teneriffe – Santa Cruz, Simon's Bay (at Cape of Good Hope)
Point of arrival in Australia	King George Sound
Wrecked or landed	Landed several times with boat for exploration and to gather wood and water. Stayed 12 days.
Other landings, if any	
Available primary sources	Several manuscript versions of journals kept on the voyage have survived and are kept in the British Public Record Office. Correspondence relating to the voyage is also held in the British PRO. A revised version of Vancouver's journal was first published in 1798, and translated and republished several times since. For more detail on sources see Vancouver (1984, pp.257–269)
References	Vancouver 1984.

Comments	The lengthy 4-volume journal of this voyage was not read, but the very comprehensive index did not include cats. Vancouver's instructions included taking every care to ensure that 'Dogs, or any other Animals' were prevented from getting into the plant frame (Lamb's introduction to Vancouver 1984, p.44). The index confirms that at least one dog was indeed on board (the index containing an entry under 'dogs': 'Newfoundland, on *Discovery*, amazes natives of Rapa Island'), so it is perhaps significant that cats are not also specified.

Name of vessel	*Recherche* and *Esperance*
Name of Captain	A. D'Entrecasteaux
Type of vessel	French
Port of departure	Brest
Date of departure	28 September 1791
Date of landfall	9 December 1792
Places visited en route	Bertheaume (France, to put off stowaways), Santa Cruz, Cape of Good Hope, Tasmania, New Caledonia, Buka Is., New Ireland, Vendola Is., Jesus-Maria Is., Los Negros Is., Ambonia (for five weeks).
Point of arrival in Australia	Observatory Island, Esperance Bay (although previously touched at Tasmania).
Wrecked or landed	Landed with boat. Specimens collected and repairs carried out while at anchor for six days.
Other landings, if any	Mainland at Esperance Bay, then Tasmania (for the second time).
Available primary sources	Several documents relating to this voyage are held on microfilm at the National Library of Australia: see Horner (1995, p.301). The list includes ministerial correspondence, instructions, preparations, dossiers, papers, journals, observations, logs and charts. The personal journal of Jacques-Julien Labillardière was published in 1799, and an English translation in 1800. An official account of the voyage, taken largely from D'Entrecasteaux' journals, has also been published (Rossell 1808), but never translated into English.
References	Horner 1995; Marchant 1982.
Comments	There was certainly a dog on board the *Esperance*, as while the party was anchored at Esperance Bay, naturalist Claude-Antoine-Gaspard Riche went ashore and failed to return. A search party, which included Riche's dog, was sent off the next day. A search of the opening stages of Labillardière's account revealed no cats, and although they appear in his vocabulary of Malay ('*koutchien*, *touffa*'), they are omitted from vocabularies from Cape van Diemen (Melville Is.), Friendly Islands, New Caledonia and Waygiou.

Name of vessel	*Geographe* and *Naturaliste*
Name of Captain	N. Baudin (and E. Hamelin on the *Naturaliste*)
Type of vessel	French
Port of departure	Le Havre
Date of departure	18 October 1800
Date of landfall	31 May 1801
Places visited en route	Tenerife, Port North-West (Mauritius)
Point of arrival in Australia	33°30'55'
Wrecked or landed	Landed with boat in Geographe Bay.
Other landings, if any	Hamelin: Swan River and approaches (14 June–28 June); Shark Bay (17 July–4 September). Baudin: Shark Bay (26 June–11 July); Dampier Archipelago (27 July); Bonaparte Archipelago (11 August–13 August).
Available primary sources	Journal of Baudin (1974), including Appendices listing provisions, navy supplies and refreshments, instruments for navigation etc., crews, and so on. An official account of the voyage, by Peron (1975) has also been published in English. The journal of Louis de Freycinet (1815) has also been published in French, but not translated. Records from the Baudin Expedition are also available in the Battye Library private archives: Baudin Expedition. Records, 1801–1821 [manuscript], 27 cm. Battye Library, Priv Arch. Stack MN 584, Baudin papers, ACC 282A, 407A. These records, which I have not read, include transcripts of letters, journals and other papers of members of the Baudin Expedition, including Nicolas Baudin, Francois-Michel Ronsard, Emmanuel Hamelin, Jacques de Saint-Cricq, Etienne Giraud, Victor Couture, S. Levillain, Francois Heirisson, Louis de Freycinet.
References	Henderson 1980; Marchant 1982.
Comments	Two boats were lost on this voyage, and one foundered but was later repaired and refloated: *Geographe's* chaloupe was lost in Geographe Bay 5 June 1801; *Naturaliste's* skiff foundered at Rottnest 17 June 1801; and her chaloupe was lost at Cottesloe 19 June 1801. The published journals of both Baudin and Peron have been read. Despite the former journal in particular containing great detail (being over 600 pages long), no reference to cats was found in either work.

Name of vessel	*Investigator*
Name of Captain	M. Flinders
Type of vessel	English
Port of departure	Portsmouth
Date of departure	18 July 1801 (from Spithead)
Date of landfall	8 December 1801
Places visited en route	Simon's Bay (large cove in False Bay, East of Table Bay on the Cape of Good Hope)
Point of arrival in Australia	King George's Sound.
Wrecked or landed	Landed with boat.
Other landings, if any	Princess Royal and Oyster Harbours, and at several points along the south coast around to Port Jackson. On this part of the voyage, the *Investigator's* cutter was wrecked at Cape Catastrophe (34°58'S 135°56'E). After spending 12 weeks at Port Jackson, the circumnavigation was recommenced to the north, and many landings made to New Year's Isle, from whence they sailed to Timor (arrived 31 March 1803, taking on water and food, including live buffalo, pigs and kids). From Timor, the next landing was on the mainland at Goose-Island Bay, at the Archipelago of the Recherche. Sydney Cove was again reached 9 June 1803.
Available primary sources	Two journals from the voyage have been published: that of Flinders (1966), and that of gardener Peter Good (1981).
References	Flinders (1966); Good (1981).
Comments	Both Flinders' and Good's journals have been read, without finding reference to cats. This is particularly interesting, as it is known that there were cats on board the *Investigator* – one, Trim, being Flinders' beloved pet about which he wrote a story (see above). Neither Trim, nor any other cats on board are mentioned by Flinders or Good at any point, even during the wreck of the Porpoise, and Flinders' subseqent imprisonment on Mauritius, when Trim was lost (apparently much to Flinders' distress). Good mentions dogs on board the *Investigator*, which were used for hunting kangaroos after their first stop at Port Jackson.

Name of vessel	*Geographe* and *Casuarina*
Name of Captain	N. Baudin (and L de Freycinet, on the *Casuarina*)
Type of vessel	French
Port of departure	Port Jackson
Date of departure	17 November 1802
Date of landfall	13 February 1803 (in WA – *Casuarina*, which was joined by the *Geographe* 17 February 1803)
Places visited en route	King Island, Kangaroo Island, Ceduna region.
Point of arrival in Australia	King George Sound (arrival in WA)
Wrecked or landed	Landed with boat; *Casuarina* beached at Princess Royal Harbour 21 February 1803.
Other landings, if any	Geographe Bay and Bunbury Region (*Geographe* 11 March), Rottnest Island (*Casuarina* 13 March), Shark Bay (16 March–23 March), Bonaparte Archipelago (25 April).
Available primary sources	(see *Geographe* and *Naturaliste* entry)
References	Marchant 1982.
Comments	On this part of the voyage dogs are mentioned in connection with hunting game on shore, on several occasions. As they were not mentioned previously, it is assumed that they were taken on board at Port Jackson. On the 19th January, a rooster and two hens, and a boar and sow were left on Kangaroo Island to 'multiply and possibly be of use to future navigators in these regions' (Baudin 1974, p.468). However, no mention was made of cats or their release.

Name of vessel	*George* (*Alfred*)
Name of Captain	?
Type of vessel	Built Chittagong 1804, registered at Calcutta.
Port of departure	?
Date of departure	?
Date of landfall	1804 (?)
Places visited en route	?
Point of arrival in Australia	?
Wrecked or landed	Wrecked (?)
Other landings, if any	
Available primary sources	None
References	Initial reference to wreck in Phipps (1840); Henderson 1980.
Comments	No wreck located.

Name of vessel	*Rapid*
Name of Captain	?
Type of vessel	American trader
Port of departure	Boston
Date of departure	29 September 1810

Date of landfall	7 January 1811
Places visited en route	?
Point of arrival in Australia	Ningaloo Reef, 22°44'S 113°41'E, 1 nautical mile offshore.
Wrecked or landed	Wrecked.
Other landings, if any	?
Available primary sources	Archaeological evidence. Loney does not disclose his sources.
References	Henderson 1979; Loney 1994.
Comments	Loney claims that this trader, bound for Canton, was carrying a mixed cargo which included 330 000 Spanish dollars. The wreck broke up after a day at which point the crew of 22 left in three boats. All apparently reached safety. Cats are quite likely to have been on this vessel, and Henderson notes that debris were found near the beach, which 'would indicate that planking from the wreck came ashore in that area' (1979, p.20).

Name of vessel	*Correo de Azia*
Name of Captain	?
Type of vessel	?
Port of departure	?
Date of departure	?
Date of landfall	25 November 1816
Places visited en route	?
Point of arrival in Australia	Shark Bay
Wrecked or landed	Wrecked (?)
Other landings, if any	
Available primary sources	None
References	Western Australian Maritime Museum Shipwreck Database; Horsburgh 1841.
Comments	Wreck not found. No other information available.

Name of vessel	*Uranie*
Name of Captain	L. de Freycinet
Type of vessel	French
Port of departure	Toulon
Date of departure	17 September 1817
Date of landfall	13 September 1818
Places visited en route	Gibraltar, Santa Cruz, Rio de Janeiro, Cape Town, Ile de France (Mauritius), St Denis Harbour (Reunion Is).
Point of arrival in Australia	Dirk Hartog Island
Wrecked or landed	Landed with boats.
Other landings, if any	Mainland at Shark Bay, where the party stayed until the 26 September. On departing for Timor, the *Uranie* hit a sandbank and was stranded until the tide rose, spending the entire night in 'one or two inches of water' (de Freycinet 1996, p.53).
Available primary sources	Journal of Rose de Freycinet, Louis de Freycinet's wife, has been translated and published (de Freycinet 1996). Louis de Freycinet's journal has also been published (de Freycinet 1927–39), but not translated. The papers of Joseph Paul Gaimard, French surgeon and naturalist on board the *Uranie* are also held in the Battye Library: Gaimard, Paul, 1793-1858. Journal, 1817–1819 [manuscript] 7 cm. (489 pages, large folio). Battye Library, MN 1188, Papers of Joseph Paul Gaimard, ACC 3506A, Priv. Arch. Stack. Also available on microfilm.
References	L. de Freycinet 1927–39; R. de Freycinet 1996.
Comments	Journal of Rose de Freycinet read; no mention of cats found (even during shipwreck of *Uranie* at French Bay, Falkland Islands). Other animals are, however, mentioned. For example, at Sydney they took on board 'a pair of merino sheep ... a cassowary [sic] ... two other young cassowaries, eight black swans ... a cassican ... two she-goats ... a cow, a calf and a dozen beautiful sheep' (p.121).

Name of vessel	*Mermaid*
Name of Captain	P.P. King
Type of vessel	Colonial Australian
Port of departure	Port Jackson
Date of departure	22 December 1817
Date of landfall	20 January 1818
Places visited en route	Twofold Bay, Recherche Archipelago.
Point of arrival in Australia	King George Sound (arrival in WA)
Wrecked or landed	Landed with boat.
Other landings, if any	Exmouth Gulf; Dampier Archipelago, then to Cape van Diemen, Goulburn Is, Coepang, Barrow Is.

Available primary sources	Journal published (King 1827); Hordern gives list of stores and equipment (401–410); charts (given by Hordern).
References	King 1827; Hordern 1997.
Comments	Journal and stores/equipment list read: no mention of cats, although it is clear that there was a water-spaniel on board (King 1827, p.46).

Name of vessel	*Lively*
Name of Captain	?
Type of vessel	French-built whaler
Port of departure	?
Date of departure	?
Date of landfall	1818
Places visited en route	?
Point of arrival in Australia	Rowley Shoals, 17°S 119.5°E
Wrecked or landed	Wrecked and sunk.
Other landings, if any	
Available primary sources	Archaeological artefacts.
References	Henderson 1980; Western Australian Maritime Museum Database.
Comments	Wreck found – no cat remains recovered.

Name of vessel	*Mermaid*
Name of Captain	P.P. King
Type of vessel	Colonial Australian
Port of departure	Port Jackson
Date of departure	8 May 1819
Date of landfall	19 September 1819
Places visited en route	Several landings along east coast of Australia, Arnhem Land, Cobourg Peninsula, Joseph Bonaparte Gulf.
Point of arrival in Australia	Cambridge Gulf, West Arm (arrival in WA).
Wrecked or landed	Landed with boat.
Other landings, if any	Kimberley coast, to Cape Voltaire.
Available primary sources	Journal published (King 1827); charts (given by Hordern).
References	King 1827; Hordern 1997.
Comments	Journal read – no cats mentioned. There was, however, also a dog on this voyage, mentioned ashore when the boat was repaired at Endeavour River. During repairs the boat was secured to the shore within 10 feet of a steep beach (King 1827, p.211). There were also plenty of rats on board the Mermaid – King provides details of their depredations (1827, pp.279, 324).

Name of vessel	Unidentified wreck
Name of Captain	?
Type of vessel	Most likely a whaler or sealer
Port of departure	?
Date of departure	?
Date of landfall	c.1820
Places visited en route	?
Point of arrival in Australia	55 km east of Eyre.
Wrecked or landed	Wrecked
Other landings, if any	
Available primary sources	Artefacts, Aboriginal story.
References	Henderson 1980.
Comments	

Name of vessel	*Mermaid*
Name of Captain	P.P. King
Type of vessel	Australian Colonial
Port of departure	Port Jackson
Date of departure	13 July 1820
Date of landfall	5 September 1820
Places visited en route	Several landings along east coast of Australia, Arnhem Land, Melville Is.
Point of arrival in Australia	Cape Voltaire
Wrecked or landed	Landed with boat.
Other landings, if any	The Mermaid was careened at Careening Bay (in Port Nelson) from 21 September 1820 to 5 October 1820, and left the coast at Brunswick Bay.

Available primary sources	Journal published (King 1827); charts (given by Hordern).
References	King 1827; Hordern 1997.
Comments	Journal read - no cats were mentioned while the vessel was careened (or on the rest of the voyage).

Name of vessel	*Bathurst*
Name of Captain	P.P. King
Type of vessel	Australian Colonial
Port of departure	Port Jackson
Date of departure	26 May 1821
Date of landfall	23 July 1821
Places visited en route	North-east coast of Australia, Goulburn Islands.
Point of arrival in Australia	Careening Bay (Port Nelson)
Wrecked or landed	Landed with boat.
Other landings, if any	Along coast to Pt Gantheaume, then to Mauritius, then back to King George Sound (10 November 1821), Rottnest Island, Shark Bay, North West Cape, Dampier Archipelago, Cape Leveque.
Available primary sources	Journal published (King 1827); charts (given by Hordern).
References	King 1827; Hordern 1997.
Comments	Journal read, no cats mentioned.

Name of vessel	*Belinda*
Name of Captain	T. Coverdale
Type of vessel	Brig on sealing expedition
Port of departure	Sydney
Date of departure	17 May 1824
Date of landfall	mid-June 1824
Places visited en route	
Point of arrival in Australia	Near Middle Island in the Recherche Archipelago
Wrecked or landed	Wrecked.
Other landings, if any	
Available primary sources	Contemporary newspaper reports – see Henderson 1980.
References	Henderson 1980.
Comments	Crew reached shore and proceeded towards Sydney in two boats, one of which foundered. All survivors were rescued by the brig *Nereus*, which had been sealing in the same area, and returned to Sydney.

Name of vessel	*Astrolabe*
Name of Captain	D. D'Urville
Type of vessel	French corvette
Port of departure	Toulon
Date of departure	25 April 1826
Date of landfall	8 October 1826
Places visited en route	Gibraltar, Santa Cruz, La Praya (Cape Verde Is.)
Point of arrival in Australia	King George Sound
Wrecked or landed	Landed with boat.
Other landings, if any	
Available primary sources	D'Urville's Journal has been translated and published (D'Urville 1987). The editors have summarized some sections of the journal, and have included excerpts from Officers' Journals in other parts.
References	D'Urville 1987.
Comments	The journal was read, and no reference to cats found (although D'Urville did have a pet cockatoo). At Oyster Harbour, D'Urville also retained the services of an Englishman (who had been with a whaling party they met with at the harbour) and his dogs, to accompany the French on a kangaroo hunt.

CONCLUSION

No direct reference has been found in any of the material examined to the deliberate release or escape of cats onto the north or western coasts of the Australian mainland on either Macassan or European vessels. With the exception of the Dutch ship *Konign der Nederlanden*, recorded by Stevens as (unsuccessfully) attempting to carry cats in 1857, no evidence has been found for cats on board Dutch ships of any description. They were, however, recorded on board English and American ships, suggesting the possibility that the ship's cat was a phenomenon that originated with the English, and was adopted by the Americans. Other evidence suggests that the Dutch may have been more likely to carry dogs on their vessels for rodent control. No direct references to the presence of dogs on Dutch ships have been found, although evidence exists of dogs on board French vessels. Evidence has also been found which places dogs on board American and English ships, alongside cats (in the case of Cook and Flinders), and perhaps instead of them (in the case of Vancouver and King). The absence of Matthew Flinders' cat 'Trim' from journals written on board the *Investigator* makes it clear, however, that the nature of most available European sources is such as to obscure the presence of cats. Thus while it cannot be assumed that they were regularly carried on Dutch vessels, it remains a possibility that they arrived with wrecks – in particular the *Zuytdorp*, and possibly the *Vergulde Draeck*, because of their proximity to the mainland coast. It is unlikely that any of the voyages of exploration deliberately released cats via boat onto the mainland; certainly there is no record of such an occurrence. Although there is no documentary evidence to support the proposal, it remains likely that there were cats on board Dampier's *Cygnet*, and that these would have had ample opportunity to escape onto the mainland when that vessel was careened in the Kimberley in 1688. Such an event could explain Aboriginal perceptions of the early arrival of cats on the mainland. More recently, cats could also have arrived with the wreck of the *Rapid* in 1811, or with sealers and whalers who put in to King George Sound from the beginning of the nineteenth century.

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The vascular flora of the Warren bioregion, south-west Western Australia: composition, reservation status and endemism

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ABSTRACT

We provide a comprehensive list of the vascular flora of the Warren bioregion of Western Australia, a table of species reservation status, and a list of endemic and conservation taxa. The flora totals 2283 taxa, 1853 of which are native. One hundred and seventy of the taxa recorded await formal description. Important families include Orchidaceae (6.9 per cent), Myrtaceae (6.6 per cent), Papilionaceae (8.0 per cent), Proteaceae (5.9 per cent) and Cyperaceae (4.9 per cent).

Approximately 4 per cent of the native flora is endemic, a further 66 taxa have distributions extending just beyond the boundary of the bioregion. The majority of the endemic taxa occupy swamps, and granite rocks and fringes, with a lesser number occurring in the tall eucalypt forests.

The Warren has a high proportion of reserved lands, with 83 per cent of the recorded taxa occurring within conservation reserves and a further 6 per cent reserved within forest blocks.

INTRODUCTION

This paper provides a comprehensive list of the vascular flora of the Warren Bioregion of Western Australia (WA) (Beard 1980; Thackaway and Cresswell 1995), a table of their reservation status, and a list of endemic and conservation taxa. The bioregion is centred at approximately 116° 00' E , 34° 30' S, the Warren has an area of 832 300 ha (Beard and Sprenger 1984).

The study area includes the entire Warren Bioregion (Warren) in addition to parcels of land occurring adjacent to the boundary, principally along the eastern and northern edge of the Leeuwin-Naturaliste Ridge (Figs 1 and 2). The Warren lies in the extreme south-west corner of WA. Beard (1980) considered it one of four sub-districts within the Darling Botanical District. It has subsequently been recognized as a separate bioregion (Thackaway and Cresswell 1995). The Warren is characterized by a short summer dry period (3–4 months) relative to the remainder of the south-west, and has an annual rainfall of 600–1500 mm. The area is the wettest and least seasonal part of WA. The northern boundary is drawn where karri (*Eucalyptus diversicolor*) ceases to be a significant component of the flora (Beard 1980).

The vegetation of the Warren includes the tall forests of karri (*E. diversicolor*) and tingle (variously *E. brevistylis, E. jacksonii*, and *E. guilfoylei*) for which the region is recognized. On poorer soils jarrah-marri (*E. marginata* and *E. calophylla)* forest occurs. Within these more inland forested areas, valley floors are often broad and dominated by sedges, rushes and various shrubs e.g. *Agonis* spp. The coastal belt of the Warren supports various woodlands (*Agonis flexuosa* as a common dominant) and heaths on unconsolidated aeolian sands and limestone ridges. Lying between the forested uplands and the coastal dunes are broad sandy swampy plains. These are a mosaic of low-lying sedge swamps dominated by Cyperaceae and Restionaceae, and low woodlands of *Banksia* spp. and various shrubs on sandy rises (see Beard 1981; Churchward *et al.* 1988).

Much of the Warren is public land, the vast majority being multiple-use State forest and conservation reserves. Private land constitutes only 36 per cent of the total area of the Warren (Wardell-Johnson *et al.* 1995). Private land use is dominated by broad-scale agriculture, with a more recent trend to more intensive horticulture and viticulture. Recreation and tourism is a significant feature of the region's land use on both public and private land.

The vascular flora of the Warren bioregion was most recently reviewed by Hopper *et al.* (1992). That review interpreted the Warren boundary more broadly than the current study, incorporating records of taxa based on imprecise collecting localities such as 'Albany', a regional centre just outside the Warren boundary. Earlier, Beard (1990) provided a review of the coastal flora of the South-West Botanical Province.

Considerable floristic survey work has been completed within the Warren since these reviews. For example,

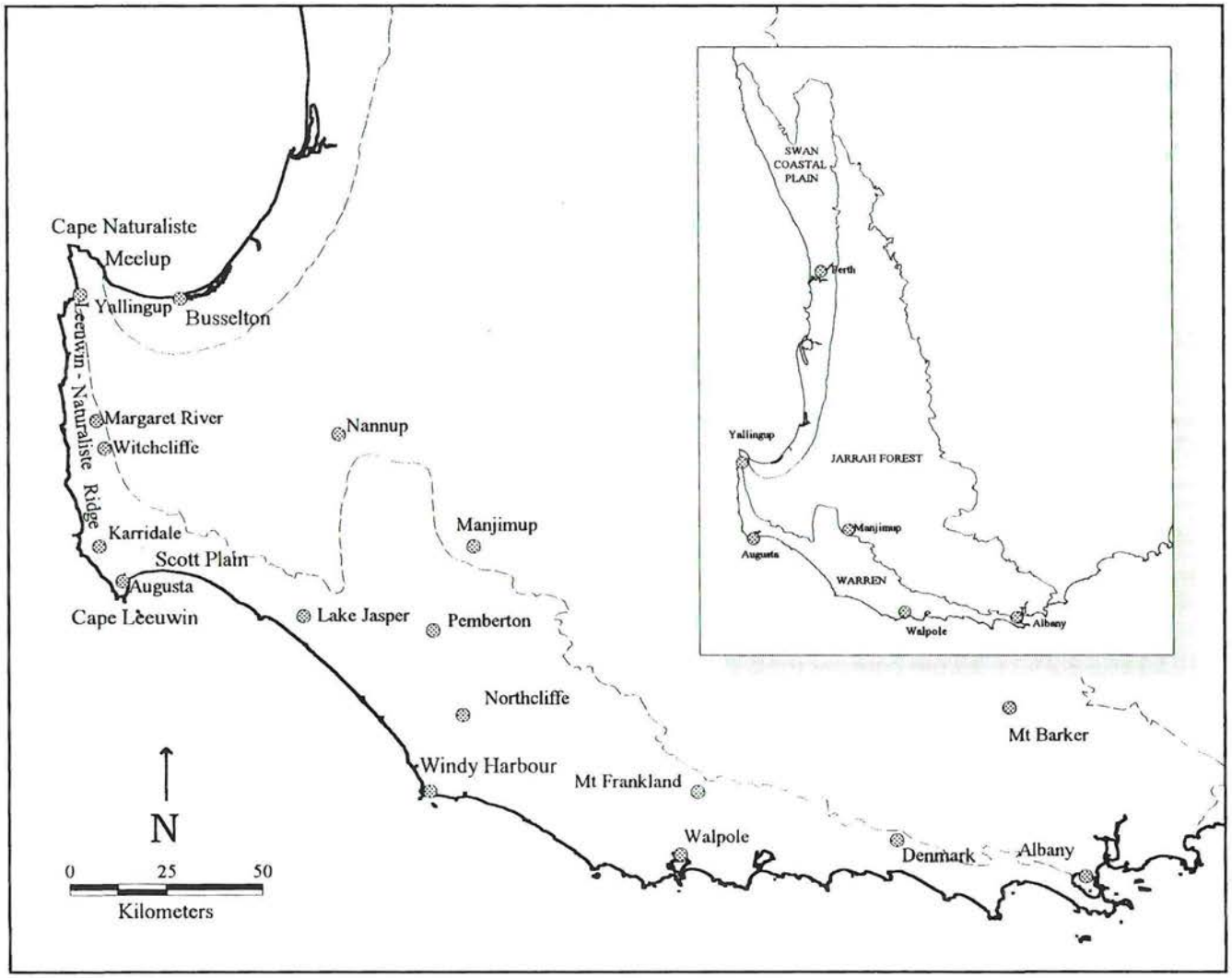


Figure 1. Location of the Warren and adjoining bioregions, South-west Western Australia (Beard 1980; Thackaway and Cresswell 1995).

surveys within the Tingle Mosaic, an area of locally endemic eucalypts largely within the Warren (Wardell-Johnson *et al.* 1995; Wardell-Johnson and Williams 1996) and a major survey of the coastal and near-coastal communities of the Warren (Gibson and Lyons unpublished). More recently surveys have been undertaken as part of the Regional Forest Agreement process (see Gioia *et al.* 1998). Representative collections of the material collected in the course of these studies has been lodged with the Western Australian Herbarium. Over recent years duplicate specimens held in regional herbaria (Albany and Manjimup) have also been lodged at the Western Australian Herbarium.

Considerable taxonomic work relevant to diverse plant groups within the Warren has been undertaken in the last few years. Examples include genera within the Cyperaceae, Restionaceae (Meney *et al.* 1996; Briggs and Johnson 1998) and Epacridaceae (*Andersonia*) (Lemson, unpublished). This work has led to the circumscription of many new taxa within the Warren. Also, many collections have been redetermined in the process of completing a Flora of the Warren and adjoining areas (Wheeler unpublished).

These projects, coupled with considerable general collecting, have meant it is timely to revisit the flora of the Warren. In particular, the current level of knowledge and available data enable an appraisal of the reservation status of the flora.

METHODS

Flora Data Compilation

The flora data for the study area were compiled from three main sources.

1. Herbarium data

Data were extracted from the specimen database of the Western Australian Herbarium (WAHERB). The data

include herbarium collections incorporated up to March 1998. Collection records were captured by performing area-based queries (from specimen geo-codes) and by retrieving all records of taxa listed in Hopper *et al.* (1992). Where queries included areas beyond the Warren boundary, the non-Warren collections were manually removed by inspecting the collection locations. Record locations were checked by comparing the stated latitude and longitude, with the word description of the collection locality. Collection locality data were often of poor resolution. Localities such as 'Manjimup' and 'Albany' (towns adjacent to, but outside the Warren) were excluded. Many older collections with similarly broad localities such as 'King George's Sound' were also removed.

2. Quadrat based floristic surveys

Floristic survey data were incorporated from several studies completed within the Warren (Wardell-Johnson *et al.* 1989; Wardell-Johnson *et al.* 1995; Wardell-Johnson *et al.* unpublished; Gibson and Lyons unpublished). These data had accurate geo-codes, and selected specimens of the taxa recorded were vouchered at the Western Australian Herbarium.

3. Flora checklists and sight records

Lists of the flora were available for several major reserves and forest blocks within the study area. Checklists have been compiled for Leeuwin-Naturaliste, Scott, Torndirrup and West Cape Howe National Parks (Keighery 1988a, 1988b; Keighery unpublished) and for Yelverton, Forest Grove and Chester Forest Blocks (Keighery unpublished). Selected taxa from these areas are vouchered at the Western Australian Herbarium. Some records of taxa known to occur sporadically within the Warren, such as roadside weeds and garden escapes, were also included.

Reconciling the data sets with current taxonomy was a major component of data compilation. The nomenclature generally follows Green (1985) and current usage at the Western Australian Herbarium. For unvouchered records of taxa subject to recent revisions, determinations were reconciled by consulting current revisions and flora treatments. Records were excluded where the taxonomy could not be adequately resolved.

Additional taxa not captured from these sources but listed in Hopper *et al.* (1992) were included where they were known, from anecdotal knowledge, to occur within the study area. However, many records were excluded owing to unresolvable changes in taxonomy, or where they were shown to occur outside the study area as presently defined.

Data Allocation to Blocks

CALM lands within the study area fall into two broad categories: conservation reserves and forest blocks. Conservation reserves include national parks, nature reserves and conservation parks. Forest blocks are areas designated for operational purposes and may contain a mixture of tenures including State forest, timber reserve, executive director freehold and leasehold. Land use varies within forest blocks ranging from plantation silviculture, logging, recreation, wildflower harvesting, and apiculture, to areas managed primarily for conservation. These two major categories of land represent the vast majority of the reserved lands within the study area. Other reserves within the study area include a multitude of special purpose reserves vested in local and State government. A summary of the existing and proposed CALM managed reserves within the study area is provided in CALM's planning documents (CALM 1987b, 1992, 1994).

CALM lands were divided into a system of blocks, to which flora records were allocated. Two categories of blocks were delimited: reserve blocks and forest blocks. Reserve blocks are sub-sections or entire national parks, nature reserves, conservation parks. In some cases, small nature reserves were included in an adjacent national park or nature reserve block. Alternatively, several small reserves were amalgamated into a single reserve block. Forest blocks follow existing forest blocks used by CALM.

Shannon and D'Entreacasteux National Parks were sub-divided into a series of reserve blocks that correspond to the administrative boundaries devised for park management (CALM 1987a). The reserve blocks within Mount Frankland National Park represent the forest block boundaries that existed prior to the park's gazettal (Appendices 1, 2, and Fig. 2). Data from several areas of CALM land outside the Warren were included to provide full documentation of the flora of major national parks that extend beyond the Warren boundary. These include the northern areas of Leeuwin-Naturaliste and Mount Frankland National Parks.

For forest blocks that straddle the Warren boundary, records were included from that portion of the block that is within the Warren. Data from some forest blocks extending beyond the Warren (Yelverton, Chester and Witchcliffe) were retained as they had available checklists or floristic survey data. Three reserves were included that are not CALM estate. These include Meelup Reserve 21629 (Conservation and Recreation), at the northern tip of the Leeuwin-Naturaliste Ridge, Reserve 12951 (Water, Camping and Recreation) adjacent to Scott National Park, and Reserve 23579 (Camping and Recreation) on the Hay River east of Denmark. These miscellaneous reserves were included because they contain several taxa of particular interest and considerable data were available for them. They are not included in the estimates of reservation of the flora (see below).

The WAHERB data were allocated to the blocks using a combination of geo-codes and collection location information. Records were all allocated by inspection since the two data types were sometimes equivocal. Records which could not be allocated to a block because of low resolution locality data were retained as records for the study area. Accurately geo-coded floristic survey data and the national park and forest block checklists were readily allocated to the system of blocks.

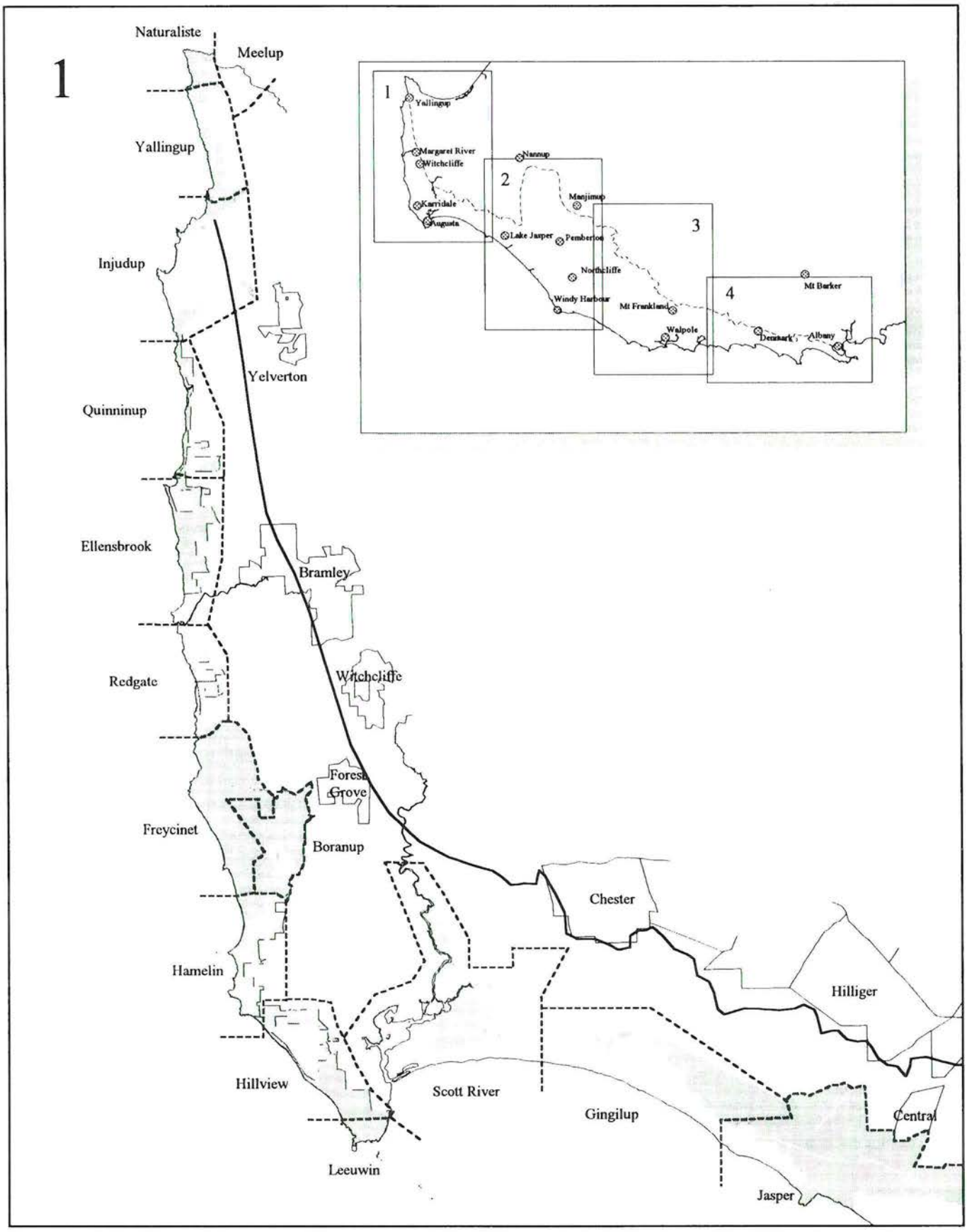


Figure 2. Study area showing the blocks listed in Appendix 1. The heavy line is Beard's (1980) Warren boundary. Conservation reserves are shaded. Dotted lines contain reserves included under each block name.

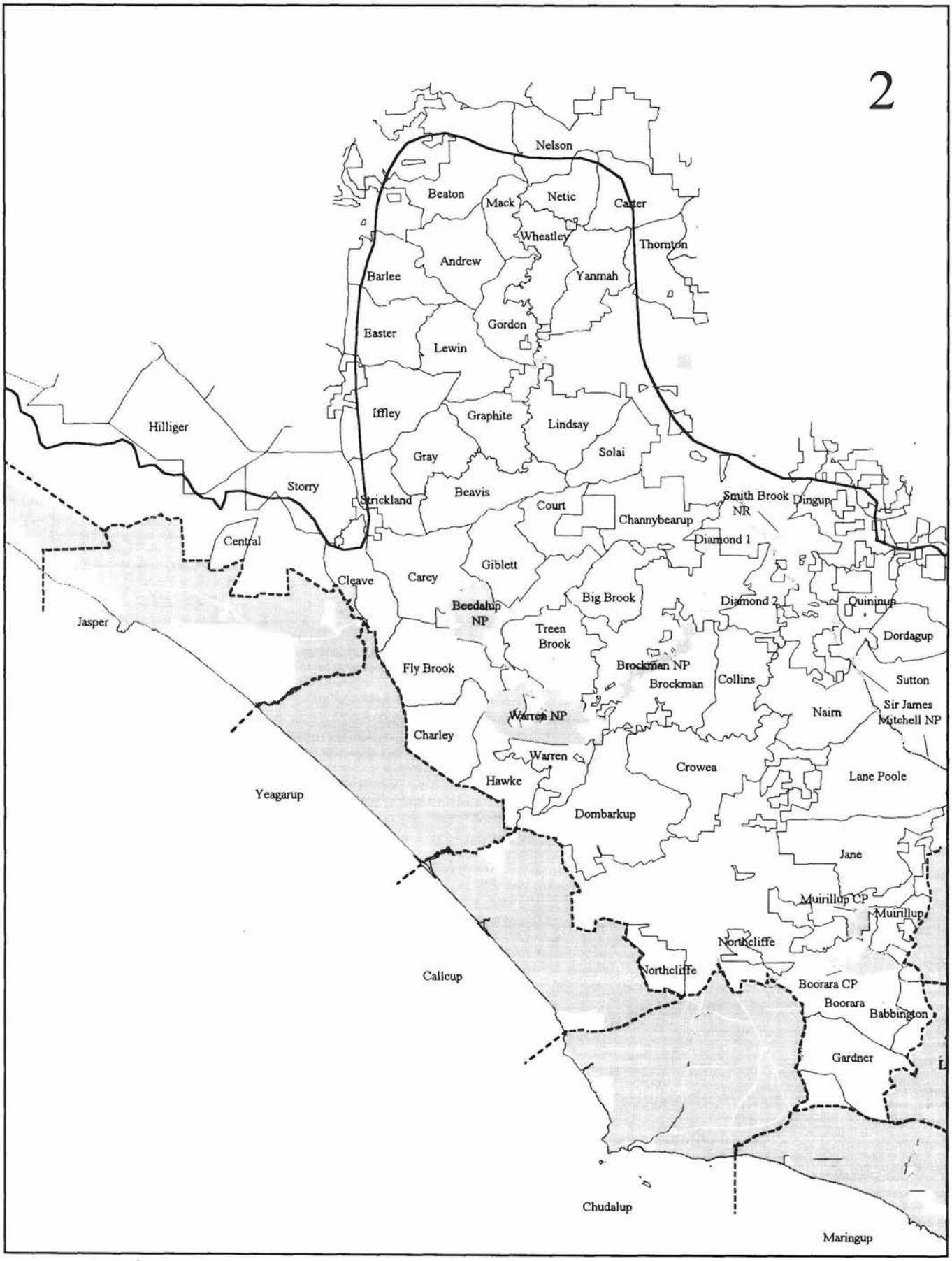


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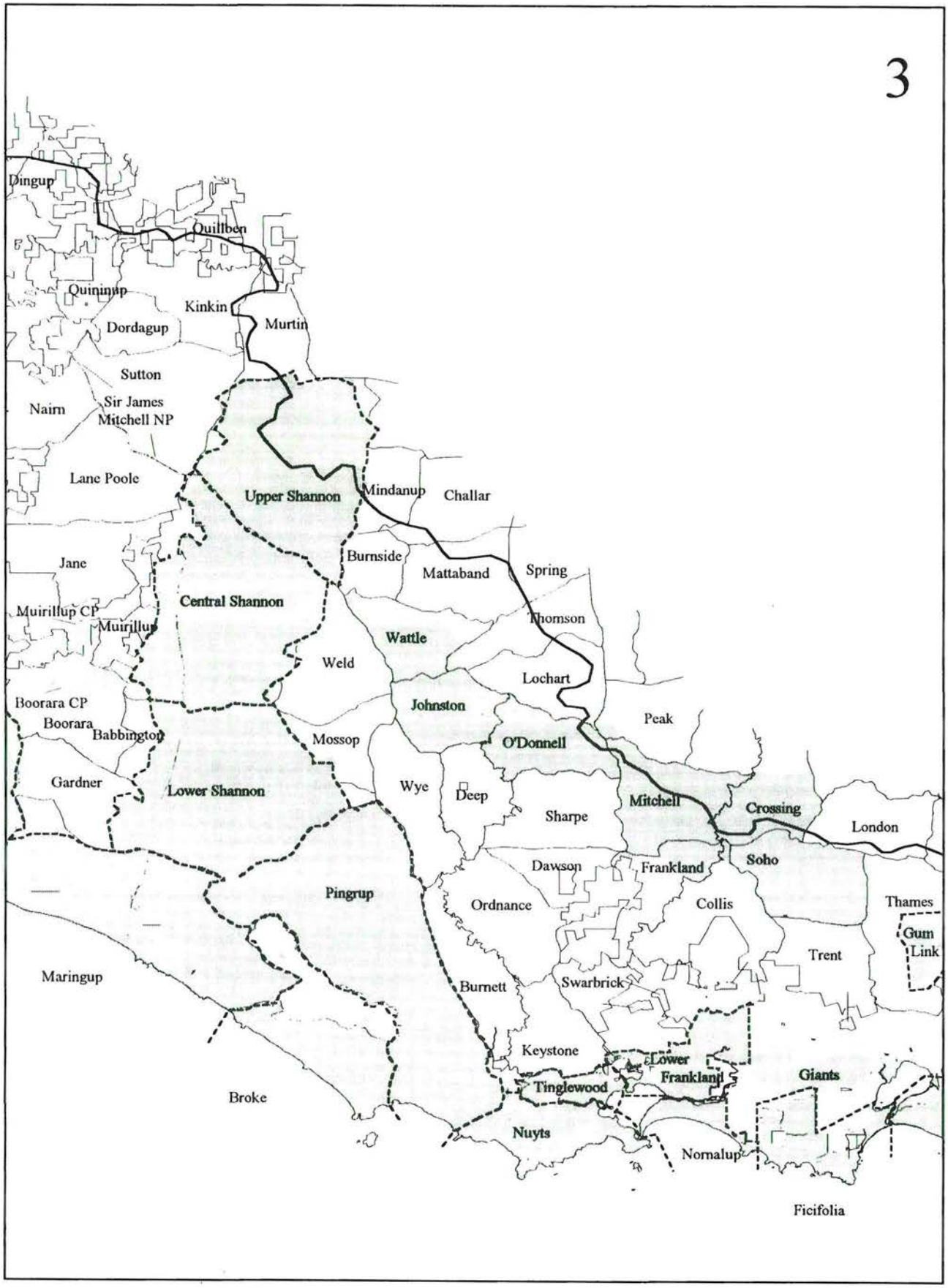


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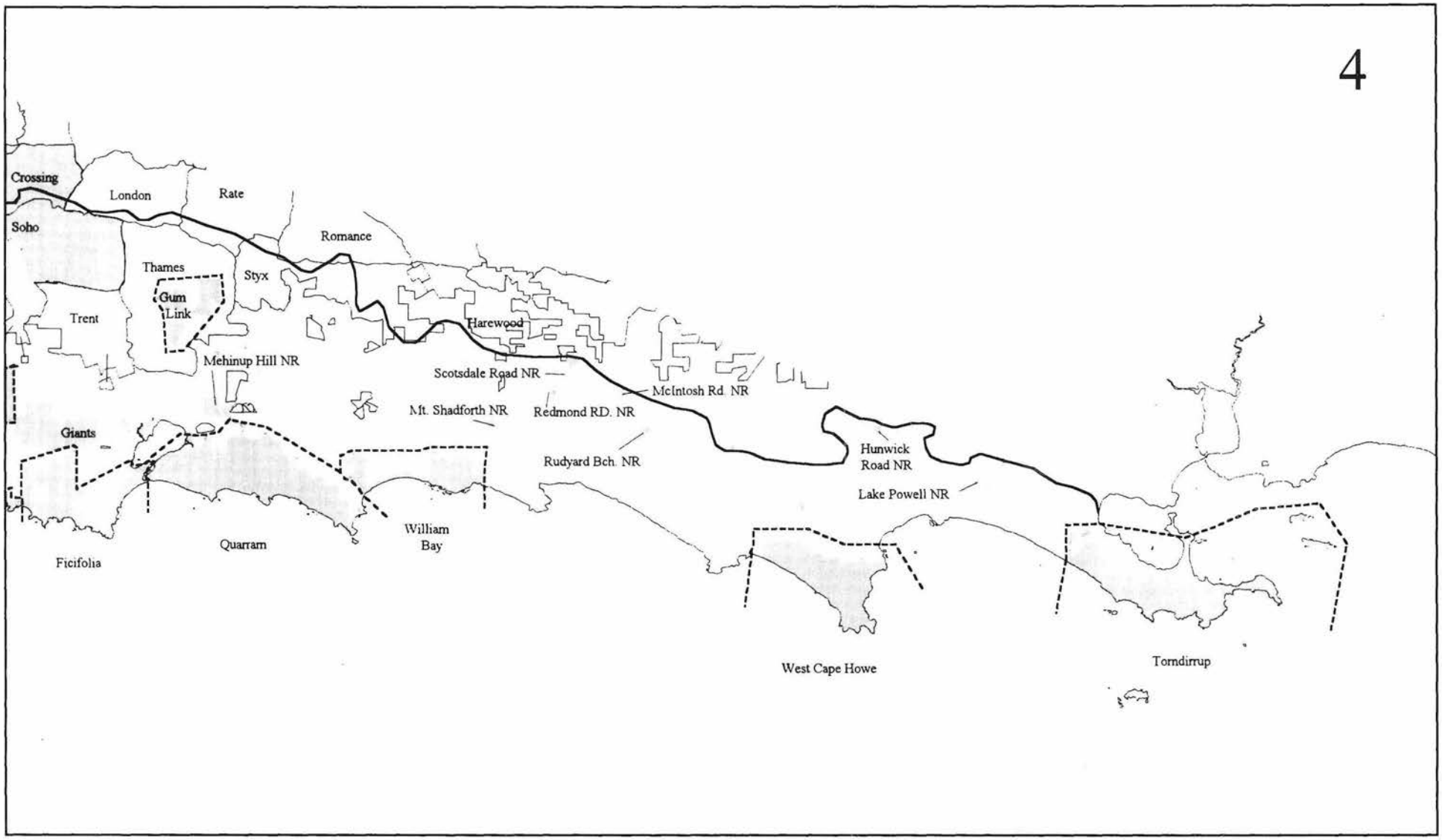


Figure 2 (continued)

RESULTS

The total data set contains approximately 54 000 records within an average of 23.6 records per taxon. Forty-five per cent of the records were derived from WAHERB, with 47 per cent from floristic survey data and 7 per cent from the checklists of Keighery (1988a, 1988b, unpublished). The remainder are individual species records from Hopper *et al.* (1992) and the authors.

The Flora

The vascular flora of the study area totals 2282 taxa, including 1853 native and 429 naturalized taxa (Appendix 1, Table 1). This is a 17 per cent increase in taxa compared with the list of Hopper *et al.* (1992). Sixty-three taxa that occur within the study area were recorded only at localities outside the boundary of the Warren (Appendix 3). The total flora contains 140 families (28 contain exclusively introduced taxa). The total number of genera recorded was 690. Of these, 259 contained exclusively introduced taxa.

The dominant families are shown in Table 2. As noted by Hopper *et al.* (1992), the Monocotyledon families Orchidaceae, Poaceae, Cyperaceae, Restionaceae and Anthericaceae show disproportionately high representation within the Warren compared with the State's flora as a whole (Green 1985). The families with the greatest number of native genera include Asteraceae, Papilionaceae, Orchidaceae, Myrtaceae, Restionaceae, Poaceae, Cyperaceae, Proteaceae, and Epacridaceae.

The major genera are listed in Table 3. The largest genera are similar to those reported by Hopper *et al.* (1992) although *Schoenus, Hibbertia* and *Boronia* are larger in the current study. Hybrid taxa are not included in the main list with the exception of some naturalized taxa. These are taxa which are common and often widespread, and are usually of horticultural origin (e.g. *Freesia leichtlinii* x *refracta*). Appendix 4 lists other hybrids recorded from the study area. The Western Australian Herbarium does not have voucher specimens from the Warren for some of the taxa listed in checklists and floristic surveys. These are shown in Appendix 1.

Table 1. Numbers of vascular plant taxa recorded from the study area. Figures in parentheses are numbers recorded by Hopper *et al.* (1992).

MAJOR GROUP	NATIVE	INTRODUCED	TOTAL
Ferns	19 (17)	3 (2)	22 (19)
Gymnosperms	2 (3)	5 (2)	7 (5)
Monocotyledons	573 (481)	131 (99)	704 (580)
Dicotyledons	1259 (1127)	290 (216)	1549(1343)
Totals	1853 (1628)	429 (319)	2282 (1947)

Endemic and Conservation Taxa

The flora of the Warren includes 72 endemic taxa, 3.9 per cent of its known native flora (Table 4). Another 13 taxa are recorded as being endemic to the larger study area. Many of the latter are taxa with distributions that include Cape Naturaliste and/or Meelup and often extend the length of the Leeuwin-Naturaliste Ridge. A further 53 taxa have distributions centred on the study area. These taxa may extend only a few kilometres beyond the boundary or may have one or two outliers some distance from the boundary. Table 4 lists the endemics and their geographic and habitat occurrences.

A large number of the endemic taxa occur in swamp or granite habitats. Endemic members of the Orchidaceae appear to be centred in consolidated coastal dunes and adjacent woodlands. A lesser number of endemic taxa occur within the tall forests that characterize the Warren. Even within the tall forests (karri and tingle) the endemic taxa occur in particular habitats. For example, the recently discovered *Anthocercis sylvicola* occurs near water-shedding granites (MacFarlane and Wardell-Johnson 1996). Similarly, the dominants of the tingle forests, themselves endemic (*Eucalyptus brevistylis, E. jacksonii,* and *E. guilfoyei*), are associated with high hills in granitic terrain (Wardell-Johnson and Coates 1996). Geographically, endemic taxa are concentrated in areas such as the Leeuwin-Naturaliste Ridge, Scott Plain, and the area in the vicinity of Walpole.

The flora of the Warren includes 199 taxa (including 3 hybrids) listed by CALM as 'declared rare or priority flora' (CALM 1998). Table 5 lists the numbers of taxa in each category (see Appendix 1 for definition of codes). Hopper *et al.* (1992) list three taxa as presumed extinct (not collected or reliably observed over the last 50 years). Of these *Meziella trifida* was rediscovered within Chester forest block, D'Eentreacasteaux National Park and north of Walpole. The remaining two species, *Scaevola attenuata* and *Tetratheca elliptica,* have been reduced to synonymy with *Scaevola nitida* Carolin (1992) and *Tetratheca setigera* respectively.

Reservation Status

The occurrences for the taxa within blocks are listed in Appendix 1. Blocks were categorized as reserve blocks (conservation reserves) and forest blocks. For each taxon the number of reserve block and forest block occurrences is shown. Data from reserves with multiple blocks were amalgamated to show the number of reserves for which each taxon was recorded. Appendix 4 lists the blocks and their codes.

The reservation status of the native flora is summarized in Table 6. Almost 89 per cent of the native flora was recorded from CALM managed lands and 83 per cent from primary conservation reserves. Almost half of the flora (46.6 per cent) is recorded from three or more conservation reserves, and a further 36.4 per cent are recorded from one or two reserves. Several of the national parks within the

Table 2. Dominant families within the study area ordered within major group by the number of native taxa.

FAMILY	TOTAL TAXA	NATIVE TAXA	INTRODUCED TAXA	TOTAL GENERA	NATIVE GENERA	%TOTAL TAXA	%NATIVE TAXA	%INTRODUCED TAXA
Monocots								
Orchidaceae	158	157	1	23	22	6.9	8.5	0.2
Cyperaceae	113	105	8	19	16	4.9	5.7	1.9
Restionaceae	63	63		21	21	2.7	3.4	
Poaceae	130	51	79	66	21	5.6	2.7	18.4
Anthericaceae	40	40		11	11	1.7	2.2	
Dicots								
Myrtaceae	152	150	2	24	22	6.6	8.1	0.5
Papilionaceae	183	141	42	43	27	8.0	7.6	9.8
Proteaceae	135	135		16	16	5.9	7.3	
Epacridaceae	81	81		15	15	3.5	4.4	
Asteraceae	132	80	52	72	36	5.8	4.3	12.1
Stylidiaceae	67	67		2	2	2.9	3.6	
Mimosaceae	55	50	5	3	2	2.4	2.7	1.2
Apiaceae	53	48	5	18	13	2.3	2.6	1.2
Goodeniaceae	44	44		8	8	1.9	2.4	
Rutaceae	41	41		7	7	1.8	2.2	
Droseraceae	36	36		1	1	1.6	1.9	
Dilleniaceae	34	34		1	1	1.5	1.8	
Totals	**2282**	**1853**	**429**	**690**	**431**			

Table 3. Dominant genera within the study area.

GENUS	NATIVE TAXA	INTRODUCED TAXA	TOTAL
Stylidium	62		62
Caladenia	50		50
Acacia	49	5	54
Schoenus	39		39
Leucopogon	37		37
Drosera	36		36
Hibbertia	34		34
Boronia	29		29
Eucalyptus	29		29
Melaleuca	27	1	28

Warren such as Leeuwin-Naturaliste, Mount Frankland, Shannon, and D'Entrecasteaux, are much larger than the blocks delimited over the remainder of the study area. When the data are examined at the level of reserve blocks the estimate of reservation is increased such that almost 53 per cent of the recorded taxa occur in three or more reserve blocks (Table 6).

A small number of taxa were recorded only from forest blocks (but may occur on lands outside the CALM estate). Many of these were recorded from forest blocks such Yelverton, Chester, and Forest Grove. These blocks are at the edge of the Warren east of the Leeuwin-Naturaliste Ridge. They also include the forest blocks for which comprehensive checklists were available. Another group of forest blocks contain taxa not recorded elsewhere within the study area (London, Styx, Collis, Rate and Thames). These blocks are at the north-east edge of the Warren in the vicinity of Mount Frankland National Park.

The Warren represents the distributional limit of many of the taxa recorded exclusively from forest blocks. Several taxa are widespread within the south-west and only occur within the Warren at its margin (e.g. *Leptospermum erubescens, Allocasuarina thuyoides*). Some have distributions ending in the west of the study area at the eastern edge of the Leeuwin-Naturaliste Ridge or Scott Plain (e.g. *Conospermum caeruleum* ssp. *spathulatum, Leucopogon cymbiformis*). Others have distributions centred to the east of the study area and reach their range limits at the eastern edge of the Warren (e.g. *Dryandra serra*, *Melaleuca violacea,* and *Drosera scorpioides)*. Many of the taxa for which the Warren represents the edge of their range are reserved elsewhere (e.g. *Brachysema melanopetalum* and *Dryandra serra*).

Some endemic taxa and species with distributions centred on the study area were recorded only from forest blocks (Table 7). These are generally taxa with small geographic ranges. Again, forest blocks on the eastern side of the Leeuwin-Naturaliste Ridge and the north-east edge of the study area contain many of these taxa.

Table 4. Taxa endemic to the Warren, the larger study area and those with distributions centred within the study area.

TAXON	HABITAT	DISTRIBUTION
ENDEMIC TO WARREN		
Acacia aff. pentadenia (Annels ARA 1158)	Karri forest	Walpole-Mt Frankland
Acacia scalpelliformis	Tall forest: karri, marri	Central Warren
Adenanthos detmoldii	Swamps / near coastal heath	Scott Plain
Agonis sp.Lake Jasper (B.Hammersley 567) PN	Swamps	Scott Plain-Denmark, W. Nannup
Alexgeorgea ganopoda	Swamps and fringing shrubland	Scott Plain, N. Walpole-Walpole
Andersonia geniculata MS	Swamps and fringing woodlands	Walpole-S. Lake Muir
Andersonia redolens MS	Jarrah/marri Woodland	N. Walpole
Anthocercis sylvicola	Karri forest	N. Walpole-Denmark
Anthotium sp.Peaceful Bay (J.R.Wheeler 3772 & S.J.Patrick) PN	Swamps, estuarine fringes	Peaceful-Bay-N. Walpole
Astartea sp.big bracteoles (A.R.Annels 995) PN	Valley floors, granites	N. Walpole-Walpole
Astartea sp.long stalks (D.Foreman 1490) PN	Coastal shrubland	Walpole
Banksia occidentalis ssp. formosa	Coastal heath basalt/granite	Black Point
Banksia seminuda ssp. remanens	Coastal granites	Walpole
Boronia exilis	Swamp heath	Scott Plain
Boronia virgata	Swamps and fringing shrubland	N. Walpole, Walpole-Denmark
Bossiaea disticha	Coastal heath and woodlands	Leeuwin-Naturaliste Ridge
Brachyscias verecundus MS	Granites	Shannon
Caladenia abbreviata MS	Coastal *Agonis flexuosa* woodlands	Augusta, Walpole
Caladenia applanata ssp. erubescens MS	Coastal woodlands and scrubs	Walpole-Denmark
Caladenia evanescens MS	Consolidated coastal dunes	Peaceful Bay
Caladenia excelsa MS	Jarrah/marri on sand	Leeuwin-Naturaliste
Caladenia gardneri MS	Coastal woodlands and scrubs	Yallingup-Walpole
Caladenia interjacens MS	Coastal woodlands and scrubs	Walpole
Caladenia nivalis MS	Coastal dunes and granites	Leeuwin-Naturaliste
Caladenia thinicola MS	Consolidated coastal dunes	South coast W of Warren river
Cyanicula gertrudiae MS	Consolidated coastal dunes	Yallingup-Albany
Chamaexeros longicaulis	Coastal	Walpole
Chamelaucium floriferum ssp. diffusum MS	Granite	Northcliffe-Denmark
Chamelaucium floriferum ssp. floriferum MS	Coastal granite	Walpole
Chordifex isomorphus	Ironstone heath	Scott Plain
Choretrum lateriflorum	Karri/jarrah forest	Widespread western Warren
Conospermum quadripetalum	Coastal scrubs/heath	Scott Plain, Albany
Darwinia ferricola MS	Swamp heath/ironstone	Scott Plain
Eriochilus scaber ssp. orbifolia MS	Coastal scrubs/woodlands	Walpole
Eryngium pinnatifidum var. coastal granite (G.J. Keighery 1885)	Coastal granites	Cape Leeuwin
Eucalyptus brevistylis	Tall forest	Walpole
Eucalyptus calcicola	Coastal sand/limestone	Leeuwin-Naturaliste
Eucalyptus guilfoylei	Tall forest	Walpole
Eucalyptus jacksonii	Tall forest	Walpole
Eucalyptus virginae MS	Jarrah/marri woodland on granites	Denmark
Genus sp.Nillup (R.D.Royce 98) PN	Swamps	Nillup-Scott Plain
Gonocarpus hexandrus ssp. hexandrus	Swamps	N Walpole
Grevillea brachystylis ssp. australis	Wet heaths	Scott Plain
Grevillea papillosa	Swamps and wet scrubs/woodlands	Scott Plain
Grevillea sp.Scott River (G.J.Keighery 4070) PN	Ironstone shrubland	Scott Plain
Hakea tuberculata	Ironstone shrubland	Scott Plain, Gingilup, Albany
Hibbertia sp.hairy sepals (J.R.Wheeler 2464) PN	Coastal woodlands, jarrah forest	Widespread
Hypolaena macrotepala MS	Creekline/valleys	Upper Shannon

Jansonia formosa	Swamps and woodlands in drainage lines	Margaret River-E. Scott plain, Walpole
Kennedia glabrata	Granites	Scattered South Coast
Kennedia macrophylla	Coastal granites	Cape Leeuwin
Lambertia rariflora ssp. lutea	Jarrah forest	N. Walpole
Leucopogon sp.Windy Harbour (A.Strid 21460) PN	Swamps, coastal wet heaths/scrubs	Scott Plain-Windy Harbour
Lomandra ordii	Forest, woodlands and swamps	Walpole
Lysinema ciliatum forma Denmark (D.H.Perry s.n.12/1961) PN	Swamps	Denmark
Meeboldina crassipes	Swamps	Lake Jasper-N. Walpole
Melaleuca basicephala	Swamps	Scott Plain-Walpole
Melaleuca incana ssp. Gingilup (N.Gibson & M.Lyons 593) PN	Swamps	Scott Plain
Melaleuca ringens	Coastal heath	Windy Harbour-E. Walpole
Meziella trifida	Swamps	Scott Plain, Walpole
Microtis familiaris	Swamps	Denmark
Pericalymma megaphyllum MS	Ironstone/swamps	Scott Plain
Philydrella pygmaea ssp. minima	Swamps	Scott Plain
Stylidium glaucum ssp. angustifolium	Swamps	Scott Plain-Albany
Stylidium laciniatum	Swamps	Widespread
Stylidium leeuwinense	Heath/swamps/coastal woodlands	N. Augusta, Scott Plain, Walpole.
Synaphea nexosa	Swamps	Scott Plain
Tetratheca filiformis	Swamps and wooded creeks	Widespread
Thelymitra jacksonii MS	Jarrah/marri forest	Walpole
Thomasia heterophylla MS	Karri forest, valleys/creeks	Widespread
Thomasia quercifolia	Coastal heath/woodland	Walpole-Albany
Utricularia paulineae	Swamps	Karridale
ENDEMIC TO STUDY AREA		
Acacia lateriticola glabrous variant PN (B.R.Maslin 6765)	Jarrah/marri forest	Cape Naturaliste, Scott Plain
Aotus carinata	Swamps/wet heath	Scott Plain
Caladenia applanata ssp. applanata MS	Coastal woodlands/scrubs	Leeuwin-Naturaliste and south coast
Caladenia caesarea ssp. maritima MS	Coastal granites	Meelup, Cape Naturaliste
Caladenia meridionalis MS	Coastal woodlands/scrubs	South Coast
Conostylis aculeata ssp. gracilis	Coastal woodlands/scrubs	Meelup, Cape Naturaliste
Dryandra sessilis var. cordata	Coastal limestone	Leeuwin-Naturaliste, Walpole
Eucalyptus phylacis	Coastal jarrah/marri	Laterite/granite
Hydrocotyle hamelinensis MS	Coastal granite	Leeuwin-Naturaliste
Johnsonia inconspicua	*Banksia/Agonis* woodlands	Yelverton
Stylidium lowrieanum	Coastal woodlands and karri forest	Leeuwin-Naturaliste
Tripterococcus brachylobus MS	Heath	Scott Plain, Yelverton
Wurmbea calcicola	Coastal	Cape Naturaliste
DISTRIBUTION CENTRED ON STUDY AREA		
Acacia pentadenia	Karri forest	Widespread
Acacia subracemosa	Karri, jarrah/marri forest	Karridale/Witchcliffe
Actinotus laxus MS	Swamps/wet heaths/sedgelands	Yelverton, Scott Plain-Walpole
Actinotus sp.Walpole (J.R.Wheeler 3786) PN	Karri forest	Witchcliffe, Pemberton, Walpole
Amperea protensa	Swamps/wet heaths/sedgelands	Widespread
Andersonia amabile MS	Swamps	Black Point, N. Walpole-Denmark
Aotus sp.Scott River (K.F.Kenneally 2371) PN	Swamps	Scott Plain-Walpole, Mt. Barker
Astartea sp.Mt Johnston (A.R.Annels 5645) PN	Granites	N. Walpole
Astartea sp.Scott Plain (D.Backshall 88233) PN	Swamps	Scott Plain-Lake Jasper, Windy Harbour

TAXON	HABITAT	DISTRIBUTION
Astartea sp.wing tips (M.E.Trudgen 12044) PN	Swamps	Yelverton, Walpole
Baeckea arbuscula	Wet heath	Scott Plain Lake Jasper, Mt. Frankland
Banksia verticillata	Coastal granite	Walpole, Torndirrup, Mt Manypeaks
Boronia anceps	Swamps, ironstone heath	Capel, Cape Naturaliste, Scott Plain
Boronia gracilipes	Karri, jarrah, marri forest	Widespread
Boronia juncea ssp. laniflora	Swamps	Walpole
Boronia juncea ssp. micrantha	Melalueca swamps and sedgelands	Scott Plain, Walpole-Albany
Boronia juncea ssp. minima	Swamps , wet heaths and sedgelands	Scott Plain-Walpole
Caladenia citrina MS	Jarrah/marri forest	Margaret River
Calothamnus sp.Scott Plain (R.D.Royce 84) PN	Swamps	Scott Plain, S. Busselton
Chordifex amblycoleus	Swamps/sedgelands	Scott Plain-W. Walpole
Chordifex jacksonii MS	Swamps/sedgelands	Black Pt, Windy Harbour, Walpole
Comesperma nudiusculum	Swamps	Widespread scattered
Conospermum capitatum ssp. capitatum	Jarrah forest, Heath	Scattered
Crowea angustifolia var. angustifolia	Karri and jarrah/marri forest	Walpole-Albany
Drosera enodes	Wet heath	Busselton, Scott Plain-Walpole
Drosera gigantea ssp. geniculata	Wet heath	Scott Plain
Drosera hamiltonii	Peaty swamps	Walpole-Albany
Eriochilus valens MS	Jarrah woodland	Walpole
Eucalyptus diversicolor	Karri forest	Widespread
Eucalyptus ficifolia	Coastal eucalypt woodlands	Walpole to Albany, Stirling Range outlier
Gonocarpus pusillus	Swamps and woodlands	Scattered Yelverton-Albany
Hibbertia sp.rigid bracts (J.R.Wheeler 3220) PN	Jarrah woodland-heaths and swamps	Widespread
Hypocalymma sp.Scott River (A.S.George 11773) PN	Swamps, fringing woodlands	Margaret River, Scott Plain-Walpole
Hypolaena viridis MS	Jarrah/marri woodland (lowlands)	Margaret River, Scott Plain, Walpole
Lepidosperma persecans	Riparian zones	Pemberton, Stirling Range
Lepyrodia porterae MS	Swamps, heath/shrublands	Scott Plain
Leucopogon gilbertii	Swamps	Scott Plain, Walpole, N. Walpole
Leucopogon tenuicaulis MS	Swamps	Scott Plain, Walpole
Microtis globula	Wet peaty heath	Walpole
Microtis pulchella	Swamps	Pemberton-E. Albany
Orthrosanthus polystachyus	Karri forest, coastal woodlands	Widespread
Platychorda applanata	Swamps	Scott Plain-Albany
Schoenus multiglumis	Swamps and woodlands/shrublands	Windy Harbour/Northcliffe-Albany
Sphaerolobium rostratum	Swamps	Walpole-Denmark
Stylidium pritzelianum	Forests and woodlands (karri/jarrah/marri)	Walpole-Albany
Synaphea intricata	Heath and jarrah/marri near swamps	N. Walpole
Tremulina cracens MS	Swamps	E. Scott Plain, Manjimup-Walpole
Trymalium venustum	Karri/jarrah forest	Shannon, Walpole-Albany
Tyrbastes glaucescens	Creeks/drainage lines/forest	W. Busselton, Scott Plain-Walpole
Verticordia fimbrilepis ssp. australis	Granite	North Walpole
Xanthosia eichleri	Jarrah/marri forest, shrubland	N. Walpole-Denmark
Xanthosia huegelii ssp. Southern (G.J.Keighery 2165) PN	Karri, jarrah forest	Widespread
Xyris roycei	Swamps	Margaret River, Scott Plain-Walpole

Table 5. Numbers of rare and priority taxa recorded from the study area. Figures in parentheses are hybrids (see Appendix 3).

DESCRIPTION	NUMBER OF TAXA
Declared rare flora	31 (1)
Priority 1	28 (1)
Priority 2	50
Priority 3	54
Priority 4	36 (1)
Total	199 (3)

DISCUSSION

The Flora

The Warren bioregion has a rich flora with 2282 (1853 native) taxa recorded. The family and generic composition are consistent with patterns demonstrated previously (Marchant 1973; Hopper *et al.* 1992). The data confirm the importance of the Warren as a centre for diversity of herbaceous perennial taxa and for the conservation of conservative high rainfall taxa.

Data available for the southern two thirds of the Swan Coastal Plain Bioregion (Beard 1980; Thackaway and Cresswell 1995) show a similar pattern of family composition with some exceptions ([1] Keighery B.J., personal communication). However, some differences are apparent, for example, the Haemodoraceae is more speciose on the Swan Coastal Plain compared with that of the Warren probably reflecting the former's affinities to the northern sandplains.

Endemism

The level of endemism within the flora reported here is a slight reduction from that found by Hopper *et al.* (1992). Based on native taxa alone, Hopper *et al.* (1992) found 5.1 per cent of the flora to be endemic, compared with 3.9 per cent in the current study. In part this is owing to increased survey effort, with many taxa previously regarded as endemic being recorded outside the Warren in suitable habitats. Data available for the southern two-thirds of the Swan Coastal Plain Bioregion show 2.3 per cent of the

[1] B.J. Keighery, Department of Environmental Protection, Western Australia.

Table 6. Taxa reservation status for the study area. Note categories are not unique.

RESERVATION CATEGORY	No. NATIVE TAXA	% NATIVE FLORA
Not recorded from conservation reserve block or forest block	211	11.4
Forest block only	106	5.7
1 or 2 conservation reserve blocks	559	30.2
Three or more conservation reserve blocks	979	52.8
1 or 2 conservation reserves	673	36.4
Three or more conservation reserves	865	46.7
Total native flora	1853	

Table 7. Taxa that are endemic or have distributions centred on the study area, recorded only from forest blocks.

TAXON/DISTRIBUTION	FOREST BLOCK
Endemic to Warren	
Andersonia redolens ms	Collis
Endemic to study area	
Adenanthos detmoldii	Chester
Darwinia ferricola	Chester
Johnsonia inconspiqua	Yelverton
Centred on study area	
Synaphea intricata	London, Romance, Thames, Styx
Calaldenia citrina	Bramely, Forest Grove
Verticordia fimbrilepis ssp. *australis*	Rate, Styx
Astartea sp. wing tips (M.E. Trudgen 12044) PN	Keystone, Yelverton

native flora to be endemic (Gibson *et al.* 1994; Keighery B.J., personal communication). The level of endemism within the High Rainfall Zone of Hopper (1979), essentially equivalent to Beard's Darling Botanical District (Beard 1980) is likely to be much higher. Estimates of up to 75 per cent have been made for the Western Australian flora as a whole (Hopper *et al.* 1996).

The habitat and geographic distribution of Warren endemic taxa is not uniform across the bioregion. Many of the listed endemic taxa occur in swampy habitats and other small scale mesic sites such as granite rocks and seepage areas (see also Hopper *et al.* 1992; Wardell-Johnson and Horwitz 1996). While fewer endemic taxa are recorded from the tall forests, these too have distributions related to local scale hydrological and edaphic factors (Wardell-Johnson and Coates 1996). Several geographic areas stand out as containing high numbers of endemic taxa. These include the Scott Plain, the area in the vicinity of Walpole, and the Leeuwin-Naturaliste Ridge.

Reservation Status

In terms of plant assemblages, the Warren is very well reserved compared with other bioregions in WA. In an assessment of natural regions nationwide Thackaway and Cresswell (1995) found the reserve system of the Warren scored favourably in terms of reserved area and level of representativeness. The proportion of reserved lands (conservation reserves and State forest) within the Warren is much higher than that of the Darling Botanical District as a whole (approximately 60 per cent versus 34 per cent of the land area) (Wardell-Johnson *et al.* 1995).

The flora of the Warren is well reserved with 83 per cent of the taxa known from secure conservation reserves and a further 6 per cent from CALM managed forest blocks. Some reservation status data are available for the flora of other regions within Australia. In Tasmania approximately 84 per cent of the flora was recorded from secure (conservation) reserves in a review by Kirkpatrick *et al.* (1991). In the southern Carnarvon-northern Geraldton Sandplains Bioregions (Beard 1980; Thackaway and Cresswell 1995) an area at the arid fringe of the south-west, Keighery *et al.* (in press) found 73 per cent of the total flora recorded from reserves. The Swan Coastal Plain Bioregion (see Fig. 1) occurs within the High Rainfall Zone proposed by Hopper (1979). It is the most climatically similar area to the Warren for which reservation data are available. Despite the highly developed nature of the plain (it includes the Perth metropolitan area), Keighery (unpublished) found 87 per cent of the native flora occurred in conservation reserves in the southern two thirds of the bioregion. Twelve per cent of the flora was recorded only from a single reserve. Thackaway and Cresswell (1995) list the Swan Coastal Plain as having 1–5 per cent of the area in reserves with a high level of bias, yet the flora reservation is quite high. This is consistent with patterns found in southern Africa (Rebelo 1994). In modelling optimal reserve placement to include the flora of the region, species were accumulated very rapidly such that in an optimal configuration 10 per cent of southern Africa was required to capture 93 per cent of the taxa. An additional 13 per cent of the land area was required to include the remaining 7 per cent of the flora. While small total areas can be successful in achieving species reservation, it is unlikely that small reserves will be sustainable in terms of evolutionary processes in the longer term.

The current study and assessment of the Warren reserve system by Thackaway and Cresswell (1995) places the Warren among the best reserved bioregions in WA. Many areas still lack detailed botanical exploration and as such the known flora list is likely to increase.

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APPENDIX 1

Flora list for the study area.

Explanation of column headings and codes

Family/Taxon
Families are listed alphabetically including ferns, fern allies, monocots and dicots. Introduced taxa are denoted by an asterisk.

Block codes
See Appendix 2 for an index to the codes. Codes separated by a slash represent records for which the location occurs on the boundary of several blocks. Bold codes are blocks which are national parks, nature reserves or conservation parks.

Conservation code
As defined by the Western Australian Department of Conservation and Land Management (1998).

R: Declared Rare Flora – Extant taxa (= Threatened Flora = Endangered + Vulnerable)
Taxa which have been adequately searched for, and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection, and have been gazetted as such, following approval by the Minister for the Environment, after recommendation by the State's Endangered Flora Consultative Committee.

1: Priority 1 – Poorly Known Taxa
Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, eg. road verges, urban areas, farmland, active mineral leases, etc., or the plants are under threat from disease, grazing by feral animals etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need for further survey.

2: Priority Two – Poorly Known Taxa
Taxa which are currently known from one or a few (generally <5) populations, at least some of which are believed to be under immediate threat (ie. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.

3: Priority Three – Poorly Known Taxa
Taxa which are known from several populations, at least some of which are not believed to be under immediate threat (ie. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but are in need of further survey.

4: Priority Four – Poorly Known Taxa
Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by identifiable factors. These taxa require monitoring every 5–10 years.

Endemic taxa
E Endemic to the Warren Bioregion
ES Endemic to the study area.
C Taxa with distributions centred on the study area.

Number of reserves
Number of national parks, nature reserves or conservation parks for which each taxon is recorded.

Number of reserve blocks
Number of reserve blocks for which each taxon is recorded. (Larger reserves are subdivided into several blocks.)

Number of forest blocks
Number of forest blocks for which each taxon is recorded.

No Warren voucher
Taxa for which no collection within the study area exists at the WA Herbarium.

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Adiantaceae							
Adiantum aethiopicum	**benp**,ca,**dech**,di2,fg,**lnb**,**lne**,**mtfcr**,**tonp**,**wch**,**wnlf**			7	8	3	
Anogramma leptophylla	**lne**,**wch**,**wnp**			3	3		
Cheilanthes austrotenuifolia	br,bu,**dech**,**lne**,**lni**,**lnl**,**lnn**,**lnq**,lon,me,**mtfcr**,**mtfs**,**tonp**, **wch**,**wng**,**wnt**,wy			6	12	4	
Cheilanthes sieberi ssp. sieberi	**lnb**,**us/sjm**			3	3		
Agavaceae							
* Agave americana							1
Aizoaceae							
* Aptenia cordifolia	**lny**			1	1		
* Carpobrotus aequilaterus	**wch**			1	1		
* Carpobrotus edulis	**dep**, **lnl**,**lnn**,**tonp**,**wch**			4	5		
Carpobrotus modestus	**dep**,**lnl**,**tonp**,**wnf**,**wnnu**			4	5		
Carpobrotus virescens	**dec**,**lne**,**lnh**,**lni**,**lnl**,**lnn**,**lnq**,**lnr**,**lny**,me,**wch**,**wnnu**			4	11		
Disphyma crassifolium ssp. clavellatum	**lnq**,**tonp**,**wch**,wy			3	3		1
* Drosanthemum candens	**lnf**,**lnh**			1	2		
* Galenia pubescens	**wch**			1	1		
* Lampranthus glaucus	**tonp**			1	1		
* Lampranthus multiradiatus	**tonp**			1	1		
* Mesembryanthemum crystallinum	**lnf**,**lnl**			1	2		1
* Ruschia tumidula	**tonp**			1	1		1
* Tetragonia decumbens	**lnf**,**lni**,**lnn**,**lnq**,**lny**,me,**tonp**,**wnf**,			3	7		
Tetragonia implexicoma	**lnf**,**lni**,**lnl**,**lnn**,**lny**,me,**tonp**,**wch**,**wnf/wnn**			4	9		
Tetragonia tetragonoides	**lnl**,**lnn**,**tonp**,**wch**			3	4		
Alliaceae							
* Allium ampeloprasum							1
* Allium triquetrum	**tonp**			1	1		
* Nothoscordum gracile							1
Amaranthaceae							
Alternanthera nodiflora	**lnb**,**scnp**,ye			2	2	1	
* Amaranthus albus							
* Amaranthus caudatus							
* Amaranthus hybridus							
* Amaranthus powellii							
Hemichroa diandra	**tonp**,**wch**			2	2		1
Ptilotus drummondii	**dep**,**lnf**,**lnh**,**lnn**,**lnq**,**lny**,me,**wch**			3	7		
Ptilotus drummondii var. drummondii	**lnf**,**lnh**			1	2		
Ptilotus manglesii	**lne**,**lnn**,**lnq**,**lnr**			1	4		
Ptilotus sericostachyus	ca,**dem**,**dep**,**lnh**			2	3	1	
Ptilotus sericostachyus ssp. roseus	**lnn**,me			1	1		
Ptilotus sericostachyus ssp. sericostachyus	**dem**,**dep**,**lnh**,**lnl**,**lnn**,**lny**,**wn**,**wnn**			3	8		
Ptilotus stirlingii	**dej**,**lnb**,**lnf**,**lnh**,**lni**,**lnl**,**lnq**			2	7		
Ptilotus stirlingii var. laxus	**dep**			1	1		1
Amaryllidaceae							
* Agapanthus praecox ssp. orientalis	**wnt**			1	1		
* Amaryllis belladonna	**lnb**,**lne**,**lni**,**wch**			2	4		
* Narcissus pseudonarcissus							
* Narcissus tazetta	**lnb**,**lne**			1	2		1
Anthericaceae							
Agrostocrinum scabrum	23579,br,bu,chs,col,**deb**,**dej**,**dep**,di1,fg,**lnb**,**lnf**,**lni**, **lnl**,**lnn**,lon,me,**mtfcr**,**mtfs**,**qunr**,ro,**rrnr**, **scnp**,st,th,**tonp**,**wch**,**wnf**,**wng**,**wnlf**,**wnt**,wy			9	19	11	
Agrostocrinum sp. Coastal (G.J. Keighery 8846)	**lnl**			1	1		
Caesia micrantha	12951,23579,chs,**lne**,**lnh**,**lnl**,**lnn**,**lny**,me,**sbnr**,**scnp**, st,wi,**wnf**,**wnlf**			4	9	3	
Caesia occidentalis	chs,fg,**lnb**,**lnf**,**lnl**,**qunr**,**scnp**,**tonp**,**wch**,**wnf**			6	8	2	
Chamaescilla corymbosa	br,chs,**deb**,**dej**,**dep**,di1,din,fg,**lne**,**lnh**,**lni**,**lnq**,**lnr**,lon,me,**qunr**, **rrnr**,**scnp**,st,sto,**tonp**,**wch**, **wnf**,**wng**,**wnlf**,**wnn**,**wnnu**,**wnt**			8	19	8	
Chamaescilla corymbosa var. corymbosa	bur,co,**dech**,mos/**sjm**,**mtfo**,**scnp**,**wnf**,**wnnu**,wy			5	6	4	
Chamaescilla corymbosa var. latifolia	wy					1	1
Chamaescilla corymbosa var. paradoxa							
Chamaescilla spiralis							

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Corynotheca micrantha	**deb,dec,dej,lnb,lnhv,lnl,lnn,qunr,wbnp,wnn**			5	10		
Corynotheca micrantha var. panda	**dep,wbnp,wn,wnf**			3	4		
Dichopogon capillipes	**lny**,me			1	1		1
Hodgsoniola junciformis	12951,chs,**dej,ginr,lny,scnp**			4	4	1	
Johnsonia acaulis	**lne,lni,lnn,lnq,scnp**			2	5		
Johnsonia inconspicua	ye	1	ES			1	
Johnsonia lupulina	23579,br,**brnp**,bu,chs,col,**dec,dech,dej,dep**,din,fb, fg,**glnr**,ke,**lnb,lne,lnf,lni,lnl,lnq**,lon,**ls**,me,mos**sjm, mtfcr,mtff,mtfm,mtfo,mtfs,qunr**,ro,**rrnr,scnp**,sto,th, **us,wbnp,wch,wnf,wng,wnlf,wnnu**,wy			13	29	14	
Johnsonia teretifolia							
Laxmannia jamesii	23579,**glnr,tonp**,ye	R		2	2	1	
Laxmannia minor	cu,lon,**us/sjm,wbnp**			3	3	2	
Laxmannia ramosa ssp. ramosa	chs					1	1
Laxmannia sessiliflora ssp. australis	chs,**dech,lnq**,me,**mtfw,scnp**			4	4	1	
Laxmannia squarrosa	th/ra			2			
Sowerbaea laxiflora	12951,23579,chs,**deb,dec,dech,dej,dem,dep,dey,lnb, lnh,lni,lnl,lnn,lny**,me,**qunr,scnp,wch,wn,wnf,wnn,wnnu**			6	20	1	
Thysanotus arbuscula	**lnn**			1	1		
Thysanotus arenarius	**deb,dem,dep,lnf,lnh,lnn,lnq,lnr,lny**,lon,me,**scnp,wnt**			4	11	1	
Thysanotus dichotomus	chs,**cs/ls,dec,dej,lnhv,lnl,lny**,or,**scnp,tonp,wch,wn**			7	11	2	
Thysanotus formosus	chs,**scnp**	1		1	1	1	1
Thysanotus glaucifolius							
Thysanotus glaucus	12951,ye	4				1	
Thysanotus gracilis	chs,**deb,dem,dep,ginr,glnr,mtfcr,qunr,scnp**,st,**tonp,wch,wnf**			9	11	2	
Thysanotus manglesianus	br,**dec,dep,dey**,fb,**lnn**,me,**scnp,wn,wnf,wnnu**,ye			4	8	3	
Thysanotus multiflorus	12951,23579,br,bu,cacl,chs,col,**deb,dej,dep**,di1,fg,**ginr, glnr,lnb**,lon,me,**menr,mtfcr,mtfm,mtfs,qunr**,ro,**rrnr,scnp**,st, th,**tonp,wbnp,wch,wn,wnf,wng,wnlf,wnt**,wy			13	21	13	
Thysanotus patersonii	chs,col,fg,**lnb,lnhv,lnl,lny**,me,**scnp,tonp,wch,wnf,wnnu**			5	9	3	
Thysanotus pauciflorus	lon,**mtfcr,tonp**			2	2	1	
Thysanotus pseudojunceus	bu,**dep,mtfs,wch,wnlf**			4	4	1	
Thysanotus sparteus	chs,**dec,dep**,fg,**glnr,lnb,mtfcr,mtfs,tonp,wch,wng, wnlf**,wy/**dep**			7	10	3	
Thysanotus tenellus	12951,chs,**lnh**,lon,**menr,scnp**,th,**tonp,us/sjm**			6	6	3	
Thysanotus thyrsoideus	**dej,dey**,lon,mos/**sjm,mtfcr,mtfm,mtfs,qunr**,ro,**rrnr**,th, **wch,wnt**,ye			7	10	5	
Thysanotus triandrus	ca/cl,fg,**lni,mtfo,scnp**,sh,**wch**			4	4	4	
Tricoryne elatior	chs,**dej**,do,fg,**lnf,lnh,lnl,lnn,lnr,lpnr**,me,**mtfs,qunr,scnp**,th, **tonp,wbnp,wch,wnf,wnn**,w			10	16	4	
Tricoryne humilis	23579,chs,**dej,dep**,fg,**ginr,lny,mtfcr,mtfo,scnp**,sh,st,**tonp, us/sjm,wnf**			9	11	4	
Tricoryne tenella							1
Apiaceae							
Actinotus glomeratus	bu,**dec,dech,dej,dem,dep,glnr,lnl**,lon,me,**mtfcr,mtfm, qunr**,ro,**scnp**,sto,th,th/ra,**tonp**,tr,**us,wch,wnf,wnlf,wnn**,ye			10	17	8	
Actinotus laxus MS	12951,**dec,dech,dep**,ke/**wnt,scnp**,we,**wnlf**,ye		C	3	6	3	
Actinotus omnifertilis	bu,ca,chs,**cs,dech,dep,glnr**,ke,**lnb,lnl,mtfcr,mtfm,qunr**, ra/st,**scnp**,th,**tonp,wbnp,wch,wn,wnf,wng,wnlf,wnt**,wy			11	18	8	
Actinotus sp.Walpole (J.R.Wheeler 3786) PN	fg,ke,**lnb**,po/ja,**wnt**	3	E	2	2	4	
* Ammi majus	**lny**			1	1		
Apium annuum	**lne,lnh,lnl,lnq,lnr,scnp,wch**			3	7		
Apium prostratum	**dech,dej,lne,lni,lnl,lnq**,me,**tonp,wbnp**			4	8		
Apium prostratum var. filiforme	**qunr,tonp,wbnp,wch,wnf,wnnu**			5	6		
Apium prostratum var. prostratum	**dec,lnl,lnn,lnq,scnp,tonp,wbnp,wch,wn,wnf**			7	10		
* Berula erecta	**ln,lne,lnhv,lnl**			1	4		
Brachyscias verecundus MS	**us/sjm**	1	E	2	2		
Centella asiatica	**dech,dej**,dor,**lne,lnhv,lnl,lnn,lnq,lnr,scnp,tonp,wch**			5	11	1	
* Conium maculatum							1
* Daucus carota	**wch**			1	1		

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Daucus glochidiatus	br,**deb**,**dec**,**dech**,**dej**,**dem**,**dey**,din,fg,**lnb**,**lnf**,**lnh**,**lni**,**lnl**,**lnn**,**lnq**,**lnr**,**lny**,me,**mtfcr**,**mtfs**,**qunr**,**scnp**,st,**us/sjm**,**wbnp**,**wch**,wi,**wn**,**wng**,**wnnu**,**wnt**			10	27	5	
Eryngium pinnatifidum	12951,**dej**,**dem**,**lnf**,**lnh**,**lni**,**lnl**,**lnn**,**lnq**,**lnr**,**lny**,**scnp**,**wnf**			4	12		
Eryngium pinnatifidum var.coastal granite (G.J. Keighery 1885)	**lnl**		E	1	1		
* Foeniculum vulgare	**lnh**,**lnl**,**lny**			1	3		
Homalosciadium homalocarpum	12951,chs,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,**lnf**,**lnh**,**lnl**,**mtfm**,**qunr**,**scnp**,**sjm**,**tonp**,**us**,**us/sjm**,**wbnp**,**wch**,**wnn**,**wnnu**			11	20	1	
Hydrocotyle alata	12951,chs,**ginr**,**lnl**,**lnn**,lon,me,**scnp**,**sjm**,th,**tonp**,**us**,**us/sjm**,**wch**,**wnf**			8	9	3	
Hydrocotyle blepharocarpa	**dey**,**lnh**,**lni**,**lnl**,**lnn**,**lny**,**scnp**,**sjm**,**wnnu**			5	9		
Hydrocotyle callicarpa	**brnp**,**dej**,**lnb**,**lnh**,**lnn**,**lny**,**qunr**,**scnp**,**sjm**,**tonp**,**wch**,**wnf**,**wnt**			9	13		
Hydrocotyle diantha	**deb**,**dec**,**dech**,**dem**,**lnh**,**lnl**,**lnn**,**lnq**,lon,**scnp**,**sjm**,**tonp**,**wnt**			6	12	1	
Hydrocotyle hamelinensis MS	**lnn**,**lny**	2	ES	1	2		
Hydrocotyle hirta	bb,ca,**dech**,ke,**lnb**,**wch**,**wnp**,**wnt**			4	5	3	
Hydrocotyle hispidula	**lnh**,**lnl**,**lnn**,**lny**			1	4		
Hydrocotyle pilifera	**lnh**,**scnp**,**tonp**,**wch**			4	4		
Hydrocotyle pilifera var. glabrata	**lnh**			1	1		
Hydrocotyle pilifera var. pilifera	**lnh**			1	1		
Hydrocotyle plebeya	**lnhv**,**lnl**,**lnr**,**scnp**,**wn**,**wnf**,**wnn**			3	7		
Hydrocotyle puberula MS	**dech**,**mtfcr**,**wch**,**wnn**			4	4		
Hydrocotyle scutellifera	bur,**dech**,**menr**,**wnf**			3	3	1	
Hydrocotyle tetragonocarpa	**dec**,**dep**,**lnf**,**lnh**,**lnl**,**lnr**,**wbnp**,**wnf**,**wnnu**			4	9		
Pentapeltis peltigera	br,chs,fg,**scnp**			1	1	3	
Pentapeltis silvatica	col,**dep**,**lnb**,lon,**mtfcr**,**mtff**,**mtfm**,**mtfs**,**qunr**,ro,**rrnr**,st,**wnlf**,wy			6	9	5	
Platysace compressa	23579,br,bu,chs,col,da,**dej**,**dem**,**dep**,fg,**glnr**,**lnh**,**mtfcr**,**mtff**,**mtfm**,**mtfs**,**qunr**,ro,**rrnr**,**scnp**,st,th,**tonp**,**wbnp**,**wch**,wi,**wnf**,**wng**,**wnlf**,**wnn**,**wnnu**,**wnt**			11	21	10	
Platysace filiformis	br,bu,col,**cs**,**dej**,**dep**,gi,**lnb**,**ls**,mos/**sjm**,**mtfcr**,**mtff**,**mtfj/mtfw**,**mtfm**,**mtfo**,**mtfs**,ro,**scnp**,sto,sw,**wch**,we,**wnlf**,**wnnu**,ye			9	18	10	
Platysace haplosciadia	**lnhv**,**lnq**,me,ye			1	2	1	
Platysace pendula	**deb**,**dech**,**dem**,**dep**,dor,**glnr**,ke,**lnf**,**mtfcr**,**mtfo**,**qunr**,ro,**scnp**,st,th,**wbnp**,**wch**,**wnf**,**wng**,**wnlf**,**wnt**,wy			9	16	6	
Platysace tenuissima	ba,br,chs,col,di1,din,dor,fg,**lnb**,**lnf**,**lnhv**,**lnl**,**lnq**,**lny**,na,**scnp**,th,wi			2	7	11	
Schoenolaena juncea	23579,**dep**,**ginr**,**scnp**,th,**us**,**wnf**			5	5	1	
Trachymene coerulea var. coerulea	**lnf**,**lnh**			1	2		
Trachymene cyanopetala	**dej**			1	1		
Trachymene pilosa	chs,co,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,**lnb**,**lne**,**lnf**,**lnh**,**lnhv**,**lni**,**lnl**,**lnn**,**lnq**,**lnr**,**lny**,lon,me,**qunr**,**scnp**,**tonp**,**wbnp**,**wch**,**wnf**,**wnn**,**wnnu**			8	26	3	
Trachymene sp.Walpole (A.S.George 15063) PN	bu,crw,**dech**,ga,lon,**wbnp**,**wn**,**wnlf**,**wnt**			3	5	4	
Xanthosia atkinsoniana	**dech**,**lnf**,**lnhv**			2	3		
Xanthosia candida	ba,br,bu,ca,chs,co,col,**dec**,**dech**,**dej**,di1,din,fg,**lnb**,**lnf**,**lni**,**lnl**,**lnn**,**lnq**,**lnr**,**lny**,**ls**,me,**mtfcr**,**mtfm**,na,qun6,**qunr**,**scnp**,st,**tonp**,**wbnp**,**wch**,**wnf**,**wnlf**,**wnnu**,**wnt**,ye			10	23	14	
Xanthosia ciliata	ye					1	
Xanthosia eichleri	bu,bu/or,**menr**,**qunr**,ra/th/st,**scnp**,st		C	3	3	5	
Xanthosia huegelii	br,bu,chs,col,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,din,fg,**glnr**,**lnf**,**lnn**,**lnq**,**lnr**,**lny**,lon,mos/**sjm**,**mtfcr**,**mtff**,**mtfm**,**mtfs**,na,**qunr**,**rrnr**,**scnp**,sh,st,sto,th,**tonp**,**wbnp**,**wch**,**wnf**,**wnn**,**wnnu**,wy			12	26	14	
Xanthosia huegelii ssp. southern (G.J.Keighery 2165) PN	col,qun6,**scnp**,**wn**		C	2	2	2	
Xanthosia pusilla	ba,**brnp**,chs,co,**dep**,di1,gry,ke,**mtfcr**,**mtfo**,**scnp**,**tonp**,**wbnp**,**wch**,**wnf**,**wnnu**,wy			8	10	7	
Xanthosia rotundifolia var. rotundifolia	23579,bu,col,**dep**,ke,mos/**sjm**,**mtfcr**,**mtff**,**mtfm**,**mtfo**,**mtfs**,ro,**rrnr**,sh,st,th,**tonp**,tr,**wch**,we/mo,**wnf**,**wng**,**wnlf**,**wnt**			7	14	11	
Xanthosia singuliflora	ra/st					2	

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Apocynaceae							
Alyxia buxifolia	**lni,lnn,lny**,me			1	3		1
* Vinca major							
Araceae							
* Zantedeschia aethiopica	**lnb,lne,lnh,lnhv,lni,lnl,lnq,lny**,me,**wch**			2	9		
Araliaceae							
* Hedera helix	**wnt**			1	1		
Asclepiadaceae							
* Gomphocarpus fruticosus							1
Asparagaceae							
* Asparagus asparagoides	**lnb,lne,lni,lnl,lnn**,me			1	5		
Asphodelaceae							
* Asphodelus fistulosus							
Bulbine semibarbata	**lnf,lnh,lnl,lnn,lnq,lny**,me,**scnp,tonp,wch,wnf**			5	10		
* Trachyandra divaricata	**lne,lnh,lnhv,lni,lnl,lnn,lny**,me,**wnf**			2	8		
Aspleniaceae							
Asplenium aethiopicum	**benp,dec,dech,dep,lnb,lne,lnl**,lon,**mtfcr,mtfs**,pow,sh, **tonp,wnlf,wnp**	4		6	12	3	
Asplenium flabellifolium	**benp,dech,ginr,mtfcr,mtfs,tonp,wch**,we,**wnt**			7	8	1	
Asplenium obtusatum	**deb**	R		1	1		
Asplenium trichomanes	**lnb,lnf,lnhv**			1	3		
Asteraceae							
* Achillea millefolium							
Actites megalocarpa	**lne,lnf,lnh,lnhv,lni,lnl,lnn,lnq**,me,**tonp,wch,wnf,wnnu**			4	12		
Angianthus drummondii							
Angianthus preissianus	fg,**lnb,lni,lnl,scnp,wbnp,wch**			4	6	1	
* Arctotheca calendula	**lnb,lnf,lnh,lni,lnl,lnn,lny**,me,**scnp,tonp,wch,wnnu**,ye			5	11	1	
* Arctotheca populifolia	**dech,dep,dey,lne,lnf,lnh,lnl,lnn,lny**,me,**tonp,wbnp,wch**,wn			6	13		
* Aster subulatus	**lnl,lnq,lnr,scnp,wbnp**			3	5		
Asteridea asteroides	**wch**			1	1		1
Asteridea chaetopoda	**tonp**			1	1		
Asteridea nivea	**tonp,wbnp,wch**			3	3		
Asteridea pulverulenta	**deb,dem,dep,lnf,lnhv,lnl,lnn,qunr,scnp,tonp,wbnp,wch,** **wn,wnf,wnn,wnnu**,ye			8	16	1	
* Berkheya rigida	**lnh,lnl,lnr**			1	3		
Blennospora sp.Ruabon (B.J.Keighery & N.Gibson 20) PN	12951,**scnp**	3			1	1	
Brachyscome bellidioides	**tonp**			1	1		
Brachyscome billardierei	**tonp**	1			1	1	
Brachyscome ciliaris	**wch,wn,wnf,wng**			2	4		
Brachyscome exilis	**tonp,wch**			2	2		
Brachyscome iberidifolia	**dec,dech,dej,dep,dey,lnf,lnh,lnl,lnn,lnr,lny**,me,**wbnp,** **wnf,wng**,ye			4	14	1	
Bracteantha bracteata							
* Carduus pycnocephalus	**lni,lnl,lnn,lny**,me,**scnp,tonp**			3	6		
* Carduus tenuiflorus	**wnnu**			1	1		
* Centaurea melitensis	**lnf,lnh,lnn,lny**			1	4		
Centipeda cunninghamii	dor,**scnp**			1	1	1	
* Chrysanthemum segetum	fg					1	
* Cirsium arvense							
* Cirsium vulgare	dor,**lnb,lnl,lnn,mtfcr,mtff,scnp**,sw,**wch,wng**			5	8	2	
* Conyza albida	**dec,dech**,gry,**lne,lnl,scnp,tonp,wbnp,wch,wnf,wnt**			7	10	1	
* Conyza bonariensis	do,**lnh,mtfs,scnp,tonp,wbnp,wch,wnlf**			7	7	1	
* Conyza canadensis	**tonp**			1	1		1
* Conyza parva	do,**lne,wch**			2	2	1	
* Coreopsis grandiflora							1
Cotula australis	**lnn,wch**			2	2		
* Cotula bipinnata	me						1
Cotula coronopifolia	**lne,lnl,scnp,tonp,wbnp,wch,wnf,wnn**			6	8		
Cotula cotuloides	**lnl,wch**			2	2		1
* Cotula turbinata	**lni,lny**			1	2		

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Craspedia variabilis	23579,**deb,dec,dech,dej,dem,dep,dey,ginr,lnf,lnh,lnq,** **lny,qunr,scnp,tonp,wbnp,wch,wnf,wnn,wnnu**			9	20		
* Crepis capillaris	**lnl**,mu,**sbnr**			2	2	1	
* Cynara cardunculus							1
* Delairea odorata							1
* Dittrichia graveolens	23579,**lni,lnn,tonp,wch**			3	4		
* Dittrichia viscosa	**tonp,wbnp**			2	2		
* Erigeron karvinskianus							
Euchiton gymnocephalus	bb,po/**sjm,us/sjm,wch,wn**	3		4	4	2	
Euchiton sphaericus	**deb,dec,dej,dey,lnb,lnl,scnp,wbnp,wch,wnf**			6	10		
Gamochaeta americana							
* Gamochaeta falcata	**wnlf**			1	1		
* Gazania linearis							
Gnaphalium indutum	**lnh,lnq,wbnp,wch**			3	4		
Gnephosis tenuissima							
* Hedypnois rhagadioloides	**lnl,lnn**			1	2		
Helichrysum macranthum	**dep,lni**			2	2		
Hyalosperma cotula	12951,chs,**dey,lnb,lnf,lnh,lnhv,lnl,lnn,lny**,me,**qunr,scnp,** **tonp,us/cs/sjm,wch,wnn**			9	15	1	
Hyalosperma pusillum	**dech,ginr**,lon,**scnp**			3	3	1	
Hyalosperma simplex ssp. graniticola	**sjm,sjm/us**			2	2		
Hyalosperma simplex ssp. simplex	**lnh,lnn,scnp**			2	3		
* Hypochaeris glabra	12951,23579,ba,br,bu,chs,col,**deb,dech,dej,dey**,di1,fg,** **lnb,lni,lnl,lnn,lny**,lon,me,**mtfcr,mtff,qunr,scnp**,sto,sw,**tonp,** **wbnp,wch,wn,wnf,wng,wnlf,wnn,wnnu,wnt**			9	23	10	
* Hypochaeris radicata	**lnl**			1	1		
Ixiolaena viscosa	chs,**deb,dech,dep**,ke,**lnhv,qunr,scnp,tonp,wbnp,wch,** **wn,wnn**			8	11	2	
Lagenophora huegelii	ba,bea,br,bu,**deb,dec,dech,dej,dem,dep,dey**,di1,din,fg,** **lnb,lne,lnf,lnl,lnr,lny**,lon,**mtff,mtfm,mtfs**,na,**qunr,scnp**,st,** **tonp,wbnp,wch,wnf,wnn,wnnu,wnt**			9	25	10	
* Leontodon saxatilis	chs,fg,**lnh,lnhv,lnl,scnp**			2	4	2	
Leptinella drummondii		2					
Leptorhynchos scaber	**dec,dep,lnf,lnh,qunr,scnp,tonp,wbnp,wch,wn,wnn,wnnu**			8	12		
* Leucanthemum maximum							
Leucophyta brownii	**dech,dej,dey,lnf,lnh,lni,lnl,lnq,lnr,lny**,me,**qunr,tonp,** **wbnp,wch,wnf,wnnu**			7	16		
Millotia myosotidifolia	**deb,dec,dej,dem,dep,dey,lnf,lnh,lnl,lnn**,lon,me,**wch,** **wnf,wnn,wnnu**			4	14	1	
Millotia tenuifolia	chs,co,**dej,dem,dep,dey**,me,**wnn**			2	5	2	
Millotia tenuifolia var. laevis		2					
Millotia tenuifolia var. tenuifolia							
Myriocephalus helichrysoides	**lnn**			1	1		
Myriocephalus pygmaeus							
Olearia axillaris	**deb,dec,dech,dej,dem,dep,dey,lne,lnf,lnh,lnhv,lni,lnl,lnn,** **lnq,lnr,lny,qunr,scnp,tonpwbnp,wch,wnf,wnn,wnnu**			8	25		
Olearia cassiniae	**dec,dej,dem,dep,dey,lnhv,tonp,wnf,wnnu,wnt**			4	10		
Olearia ciliata	**lnn,tonp,wch**,ye			3	3	1	
Olearia elaeophila	ki,**lnl,wnf**			2	2	1	
Olearia muricata	**wch**			1	1		
Olearia paucidentata	23579,bu,ca,cha,col,**cs,dec,dech,lnb,lnhv,lnl,lnn,ls**,ma,** **mtfcr,mtff,mtfm,mtfs**,qun6,ro,**scnp,wnf,wnlf,wnnu**			6	16	7	
Olearia ramosissima							
Olearia rudis	**lnb,lnhv,lni,lnl**			1	4		
* Osteospermum clandestinum							1
Ozothamnus cordatus	**deb,dec,dech,dej,dep,dey,lnf,lnl,lnn,lny**,me,**qunr,scnp,** **tonp,wbnp,wch,wnf,wnlf,wnn**			8	19		
Ozothamnus ramosus	bu,col,crw,**cs,dech**,lon,mo,mos/we,**mtfcr,mtff,mtfm**,qui,sw,** **wn,wnf,wng,wnlf,wnt**			4	10	9	
* Pentzia suffruticosa	**lnh**			1	1		
Picris angustifolia ssp. angustifolia	**dec,dej,dem,dep**,do,**lnh,lnhv,lnl,wnnu**			3	8	1	
Picris squarrosa	**dech,lnl**			2	2		1
Pithocarpa pulchella var. melanostigma MS	**scnp,wch**			2	2		

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Podolepis canescens	**lnb,lnhv**			1	2		1
Podolepis gracilis	12951,**deb,ginr,lnb,lnf,lnh,lnl,lnn,lnq,lny,qunr,scnp, tonp,wch,wnf**			8	14		
Podolepis lessonii	**lnf,lni**,me			1	2		
Podolepis nutans	**tonp**			1	1		
Podolepis rugata	**dep,tonp,wch,wnnu**			4	4		
Podotheca angustifolia	**dec,dech,dem,dep,dey,lnb,lnf,lnh,lni,lnl,lnn,lnq,lnr, lny,qunr,scnp,tonp,wch,wnf,wnnu**			7	20		
Podotheca chrysantha	**lnh**			1	1		1
Podotheca gnaphalioides							
* Pseudognaphalium luteoalbum	23579,gry,**lnl,lnn,lny**,me,**scnp,wbnp,wch**			4	6	1	
Pterochaeta paniculata	**lny,scnp**			2	2		1
Quinetia urvillei	chs,**dech,lnn,lny,scnp,sjm,tonp,wbnp,wch,wnnu**			8	9	1	
Rhodanthe citrina	23579,**deb,dec,dech,dej,dem,dep,dey**,gry,**lnb,lnf,lnh, lni,lnl,lnn,lnr,qunr,scnp,tonp,wbnp,wch,wnf,wnn,wnnu**			8	22	1	
Rhodanthe corymbosa	**lnn,lny**			1	2		
Rhodanthe pyrethrum	**wch**	3		1	1		
* Senecio diaschides	co,fg,**mtff**,wa			1	1	3	
* Senecio elegans	**dec,dech,dem,dep,dey,lnh,lnhv,lni,lnl,lnn,lny,mtfcr, scnp,tonp,wbnp,wch,wnf,wnn**			8	18		
Senecio glomeratus	**dej,mtfo,scnp,wch,wnf**			5	5		
Senecio hispidulus	br,**dep,lnb,lnl,scnp,snp**,st,**tonp,wch,wng**			7	8	2	
Senecio hispidulus var. hispidulus	bu,**dech,lnf,scnp,wch,wn**			5	5	1	
* Senecio jacobaea							
Senecio lautus	**deb,dec,dech,dej,dem,dep,dey,lnb,lne,lnf,lnh,lnhv,lni, lnl,lnn,lnr,lny,qunr,scnp,tonp,wbnp,wch,wnf,wnn**			8	24		
Senecio lautus ssp. dissectifolius	**tonp**			1	1		
Senecio lautus ssp. maritimus	**dep,lnh,lnl,wch,wnf,wnn,wnnu**			4	7		
Senecio minimus	dor,**tonp,wch**,ye			2	2	2	
Senecio quadridentatus	**lnb,tonp,wch**			3	3		1
Senecio ramosissimus	bu,**dec,dej**,go,**lnb,lnhv,lni,lnl,mtfcr,mtff,tonp,wch, wn,wnf,wnlf,wnn**			6	14	2	
* Senecio vulgaris							1
* Sigesbeckia orientalis	**dech,lnb,lnl**			2	3		
Siloxerus filifolius	**dech,dep,lnb,tonp,us/sjm,wnf,wnnu**			6	8		
Siloxerus humifusus	12951,23579,chs,**deb,dec,dej,dem,dep,lnb,lnhv,lnl, lnn,lny**,lon,mo,**qunr,scnp,tonp,wbnp,wch,wn,wnf,wnn,wnnu**			8	19	3	
Siloxerus multiflorus	**lnn,lny**			1	2		1
* Silybum marianum							1
* Soliva pterosperma	**wch**			1	1		1
* Sonchus asper	**lne,lnf,lni,lnl,lnq,scnp,wch,wnt**			4	8		
* Sonchus asper ssp. glaucescens	**mtf,wch**			2	2		
Sonchus hydrophilus	**lnl,scnp,wch**			3	3		
* Sonchus oleraceus	bu,**dej,lnb,lnh,lnhv,lnl,lnn,lny**,me,**qunr,scnp**,sw, **tonp,wch,wnlf,wnnu**			7	13	2	
* Taraxacum officinale							
* Tolpis barbata							
Trichocline sp.Treeton (B.J.Keighery & N.Gibson 564) PN	**lni**	2		1	1		
Trichocline spathulata	ba,br,col,fg,**lnb,lnl**,sto,**wnlf**			2	3	5	
* Urospermum picroides	**lnn**			1	1		1
* Ursinia anthemoides	chs,**lnn,lny,tonp,wch**,ye			3	4	2	
* Ursinia speciosa	**lnh**			1	1		
* Vellereophyton dealbatum	12951,23579,chs,**dec,dech,dej**,din,**lnl,lnn**,lon, **mtfs,scnp,tonp,wch,wn,wnf,wnt**			7	12	3	
Waitzia nitida	**lnn,tonp**			2	2		1
Waitzia suaveolens var. suaveolens	**dep,lnl,lny,qunr,tonp,wbnp,wch,wn,wnnu**			7	9		
* Xanthium occidentale							
* Xanthium spinosum							1
Boraginaceae							
* Borago officinalis							1
* Echium plantagineum	**dej,dep**/bu,**lni**			2	3	1	

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Myosotis australis	**dec,dey,ln**			2	3		
Boryaceae							
Borya constricta	br,**lne,lnq,tonp,us/sjm**			4	5	1	
Borya nitida	**tonp**			1	1		
Borya scirpoidea	chs				1		1
Borya sphaerocephala	**dech,dep,menr,mtfw,mucp,qunr,sjm,us,wbnp,wch,wng**			10	11		
Brassicaceae							
* Brassica napus	**lnn**			1	1		
* Brassica rapa							1
* Brassica tournefortii	**lni,lny,tonp,wch**			3	4		1
* Cakile maritima	**dech,dep,dey,lne,lnh,lni,lnl,lnr,lny**,me,**tonp,wbnp,wch,wnnu**			6	13		
* Capsella bursa-pastoris							1
* Cardamine hirsuta	**dech,lnb**			2	2		
Cardamine paucijuga	**lnl**			1	1		1
* Coronopus didymus	**lnl**			1	1		
* Diplotaxis muralis	**lnb,lnhv,lnl**			1	3		
* Heliophila pusilla	**deb,lnb,lne,lnf,lnh,lnhv,lni,lnl,lnn,lnr,lny,scnp,tonp,wch,wnf**			6	15		
* Hirschfeldia incana							
* Hornungia procumbens	**lnh,tonp**			2	2		
* Lepidium africanum	**lnh,tonp**			2	2		
* Lepidium bonariense							
Lepidium foliosum	**lnl**			1	1		
Lepidium pseudotasmanicum		4					
Lepidium rotundum	**lnf,lnh,lnn,qunr,tonp,wch,wn**			5	7		
* Lobularia maritima							
* Matthiola incana	**lny**			1	1		1
* Raphanus raphanistrum	fg,**lne**			1	1	1	
Rorippa dictyosperma	**mtff,mtfs,wnlf**	2		2	3		
* Rorippa nasturtium-aquaticum	**dec,dep,lne,lnhv,lnl,wnnu**			3	6		
* Sisymbrium irio	**lnl**			1	1		1
Stenopetalum robustum	**deb,dem,dep,lnb,lne,lnf,lnh,lnhv,lni,lnn,lny,scnp,tonp, wch,wnf,wng,wnn,wnnu**			6	18		
Caesalpiniaceae							
Labichea punctata	br,me,**wnnu**			1	1	1	
Callitrichaceae							
* Callitriche stagnalis	do,**qunr,wbnp,wnf,wnlf**			3	4	1	
Campanulaceae							
* Wahlenbergia capensis	**lnn,scnp,wnf**			3	3		
Wahlenbergia communis							
Wahlenbergia gracilenta	**dech,dep,lnb,lnhv,lnl,lnn,lny**,lon,**mtfs,scnp,tonp,wch,wnf**			7	12	1	
Wahlenbergia littoricola	bb,ca,car/ya,qun6,**wch**			1	1	5	
Wahlenbergia multicaulis	**dep,lne,scnp,wch**			4	4		
Wahlenbergia preissii	chs,fg,lon					3	
Caryophyllaceae							
* Cerastium balearicum							
* Cerastium glomeratum	**dec,dej,dey,lnb,lnl,lnn,scnp**,st,sty,**tonp,wnt**			5	9	2	
Cerastium pumilum	**deb,dey,wch**			2	3		
* Corrigiola litoralis	**scnp,wch**			2	2		
* Moenchia erecta	**tonp**			1	1		1
* Petrorhagia velutina	fg,**lnl,lnn,lny**,me,**scnp,tonp,wch,wnf**			5	7	1	
* Polycarpon tetraphyllum	me,**wch**			1	1		
* Sagina apetala	**tonp**			1	1		
* Sagina maritima	**lnh,lni,lnl,lnq**,me,**wch**			2	5		
* Sagina procumbens							
* Silene gallica	fg,**lne,lnh,lnl,lnn,lny**,me,**scnp,wch,wnf,wnt**			4	9	1	
* Silene gallica var. gallica	**lny,wnf**			2	2		
* Silene gallica var. quinquevulnera	**wch,wnlf**			2	2		
* Silene nocturna	**lnh,lnn**,me			1	2		
* Silene vulgaris							
* Spergula arvensis	**lnn**			1	1		1
* Spergularia diandra	**lny**			1	1		
* Stellaria media	**dec,dem,lnn,lny,tonp,wch,wnf,wnn**			5	8		
* Vaccaria hispanica							

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Casuarinaceae							
Allocasuarina decussata	bb,bu,bur,col,crw,**cs**,da,**dec**,**dech**,dee,lon,**ls**,mos/**sjm**,**mtfcr**, **mtff**,**mtfj**,**mtfm**,**mtfo**,**mtfs**,**mtsnr**,na,po/**sjm**,ro,**rrnr**,st,su, su/**us**,sw,tr,**us/cs/sjm**,**wch**,**wnf**,**wng**,**wnlf**,**wnnu**,**wnp**,**wnt**			8	21	16	
Allocasuarina fraseriana	23579,chl,col,**deb**,**dej**,**dep**,**dey**,fg,**glnr**,if,ke,**lne**,**lnh**,**lni**,**lnl**, **lnn**,**lny**,lon,mos,**mtfcr**,**mtff**,**mtfs**,**qunr**,ro,**scnp**,st,th,**tonp**, **wch**,**wn**,**wnf**,**wng**,**wnlf**,**wnn**,**wnnu**,**wnt**,wy			9	25	11	
Allocasuarina huegeliana	**tonp**			1	1		
Allocasuarina humilis	br,**deb**,**dep**,**lne**,**lnl**,**lnn**,**lnq**,**lny**,me,**qunr**,to,**tonp**,**wbnp**, **wch**,**wn**,**wnf**,**wnn**,**wnnu**			7	15	1	
Allocasuarina lehmanniana ssp. lehmanniana	**tonp**			1	1		
Allocasuarina thuyoides	st					1	
Allocasuarina trichodon	**tonp**,**wnf**,			2	2		
Centrolepidaceae							
Aphelia brizula	23579						
Aphelia cyperoides	12951,chs,col,**dech**,fg,**ginr**,**lne**,**lnl**,**lnn**,**lnr**,**lny**,lon,me,**qunr**, **scnp**,st,**tonp**,**us/sjm**,**wch**,**wnf**,**wng**,**wnlf**			10	16	5	
Aphelia drummondii	chs,**scnp**			1	1	1	1
Centrolepis alepyroides							
Centrolepis aristata	12951,23579,br,chs,**deb**,**dec**,**dech**,**dej**,fg,**ginr**,**lne**,**lnf**, **lnh**,**lnn**,**lnr**,me,**scnp**,th,**tonp**,**us/sjm**,**wch**,**wnf**			9	16	4	
Centrolepis drummondiana	chs,**dej**,fg,**ginr**,**lne**,**lnq**,**lny**,**scnp**,**tonp**,**wch**			6	8	2	
Centrolepis fascicularis	br,**lnb**			1	1	1	
Centrolepis glabra	12951,**tonp**,**wch**			2	2		
Centrolepis humillima	**tonp**,**wch**			2	2		
Centrolepis mutica	12951,**dech**,**scnp**			2	2		
Centrolepis pilosa	**tonp**,**wch**			2	2		
Centrolepis polygyna	**dech**,**lne**,**lnh**,**lni**,**lnl**,**lnr**,**tonp**,**wbnp**,**wch**,**wnnu**			6	10		
Centrolepis strigosa	**wch**,**wnnu**			2	2		
Centrolepis strigosa subsp. strigosa	**wch**			1	1		
Cephalotaceae							
Cephalotus follicularis	ca,**dech**,**dej**,**dep**,**dey**,th/**mtfs**,**tonp**,**wch**			4	7	2	
Chenopodiaceae							
Atriplex cinerea	**lni**,**lnl**,**lnn**,me			1	3		1
* Atriplex hortensis							1
Atriplex hypoleuca	**tonp**,**wch**,**wnf**,**wnlf**			3	4		
Atriplex isatidea	**lnn**,**lny**,me,**tonp**,**wbnp**,**wnf**			4	5		
* Atriplex prostrata	23579						1
Atriplex pumilio							
* Chenopodium album	bb,**ln**,**lnl**			1	2	1	
* Chenopodium ambrosioides	**tonp**			1	1		
* Chenopodium glaucum	**lnl**,**wch**,**wnf**			3	3		
* Chenopodium murale	**lnf**,**lnh**,**lni**,**lnr**,**lny**,me,**scnp**,sol,**wch**			3	7	1	
Chenopodium pumilio	br,**lnn**			1	1	1	
Dysphania glomulifera ssp. glomulifera							
Enchylaena tomentosa	**lni**,**lnn**,**lny**,me			1	3		1
Halosarcia halocnemoides ssp. halocnemoides	**lnhv**			1	1		1
Halosarcia indica subsp. bidens	**scnp**			1	1		1
Halosarcia lepidosperma	23579						
Halosarcia pergranulata ssp. pergranulata	**lnhv**			1	1		1
Halosarcia pterygosperma ssp. pterygosperma							1
Halosarcia syncarpa							1
Maireana brevifolia	**lnl**,**lnn**			1	2		1
Maireana oppositifolia	**tonp**,**wch**			2	2		
Rhagodia baccata	**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,**lne**,**lnf**,**lnh**,**lni**,**lnl**,**lnn**,**lnq**, **lnr**,**lny**,**qunr**,**scnp**,**tonp**,**wbnp**,wch,**wnf**,**wnn**,**wnnu**			8	24		
Rhagodia baccata ssp. baccata	**dec**,**dech**,**dem**,**lnb**,**lne**,**lnhv**,**lni**,**lnl**,**lnn**,**lnq**,**lny**,me,**qunr**, **tonp**,**wbnp**,**wnnu**			6	15		
Rhagodia baccata ssp. dioica	**lnn**			1	1		1
Salsola kali							1

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Sarcocornia blackiana	**dep,lnh,lnq,wbnp,wnnu**			4	5		
Sarcocornia quinqueflora				4	9		
ssp. quinqueflora	23579,**lne,lni,lnl,lnn,lnq,lnr,scnp,tonp,wch**						
Suaeda australis	**scnp**			1	1		
Threlkeldia diffusa	**lne,lnf,lnh,lni,lnl,lnn,lnq,lnr**,me,**qunr,tonp,wbnp,wch,wnf**			6	13		
Clusiaceae							
Hypericum gramineum	**tonp**			1	1		1
Hypericum japonicum							
* Hypericum perforatum var. angustifolium	fg,**lnb,lnhv,lnl**			1	3	1	
Colchicaceae							
Burchardia monantha	col,lon,th					3	
Burchardia multiflora	12951,bu,chs,fg,**ginr,lnb,lnl,lnn**,lon,**qunr,scnp**,st,th,**wch, wnf,wng,wnlf,wnnu**			6	11	6	
Burchardia umbellata	chs,**dech**,fg,**glnr,lnb,lnf,lni,lnl,lnn,lnq,lny**,me,**mtfcr,mtff, mtfs**,na,no,**qunr,scnp**,st,th,**tonp,wch,wnf,wng,wnlf,wnt**			9	20	6	
Wurmbea calcicola	**lnn**	R	ES	1	1		
Wurmbea dioica ssp. alba	**dech,lne,lnhv,lni,tonp,wnf,wnnu**			4	7		
Wurmbea monantha	**dep**,gry,**lnhv,lni,wnf,wnnu**			3	5	1	
Wurmbea tenella							
Commelinaceae							
Cartonema philydroides	**dec,dej**			1	2		
Convolvulaceae							
Calystegia soldanella	**deb,lne**			2	2		
Dichondra repens	**dec,dech,dej,dep,dey,lnb,lnh,lnhv,lni,lnl,lnn,lny**,me, **qunr,wbnp,wch,wnf,wnt**			6	17		
* Ipomoea indica							
Wilsonia backhousei	**lnq,wch**			2	2		1
Wilsonia humilis	**lnq,tonp,wch**			3	3		
Crassulaceae							
* Aeonium haworthii	**tonp**			1	1		
* Cotyledon orbiculata	**tonp**			1	1		
Crassula closiana	**scnp,tonp,wch**			3	3		
Crassula colorata	**deb,dec,dej,dem,dep,dey,lnf,lnh,lni,lnn,lnq,lny**,me, **qunr,scnp,tonp,wbnp,wch**			7	17		
Crassula colorata var. acuminata	**dej,lnf,wbnp,wnn**			4	4		
Crassula colorata var. colorata	chs,**lnh,lny**			1	2	1	
Crassula decumbens var. decumbens	**wnlf**			1	1		
Crassula exserta	bur,**lnb**,me,**scnp,tonp,wch**			4	4	1	
* Crassula glomerata	**lne,lnh,lnhv,lni,lnl,lnn,lnq,lnr,lny**,me			1	9		
* Crassula natans	**lnb,lni,lnl,lnn**,me,**scnp,tonp,wch**			4	7		
Crassula peduncularis	**scnp,tonp**			2	2		
Crassula sieberiana ssp. tetramera							
* Crassula tetragona	**tonp**			1	1		1
* Crassula thunbergiana ssp. thunbergiana	**lnh**			1	1		
Cucurbitaceae							
* Cucumis myriocarpus							1
Cupressaceae							
* Callitris rhomboidea	bb					1	
Cuscutaceae							
Cuscuta australis							
* Cuscuta campestris	**wbnp,**			1	1		
* Cuscuta epithymum	**dec,lnh,lnl,lnn,lnq**,me			2	5		
Cyatheaceae							
* Sphaeropteris cooperi	if,li					2	
Cymodoceaceae							
Amphibolis antarctica							
Amphibolis griffithii	**lnh**			1	1		
Thalassodendron pachyrhizum	**lnh**			1	1		
Cyperaceae							
Baumea acuta	bo,**dep,lnl,lnq,wch**			3	4	1	
Baumea arthrophylla	**tonp**			1	1		
Baumea articulata	**dej,dey**,do,**lnhv,lnl,lnr,scnp,wch**			4	7	1	

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Baumea juncea	23579,chs,col,**deb**,**dech**,**dej**,**dep**,**dey**,fg,**ginr**,ki/dor,**lne**,**lnf**, **lnl**,**lnr**,**lny**,**mtfm**,**mtfo/mtfj**,**qunr**,**scnp**,sto,**tonp**,**us**,**wbnp**,**wch**, **wn**,**wnf**,**wnnu**			11	23	6	
Baumea preissii ssp. laxa MS	**dep**,**lni**			2	2		
Baumea preissii ssp. preissii MS	chl,**dech**,**lnq**,**lnr**			2	3	1	
Baumea riparia	bu,**dep**,**scnp**,**tonp**			3	3	1	
Baumea rubiginosa	**dec**,**dech**,**dej**,**dey**,**wch**,**wn**,**wnf**,**wnlf**			3	8		
Baumea vaginalis	col,**deb**,**dech**,**dej**,**dem**,**dey**,fb,fg,**ginr**,hi,**lnb**,**scnp**,th/ra, **wbnp**,**wch**,**wnlf**			7	11	6	
Bolboschoenus caldwellii	**scnp**			1	1		
Carex appressa	**dep**,**lne**,**lnr**,me,**qunr**,**tonp**,**wch**			5	6		
* Carex divisa	**lnn**			1	1		
Carex fascicularis	bb,**dey**,**wch**			2	2	1	
Carex inversa	**lnn**,me			1	1		
Carex preissii	**dec**,**dem**,**lnb**,**lne**,**lnf**,**lnh**,**lni**,**lnl**,**lnn**,**lnq**,**lny**,**tonp**,**wbnp**, **wch**,**wnf**			6	15		
Chorizandra cymbaria	12951,chs,col,**dep**,**ginr**,hi,**lnl**,**scnp**,wi,**wnt**			5	5	4	
Chorizandra enodis	chs,col,**dej**,**dem**,**lnb**,**lnl**,qun6,**scnp**			3	5	3	
Chorizandra multiarticulata	**dej**	3		1	1		
Cyathochaeta avenacea	23579,bo,br,bu,bur,chs,cl,co,col,**dec**,**dech**,**dej**,**dep**,fg,**ginr**, **glnr**,ke,**lnb**,**lne**,**lnh**,**lnhv**,**lnl**,**lny**,lo,lon,**mtfcr**,**mtff**,**mtfm**,**mtfo**, **mtfs**,**qunr**,ra/st,re,ro,**rrnr**,**scnp**,st,th,th/**mtfs**,**tonp**,tr,**wch**, **wn**,**wnf**,**wng**,wy			11	25	19	
Cyathochaeta clandestina	chs,col,**dech**,**dej**,**dem**,**dep**,**glnr**,**lnb**,**lne**,**lnh**,**mtfcr**,**mtfs**,re, **scnp**,st,th,to,**tonp**,tr,**wch**,**wng**,wy,wy/**dep**			8	14	7	
Cyathochaeta stipoides	chs,**dech**,**dej**,**dem**,ja,**scnp**,**wnf**,wy	3		3	5	3	
Cyathochaeta teretifolia	**mtfm**,ye	3		1	1	1	
* Cyperus congestus	bb,**lne**,**wch**,**wnlf**,ye			3	3	2	
* Cyperus eragrostis							
* Cyperus laevigatus	**lnh**,**lnl**			1	2		
* Cyperus polystachyos	**lnq**			1	1		
* Cyperus tenellus	12951,23579,chs,**ginr**,**lne**,**lnhv**,**lnl**,**lnn**,**lnq**,**lny**,me,**scnp**, **tonp**,**wch**			5	10	1	
Evandra aristata	12951,23579,bu,chs,col,**deb**,**dec**,**dech**,**dej**,**dep**,**ginr**,**glnr**, ja,ke,**mtfcr**,**mtfm**,**mtfs**,no,**qunr**,**scnp**,sto,th,**wbnp**,**wch**,**wnf**, **wng**,**wnlf**,**wnt**,wy			9	18	9	
Evandra pauciflora	lon,**mtfs**,th,**wch**			2	2	2	
Gahnia decomposita	bur,chs,fg,**mtfo**,**tonp**,**wch**,we,wi,**wnf**,**wnlf**,**wnt**			4	6	5	
Gahnia sclerioides	**wch**,**wnlf**,**wnnu**,ye	3		2	3	1	
Gahnia sp.Headland (G.J.Keighery 8501) PN	**tonp**,**wch**			2	2		
Gahnia trifida	23579,**dej**,fg,**lnb**,**lnh**,**lnhv**,**lnn**,**lny**,lon,**qunr**,ro,**scnp**,st,th,**us**, **wch**,**wnf**,**wng**,**wnn**,**wnt**			7	14	5	
Gymnoschoenus anceps	bu,chs,col,**dech**,**dej**,**dep**,**dey**,fg,**ginr**,**glnr**,**lnb**,**ls**,**mtfm**,**mtfs**, **qunr**,**scnp**,th,**tonp**,**wch**,wi,**wnf**,**wng**,**wnt**,wy,ye			11	17	8	
Isolepis cernua	chs,**dech**,**dej**,**lne**,**lni**,**lnl**,**lnn**,**lnq**,**lny**,me,**mtfm**,**tonp**, **wbnp**,**wch**,**wnf**			7	13	1	
Isolepis cyperoides	12951,**ginr**,**scnp**,**tonp**,**us/sjm**,**wch**			6	6		
Isolepis fluitans	**lne**,**lnq**,**wch**			2	3		
Isolepis inundata	**tonp**,**wch**,**wnlf**			3	3		
* Isolepis marginata	12951,chs,**deb**,**dec**,**dech**,**dej**,**dey**,din,fg,**lne**,**lnh**,**lni**,**lnl**, **lnn**,**lny**,**mtfcr**,**scnp**,**sjm**,th,**tonp**,**wbnp**,**wch**,wh,**wn**,**wnf**,**wnn**			9	20	5	
Isolepis nodosa	23579,chl,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,dor,**lnb**,**lne**,**lnf**, **lni**,**lnl**,**lnn**,**lnq**,**lnr**,**lny**,**qunr**,**scnp**,**tonp**,**wbnp**,**wch**,**wn**,**wnf**, **wnnu**,**wnt**			8	25	2	
Isolepis oldfieldiana	**wch**			1	1		
Isolepis producta	**dec**			1	1		
* Isolepis prolifera	**dec**,do,**lne**,**lni**,**lnl**,**qunr**,**scnp**,**tonp**,**wch**,**wnf**,**wnn**,**wnnu**			7	11	1	
Isolepis setiformis	**dej**,**lnb**,**scnp**,**tonp**,**us/sjm**			6	6		
Isolepis stellata	**lnn**,**scnp**,**tonp**			3	3		
Lepidosperma carphoides	**scnp**			1	1		1
Lepidosperma drummondii	**wng**			1	1		

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Lepidosperma effusum	bb,bu,col,**cs**,da,**dec**,**dech**,**dej**,**dep**,gry,**lnb**,**lne**,**lnhv**,**lnl**,**lnn**, **lny**,**mtfcr**,**mtff**,**mtfw**,**mtsnr**,po/**sjm**,**qunr**,**rrnr**,**scnp**,sw,**tonp**,**us**, **wbnp**,**wch**,**wnf**,**wng**,**wnlf**,wnn,wnnu,wnp,**wnt**,ye			13	30	8	
Lepidosperma gladiatum	**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,**lne**,**lnf**,**lnh**,**lni**,**lnl**,**lnn**,**lny**, me,**qunr**,**scnp**,**tonp**,**wbnp**,**wch**,wn,**wnf**,wnn,wnnu			8	23		
Lepidosperma gracile	ba,bb,ca,col,**cs**,**dep**,**mtfcr**,st,tb,th,**wnf**,**wnlf**,**wnt**			4	6	7	
Lepidosperma leptostachyum	bu,bur,col,da,dee,**dep**,fg,**glnr**,**lnb**,**lnhv**,lon,**mtfcr**,**mtff**, **mtfm**,**mtfs**,ro,**rrnr**,sh,st,sw,th,tr,**wnf**,**wng**,**wnlf**,wnnu,**wnt**			6	14	13	
Lepidosperma longitudinale	12951,23579,col,**dech**,**dej**,**dep**,**ginr**,ke,**mtfm**,**qunr**, **scnp**,**wch**,**wnf**			7	9	2	
Lepidosperma persecans		C					
Lepidosperma pubisquameum	**dech**,**dep**,**ginr**,**lnhv**,mos/**sjm**,**mtfm**,**mtfo**,**scnp**,wy			6	8	2	
Lepidosperma resinosum	**dej**			1	1		
Lepidosperma scabrum	**dech**,no			1	1	1	
Lepidosperma squamatum	12951,23579,bu,chs,col,**deb**,**dec**,**dech**,dee,**dej**,**dem**,**dep**, fg,**ginr**,**glnr**,**lnb**,**lne**,**lnf**,**lnh**,**lnhv**,**lni**,**lnl**,**lnn**,**lnq**,**lnr**,**lny**,lon,me, **menr**,**mtfcr**,**mtff**,**mtfm**,**mtfs**,na,**qunr**,ro,**rrnr**,**scnp**,st,th,to,**tonp**, **wbnp**,**wch**,wi,**wnf**,**wng**,**wnlf**,wnn,wnnu,**wnt**,wy			13	36	12	
Lepidosperma striatum	**dech**,**dej**,**tonp**,**wch**			3	4		
Lepidosperma tenue	br,**dec**,**dep**,me,**mtfcr**,ro,st,su/**us**,**tonp**,**wch**,**wng**,**wnlf**,**wnp**,wy			6	9	5	
Lepidosperma tetraquetrum	bb,**cs**,fg,ke,**lnb**,**mtfcr**,**scnp**,sol,sw,**wch**,**wnlf**,**wnt**			6	7	5	
Lepidosperma viscidum	**us/sjm**,**wch**,**wn**,**wnlf**			4	5		
Mesomelaena graciliceps	12951,bu,chs,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,fg,**ginr**,ja,**lnb**, **lne**,**lnl**,**lnn**,**lnq**,me,**mtff**,**mtfm**,**mtfo**,**mtfs**,**mtsnr**,**qunr**,**scnp**, th/**mtfs**,**tonp**,**us**,**wbnp**,**wch**,wi,**wnf**,**wng**,**wnlf**,wy			12	26	7	
Mesomelaena preissii	sto					1	
Mesomelaena stygia	col,**dej**,**glnr**,**lni**,me,**mtfcr**,**mtfs**,st,th,**wch**,**wnf**,**wng**,**wnlf**			6	9	3	
Mesomelaena stygia ssp. stygia	st,th/ra					3	
Mesomelaena tetragona	12951,23579,chs,col,**dej**,**dep**,fg,**ginr**,**glnr**,ke,**lnb**,**lnl**,lon, me,**mtfcr**,**mtff**,**mtfo**,**mtfs**,**qunr**,ro,**scnp**,sh,th,**tonp**,**wch**, **wnf**,**wng**,**wnlf**,**wnnu**,wy,ye			10	18	10	
Reedia spathacea	**dech**,**dep**,ke,**mtfm**	4		2	3	1	
Schoenoplectus lateriflorus							
Schoenoplectus pungens							
Schoenoplectus validus	**lne**,**lnl**,**lnr**			1	3		
Schoenus acuminatus	23579,27398,**dech**,**dep**,**glnr**,**mtfcr**,**mtfm**,**mtfs**,**snp/sjm**,th, **tonp**,**wnf**,wy/**dep**			8	11	2	
Schoenus asperocarpus	**scnp**,**tonp**,**wch**			3	3		
Schoenus bifidus	bu,bur,**dep**,**glnr**,lon,me,**mtfcr**,**mtff**,**mtfs**,ro,**rrnr**,**scnp**,th, **tonp**,tr,**wch**,**wnf**,**wng**,**wnlf**,wy			8	12	7	
Schoenus breviculmis	**lnl**			1	1		
Schoenus brevisetis	chs,col,**deb**,**dec**,**dech**,**dej**,**dep**,**ls**/ba,**qunr**,th,**tonp**,**wbnp**, **wch**,**wnf**,**wnn**			7	12	4	
Schoenus caespititius	**dech**,**glnr**,re,**tonp**,**wch**,**wnf**,**wng**,**wnnu**,ye			5	7	1	
Schoenus cruentus	chs,col,**dech**,**dej**,**dem**,**dep**,hi,**lnl**,**scnp**,**tonp**,**wbnp**,**wch**,wy			6	9	4	
Schoenus curvifolius	**deb**,**dech**,**dep**,fg,**ginr**,**lne**,**lnl**,**lnn**,**lnq**,me,**qunr**,**scnp**,sto,th, **tonp**,**wbnp**,**wch**,**wn**			9	14	3	
Schoenus discifer	col,fg,**scnp**,**tonp**,**wch**			3	3	2	
Schoenus efoliatus	12951,23579,chs,col,**deb**,**dech**,**dej**,**dep**,dor,fg,**ginr**,ke, **lnh**,**lnl**,**ls**,**mtfm**,**mtfo**,**qunr**,**scnp**,**tonp**,**us**,**wbnp**,**wch**,**wnf**, **wnlf**,**wnt**,wy			11	19	6	
Schoenus elegans	**scnp**			1	1		
Schoenus fluitans	**dec**	2		1	1		
Schoenus grammatophyllus	me						1
Schoenus grandiflorus	**deb**,**dec**,**dej**,**dep**,fg,**glnr**,**lnb**,**lne**,**lnf**,**lni**,**lnl**,**lnn**,**lnq**,**lnr**,**lny**, **mtfs**,**qunr**,ro,st,th,**tonp**,**wbnp**,wch,**wnf**,**wng**,**wnlf**,wnn,wnnu			9	24	4	
Schoenus humilis	**wch**			1	1		1
Schoenus indutus	**scnp**	1		1	1		
Schoenus laevigatus	col,**tonp**			1	1	1	
Schoenus lanatus	**lnhv**,**lnl**,**tonp**,**wch**			3	4		
Schoenus loliaceus	**scnp**	2		1	1		
Schoenus maschalinus	**tonp**,**us/cs/sjm**,**wch**,ye			4	4	1	
Schoenus multiglumis	**dech**,**dep**,lo,**ls**,**mtfm**,no,ra,st,th,**tonp**,tr,**wn**,**wnf**,**wng**		C	5	8	6	

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Schoenus nanus	**wn**			1	1		
Schoenus nitens	**deb**,**dec**,**dech**,**dem**,**dey**,**lnb**,**lnf**,**lnl**,**lnq**,**qunr**,**scnp**,**tonp**, **wch**,**wnf**			7	14		
Schoenus obtusifolius	**tonp**			1	1		
Schoenus odontocarpus	12951,**scnp**,**wch**			2	2		
Schoenus pedicellatus	**deb**			1	1		
Schoenus plumosus	**tonp**			1	1		
Schoenus subbarbatus	**dec**,**lne**,**lnq**,**wnf**			3	4		
Schoenus subbulbosus	chs,**dep**,fg,**lne**,**mtfcr**,ro,**tonp**,**wch**,**wnf**,**wng**,wy			6	7	4	
Schoenus subfascicularis	**dep**,**wch**,**wnf**			3	3		
Schoenus subflavus	**dej**,fg,**glnr**,**lnb**,lon,**mtfcr**,**mtfs**,**mtfw**,**scnp**,th,**wnf**,**wng**,ye			6	9	4	
Schoenus sublateralis	**dec**,**dech**,**dej**,**dem**,**dep**,**ginr**,ke,**lnh**,**lnq**,**qunr**,**scnp**,sto, **tonp**,**wbnp**,**wch**,wy,ye			8	13	4	
Schoenus sublaxus	**dech**,**dep**,**ginr**,ke,**lnf**,**mtfm**,**qunr**,**tonp**,**wch**,**wnf**,**wnt**,wy			8	10	2	
Schoenus submicrostachyus	**dep**,**tonp**,**wch**,**wnf**			4	4		
Schoenus tenellus	**ginr**,**mtfs**,**wch**			3	3		
Schoenus trachycarpus	**dech**			1	1		
Schoenus unispiculatus							
Schoenus variicellae	**ginr**			1	1		
Schoenus vel sp. aff. brevisetis	**deb**,**dech**,**dep**,**wn**,**wnn**,**wnt**			2	6		
Tetraria capillaris	ba,bur,co,col,**dem**,**dep**,di1,din,fg,**ginr**,**lnb**,**lne**,**lnf**,**lnh**,**lnhv**, **lni**,**lnq**,**lny**,**mtff**,na,no,**qunr**,**scnp**,th,**tonp**,**wch**,wi,ye			8	16	12	
Tetraria octandra	br,bur,ce,chs,col,**dep**,din,fg,**lnb**,**lnf**,**lnh**,**lnl**,me,mos/**sjm**, **mtfcr**,**mtff**,**mtfo**,**mtfs**,**rrnr**,**scnp**,th,**tonp**,**wbnp**,**wch**,**wnf**, **wng**,**wnlf**,**wnn**,wy			10	19	10	
Tricostularia compressa	**glnr**,**mtfcr**,**wng**			3	3		1
Tricostularia neesii	chs,**dep**,**lnb**,**lnl**,**mtfcr**,**mtfs**,**rrnr**,**scnp**,th,**tonp**,tr,**us**,**wch**,**wnf**			9	11	3	
Tricostularia neesii var. elatior	col,**dej**,**ginr**,**mtfm**,**mtfs**,**scnp**,**tonp**,**wnf**,**wng**			6	8	1	
Tricostularia neesii var. neesii	chs,**dej**,fg,**ginr**,**scnp**,sh			3	3	3	
Dasypogonaceae							
Acanthocarpus preissii	**dec**,**dech**,**dej**,**dem**,**dep**,**lne**,**lnf**,**lnh**,**lnhv**,**lni**,**lnl**,**lnn**,**lnq**, **lny**,**scnp**			3	15		
Baxteria australis	12951,chs,**dech**,**dep**,**ginr**,**glnr**,**lni**,**mtfcr**,**mtfm**,**mtfo**,**qunr**, **scnp**,th,**wbnp**,**wnf**,**wnt**			9	13	2	
Calectasia cyanea	**tonp**			1	1		
Calectasia grandiflora	**menr**,**qunr**			2	2		
Chamaexeros longicaulis	**wnnu**,**wnt**	2	E	1	2		
Dasypogon bromeliifolius	12951,23579,br,bu,chs,co,col,**deb**,**dech**,**dej**,**dem**,**dep**, fg,**ginr**,**glnr**,if,ke,ki/dor,**lnb**,**lne**,**lnq**,**lnr**,lon,**ls**,mos/**sjm**,**mtfcr**, **mtfo**,**mtfs**,no,**qunr**,ro,**scnp**,sto,th,to,**tonp**,**us**,**wbnp**,**wch**,we, **wnf**,**wng**,**wnlf**,**wnnu**,**wnt**,wy			13	27	18	
Dasypogon hookeri	chs,**dej**,if,**lne**,**lnr**,**scnp**,ye			3	4	3	
Kingia australis	bu,bur,chs,col,**dep**,fg,**glnr**,ke,lon,me,**mtfcr**,**mtff**,**mtfm**, **mtfo**,**mtfs**,ro,**scnp**,sh,st,sw,th,tr,**wch**,we,**wnf**,**wng**,**wnlf**,**wnt**,wy			6	13	15	
Lomandra brittanii	**mtfs**,**us**			2	2		
Lomandra caespitosa	br,**dec**,**dey**,fg,**lnb**,**lnn**,me,mos,**mtfcr**,**mtfm**,**mtfp**,**mtfs**,qui, **scnp**,st,th,**tonp**,**us**,**wbnp**,**wnf**,**wnlf**,**wnn**,ye			8	15	7	
Lomandra collina	23579,**ginr**,**wch**			2	2		
Lomandra drummondii	bu,col,**dep**,di1,fg,**glnr**,go,lon,**mtfcr**,**mtff**,**mtfm**,**mtfs**,ro,st, th,th/**mtfs**,tr,**wnf**,**wng**,**wnlf**,wy			4	9	12	
Lomandra hastilis	chl,**dech**			1	1	1	
Lomandra herrmaphrodita	br,**dech**,**mtfo**,th,**wnlf**			3	3	2	
Lomandra integra	bb,br,bu,ca,ce,chs,col,**cs**,**dec**,**dech**,dee,**dep**,di1,fg,**glnr**,gry, **lnb**,**lnf**,**lni**,**lnl**,**lny**,lon,mos/**sjm**,**mtfcr**,**mtff**,**mtfm**,**mtfo**,**mtfs**, na,**qunr**,ro,**rrnr**,**scnp**,st,sw,th,wh,**wnf**,**wng**,**wnlf**,**wnt**			10	23	19	
Lomandra maritima	**tonp**			1	1		
Lomandra micrantha	**glnr**,**lnn**,**tonp**,**wch**			4	4		
Lomandra micrantha ssp. micrantha	**lnl**,**lnn**,**tonp**			2	3		
Lomandra nigricans	23579,bu,chs,co,col,da,**dech**,**dej**,fg,ga,**glnr**,ke,**lnb**,**lnf**, **lni**,**lnq**,lon,mos/we,**mtfcr**,**mtff**,**mtfs**,**mtfw**,qui,**rrnr**,**scnp**, sh,sto,sw,th,**tonp**,tr,**wch**,**wn**,**wnf**,**wng**,**wnlf**,**wnt**,wy			9	20	18	
Lomandra nutans	hi,lo					2	
Lomandra odora	**lnn**,**scnp**			2	2		

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Lomandra ordii	bu,**cs**,**dep**,**dep**/bu,ga/**dem**,**wnf**	3	E	3	4	3	
Lomandra pauciflora	23579,ba,bb,bu,car,col,**cs**/po,da,di1,din,fg,**lnb**,**lne**,**lnf**,**lnh**, **lni**,**lnl**,**lnn**,**lnr**,**lny**,lon,**ls**,mos/**sjm**,**mtfcr**,**mtff**,**mtfm**,**mtfs**,na,ro, **rrnr**,**scnp**,sh,st,sw,th,**tonp**,tr,**wbnp**,**wch**,wi,**wn**,**wnf**,**wng**, **wnlf**,**wnnu**,**wnt**,wy/bu,ye			10	27	22	
Lomandra preissii	din,**lnn**,me,**rrnr**,**scnp**,st			3	3	2	
Lomandra purpurea	23579,chs,**dej**,fg,ja,**lnl**,**mtfcr**,**scnp**,**tonp**,**wch**,**wng**,**wnlf**,**wnt**			7	9	3	
Lomandra sericea	chs,co,**dep**,fg,**glnr**,**lnb**,**lny**,lon,**mtfcr**,**mtfo**,**mtfs**,**qunr**,ro,**rrnr**, **scnp**,**wch**,**wn**,**wnlf**,wy			9	13	6	
Lomandra sonderi	bur,chs,col,**dec**,**dech**,**dep**,fg,ke,**lnl**,**lnn**,**lny**,me,**mtfo**,**mtfs**, **qunr**,ro,**scnp**,th,**tonp**,**wch**,we,**wnt**,wy,ye			8	13	10	
Lomandra spartea	chs					1	1
Lomandra suaveolens	**deb**,**lne**,**lnl**,**lnn**,**lnr**,**lny**,**mtfp**,**qunr**,su/**us**,**wnn**			6	10	1	
Dennstaedtiaceae							
* Hypolepis dicksonioides							
* Hypolepis rugosula	if					1	
Pteridium esculentum	23579,ba,bb,br,bu,chs,co,col,**cs**,da,**dec**,**dech**,dee,**dej**, **dep**,di1,din,fg,ke,**lnb**,**lne**,**lnh**,**lni**,**lnl**,**lnn**,**lnq**,**lny**,lon,**ls**,me, mos/**sjm**,**mtfcr**,**mtff**,**mtfm**,**mtfo**,**mtfs**,**mtsnr**,na,no,**scnp**,sw, th,**tonp**,tr,**wch**,we,**wnf**,**wng**,**wnlf**,**wnnu**,**wnp**,**wnt**,wy			10	30	22	
Dilleniaceae							
Hibbertia acerosa							
Hibbertia amplexicaulis	23579,ba,bb,br,bu,col,da,**deb**,dee,**dej**,**dem**,**dep**,di1,din, fg,**ginr**,**glnr**,**lnb**,**lnf**,**lnh**,**lni**,**lnl**,**lny**,lon,**mtfcr**,**mtff**,**mtfm**,**mtfs**, **qunr**,ro,**rrnr**,**scnp**,sh,st,sw,th,**tonp**,tr,**wbnp**,**wch**,we,wi,**wnf**, **wng**,**wnlf**,**wnn**,**wnnu**,**wnt**,wy			12	28	20	
Hibbertia commutata	23579,br,bu,co,col,**dech**,**dep**,fb,fg,**glnr**,**lnb**,lon,me,**mtfcr**, **mtff**,**mtfm**,**mtfs**,**mtsnr**,ro,**rrnr**,st,th,**wch**,**wnf**,**wng**,**wnlf**,ya			8	14	11	
Hibbertia cuneiformis	bb,**benp**,br,**brnp**,chl,co,crw,**cs**,**deb**,**dec**,**dech**,**dej**,**dem**, **dep**,**dey**,di1,din,fg,le,**lnb**,**lne**,**lnf**,**lnh**,**lnhv**,**lni**,**lnl**,**lnn**,**lnq**, **lnr**,**lny**,**ls**,me,**mtff**,**mtsnr**,no,**qunr**,**scnp**,**tonp**,**wbnp**,**wch**,**wn**, **wnf**,**wnlf**,**wnn**,**wnnu**,**wnp**,**wnt**			13	36	10	
Hibbertia cunninghamii	23579,bb,**benp**,br,**brnp**,bur,co,col,**dech**,**dep**,di1,fg,le, **lni**,**lnl**,**lnn**,**lnq**,**lny**,**ls**,me,mo,**mtff**,mtfo,**mtfs**,na,ro,**scnp**,st,su/ **us**,sw,th,**tonp**,**wbnp**,**wch**,we,**wnf**,**wnlf**,**wnn**,**wnnu**,ye			11	22	17	
Hibbertia depressa	**glnr**,th,**wbnp**,**wch**,**wng**			4	4	1	
Hibbertia enervia	23579						
Hibbertia ferruginea	**scnp**,ye			1	1	1	
Hibbertia furfuracea	bu,**dej**,**ginr**,**lnb**,**lne**,**lnf**,**lnh**,**lni**,**lnl**,**lnq**,**menr**,**mtfcr**,**mtfs**,**mtsnr**, **qunr**,**scnp**,st,**tonp**,**wbnp**,**wch**,**wnf**,**wng**,**wnlf**,**wnn**,**wnnu**,**wnt**			12	24	2	
Hibbertia glaberrima	**wch**,**wnf**,**wnnu**	2		2	3		1
Hibbertia glomerata							
Hibbertia glomerosa	**scnp**			1	1		1
Hibbertia grossulariifolia	**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,do,**lnb**,**lne**,**lnf**,**lnh**,**lni**,**lnl**,**lnq**,**l ny**,**qunr**,**tonp**,wa,**wbnp**,**wch**,**wnf**,**wnn**,**wnnu**,**wnp**			7	22	2	
Hibbertia huegelii	br					1	
Hibbertia hypericoides	br,chs,fg,**glnr**,**lnb**,**lnf**,**lnh**,**lnl**,**lnn**,**lnq**,**lny**,me,**qunr**,**scnp**, th,**wnf**,**wng**,ye			5	12	5	
Hibbertia inclusa							
Hibbertia inconspicua	bea/ca,br,**brnp**,col,crw,**cs**/po,**dech**,fg,**lnl**,lon,mos/**sjm**, **mtfs**,na,**scnp**,**wnlf**,ye			8	8	11	
Hibbertia microphylla	23579						
Hibbertia montana		4					
Hibbertia perfoliata	**cs**,**dec**,**dej**,**lnb**,**lnl**,**wch**			4	6		
Hibbertia pilosa	**benp**,fg,**lnb**,**mtfcr**			3	3	1	
Hibbertia polystachya	me						
Hibbertia pulchra	**scnp**,**tonp**,**wnf**			3	3		
Hibbertia quadricolor	**wnnu**			1	1		
Hibbertia racemosa	chl,co,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,**ginr**,**lnf**,**lni**,**lnl**,**lnn**,**lnq**, **lnr**,**lny**,**qunr**,**scnp**,th,to,**tonp**,**wbnp**,**wch**,**wnf**,**wnn**,**wnnu**			9	22	3	
Hibbertia rhadinopoda	br,chs					2	

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Hibbertia serrata	bb,**brnp**,bu,cha,col,**cs**,da,**dech**,**dep**,din,ke,**lnb**,**lnf**,**lni**,**lnn**, **lnq**,**lny**,**ls**,**mtfcr**,**mtff**,**mtfs**,or,po/ja,**rrnr**,sw,th,**wch**,**wnlf**,**wnp**, **wnt**,ye			8	19	13	
Hibbertia silvestris	ba,bb,st	4				3	
Hibbertia sp.hairy sepals (J.R.Wheeler 2464) PN	**dech**,**mtfcr**,**wnf**,**wnnu**,wy		E	3	4	1	
Hibbertia sp.rigid bracts (J.R.Wheeler 3220) PN	**lnf**,**lnq**,**mtfcr**,**mtfs**,**qunr**,**scnp**,th,**wnf**,ye		C	5	7	2	
Hibbertia spicata	me						
Hibbertia stellaris	12951,chs,col,**dej**,lon,**mtfm**,**scnp**,sto,th			3	3	5	
Hibbertia subvaginata	sto					1	
Hibbertia vaginata	**benp**				1	1	
Droseraceae							
Drosera binata	**dep**,**wnf**	2		2	2		
Drosera bulbosa	**scnp**,**wch**			2	2		
Drosera bulbosa ssp. bulbosa	**dech**			1	1		
Drosera dichrosepala	**lnq**,**mtfs**			2	2		
Drosera enodes	**ginr**,**scnp**		C	2	2		
Drosera erythrogyne	**dech**,st			1	1	1	
Drosera erythrorhiza	chs,**deb**,**dech**,**dej**,**dep**,fg,**lnn**,me,no,**scnp**,sto,to,**tonp**, **wbnp**,**wch**,**wnf**,**wnn**,**wnnu**			7	12	4	
Drosera erythrorhiza ssp. collina	fg					1	
Drosera erythrorhiza ssp. erythrorhiza	co,ke,**lnf**			1	1	2	
Drosera erythrorhiza ssp. squamosa	**qunr**,**wch**			2	2		1
Drosera fimbriata	**wbnp**	R		1	1		
Drosera gigantea	chs,**dej**,**lnq**,me			2	2	1	1
Drosera gigantea ssp. geniculata	**scnp**			1	1		
Drosera gigantea ssp. gigantea	**lnn**			1	1		
Drosera glanduligera	12951,bu,chs,**dech**,fg,**menr**,**mtfs**,**qunr**,**scnp**,**sjm**,**tonp**, **wch**,**wnf**			9	9	3	
Drosera hamiltonii	**dep**,ke,**tonp**,**wch**		C	3	3	1	
Drosera huegelii	**dep**,fg,**mtfs**,**scnp**,**tonp**,**wch**,**wnf**,wy/**dep**			6	6	2	
Drosera macrantha ssp. macrantha	12951,**dech**,**dej**,fg,**lnh**,**lnn**,**scnp**,**wng**			4	6	1	
Drosera menziesii	23579,**dep**,**glnr**,**menr**,**mtfcr**,**qunr**,**scnp**,th,**tonp**,**wch**,wn,**wnf**			9	10	1	
Drosera menziesii ssp. menziesii	12951,chs,**deb**,**dech**,**dej**,fg,**glnr**,**lnf**,**lnn**,**lnq**,me,**qunr**,**scnp**, to,**tonp**,**wbnp**,**wch**,**wnf**,**wng**			9	15	2	
Drosera menziesii ssp. penicillaris	**deb**,**lnb**,**lnn**,**wbnp**			3	4		
Drosera microphylla	me						
Drosera modesta	**tonp**,**wch**			2	2		
Drosera myriantha	col,**dech**,**ginr**,**scnp**,st,**wnlf**			4	4	2	
Drosera neesii	23579,**glnr**,**ls**,**scnp**,th,**tonp**,**wch**,we,**wnf**			6	6	2	
Drosera neesii ssp. neesii	12951,23579,col,**deb**,**dech**,**dep**,ke,lon,**mtfcr**,no,**scnp**, **tonp**,**us**,**wbnp**,**wch**,**wnf**,**wnn**,w			8	12	5	
Drosera nitidula ssp. omissa	12951,**scnp**			1	1		
Drosera occidentalis ssp. australis	**dem**			1	1		1
Drosera paleacea							
Drosera pallida	12951,23579,bu,col,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,di1, fg,**glnr**,**lnf**,**lnn**,lon,me,**mtfcr**,**mtff**,**mtfm**,**mtfo**,**mtfs**,na,no, **qunr**,ro,**rrnr**,**scnp**,sh,st,sw,th,**tonp**,tr,**wbnp**,**wch**,**wnf**,**wng**, **wnlf**,**wnn**,**wnnu**,**wnt**,wy			11	27	14	
Drosera platypoda	col,**dep**,**mtfm**,**scnp**,**wbnp**			4	4	1	
Drosera platystigma							
Drosera pulchella	chs,col,**dech**,**dej**,**dep**,**mtfm**,**mtfs**,**qunr**,**scnp**,**tonp**,**us**, **wbnp**,**wch**,**wnf**,wy			9	12	3	
Drosera roseana	**dech**			1	1		
Drosera rosulata	lon					1	
Drosera scorpioides	lon,sh					2	
Drosera stelliflora	**lnq**			1	1		
Drosera stolonifera ssp. stolonifera	me						
Drosera stricticaulis							
Drosera subhirtella ssp. subhirtella	**dech**,**dej**			1	2		1
Drosera tubaestylis	me						

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Epacridaceae							
Acrotriche cordata	**dec,dech,dem,dep,lnf,lnh,lnl,qunr,tonp,wbnp,wch, wnf,wnnu**			7	13		
Acrotriche depressa	**tonp**			1	1		
Andersonia amabile MS	col,**dej,dep,ginr,qunr**,ra/st,**wbnp**	3	C	4	5	3	
Andersonia annelsii MS		2					
Andersonia auriculata	**glnr,mtff,mtff/mtfm,mtfp,qunr**,th,th/tr/mfs,**wnf,wng**	2		4	7	3	
Andersonia barbata	**dech**			1	1		
Andersonia caerulea	12951,23579,chs,col,**dech,dej,dep**,fg,**ginr,glnr**,hi,if,ke,**lnb, lne,lnf,lnl,lnn**,mos/**sjm,mtfcr,mtff,mtfm,mtfo,mtfs,qunr**,ro, **scnp**,sh,**sjm**,st,sto,th,to,**tonp**,tr,**wbnp,wch**,we,**wnf,wng, wnlf,wnn,wnnu,wnt**			12	27	14	
Andersonia geniculata MS	**dep,dep/ls,mtfm**,or/ke,sh/**mtfo/mtfm**,wy		E	3	4	4	
Andersonia involucrata	**lnn,scnp**			2	2		
Andersonia latiflora							
Andersonia macronema	**dep**			1	1		
Andersonia micrantha	br,**dech**,hi,**lnq,tonp,wbnp,wch,wn,wnf**			6	7	2	
Andersonia redolens MS	col	1	E			1	
Andersonia simplex	**wnf**			1	1		
Andersonia sprengelioides	bu,bur,**dech,dep**,lo,lon,**menr,mtff,mtfm**/sh,**mtfp,qunr,scnp, sjm**,st,**tonp,wbnp,wch,wn,wnf,wng**,wnnu,**wnt**,wy			10	17	7	
Astroloma baxteri	**dem**,to,**tonp,wch,wnf,wng**			4	5		
Astroloma ciliatum	br,**dec,dej**,fg,**lnb,lne,lnf,lnh,lnl**,lnn,**lnq,lnr,lny,scnp, tonp,wch**,wi			5	14	3	
Astroloma drummondii	col,**lnb,lnn**,me,**mtfcr,wnf,wng**			3	5	1	
Astroloma epacridis	fg,**mtfcr**			1	1	1	
Astroloma pallidum	23579,ba,br,ce,chs,**dep**,fg,**lni,lnl**,lnn,**lnq**,me,**mtfs,qunr, scnp**,st,**tonp,wch**			7	10	6	
Astroloma sp.Nannup (R.D.Royce 3978) PN	ba,chs,fg,wi	4				4	
Astroloma stomarrhena	**tonp**			1	1		
Brachyloma preissii	23579,**deb,dec,dech,dej,dep,dey**,dor,fg,**lnb,lny,mtfs**,no, **qunr**,th,**wch,wnf,wnn,wnnu**			6	14	4	
Coleanthera myrtoides	**wbnp**			1	1		
Conostephium pendulum							
Cosmelia rubra	**dech,dep,mtfs,qunr**,sh,th,**tonp,wbnp,wch,wnf,wnlf**			7	9	2	
Croninia kingiana							
Leucopogon alternifolius	12951,col,**dej**,ke,ra,**scnp**,th,**wch**			3	3	4	
Leucopogon assimilis	br,**lnl,lnq**			1	2	1	
Leucopogon australis	23579,ba,br,bu,bur,chs,co,col,**dec,dech,dej,dep**,dor, **glnr**,hi,if,ke,ki/dor,**lnf,lnn**,lon,me,**menr**,mos/**sjm,mtfcr,mtff, mtfo,mtfs**,na,no,**qunr**,ro,**scnp**,sh,st,sto,sw,th,**tonp**,tr,**wch**,we, **wnf,wng,wnlf,wnt**,wy,ye			11	21	26	
Leucopogon capitellatus	23579,ba,bb,br,bu,co,col,da,dee,**dep**,di1,din,fg,**lnb,lnl, lnn,lnq**,lon,me,mos/**sjm,mtfcr,mtff,mtfm,mtfs**,na,no,**qunr, rrnr,scnp,sjm**,st,sw,th,tr,**wch**,we,wi,**wn,wnf,wng,wnlf**,**wnnu, wnp,wnt**,wy			9	21	22	
Leucopogon carinatus	12951,**lnq,scnp**			2	2		1
Leucopogon concinnus	**mtff**,sh			1	1	1	1
Leucopogon conostephioides	**lne,lnn,lny,scnp**,ye			2	4	1	
Leucopogon cordatus	12951,**dech,dej,ginr,lnq,lnr,qunr,scnp,wbnp**			6	8		
Leucopogon corifolius	**dem,qunr,tonp,wch**			4	4		
Leucopogon cymbiformis	ye					1	
Leucopogon distans	**dech,dep,glnr,lnf,mtfs,scnp**,th,**wbnp,wch,wnf,wng**			8	10	1	
Leucopogon distans ssp. contractus MS	**dech,scnp,wbnp**			3	3		
Leucopogon distans ssp. distans MS	**dech,dep**,fb,**mtfs,tonp**,tr,**wch,wnlf**			5	6	2	
Leucopogon elatior	**lni,lnq,lnr**			1	3		
Leucopogon elegans	**lnq**			1	1		
Leucopogon gibbosus							
Leucopogon gilbertii	27398,bu,chs,**dech**,fb,**glnr**,lon,**mtfcr,mtfm,mtfm**/sh,**mtfs**, ra/lo,ra/st,**scnp**,sh,sh/**mtfm**,st,st/ro,sto,th,th/tr/mfs,tr		C	5	7	15	
Leucopogon glabellus	**dep,glnr**,gry,**lni**,me,**mtfcr,mtfm,mtfo,mtfs**,ro,**scnp**,th,**tonp, wch,wn,wnf,wng**,ye			8	13	4	

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Leucopogon gracilis	col,**dech**,**wch**			2	2	1	1
Leucopogon gracillimus							
Leucopogon hirsutus	bur,chs,**dej**,fg,na,**scnp**,**wnf**,**wng**,**wnlf**			3	5	4	
Leucopogon obovatus	23579,col,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,fg,**glnr**,**lnb**,**lnf**, **lnl**,**ls**,**mtff**,no,**qunr**,sh,th,to,**tonp**,**wbnp**,**wch**,**wnf**,**wng**,**wnlf**, **wnn**,**wnnu**,**wnt**			10	23	5	
Leucopogon oxycedrus	**mtff**,**scnp**,to,**tonp**,**wnnu**			4	4		
Leucopogon parviflorus	br,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,**glnr**,**lnb**,**lne**,**lnf**,**lnh**,**lni**, **lnl**,**lnn**,**lnq**,**lnr**,**lny**,**qunr**,**scnp**,th,**tonp**,**wbnp**,**wch**,**wnf**,**wnn**, **wnnu**			9	26	2	
Leucopogon pendulus	12951,23579,br,bur,col,**dech**,**dep**,fg,**ginr**,**glnr**,hi,ke,**lnb**, **menr**,**mtfcr**,**scnp**,**sjm**,sto,th,**us**,**wbnp**,**wn**,**wnf**,**wnlf**,**wnnu**,**wnt**			11	16	8	
Leucopogon polystachyus	**dep/ls**,ga,ga/**dem**,**glnr**,ke,lon,**ls**,**mtff/mtfm**,**mtfs**,st,th, th/tr/mfs,**wch**,**wnf**	2		6	9	8	
Leucopogon propinquus	ba,br,bu,col,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,di1,din,do,fg, **glnr**,ki/dor,**lnb**,**lne**,**lnf**,**lnh**,**lni**,**lnl**,**lnn**,**lnq**,**lnr**,**lny**,me,**mtfcr**, **mtff**,**mtfm**,**mtfs**,na,**qunr**,ro,**rrnr**,th,**tonp**,tr,**wbnp**,**wch**,**wnf**, **wng**,**wnlf**,**wnn**,**wnnu**,**wnp**,**wnt**			10	34	14	
Leucopogon racemulosus	**dej**,**dey**,dor,fg,**ginr**,**lnb**,**mtfo**,**scnp**,**wbnp**,**wnlf**,**wnn**,**wnt**			7	10	2	
Leucopogon reflexus	23579,col,**dech**,**dep**,**qunr**,**scnp**,st,th,**tonp**,**wnf**,**wnlf**			5	7	3	
Leucopogon revolutus	chl,din,do,mos,**mtfcr**,**qunr**,**scnp**,**tonp**,**wch**,**wng**,**wnlf**, **wnn**,**wnnu**			6	9	4	
Leucopogon sp.Windy Harbour (A.Strid 21460) PN	12951,chs,**dech**,**ginr**,**scnp**,**wnf**		E	4	4	1	
Leucopogon squarrosus	**dech**,**scnp**			2	2		
Leucopogon striatus	chs,**scnp**			1	1	1	1
Leucopogon strictus	**tonp**			1	1		
Leucopogon tamariscinus	**dech**	2		1	1		
Leucopogon tenuicaulis MS	12951,**scnp**,**wnnu**		E	2	2		
Leucopogon unilateralis	bu,cha,chl,co,**cs**,**dech**,dee,**dej**,**dep**,dor,**glnr**,ki/dor,**ls**,**mtff**, **mtfm**,**mtfo**,**mtfs**,no,qui,**qunr**,ro, **scnp**,**sjm**,st,th,**tonp**,**us**, **wbnp**,**wch**,we,**wnf**,**wng**,**wnlf**,**wnnu**,**wnt**,wy			11	22	14	
Leucopogon verticillatus	ba,bb,br,bu,bur,co,col,crw,**cs**,da,**dech**,dee,**dej**,**dep**,di1, din,fg,**glnr**,**lnb**,**lnf**,**lnl**,**lny**,lon,**ls**,mossjm,**mtfcr**,**mtff**,**mtfm**, **mtfo**,**mtfs**,**mtsnr**,na,ro,**rrnr**,**scnp**,sh,st,sw,th,tr,we,wi,**wnf**, **wng**,**wnlf**,**wnnu**,**wnt**,wy			10	24	25	
Lysinema ciliatum	12951,bu,chs,**deb**,**dech**,**dej**,**dem**,**dep**,**lne**,**lnn**,me, **mtfs**,**qunr**,**scnp**,sto,to,**tonp**,**wbnp**,**wch**,**wnf**,**wng**,**wnnu**			9	16	3	
Lysinema ciliatum forma Denmark (D.H.Perry s.n.12/1961) PN			E				
Lysinema ciliatum forma Mt Barren (E.& S.Pignatti 1409) PN	**tonp**			1	1		
Lysinema ciliatum forma S.W.Coastal (N.G.Marchant 71/719) PN	**dech**,**tonp**,**wbnp**,**wch**,**wnnu**			5	5		
Lysinema conspicuum	12951,bu,chs,**dech**,**dej**,**dep**,**glnr**,lon,**mtfcr**,**mtfs**,**qunr**, **scnp**,sh,th,**tonp**,**wch**,**wn**,**wnf**,w			8	13	5	
Lysinema fimbriatum							
Lysinema lasianthum	col,**glnr**,lon,**wch**	2		2	2	2	
Monotoca tamariscina	bu,col,ke,**mtff**,**rrnr**,sw,th,**wch**,**wn**,**wnf**,**wnf/wnn**,**wng**, **wnlf**,**wnn**,**wnnu**,**wnt**			4	10	5	
Needhamiella pumilio	12951,**dech**,**scnp**,**wch**			3	3		
Oligarrhena micrantha	**wch**,			1	1		1
Sphenotoma capitatum	**dech**,**dej**,**dep**,if,**lnb**,**lnl**,lo,**qunr**,**scnp**,sh,st/ro,sto,**wch**,ye			5	8	7	
Sphenotoma dracophylloides	st					1	
Sphenotoma drummondii	**mtff**	R		1	1		
Sphenotoma gracile	12951,23579,bu,chs,col,**cs**,**cs/ls**,**deb**,**dec**,**dech**,**dej**,**dem**, **dep**,fg,**glnr**,ke,**lnf**,**ls**,**mtfcr**,**mtff**,**mtfm**,**qunr**,rast,ro,**rrnr**,**scnp**, th,**tonp**,**us**,**wbnp**,**wch**,**wn**,**wnf**,**wng**,**wnlf**,**wnnu**,**wnt**,w			12	26	10	
Sphenotoma parviflorum	bu,da/sh,**dech**,ke,mcnr,**scnp**,sw	3		3	3	5	
Sphenotoma squarrosum	**dej**,**mtfcr**,**mtfs**,st,th,**wbnp**,**wch**,**wnf**,wy			5	6	3	
Styphelia tenuiflora	**lnn**,me,**mtfcr**,**mtfs**,st,ye			2	3	2	

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Eremosynaceae							
Eremosyne pectinata	**dej,dep,scnp,tonp,wbnp,wch,wng,wnlf,wnt**			6	9		
Ericaceae							
* Erica baccans	**cs,us/cs/sjm**			2	2		
Euphorbiaceae							
Adriana quadripartita	**lnn**,me			1	1		1
Amperea ericoides	br,bu,col,da,**deb,dec,dech,dej,dep**,fg,**glnr,lnb,mtfcr,wbnp, mtff,mtfm,qunr,scnp**,th,to,**tonp,us,wch**,wi,**wn,wnf,wnlf, wnn,wnnu**,ya			11	21	8	
Amperea micrantha	**glnr**,lon,**mtfcr,mtfs**,th	2		2	3	2	
Amperea protensa	**cs,dem,dep,dep**/bu,ga,ke,**ls,scnp**,sh,th,**tonp,wbnp,** we/mo,**wnf**,wy	2	C	6	8	8	
Amperea simulans	bea/ca,br,**cs,cs**/mu,**dec,dej,dep**,di1,din,ki/dor,**ls**,mtft,**mtfw,** na,ne,ro,st,tr,**wbnp**,we,**wn,wnlf,wnnu,wnt**			5	12	14	
Amperea volubilis	chs,**dech,dej,dem,dep,glnr,scnp,wch,wnf,wnt**			5	9	1	
Beyeria viscosa	**lni,lnn,lny**			1	3		
Calycopeplus oligandrus	23579,**dep,scnp**			2	2		
* Euphorbia helioscopia	**lnh**			1	1		
* Euphorbia paralias	**dep,lne,lnh,lnl,lnn,lnq,lny**,me,**tonp,wch,wnnu**			5	10		
* Euphorbia peplus	**dep,lnb,lnh,lni,lnl,lnn,lny**,me,**wnnu**			3	8		
* Euphorbia terracina							
* Mercurialis annua	**lnh**			1	1		
Monotaxis grandiflora	chs,fg,**glnr,scnp,wch**			3	3	2	
Monotaxis occidentalis	**dej,dep**,dor,**lnf,mtfcr,scnp**,sh,**us,wnf,wnlf**			6	8	2	
Phyllanthus calycinus	**deb,dec,dech,dej,dep,dey**,din,**lnb,lne,lnf,lnh,lni,lnl,lnn, lnq,lnr,lny**,me,**qunr,scnp,tonp**,wbnp,**wch,wnf,wnnu**			8	23	1	
Phyllanthus scaber	**tonp**			1	1		1
Poranthera ericoides	**scnp,tonp,wch**			3	3		
Poranthera huegelii	bu,col,**cs,dep,lnb**,lo,**mtfcr,mtff,mtfm,mtfs**,ro,**rrnr,scnp**,st,th, **tonp,wnf,wng,wnlf**,ye			8	13	7	
Poranthera microphylla	23579,chs,**deb,dep**,fg,**lnf,lnn,lny,mtfcr,qunr,scnp,tonp, wbnp,wch,wnnu**			9	12	2	
Pseudanthus virgatus	**lnq**,me			1	1		
Ricinocarpos glaucus	br,bu,col,**cs,dep,menr,mtfcr,mtfj/mtfw**,po,sw,th,**wch**,wi, **wnlf,wnnu,wnt**,wy/bu			6	10	8	
* Ricinus communis							1
Frankeniaceae							
Frankenia pauciflora	**lnh,lni,lnl,lnq,tonp**			2	5		
Fumariaceae							
* Fumaria bastardii	**lny**			1	1		
* Fumaria capreolata	**lni,lny,tonp**			2	3		
* Fumaria muralis	**lni,lnl,lnn,tonp**			2	4		
Gentianaceae							
* Centaurium erythraea	bb,**dech**,din,fb,fg,**lne,lnf,lnh,lni,lnl,lnn,lnr**,me,**scnp**,sw, **tonp,wbnp,wch,wn,wnf,wnlf**			7	15	5	
Centaurium spicatum	23579,cha,**lnhv**,lon,**scnp**			2	2	2	
* Cicendia filiformis	12951,27398,**scnp**,st,**tonp**			3	3	1	
Sebaea ovata	**scnp,wch**			2	2		1
Geraniaceae							
* Erodium botrys	me,**tonp**			1	1		
* Erodium cicutarium	**lnh,lni,lnl,lnn,lny**,me,**tonp**			2	6		
Erodium cygnorum ssp. cygnorum							1
* Erodium moschatum							
* Geranium dissectum							1
* Geranium molle	**lny,tonp,wch**			3	3		
Geranium retrorsum	**dech,qunr,wnnu**			3	3		
Geranium solanderi	**dej,dem,dep,dey,lnb,lnh,lnl,lnq**,me,**tonp,wbnp, wch,wn,wnf,wnnu**			6	14		
* Pelargonium alchemilloides	**lnh**			1	1		
Pelargonium australe	**dech,dey,lnh**,lon,**tonp,us/sjm,wbnp**			6	7	1	
Pelargonium australe ssp. australe	**wng**			1	1		
Pelargonium australe ssp. drummondii MS	**dech,mtff,wbnp**			3	3		
* Pelargonium capitatum	bu,**deb,lne,lnn,tonp,wbnp,wch,wnf,wnnu**			6	8	1	

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Pelargonium littorale	**benp,deb,dec,dech,dep,dey,lnb,lnf,lnh,lni,lnn,lnq,lny, qunr,scnp,tonp,wbnp,wch,wn,wnf,wnlf,wnnu**			9	22		
Pelargonium littorale ssp. littorale	**dep,lnb,lnh,sjm,tonp,wn,wng**			5	7		
Goodeniaceae							
Anthotium humile	23579,**dep,mtfm,qunr,wch,wnf**			5	5		
Anthotium junciforme	chs,**lni,scnp,wnf**	4		3	3	1	
Anthotium sp.Peaceful Bay (J.R.Wheeler 3772 & S.J.Patrick) PN	lon,**wnf**		E	1	1	1	
Dampiera alata	23579,br,bu,din,fg,mos/**sjm,rrnr,scnp**,th,**us/cs/sjm**			4	5	6	
Dampiera coronata	**lnq**,me			1	1		
Dampiera diversifolia	**lnb,lnhv**			1	2		1
Dampiera fasciculata	**tonp**			1	1		
Dampiera hederacea	bu,chl,col,cou,**cs**/ja,da,**dech**,dee,do,dor,fg,ga,if,ke,**lnb, lne,lnl**,lo,lon,**mtfcr,mtff,mtfm,mtfs**,na,po/ja,po/**sjm,qunr, rrnr,scnp**,su/**us**,sw,th/**mtfs**,tr,**wbnp**,we,wi,**wnf,wng,wnlf**,w			10	20	26	
Dampiera heteroptera		3					
Dampiera leptoclada	**cs,cs/ls,dech,dej**,fg,**lni,lpnr,scnp,wnf,wng,wnlf,wnt**			6	11	1	
Dampiera linearis	12951,br,bu,bur,chs,co,col,**dec,dech,dej,dem,dep**,fg,**ginr, glnr**,ke,**lnb,lnf,lni,lnl,lnn**,lon,me,**menr**,mo,**mtfcr,mtff,mtfm, mtfo,mtfs**,na,no,**qunr**,ro,**rrnr,scnp**,sh,st,sto,su,th,**tonp**,tr, **us,wbnp,wch**,we,**wn,wnf,wng,wnlf,wnn,wnnu,wnt**,wy			14	32	21	
Dampiera sacculata	**scnp**			1	1		
Dampiera scaevolina		1					
Dampiera trigona	23579,**lne,lni,lnn,scnp,wch,wnf,wng,wnnu**			4	8		
Dampiera triloba							
Diaspasis filifolia	12951,23579,bu,chs,col,**dech,dej,dep,ginr**,hi,**lnhv**,lon, **mtfcr,mtfm,mtfm**/sh,**qunr,scnp**,th,**tonp,wch,wnf,wnnu**,wy			9	13	8	
Goodenia caerulea	br,**tonp**			1	1	1	
Goodenia claytoniacea	**ls**			1	1		
Goodenia eatoniana	cha,chs,col,**dech,dej,dep**,ea,**glnr,lnh,lnl**,lon,**menr**,mos/**sjm**,			10	19	13	
	mtfcr,mtff,mtfm,mtfo,mtfs,qunr,ro,**rrnr,scnp**,sh,**sjm**,st,th, we,**wnf,wng,wnlf**,wy,ya			1	1	2	
Goodenia filiformis	chs,fg,**ginr**						
Goodenia leptoclada	bu,**glnr**,hi,**mtfcr,mtff,wn,wnf,wng**			3	6	2	
Goodenia micrantha	chs,**lni,scnp,tonp,us/sjm,wch**			6	6	1	
Goodenia pulchella	chs,**dech,dep,lni**,po/**sjm,scnp,wnf**			5	6	2	
Goodenia pusilla	**ca,dej,lnb,mtfcr,qunr,scnp,wch,wn,wnf,wng,wnlf**			7	10	1	
Lechenaultia biloba	12951,br,**glnr,lnq**,me,mos/**sjm,scnp**,sh,sto			4	4	4	
Lechenaultia expansa	12951,chs,**dech,dej,dep**,fg,**glnr,lnn**,me,**mtfcr,qunr,scnp**, th,**tonp,wbnp,wch,wn,wnf**,			10	14	3	
Lechenaultia floribunda							
Lechenaultia tubiflora	lon,to,**tonp**			1	1	1	
Scaevola anchusifolia	**lnn**			1	1		
Scaevola auriculata	cha,do,sw,ye					4	
Scaevola calliptera	**benp**,br,co,**dej**,di1,do,fg,**lnb,lne,lnf,lni,lnn,ls**,me,mos, mos/**sjm,mtff,scnp**,sto,**wnnu**			8	12	8	
Scaevola crassifolia	**dej,dep,lnb,lnh,lni,lnn,lnq**,me,**qunr,tonp,wch,wnf**			6	11		
Scaevola glandulifera	fg,me					1	
Scaevola globulifera	**dej,lnb,lnh,lnl,qunr,scnp,tonp,wbnp,wnf,wnnu**			7	10		
Scaevola lanceolata	**lne,lni,tonp**			2	3		
Scaevola microphylla	br,bu,chl/ha,col,cou,crw,**cs**,da,di2,do,dor,ga,if,ke,me,mo, **mtfcr,mtff,mtfm,mtfs,mtfw**,na,qun6,sw,**us,wbnp**,wi,**wn,wnf, wng,wnlf,wnt**,ye			4	13	20	
Scaevola nitida	**dec,dech,dej,dem,dey,lnb,lnf,lnh,lni,lnl,lnn,lny,ls,qunr, scnp,tonp,wbnp,wch,wnf,wnn**			9	20		
Scaevola striata	23579,bo,bu,col,**dep,glnr**,ke,**lnb**,lon,**mtfcr,mtff,mtfs,qunr**, ro,**rrnr,scnp**,sh,st,th,**tonp,wn,wnf,wng,wnlf,wnnu,wnt**,wy			9	16	10	
Scaevola striata var. striata	**brnp**,col,**deb,dej,dem,dep**,ke,mo,**mtfm,qunr,scnp**,to,**tonp, wbnp,wch,wnf,wnt**			9	13	3	
Scaevola thesioides	**tonp**			1	1		
Scaevola thesioides ssp. thesioides							
Selliera radicans		1					

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Velleia macrophylla	crw,**dec**,**dem**/che,**dep**,ga/**dem**,ja,ke,**lnb**,mos,**scnp**,**wnf**, **wnnu**,**wnt**			4	8	6	
Velleia trinervis	12951,br,**brnp**,cha,chs,**cs**/po,**deb**,**dech**,**dej**,**dem**,**dep**,fg, **ginr**,**lnb**,**lni**,**lnl**,lon,me,**mtfo**,no,**qunr**,**scnp**,**tonp**,**wbnp**, **wch**,we,**wnf**,**wnn**,**wnnu**,ye			12	20	9	
Gyrostemonaceae							
Cypselocarpus haloragoides	**tonp**			1	1		
Gyrostemon sheathii	**dep**,**qunr**,**tonp**,**wbnp**,**wch**,**wnf**,**wnf/wnn**			6	7		
Gyrostemon thesioides	**tonp**,**wch**	2		2	2		
Haemodoraceae							
Anigozanthos bicolor	23579,**wch**			1	1		
Anigozanthos bicolor ssp. decrescens	**mtfs**			1	1		
Anigozanthos flavidus	23579,bb,br,bu,chl,chs,co,col,**cs**,da,**deb**,**dec**,**dech**,dee, **dej**,**dem**,**dep**,**dey**,din,fg,**ginr**,ke,**lnb**,**lne**,**lnhv**,**ls**,mos/ **sjm**,**mtfcr**,**mtff**,**mtfm**,**mtfo**,**mtfs**,na,**qunr**,**scnp**,sw,th,**tonp**,tr, **wbnp**,**wch**,**wnf**,**wng**,**wnlf**,**wnn**,**wnnu**,**wnt**,wy,wy/**dep**,ye			12	30	20	
Anigozanthos humilis	**lnf**			1	1		1
Anigozanthos manglesii ssp. manglesii	**lnb**,**lne**,**lnf**,**lnq**,**lnr**,**scnp**			2	6		
Anigozanthos preissii	23579,lo,**mtfs**,**wbnp**,**wnf**,**wnlf**			3	4	1	
Anigozanthos viridis ssp. viridis	chs,**lni**,me,**scnp**,**wnnu**			3	3	1	
Conostylis aculeata	br,**dey**,din,**lnb**,lon,**scnp**,st,th,**tonp**,**wch**			5	5	5	
Conostylis aculeata ssp. aculeata	23579,br,chl,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,fg,**glnr**,**lnb**, **lne**,**lnf**,**lnh**,**lni**,**lnl**,**lnn**,**lnq**,**lnr**,**lny**,me,**mtfcr**,na,**qunr**,**scnp**, th,**tonp**,tr,**wbnp**,**wch**,wi,**wnf**,**wng**,**wnn**,**wnnu**,ye			10	28	8	
Conostylis aculeata ssp. gracilis	**lnn**,me		ES	1	1		
Conostylis aculeata ssp. preissii	**lnl**,**lnn**			1	2		
Conostylis candicans ssp. calcicola	**lne**,**lny**			1	2		
Conostylis drummondii		R					
Conostylis juncea	br					1	
Conostylis laxiflora	chs,**lni**,**scnp**			2	2	1	
Conostylis serrulata	br,chs,**cs**,**dep**,dor,fg,**lnf**,**mtfo**,**wnf**,wy			5	5	5	
Conostylis setigera ssp. setigera	23579,bu,bur,col,**dep**,fg,**glnr**,**lnb**,**lnq**,**lnr**,**lny**,lon,me,**menr**, mos/**sjm**,**mtfcr**,**mtff**,**mtfm**,**mtfo**,**mtfs**,**qunr**,ra,ro,**rrnr**,**scnp**, sh,st,th,tr,we,**wnf**,**wng**,**wnlf**,**wnt**,wy			10	20	14	
Haemodorum discolor	me						
Haemodorum laxum	23579,br,chs,**dej**,**dep**,fg,**glnr**,lon,me,**mtfcr**,**mtfm**,**mtfs**, **scnp**,**wnf**,**wng**,**wnlf**			5	10	4	
Haemodorum paniculatum	th					1	1
Haemodorum simplex	12951,chs,**lni**,**scnp**			2	2	1	
Haemodorum sparsiflorum	23579,chs,col,**dej**,**dep**,**lni**,lo,**ls**/ba,**qunr**,ra/st,**scnp**,**tonp**, **us**,**wch**,**wnf**,**wnlf**,**wnp**			8	12	6	
Haemodorum spicatum	23579,bu,chs,cl,col,**dech**,**dep**,fg,**glnr**,lon,me,**mtfcr**,**mtfj**, **scnp**,th,**tonp**,**wch**,**wnf**,**wng**,**wnlf**,**wnnu**,**wnp**,**wnt**			7	14	7	
Phlebocarya ciliata	12951,br,chs,**deb**,**dech**,**dej**,**dem**,**dep**,dor,fg,**glnr**,ke,**lnb**,**lnf**, **lni**,**lnq**,**lnr**,**mtfcr**,**mtfs**,**qunr**,**scnp**,sto,th,**tonp**,**wbnp**,**wch**,**wnf**, **wng**,**wnlf**,**wnt**			10	22	7	
Phlebocarya filifolia	**wnn**,ye			1	1	1	
Tribonanthes australis	12951,23579,chs,col,**dech**,**lni**,**lnl**,lon,**lpnr**,me,**mtfj**, **scnp**,**wch**,**wnf**			7	8	3	
Tribonanthes brachypetala							
Tribonanthes longipetala	**tonp**			1	1		
Tribonanthes violacea	chs,col,**dech**,**lne**,**lni/lnq**,**wch**,**wnnu**			4	6	2	
Haloragaceae							
Glischrocaryon aureum	**lni**,**lny**			1	2		1
Gonocarpus benthamii	br,bu,chs,col,**cs**,da,dee,fg,**lni**,**lnl**,**mtfcr**,**mtff**,**mtfm**,po/ja, **wch**,**wnlf**			5	8	9	
Gonocarpus benthamii ssp. benthamii MS	bur,chl,chs,**cs**,**dech**,**lnl**,mos/**sjm**,na,**sjm**,**wch**,ye			5	5	6	
Gonocarpus diffusus	**dech**,**dep**,fg,**lnl**,lon,**mtfcr**,**mtfs**,po/**sjm**,**sjm**,**wnlf**,**wnt**			5	8	3	
Gonocarpus hexandrus	**dec**,**dej**,fg,**lnl**,**mtfo/mtfj**,po/**sjm**			4	6	2	
Gonocarpus hexandrus ssp. hexandrus	**dep**,**mtfm**		E	2	2		
Gonocarpus hexandrus ssp. integrifolius	chl,**qunr**			1	1	1	
Gonocarpus hexandrus ssp. serratus	ba,br,cha,**dec**,dor,ea/if,**lnb**,**wch**			3	3	6	
Gonocarpus nodulosus	**wch**			1	1		1

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Gonocarpus paniculatus	**dej,dem,dep,lnq**,lon,**mtfm,qunr,scnp**,sh,**wch,wnnu**			7	9	2	
Gonocarpus pusillus	chs,**dech,scnp**,sh,**wch**,ye	3	C	3	3	3	
Gonocarpus simplex	col,**dej,dep,ls,mtfs**,ra,ra/st,sh,th,wy	3		3	4	6	
Haloragis acutangula	**tonp**			1	1		1
Haloragis brownii	**benp**,cha,chl,**dem,dey**,dor,**lnhv,lnl,lnr,scnp,wch,wnf, wnn,wnnu**			6	11	3	
Haloragis digyna	**lne,lnf,lnn,tonp,wch**			3	5		
Haloragis tenuifolia	12951	1					1
Haloragodendron glandulosum	**menr**			1	1		
Haloragodendron racemosum	bu,**deb**,sw,**wch,wng,wnlf**			3	4	2	
Meziella trifida	chs,**dep,ls**,**ls**/mos,wy/**sjm**	R	E	3	3	3	
* Myriophyllum aquaticum							
Myriophyllum crispatum	chs,crw					2	
Myriophyllum limnophilum							
Myriophyllum salsugineum	**lnh**			1	1		
Hyacinthaceae							
* Albuca canadensis							1
Hydatellaceae							
Trithuria bibracteata	12951						1
Trithuria submersa							
Hydrocharitaceae							
Halophila ovalis							1
Ottelia ovalifolia	**scnp,wch**			2	2		
Vallisneria nana							
Hypoxidaceae							
Hypoxis glabella	**benp,dem**			2	2		
Hypoxis glabella var. glabella	**lnh**			1	1		
Hypoxis occidentalis	br,**scnp,tonp,wch**			3	3	1	
Hypoxis occidentalis var. quadriloba	**scnp**			1	1		
Iridaceae							
* Babiana angustifolia							
* Chasmanthe floribunda	**lnb**			1	1		
* Crocosmia x crocosmiiflora							
* Ferraria crispa subsp. crispa	**lnb**			1	1		
* Freesia leichtlinii x refracta	**lnl,lny,tonp**			2	3		
* Gladiolus angustus							
* Gladiolus cardinalis	fg					1	
* Gladiolus caryophyllaceus	**lnn**			1	1		
* Gladiolus undulatus	23579,**wbnp,wn,wnf,wng**			2	4		
* Homeria flaccida	**lni,tonp**			2	2		
* Iris germanica							
* Ixia maculata	**wn**			1	1		
* Ixia paniculata							
* Ixia polystachya							
Orthrosanthus laxus var. gramineus							1
Orthrosanthus laxus var. laxus	**dec,dech,dem,dep,dey,lnl,lnn,lny**,me,**scnp,wnp**			4	10		
Orthrosanthus polystachyus	bb,**dech,dej,dem**,do,**lnl**,me,**wn,wnp**		C	3	6	2	
Patersonia babianoides	**dep,mtff,mtfs,qunr**,ro,**rrnr,wnlf**,ye			5	6	2	
Patersonia juncea	12951,chs,**dej**,me,**scnp,wch**,ye			3	3	2	
Patersonia limbata							
Patersonia occidentalis	12951,bu,chs,col,**deb,dec,dech,dej,dep,dey**,fg,**lnb,lne, lnf,lnh,lni,lnl,lnn,lnq,lnr,lny**,lon,me,**mtfcr,mtfm,qunr**,ro, **scnp**,th,**tonp,wbnp,wch**,we,**wnf,wng,wnlf,wnn,wnnu**,wy,ye			9	28	10	
Patersonia pygmaea	**lnl,menr,qunr,rrnr,tonp**,ye			5	5	1	
Patersonia sp.Swamp form (N.Gibson & M.Lyons 544) PN	23579,col,**cs,deb,dej,scnp,wch**			4	5	1	
Patersonia umbrosa	ba,bb,br,bur,chl/ha,co,col,**dec,dech,dej,dep**,di1,fg,gi,**ginr, lnl,ls**,mos,mos/**sjm,mtff,mtfo**,na,no,ra,**scnp,sjm**/usc/csw, sto,sw,**tonp,us,wch,wng,wnlf,wnt**			10	18	18	
Patersonia umbrosa var. umbrosa	bu,col,da,dee,**mtfcr,mtff,mtfs,qunr**,ro,**rrnr**,sh,st,sw,th,**wnf, wng,wnlf,wnnu**,wy,ye			4	9	11	
Patersonia umbrosa var. xanthina	**brnp**,bu,chs,co,col,dee,**dep**,fb,fg,gi,**lnb,lnf,lni,lnl,lny**,me, **mtfcr,mtfm,mtfo**,na,**scnp**,wi,w			5	11	11	

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
* Romulea rosea	**deb,dey,lne,lnh,lnhv,lni,lnl,lnn,lnq,lnr,lny**,me,**qunr,scnp, tonp,wch,wnn,wnnu**			7	17		
* Romulea rosea var. australis							
Sisyrhyncium sp. (B.M.J. Hussey s.n.)	me						
* Sparaxis bulbifera	**lnb,lne,lnl**,me,**wch**			2	4		
* Sparaxis pillansii							
* Tritonia crocata							
* Tritonia lineata							
* Watsonia borbonica							
* Watsonia marginata	**lne**			1	1		1
* Watsonia meriana							
* Watsonia meriana var. bulbillifera	**lne,tonp,wch,wnf**			4	4		
* Watsonia versfeldii var. alba	**wng**			1	1		
Isoetaceae							
Isoetes australis	**mtfw,mucp,wch**,wy			3	3	1	
Juncaceae							
Juncus amabilis	**scnp**			1	1		
* Juncus articulatus	12951,cha,**dec**,dor,**lne,lnq**,me,**scnp,tonp,wnn**			5	6	2	
* Juncus bufonius	bu,**dey**,fg,**ginr,lnb,lne,lnhv,lnn,lnr**,me,**menr,scnp, tonp,us/sjm,wch,wnt**			10	14	2	
Juncus caespiticius	**dec,dech,dej,lne,lnh,lnhv,lnl,lnn,tonp,wch,wn**			5	11		
* Juncus capitatus	chs,fg,**ginr,lnb,lne,lnhv,lnn,lnr**,me,**scnp,wch,wnlf**			5	9	2	
Juncus gregiflorus	**dej/dey,dey,scnp**			2	3		
Juncus holoschoenus	23579,chs,**dec,lne,lnhv,lnr**,me,**scnp,tonp,wch,wnp,wnt**			6	9	1	
Juncus kraussii	23579,**dec,dech,dej,lne,lnl,scnp,wch,wn,wnf,wnn**			5	10		
Juncus kraussii ssp. australiensis	23579,**lnh,scnp,wnnu**			3	3		
Juncus meianthus MS	**wch**	2		1	1		
* Juncus microcephalus	bb,chl,chs,**dec**,fg,**lnb,sbnr,scnp,tonp**,wa,**wn,wnlf,wnt**			6	8	5	
* Juncus oxycarpus	**tonp,wch**			2	2		
Juncus pallidus	chs,**deb,deb/ls**,din,fg,**mtfcr,qunr,scnp,tonp,wch,wnlf,wnnu**			8	9	3	
Juncus pauciflorus	bb,do,**lnb,lne,lnq**,me,**scnp,wnt**			3	5	2	
Juncus planifolius	23579,**dej,ginr,lnb,lne,scnp,tonp,wch,wnlf,wnt**			7	9		
Juncus prismatocarpus							1
Juncus subsecundus	**scnp**			1	1		
Luzula meridionalis	**deb,dec,dey,lni,lnl,lnr,scnp,wnf**			4	8		
Juncaginaceae							
Triglochin calcitrapum	**lne,lnh,lni,lnn,lny**,me,**wch**			2	6		1
Triglochin centrocarpum	12951,**dep,dey,lnb,lnh,lnn,lnq,tonp,wch,wnf**			5	9		
Triglochin huegelii	chl,**dech,dey,scnp,wch**			3	4	1	
Triglochin lineare	**lnhv,wnf**			2	2		
Triglochin minutissimum	**lnh,lnl,lnq**,me,**tonp,wch**			3	5		
Triglochin mucronatum	**lnl**			1	1		1
Triglochin striatum	**dec,dech,dem,dey,lne,lnh,lni,lnl,lnq**,me,**scnp,tonp, wbnp,wch,wnf,wnnu**			7	15		
Triglochin trichophorum	**dec,lnf,lnh,scnp**			3	4		
Lamiaceae							
Genus sp.Nillup (R.D.Royce 98) PN	**scnp**		E	1	1		
Hemiandra australis MS	**dec,dep**	2		1	2		
Hemiandra pungens	12951,23579,**deb/ls,dec,dech,dey,lni,lnn,lny,scnp,wnnu**,ye			5	10	1	
Hemigenia incana	go,**wnnu**			1	1	1	
Hemigenia microphylla	lon,th/ra,**wnlf**	3		1	1	3	
Hemigenia obovata							
Hemigenia podalyrina	**cs,ls,mucp**,pow,sh,**sjm,snp,us,us/cs/sjm,us/sjm**,we,**wnlf**			4	7	3	
Hemigenia rigida	col,**cs,cs/sjm**,lon,**mtfj**,ro,th,**us**,ye			3	4	5	
Hemigenia sericea	**mtff**			1	1		
Hemigenia sp.Albany (G.J.Keighery 8712) PN	br,col,**dej**,hi,lo,**menr,mtfcr,mtff,mtfm,mtfs,qunr,scnp,** th,th/ra,tr,wi			5	8	8	
* Lavandula stoechas	din					1	
* Mentha aquatica							
* Mentha pulegium	dor,**lnb,lne,lnh,mtff,scnp,wbnp,wn,wnf**			5	8	1	
* Mentha spicata	bb,**lne,lnl**,me			1	2	1	
* Mentha suaveolens							
Microcorys virgata	**tonp**	2		1	1		

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Prostanthera serpyllifolia	**tonp**			1	1		1
* Prunella vulgaris	fg					1	
* Salvia verbenaca							
* Stachys arvensis	**scnp**			1	1		
Westringia dampieri	**tonp,wch,wnf**			3	3		
Lauraceae							
Cassytha capillaris	**wch**			1	1		
Cassytha flava	**dem**,ki/dor,**lne,lnf,lnh,lnn,lnq,lnr,lny,scnp**,to,**tonp,wbnp**,ye			5	11	3	
Cassytha glabella	12951,br,bur,col,**dej,dep,dey**,hi,**lnb,lnl,mtfm,qunr,scnp**, sh,sto,**tonp,us,wbnp,wch,wnf,wnt**,wy,ye			10	14	8	
Cassytha glabella forma casuarinae	**qunr**			1	1		
Cassytha glabella forma glabella	**wch,**			1	1		
Cassytha melantha	**tonp**			1	1		1
Cassytha micrantha	bu,chs,**dech**,ga,**glnr,lnb**,mos,**mtfm**,ro,**scnp**,sh,**snp**,th, **tonp,us,wch,wnf,wng,wnlf,wnt**			9	13	7	
Cassytha pomiformis	**glnr**,ke,**ls**,sw,th,**wnf**			3	3	3	
Cassytha racemosa	23579,ba,br,bu,bur,chs,col,da,**dec,dech**,dee,**dej,dem,dep, dey**,do,fg,**ginr,glnr**,ke,**lnb,lne,lnf,lnh,lnhv,lni,lnl,lnn,lnq,lny, mtfcr,mtff,mtfm,mtfs**,po/ja,**qunr,rrnr,scnp**,st,su/**us**,th,to **tonp,wbnp,wch**,wi,**wnf,wng,wnlf**,wnn,**wnnu,wnt**,ye			13	35	18	
Cassytha racemosa forma pilosa	bu,**dep,lnf,mtfcr,mtfo,mtfs,scnp**			4	6	1	
Cassytha racemosa forma racemosa	23579,co,**dep**,di1,fg,**lnb,lni,ls,mtfcr,mtfm,mtfs,scnp**,st,th, **wch,wnf,wng,wnlf,wnnu**,ye			7	13	6	
Lemnaceae							
Lemna disperma	**qunr**			1	1		
Lentibulariaceae							
Utricularia australis	chl					1	
Utricularia benthamii	ca,mos,th					3	
Utricularia inaequalis	chs,ke,**lnh,wch,wnlf**			3	3	2	
Utricularia menziesii	**scnp,tonp,wch,wnf,wnnu**			4	5		
Utricularia multifida	12951,chs,col,**dech,dej,dep,lnh,lnq**,me,**mtfm,qunr,scnp, sjm,tonp,us/cs/sjm,wch**,wn,**wnf,wng**			10	16	2	
Utricularia paulineae			E				
Utricularia simplex	**dej,scnp,wch,wnf,wng**			4	5		
Utricularia tenella	**benp**,col,**dej,lnb**,lon,**lpnr,wch,wng,wnt**			6	7	2	
Utricularia violacea	ke,**lnb,lne,lnh**,th,**wch,wnf,wng,wnlf**			3	7	2	
Utricularia volubilis	**wch,wnlf**			2	2		
Linaceae							
Linum marginale	**lnh,lnhv,lnl,wch**			2	4		
* Linum trigynum	di1,dor,fg						3
* Linum usitatissimum	me						
Lindsaeaceae							
Lindsaea linearis	23579,br,bu,bur,chs,col,crw,**dech**,dee,**dep**,di1,fb,fg,**glnr**, hi,ke,**lnb,lne,lni,lnl,lnn,lnq,lnr,lny**,lon,me,mos**sjm,mtfcr, mtff,mtfo,mtfs,qunr**,ro,**rrnr,scnp**,sh,st,sto,sw,th,**tonp**,tr,**wch, wnf,wng,wnlf,wnnu,wnt**,wy			11	26	22	
Lobeliaceae							
Grammatotheca bergiana	ca,**dec,dej**,do,dor,**lnr,scnp**			3	4	3	
Isotoma hypocrateriformis	bu,chs,**dech,dep**,fg,**lnb,lnh,lni,lnl,lnn,lny**,me,ro,**scnp**,st, **tonp,us,wch,wnf,wng,wnnu**			7	15	5	
Isotoma scapigera	**lnf,lnh,lni,tonp**			2	4		
Lobelia alata	23579,br,chs,**cs,cs/ls,deb,dec,dech,dej,dem,dep**,do,fg, **ginr,lne,lnh,lni,lnl,lnn**,me,mos,**mtfcr**,po/**sjm,qunr,scnp, tonp,us,wbnp,wch**,wn,**wnf,wnn,wnnu**			12	26	6	
Lobelia gibbosa	**dech,dep,lnf,lnh**,no,po,**scnp,tonp,us,wbnp,wch,wnf, wng,wnlf**			8	12	2	
Lobelia heterophylla	chs,**dech,dep,dey**,fg,**lnh,qunr,tonp,wch,wnf,wng,wnnu**			6	10	2	
Lobelia rarifolia	**wnf,wnlf**,ye			1	2	1	
Lobelia rhombifolia	bu,**dep,lnb,lnl,lnn**,me,**scnp,wnlf**,ye			4	6	2	
Lobelia rhytidosperma	**lnl,lny,scnp**,ye			2	3	1	
Lobelia tenuior	**deb,dec,dech,dej,dem,dep,dey,lnb,lnf,lnh,lni,lnl,lnn,lnr, lny**,me,**qunr,scnp,tonp,wbnp**,wch,**wnf,wnn,wnnu**			8	23		
* Monopsis debilis	12951,chs,**lny**,me,**scnp**			2	2	1	

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Loganiaceae							
Logania campanulata	fg,**mtfcr**,**mtfs**,st,**wch**,wy			2	3	3	
Logania fasciculata	**tonp**,**wch**			2	2		
Logania serpyllifolia	**bcp**,bu,chs,col,**cs**/po,da,**dej**,**dep**,do,fg,**glnr**,gry,**lnb**,lon, **menr**,**mtfcr**,**mtff**,**mtfm**,**mtfs**,ro,**scnp**,st,su/**us**,sw,th,**tonp**,**us**, **wbnp**,**wch**,wi,**wn**,**wnf**,**wng**,**wnlf**,**wnt**			12	21	15	
Logania serpyllifolia ssp. angustifolia	chl,**deb**,**dech**,**dej**,**dem**,**dep**,**dey**,fb,fg,**lnf**,**lnh**,**lnhv**,**lnl**,**lnr**,**lny**, me,**qunr**,**scnp**,**tonp**,**wbnp**,wch,**wnf**,**wnn**,**wnnu**			8	20	3	
Logania serpyllifolia ssp. serpyllifolia	ba,bb,br,bur,ca,co,**cs**,**dech**,**dep**,di1,din,**lnf**,lon,**ls**,mos/**sjm**, **mtfs**,na,th/**mtfs**,**tonp**,**wch**,we,**wnf**,**wng**,**wnlf**,**wnt**,ye			8	13	14	
Logania stenophylla	**tonp**			1	1		
Logania vaginalis	**deb**,**dec**,**dech**,**dem**,**dep**,fg,**ginr**,ja,**lnb**,**lnh**,**lnl**,**lnn**,**lnq**,**qunr**, **scnp**,**tonp**,wa,**wch**,wi,**wnf**,**wng**,wnlf,**wnnu**,ye			8	19	5	
Mitreola minima	**mtfcr**,th	2		1	1	1	
Phyllangium divergens	**lnl**			1	1		
Phyllangium paradoxum	12951,bu,chl,chs,**deb**,**dec**,**dech**,**dej**,**dep**,**dey**,**ginr**,**lnf**,**lnn**, **lnq**,**lny**,lon,mos/**sjm**,**mtfm**,**qunr**,**scnp**,**sjm**/**us**,st,**tonp**,**wch**, **wnf**,**wng**,**wnlf**,**wnn**,**wnt**			11	23	6	
Loranthaceae							
Amyema miquelii	**tonp**			1	1		1
Nuytsia floribunda	chs,col,**dech**,**dej**,fb,**glnr**,**lnb**,**lne**,**lnhv**,**lnl**,**lnn**,**lnq**,**lnr**,**lny**,lon, me,**mtfcr**,**mtfm**,**scnp**,sto,th,**tonp**,**wch**			7	16	6	
Lycopodiaceae							
Lycopodiella serpentina	**dej**,**dep**,**ginr**,**mtfm**/sh,ra/st,**tonp**,**wch**,**wnlf**			6	7	3	
Phylloglossum drummondii	chs,**dech**,**lni**,**lnl**,**lnn**,**lny**,me,sto,th/tr/mfs,**tonp**,tr,**wch**,**wnt**			6	8	5	
Lythraceae							
* Lythrum hyssopifolia	do,**lnl**,**wnf**			2	2	1	
Malvaceae							
Alyogyne huegelii	**lnf**			1	1		
Alyogyne huegelii var. glabrescens MS	**lni**			1	1		
Alyogyne huegelii var. huegelii MS	**lnh**			1	1		1
* Anoda cristata							
* Lavatera arborea	**tonp**			1	1		
Lavatera plebeia var. tomentosa	**lnl**			1	1		1
* Malva parviflora	1						
* Modiola caroliniana	do					1	
Sida hookeriana	bab,**dech**,**scnp**,**tonp**,**wch**,**wnt**			5	5	1	
Marsileaceae							
Pilularia novae-hollandiae	**mucp**			1	1		
Menyanthaceae							
Villarsia albiflora	crw,**dech**,**dej**,**dem**,**scnp**,**wch**			3	5	1	
Villarsia lasiosperma	**dech**,**dej**,**scnp**,**wn**,**wnf**			3	5		
Villarsia latifolia	**dec**,**dej**,**lne**,**lnf**,**lnh**,**lni**,**lnq**,**lny**,**scnp**,**wbnp**,**wnp**			5	11		
Villarsia parnassifolia	12951,23579,**deb**,**dech**,**dej**,**dem**,**dep**,go,gry,**lnl**,**mtfcr**, **mtfo**/**mtfj**,**mtfs**,**qunr**,**scnp**,**tonp**,**wbnp**,**wch**,**wn**,**wnf**,**wng**, **wnlf**,**wnn**,wy			9	20	3	
Villarsia submersa	col	4					1
Villarsia violifolia	**dech**,**dej**,**scnp**			2	3		
Mimosaceae							
Acacia aff. pentadenia (A. Annels ARA 1158)	**mtfp**,th,**wng**		E	2	2	1	
Acacia alata	br,**cs**,fg,**lnb**,**lnh**,**lnhv**,**lnl**,me,**mtfcr**,**mtfs**,**scnp**,**tonp**,**wch**,ye			6	10	3	
Acacia alata var. alata	din,if,**lnb**,**lnl**,na,**wch**			2	3	3	
Acacia applanata	**wch**			1	1		1
Acacia biflora							
Acacia browniana	bu,bur,col,**cs**/po,**dech**,**dep**,do,fg,**glnr**,lon,**ls**,me,**mtff**,**mtfo**, **qunr**,sh,th,**wch**,we,**wnlf**,wy			7	10	11	
Acacia browniana var. browniana	12951,br,ca,**dep**,fb,if,mos/**sjm**,na,**scnp**,sh,**wch**,**wnf**,**wnlf**,**wnt**			5	7	7	
Acacia browniana var. obscura	ba,crw,**dech**,do			1	1	3	
Acacia cochlearis	**deb**,**dec**,**dej**,**dep**,**lnh**,**lnhv**,**lni**,**lnl**,**lnn**,**lny**,me,**qunr**,**scnp**,**tonp**, **wbnp**,**wch**,**wnf**,**wnnu**			8	17		
Acacia consanguinea MS							
Acacia crassiuscula	bu,**cs**,**dep**			2	2	1	

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Acacia cyclops	**dec,dech,dej,dey,lnh,lni,lnn,lny,scnp**,wa,**wbnp,wnnu**			5	11	1	
* Acacia dealbata	ye					1	
Acacia divergens	bb,br,bu,bur,col,dee,**dej,dem,dep**,fg,ki/dor,le,**lnb**,lon,**ls**,me, **mtfcr,mtff,mtfo,mtfs**,po/**sjm**,ra,**scnp**,th,tr,**us**,we,wi,**wng, wnlf,wnn,wnp,wnt**,wy,ye			7	17	19	
Acacia extensa	23579,bur,chs,co,col,**dej**,di1,do,**glnr,lni**,lon,me,**mtfcr**,ro, **scnp**,st,th,we,**wnf**,wy			6	6	12	
Acacia gilbertii	car,fg,**lnb,lnq**,tho,wh,wi			1	2	5	
Acacia hastulata	12951,bu,bur,chl,col,**dec,dech**,dee,**dej,dep,dey**,ga,**ginr**,ke, **lnb**,lo,**ls**,mos/**sjm,mtff,mtfo,qunr,scnp**,st,sto,**tonp,wbnp, wch**,we,**wnf,wng,wnlf,wnn,wnt**			12	21	12	
Acacia huegelii	**lny,scnp**			2	2		
Acacia incurva	col,**hrnr**,ra/lo			1	1	3	
Acacia inops	ye	3				1	
Acacia lateriticola	br,**dep,scnp,wbnp**,wi,**wnlf**			4	4	2	
Acacia lateriticola glabrous variant (B.R.Maslin 6765) PN		3	ES				
Acacia leioderma	**dej,tonp**			2	2		
Acacia ligulata	**lny**			1	1		
Acacia littorea	**deb,dec,dech,dej,dem,dep,dey,lnb,lne,lnf,lnh,lni,lnl,lnn, lnq,lnr,lny,qunr,scnp,tonp,wbnp,wch,wnf,wnn,wnnu**			8	25		
* Acacia longifolia ssp. longifolia MS							
Acacia luteola	23579,ro,st			1	1	2	
* Acacia melanoxylon							
Acacia mooreana	do,**lni,lny**,ye	2		1	2	2	
Acacia myrtifolia	12951,23579,bb,br,bu,bur,chs,co,col,crw,**cs/us,dech**,dee, **dej,dep,dey**,di1,din,fg,**glnr**,ke,**lny**,lon,**ls**,mos/**sjm,mtfcr**,mtff, **mtfm,mtfo**,no,**qunr,rrnr,scnp**,st,th,**tonp**,tr,**us/sjm,wch**, we,wi,**wnf,wng,wnlf,wnnu,wnt**,wy			12	24	22	
Acacia nervosa	**lnn**,me			1	1		
Acacia obovata	if,**lnl**			1	1	1	
Acacia paradoxa							
Acacia pentadenia	bu,co,col,**cs**,da,dee,**dep**,di1,**glnr,lnb**,lon,**ls,menr,mtfcr,mtff, mtff/mtfm,mtfm,mtfo,mtfs**,po/**sjm,qunr**,ro,**rrnr**,st,sw,th, **tonp**,tr,**wch,wnf,wng,wnlf,wnnu,wnt**		C	12	21	13	
* Acacia podalyriifolia							
Acacia pulchella	12951,23579,chs,**deb,dec,dech,dej,dem,dep,dey**,fg,**ginr, lnb,lne,lnf,lnh,lni,lnl,lnn,lnq,lnr,lny**,me,**mtfcr,mtff,mtfs**,no, **qunr,scnp**,sto,th,**tonp**,tr,**wbnp,wch,wnf,wng,wnlf,wnn,**			10	31	7	
Acacia pulchella var. glaberrima	**lnf**,me,**mtfw**			2	2		
Acacia pulchella var. goadbyi	23579,**dej**			1	1		
Acacia pulchella var. pulchella	ba,chl,**dech**,di1,do,**lnb,lnl,lnn,ls**,me,**scnp**,sh,**wn,wnnu**			5	8	5	
* Acacia pycnantha	**lpnr**			1	1		
Acacia pycnocephala	wy					1	
Acacia rostellifera	**lne,lnf,lnh,lni,lnl,lnn,lnq,lnr,lny**			1	9		
Acacia saligna	**dej,lni,lny**,me,**tonp**			3	4		
Acacia scalpelliformis	**brnp**,car,**dech,ls,mtfcr,scnp,snp**,wi,**wnlf,wnp**		E	6	8	2	
Acacia semitrullata	fg,**lny**	3		1	1	1	
Acacia stenoptera	**lny**,lon,me,ra/st,wy			1	1	5	
Acacia subracemosa	fg,**lnb,lnf**	2	C	1	2	1	
Acacia tayloriana	**dem**	4		1	1		
Acacia tetragonocarpa	27398,chs,**scnp,wch**			3	3	1	
Acacia trigonophylla	**us/sjm**			2	2		
Acacia triptycha	**cs,lni,mtff,mtfp**,sh			3	4	1	
Acacia truncata	**tonp**			1	1		
Acacia uliginosa	fg,ke,**lnb,scnp,wnf,wnt**			3	4	2	
Acacia urophylla	bb,**benp**,bu,car,**dech,dep**,fb,fg,le,**lnb,ls,mtfcr,mtff,scnp**, sw,**wch**,wi,**wng,wnlf,wnp**,			8	13	8	
Acacia varia var. parviflora							
Acacia varia var. varia							
Acacia willdenowiana	23579						
Paraserianthes lophantha ssp. lophantha	bb,dor,**lnb**,lon,**ls,qunr,sjm,tonp,wbnp,wch,wnlf**			8	8	3	

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Molluginaceae							
Macarthuria apetala	**dech**			1	1		
Moraceae							
* Ficus carica	**lne**			1	1		
Myoporaceae							
Myoporum caprarioides	**lnl,wch**			2	2		
Myoporum insulare	**tonp,wch**			2	2		1
Myoporum oppositifolium	bb,bea,**dej**,gry,**lnb,lnf,lnh,lni,lnr,qunr,scnp**,str,**tonp,wn, wnf,wnn,wnnu**			6	13	4	
Myoporum tetrandrum	23579,**wbnp,wn,wnn**			2	3		
Myrtaceae							
Actinodium cunninghamii	**scnp,wch**			2	2		
Agonis aff. juniperina West Cape Howe (N.Gibson & M.Lyons 456)	**tonp,wch,wn**			3	3		
Agonis aff. linearifolia (A.R. Annels 866)	**dech,mtff,mucp,sjm,wnnu**			5	5		
Agonis flexuosa	23579,bu,chs,da,**deb,dec,dech,dej,dem,dep,dey**,din,fg,if, **lnb,lne,lnf,lnh,lni,lnl,lnn,lnq,lnr,lny**,me,**mtfs,mtsnr,qunr, scnp**,sw,**tonp,wbnp,wch,wnf,wng,wnlf**,wnn,wnnu,**wnp,**			10	31	7	
Agonis flexuosa var. flexuosa	br,co,**dech,dey,ginr,lnb,lnl,lnn,ls**,mos,**mtff**,na,su,**tonp, wnf,wnt**			7	11	5	
Agonis flexuosa var. latifolia	**wbnp,wch,wnf,wnlf,wnn**			3	5		
Agonis floribunda	**dech,scnp**			2	2		
Agonis hypericifolia	bu,bur,col,**cs,dep,glnr**,lon,mos/**sjm,mtfcr,mtff,mtfm,mtfo, mtfs,qunr**,ro,**rrnr**,sh,st,th,**us**,we,**wnf,wng,wnlf**,wy			8	15	11	
Agonis juniperina	chs,**deb,dech,dej**,ga,**ginr,scnp,tonp,wbnp,wch,wnf,wng**			7	10	2	
Agonis linearifolia	bur,chs,co,col,crw,**dech,dej,dem,dep**,fg,**ginr,glnr**,ke,ki/dor, **lnb,lne,lnr**,lon,**lpnr**,mos/**sjm,mtfcr,mtff,mtfo**,ro,**scnp**,th, **tonp,wch**,we,**wnf,wng,wnnu,wnp,wnt**,wy			11	22	15	
Agonis marginata	col,**deb,dep,tonp,wbnp,wch,wnnu**			5	6	1	
Agonis parviceps	23579,ba,br,bu,bur,cha,chs,co,col,crw,**dech**,dee,**dej,dem, dep**,di1,fg,**ginr,glnr**,go,ke,lnb,**lni,lnq**,lon,**ls**,mos,mos/**sjm, mtfcr,mtff,mtfm,mtfo,mtfs,mucp**,na,no,**qunr**,ro,**rrnr,scnp**, sh,st,sto,sw,th,**tonp**,tr,**us,wbnp,wch**,we,**wnf,wng,wnlf, wnnu,wnt**,wy,ye			15	29	29	
Agonis sp.Coarse Agonis (J.R.Wheeler 2939) PN	**dej,dep**/bu,**lnb,ls,mtfo,mtfs**,tr,**wn,wnf,wnlf,wnt**			5	10	2	
Agonis sp.Lake Jasper (B.Hammersley 567) PN	**dech,dej,ginr**,hi,mos,**qunr,scnp**		E	4	5	2	
Agonis spathulata	**wch**			1	1		
Astartea aff. fascicularis	23579,bur,chs,col,**deb,dech,dej,dem,dep**,do,dor,fg,**ginr, glnr**,ke,ki/dor,**lnb,lne,lni,lnl,lnq,lnr**,me,**mtfcr,mtfj,mtfm, mtfo,mtfs,qunr**,ro,**scnp**,st,sto,th,**tonp,us,wbnp,wch**,wn,**wnf, wng,wnlf,wnp,wnt**,wy,ye			12	30	14	
Astartea sp.big bracteoles (A.R.Annels 995) PN	**dep/ls,mtfcr,mtfs,wnlf**		E	4	5		
Astartea sp.Brixton Rd (G.J.Keighery 5389) PN	chs					1	
Astartea sp.Gingalup (N.Gibson & M.Lyons 119) PN	col,**ginr,us**			2	2	1	
Astartea sp.long stalks (D.Foreman 1490) PN	23579,**qunr,wnf**		E	2	2		
Astartea sp.Mt Johnston (A.R.Annels 5645) PN	**dep,mtfj,mtfo,mtfp,mtfw**	2	C	2	5		
Astartea sp.Rivers (K.Newbey 1740) PN	wh					1	
Astartea sp.Scott River (D.Backshall 88233) PN	chs,**dech,dej,ginr,scnp**	4	C	3	4	1	
Astartea sp.wing tips (M.E.Trudgen 12044) PN	ke,ye		C			2	
Baeckea arbuscula	col,**dej,dep,glnr**,lon,**mtff,mtfm,mtfm**/sh,**mtfo,mtfs**, ra,ra/st,sh,sh/**mtfm**,sh/**mtfo/mtfm**,st,st/ro,tr	4	C	3	7	8	
Baeckea astarteoides	lon,**tonp,wnf**			2	2	1	
Baeckea blackettii							
Baeckea camphorosmae	me						

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Baeckea preissiana							
Baeckea pygmaea	col,lo,**mtfj**,**mtfm**,tr			1	2	3	
Beaufortia anisandra							
Beaufortia decussata	**dep**,**glnr**,ke,lon,**mtfcr**,**mtfs**,ro,sh,th,**wch**,**wn**,**wnf**,**wng**,**wnlf**			5	9	5	
Beaufortia sparsa	12951,bu,chs,col,crw,**dech**,**dej**,**dem**,**dep**,**glnr**,ke/sw/or,lon, **mtfcr**,**mtff**,**mtfm**,no,po,**qunr**,**scnp**,sto,th,**us**,**wbnp**,**wch**,**wnf**, **wng**,**wnn**,**wnt**,wy,			9	17	12	
Callistemon glaucus	**dep**,**mtfm**,**mtfo**,sh,th,**tonp**,**wch**,**wnf**,**wnlf**			5	7	2	
Calothamnus graniticus ssp. graniticus	**lnn**,**lny**,me	4		1	2		
Calothamnus lateralis	12951,23579,col,**dech**,**dej**,**dep**,lo,lon,**scnp**,sto,th, th/tr/**mtfs**,tr,**wnf**,wy			4	5	9	
Calothamnus lehmannii	**scnp**			1	1		
Calothamnus pallidifolius	**lne**,**lni**,ye	4		1	2	1	
Calothamnus preissii	23579						
Calothamnus sanguineus	**lnn**,**lnq**,me			1	2		
Calothamnus schaueri	**glnr**,**scnp**,**tonp**,**wch**			4	4		
Calothamnus sp.Scott River (R.D.Royce 84) PN	12951,chs,**scnp**	2	C	1	1	1	
Calytrix acutifolia	**dech**,**dep**,**lnn**,**menr**,**tonp**,**wch**,**wn**,**wnnu**			6	8		
Calytrix angulata	**lnq**			1	1		1
Calytrix asperula	**mtfs**			1	1		
Calytrix flavescens	**dech**,**lnn**,**lnq**,**lny**,**scnp**			3	5		
Calytrix leschenaultii	**scnp**,ye			1	1	1	
Calytrix pulchella		3					
Calytrix tenuiramea	lon,**mtfo**,**mtfs**,th			1	2	2	
Calytrix tetragona	**tonp**			1	1		
Chamelaucium ciliatum	**tonp**			1	1		
Chamelaucium floriferum ssp. diffusum MS	**dech**,**dep**,**menr**	2	E	2	3		
Chamelaucium floriferum ssp. floriferum MS	**wn**,**wnnu**	3	E	1	2		
Chamelaucium forrestii ssp. forrestii MS	**mtfcr**,**mtfp**	2		1	2		
Chamelaucium micranthum	**tonp**			1	1		
Darwinia citriodora	**benp**,**lni**,**lnn**,**lny**,me,**tonp**			3	5		
Darwinia diosmoides	**tonp**,**wch**			2	2		
Darwinia ferricola MS	chs	R	E			1	
Darwinia oederoides	23579,chs,lon,**scnp**,th,**wn**,**wnf**			2	3	3	
Darwinia thymoides	dee,st					2	
Darwinia vestita	23579,lon,**mtfs**,to,**tonp**,**wnf**			3	3	1	
Eucalyptus albida	**wnf**			1	1		
Eucalyptus angulosa	**tonp**,**wch**			2	2		
Eucalyptus brevistylis	col,lon,**mtfcr**,**mtfs**,**mtfs**/lo,**wnlf**	3	E	2	3	3	
Eucalyptus calcicola	**lnb**,**lnf**,**lnh**	4	E	1	3		
Eucalyptus calophylla	23579,ba,**bcp**,br,bu,bur,chs,co,col,da,**dech**,dee,**dep**,di1, din,dor,fg,**glnr**,**lnb**,**lnf**,**lni**,**lnl**,**lnn**,**lnq**,**lny**,lon,**ls**,**menr**,mos/ **sjm**,**mtfcr**,**mtff**,**mtfm**,**mtfo**,**mtfs**,na,**qunr**,ra/st,ro,**rrnr**,**scnp**,sh, st,sw,th,th/tr/mfs,**tonp**,tr,**wch**,**wnf**,**wng**,**wnlf**,**wnnu**,**wnt**,wy			14	29	26	
Eucalyptus conferruminata	**tonp**			1	1		
Eucalyptus cornuta	**deb**,**dep**,**lnf**,**lnh**,**lnl**,**lnn**,me,**tonp**,**wbnp**,**wch**,**wnf**,**wnnu**,**wnt**			6	12		
Eucalyptus decipiens							
Eucalyptus decipiens ssp. chalara							
Eucalyptus diversicolor	ba,bb,br,**brnp**,bu,chs,col,crw,**cs**,da,dee,di1,dor,**lnb**,**lnf**,**lnhv**, **lnl**,**mtfcr**,**mtff**,**mtfm**,**mtfs**,**mtfw**/we,**mtsnr**,na,**rrnr**,**scnp**,st,su, sw,tho,**tonp**,**wch**,**wnf**,**wng**,**wnlf**,**wnnu**,**wnp**,**wnt**		C	10	22	17	
Eucalyptus diversifolia	co					1	
Eucalyptus doratoxylon							
Eucalyptus ficifolia	**glnr**,lon,**mtf**,**mtfcr**,**mtff**,**mtfs**,**mtfs**/mtfc,**qunr**,th,th/tr/**mtfs**, **wnf**,**wng**,**wnlf**,**wnn**		C	4	11	4	
Eucalyptus haematoxylon							
Eucalyptus goniantha ssp. goniantha		4					
Eucalyptus goniantha ssp. notactites	**tonp**			1	1		

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Eucalyptus guilfoylei	bu,col,da,mat,**mtfcr**,**mtff**,**mtfm**,or,**rrnr**,sw,tr,we,**wn**,**wnf**, **wng**,**wnlf**,**wnnu**,**wnt**		E	3	10	8	
Eucalyptus incrassata	**wch**			1	1		
Eucalyptus jacksonii	**wng**,**wnlf**,**wnnu**,**wnt**		E	1	4		
Eucalyptus lane-poolei							
Eucalyptus marginata ssp. marginata	23579,ba,br,bu,bur,chs,co,col,da,**dech**,dee,**dej**,**dep**,di1, din,fg,**glnr**,ke,**lnb**,**lnf**,**lni**,**lnq**,lon,mos/**sjm**,**mtfcr**,**mtff**,**mtfm**, **mtfo**,**mtfs**,na,no,**qunr**,ra/st,ro,**rrnr**,**scnp**,sh,st,sto,sw,th,th/tr/ **mtfs**,**tonp**,tr,**us**,**wbnp**,**wch**,we,**wnf**,**wng**,**wnlf**,wnn,wnnu,**wnt**,wy			13	27	29	
Eucalyptus megacarpa	chs,**dec**,**dej**,ga/**dem**,**lnb**,**lne**,**lnf**,**lnh**,lon,**lpnr**,**menr**,**mtfcr**, **mtff**,**mtfs**,ro,**scnp**,th,**tonp**,**wch**,**wnf**,**wng**,**wnlf**,wnn,**wnnu**, **wnt**,ye			9	21	6	
Eucalyptus missilis MS	**tonp**,**wch**			2	2		
Eucalyptus obtusa MS							
Eucalyptus patens	bu,bur,chl,chs,col,fg,ga/**dem**,**glnr**,lon,**mtfm**,**mtfo**,**mtfs**,ne, ra,ro,**scnp**,sw,th,**wn**,**wnf**,**wng**,**wnlf**,**wnt**,ye			5	11	14	
Eucalyptus phylacis	me	R	ES				
Eucalyptus recondita MS							
Eucalyptus rudis	**dec**,**scnp**			2	2		
Eucalyptus rudis ssp. cratyantha	me	4					
Eucalyptus rudis ssp. rudis	bur					1	
Eucalyptus sp.West Cape Howe (G.J.Keighery 10001) PN	**wch**	4		1	1		
Eucalyptus staeri	**glnr**,**mtfs**/lo,th,**tonp**			3	3	2	
Eucalyptus virginae MS		2	E				
Homalospermum firmum	12951,bu,col,**dec**,**dech**,**dej**,**dem**,**dep**,fg,ke,**lnb**,**ls**,**mtfcr**, **mtfo**,or,po/ja,**qunr**,**scnp**,th,**wbnp**,**wch**,we,**wn**,**wnf**,**wng**, **wnlf**,**wnt**,wy,ye			9	18	11	
Hypocalymma angustifolium	23579,chs,me,**scnp**,th,**wnlf**,ye			2	2	3	
Hypocalymma cordifolium	ba,bu,chs,**dej**,le,lo,lon,or,po/**sjm**,su/**us**,**wnlf**			4	4	9	
Hypocalymma ericifolium	chs,**dej**,**dep**,**glnr**,**scnp**,**wbnp**			4	5	1	
Hypocalymma robustum	**dej**,dor,fg,**lnb**,**lne**,**lnf**,**lni**,**lnn**,**lnq**,**lny**,me,sto,**wnf**,ye			3	9	4	
Hypocalymma scariosum	sto					1	
Hypocalymma sp.Scott River (A.S.George 11773)	12951,br,col,**dech**,**dep**,**scnp**	4	C	2	3	2	
Hypocalymma strictum	**dec**,**dech**,dor,**glnr**,ki/dor,**mtfcr**,**mtfs**,**qunr**,**scnp**,th,to,**tonp**, **wbnp**,**wch**,**wn**,**wnf**,**wng**,**wn**			9	14	3	
Kunzea ciliata	**lni**,**lnq**,**lny**			1	3		
Kunzea clavata							
Kunzea ericifolia	23579,chs,**deb**,**dej**,**lnb**,**lni**,**scnp**,**wch**,**wnf**			5	7	1	
Kunzea ericifolia ssp. ericifolia	23579						
Kunzea glabrescens	**dej**			1	1		
Kunzea micrantha	**dech**			1	1		
Kunzea micrantha ssp. micrantha	**lnf**			1	1		
Kunzea micromera	**menr**			1	1		
Kunzea recurva	12951,23579,27398,chs,**deb**,**dech**,**dej**,**dep**,**glnr**,**lnr**,**qunr**, **scnp**,th,**tonp**,**wbnp**,**wch**,**wnf**,**wng**,**wnlf**,**wnnu**,**wnt**,wy			10	17	3	
Kunzea rostrata	12951,sto,ye					2	
Kunzea spathulata	**dej**			1	1		
Kunzea sulphurea	bo,**cs/ls**,**dech**,**dep**,**dey**,**glnr**,**mtfcr**,**mtfm**,**mtfo**,**mtfs**,**qunr**,th, **wbnp**,**wnf**,**wng**,**wnlf**,**wnn**			7	16	2	
Leptospermum erubescens	chs					1	1
* Leptospermum laevigatum	**lne**,**scnp**,**tonp**			3	3		
Melaleuca acerosa	**deb**,**dech**,**dem**,**dep**,**lnb**,**lne**,**lnf**,**lnh**,**lni**,**lnn**,**lnq**,**lnr**,**lny**,me, **scnp**,**tonp**,**wch**,**wnf**,**wnnu**			6	18		
* Melaleuca armillaris ssp. armillaris							
Melaleuca basicephala	chs,**dech**,**dej**,**dep**,**ginr**,hi,**scnp**,sto,wy	4	E	3	5	4	
Melaleuca blaeriifolia	th,**wnf**			1	1	1	
Melaleuca cordata							
Melaleuca croxfordiae MS	**dep**,**glnr**,**mtfm**,th,**wch**,**wnnu**			5	5	1	
Melaleuca cuticularis	23579,col,**deb**/**ls**,**dej**,**mtfm**,**qunr**,**scnp**,**tonp**,**wnf**,**wng**,**wnn**			7	10	1	
Melaleuca densa	23579,bur,col,lon,**mtfm**,**qunr**,ro,**tonp**,**wbnp**,**wn**,**wnf**			5	6	4	
Melaleuca diosmifolia	**dech**,**qunr**,**wnnu**	3		3	3		

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Melaleuca globifera							
Melaleuca huegelii ssp. huegelii	**lne,lnf,lnh,lni,lnl,lnn,lnq,lny**			1	8		
Melaleuca incana	**dep,lnb,lne,lnn,lny,tonp,wnf,wnnu**			4	8		
Melaleuca incana ssp. Gingilup (N.Gibson & M.Lyons 593) PN	**ginr**	2	E	1	1		
Melaleuca incana ssp. incana	12951,br,chs,**dech,ginr,lnb,lnl,mtfo/mtfj,scnp,tonp,wnf**,ye			7	9	3	
Melaleuca lanceolata	**deb,lnf,lni,lnl,lnn,lnr,tonp**			3	7		
Melaleuca lanceolata ssp. occidentalis	**lnn,lny**			1	2		
Melaleuca lateritia	chs,**dech,dej,ginr**,hi,**scnp**			3	4	2	
Melaleuca microphylla	bb,**cs,cs/ls**,gr,ke,ma,**mtfcr**,na,po/**sjm,wng,wnlf,wnt**			4	7	6	
Melaleuca pauciflora	23579,chs,col,**deb,dech,dej,dep,ginr,mtfm,scnp,wnf**			5	8	2	
Melaleuca pentagona	**tonp,wch**			2	2		
Melaleuca pentagona var. pentagona	**tonp**			1	1		
Melaleuca preissiana	23579,bur,chs,col,**dech,dej,dep**,fb,**ginr,lnf**,lon,**mtfm,scnp**, sto,th,**tonp,us,wnf,wnt**			8	11	7	
Melaleuca rhaphiophylla	12951,23579,col,**dech,dej,qunr,scnp,us,wnf,wnt**			5	7	1	
Melaleuca ringens	**dech,dem,dep**	2	E	1	3		
Melaleuca scabra	th/ra					2	
Melaleuca spathulata	12951,23579,col,lon,**mtfm**			1	1	2	
Melaleuca striata	**wch**			1	1		
Melaleuca thymoides	12951,23579,**dech,dej,dem,dep**,dor,fb,**glnr,lni,lnq,lny, mtfcr,mtfm,mtfo,mtfs**,no,**qunr**,ro,**scnp**,sto,th,to,**tonp**,wbnp, **wch,wn,wnf,wng,wnlf,wnnu**,wy			10	22	7	
Melaleuca viminea	bal,**dej,tonp,wbnp,wnf,wnnu**			4	5	1	
Melaleuca viminea ssp. demissa MS	**deb,tonp,wch,wnf,wnnu**			4	5		
Melaleuca viminea ssp. viminea	**wnf**			1	1		
Melaleuca violacea	lon,th						2
Micromyrtus racemosa var. carinata MS	**lny**			1	1		
Pericalymma crassipes	23579,chs,**dech,dej,dep,ginr,glnr**,lon,**mtfcr,scnp**,sto,th, **tonp,wbnp,wch,wnf**			9	11	4	
Pericalymma ellipticum	12951,23579,chs,col,**dech,dej,dep,mtfcr,mtfm,qunr, scnp**,st,**wch**			5	8	3	
Pericalymma ellipticum var. ellipticum MS	**dej,scnp,wnlf**			3	3		
Pericalymma megaphyllum MS			E				
Pericalymma spongiocaule MS	23579,col,**scnp**,sto			1	1	2	
Rinzia schollerifolia							
Thryptomene hyporhytis	**dey/dej**			1	2		
Thryptomene saxicola	**lnh,lnn,tonp,wch**			3	4		
Verticordia fimbrilepis ssp. australis	ra/st,st	R	C			2	
Verticordia lehmannii	chs,**scnp,wnnu**	4		2	2	1	
Verticordia plumosa	12951,**dech,mtfp,tonp,wch,wnf**			5	5		
Verticordia plumosa var. brachyphylla	**scnp**			1	1		
Verticordia plumosa var. plumosa	br,**dech,dep,lnq,mtff**,ra/st,**tonp,wbnp,wnnu**			6	7	3	
Najadaceae							
Najas marina	**dem**			1	1		
Nymphaeaceae							
* Nymphaea odorata							
Olacaceae							
Olax benthamiana	**lnh,lnl**,th,**wbnp**,ya/wh			2	3	3	
Olax phyllanthi	23579,bur,**dec,dech,dej**,**dem**,**dep,dey**,ga/**dem**,mos/**sjm, mtfo,mtfs**,no,**qunr**,ra,th,**tonp,wbnp,wch**,we,**wnf,wng,wnn, wnnu,wnt**,wy			8	18	8	
Onagraceae							
Epilobium billardierianum	chs,fg,**lnl,lnq,qunr,scnp,tonp,wch**			5	6	2	
Epilobium billardierianum ssp. billardierianum	**dech,lni,lnl,lnn,lny,tonp,wbnp,wch**			5	8		
Epilobium billardierianum ssp. cinereum	**wnlf**			1	1		
Epilobium billardierianum ssp. intermedium	**dech**			1	1		
* Epilobium ciliatum	**wch**			1	1		
Epilobium hirtigerum	dor,**lne,lni,lny**			1	3	1	

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* Oenothera glazioviana							
* Oenothera stricta ssp. stricta	**lne**			1	1		
Ophioglossaceae							
Ophioglossum lusitanicum	**dech,lnh,lni,lnn,lny,wch**			3	6		
Orchidaceae							
Caladenia abbreviata MS	**lnh,lni,scnp,wnnu**	2	E	3	4		
Caladenia applanata ssp. applanata MS	**lnf,lni,lnl,lnn,lnq,lnr,lny**,me,**qunr,wbnp,wch**		ES	4	10		
Caladenia applanata ssp. erubescens MS	**wbnp,wnf**		E	2	2		
Caladenia arrecta MS	br,**lnb**	4		1	1	1	
Caladenia attingens ssp. attingens MS	br,**dem**,le/go,**lnb,lni,lnn,lnn/lny,lnq,lny**,me,**wnnu**			3	7	3	
Caladenia bicalliata ssp. bicalliata	**lne,lnf,lnr,wbnp**			2	4		
Caladenia brownii MS	**dech,dep**,fb,gi,**lnhv**,lon,me,**mtfm**/sh,**scnp,wch,wng,wnlf,wnt**			6	9	4	
Caladenia caesarea ssp. maritima MS	me	R	ES				
Caladenia cairnsiana	**dem,dey,lnb,lnhv,lni,lnn,lny,qunr,scnp,wbnp,wnf/wnnu**			6	12		
Caladenia chapmanii MS	**lni,lnn,lny**,me			1	3		
Caladenia citrina MS	br,fg		C			2	
Caladenia corynephora	**dech,lnhv,lnl,mtfs,wnlf**			4	5		
Caladenia ensata	chl,**dep**,lon,**mtfo,scnp,tonp**			4	4	2	
Caladenia evanescens MS			E				
Caladenia excelsa MS	**lne,lni,lnl,lnn,lnq,lnr,lny**	R	E	1	7		
Caladenia ferruginea	**lnb,lne,lnh,lni,lnl,lnn**,me			1	6		
Caladenia flava	br,bu,chs,col,**dec,dech**,dee,**dej,dem,dep,dey**,fg,**lnb,lne,lnf,** **lni,lnl,lnn,lnq,lny**,lon,me,**mtf**,cr,**mtfm,mtfs,qunr,scnp**,st,th, **tonp,wch,wnf,wnlf,wnnu**			8	24	9	
Caladenia flava ssp. flava MS	mos,**wnnu**,ye			1	1	2	
Caladenia flava ssp. sylvestris MS	**dep**,dor/su,**mtfs,snp**			3	3	2	
Caladenia gardneri MS	chl,**dec,dej,dem,dey,lni,lnl,lny**,me,**scnp**		E	3	8	1	
Caladenia georgei MS	chl,**lne,lni,lnn,lny**,me,**scnp**			2	5	1	
Caladenia granitora MS	**tonp**	2		1	1		1
Caladenia harringtoniae MS	bea,**benp**,car,mtft,ne/ca,ya	R		2	2	5	
Caladenia heberleana MS							
Caladenia hirta ssp. hirta MS	chs,**dep**,fg,**lnb,lne,lnf,lni,lnl,lnn,lnq,lny**			2	9	2	
Caladenia huegelii	**lni,lny**	R		1	2		
Caladenia infundibularis	br,**lnb,lne,lnf,lnh,lnhv,lni,lnl,lnn,lnq,lnr,lny**,ne,**scnp**			2	12	2	
Caladenia interjacens MS	**deb,dem,dep,wn,wnnu**	4	E	2	5		
Caladenia latifolia	bu,**deb,dec,dech,dej,dem,dep,dey,lnb,lne,lnhv,lni,lnl,lnn,** **lnq,lny**,me,**mtfs,scnp**,tr,**wbnp,wch,wnf,wng,wnnu**			7	22	2	
Caladenia longicauda	chs,**dem,scnp,tonp,wch**			4	4	1	
Caladenia longicauda ssp. clivicola MS	**lnn**,me	1		1	1		
Caladenia longicauda ssp. longicauda MS							
Caladenia longicauda ssp. merrittii MS	**lnb**			1	1		
Caladenia longiclavata	bu,chs,**cs**,fg,**mtfcr**,mu,**scnp,wch**			4	4	4	
Caladenia macrostylis	chs,fg,**lnb,lnf,lnhv,lni,lnl,lnn**			1	6	2	
Caladenia magniclavata	**dec,dep,mtff,mtfm,mtfs,wnlf**			3	6		
Caladenia marginata	12951,chs,**dep,lnb,lnf,lnh,lnhv,lnl**,lon,**scnp**,wy			3	7	3	
Caladenia meridionalis MS	**deb,dem,dep,qunr,wnnu**		ES	3	5		
Caladenia nana	chs,**lnb,lne,lnl,lnn,lnq,mtff,scnp,wch**			4	8	1	
Caladenia nana ssp. nana MS	**dep**,ke,**wch**			2	2	1	
Caladenia nana ssp. unita MS	**dem,dep,mtff,wnf,**			3	4		
Caladenia nivalis MS	**lni,lnn,lnq,lny**		E	1	4		
Caladenia paludosa MS	**lnl**,me			1	1		
Caladenia pectinata	col,**wch**			1	1	1	
Caladenia pendens MS	**dep,wnnu**			2	2		
Caladenia pholcoidea MS	**dep,lnhv**			2	2		
Caladenia plicata	**wn**	4		1	1		
Caladenia radiata							
Caladenia reptans ssp. reptans MS	chs,fg,**lnb,lne,lnl,lnn,lnq,scnp,tonp**			3	7	2	
Caladenia rhomboidiformis	**lnb,lne,lni,lnq**			1	4		
Caladenia serotina MS	**dep**			1	1		
Caladenia thinicola MS	lon,**mtfs**,st		E	1	1	2	
Caladenia viridescens MS	me	R					
Calochilus aff robertsonii	fb,**wbnp**			1	1	1	
Corybas abditus							

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Corybas despectans	**wnnu**			1	1		
Corybas recurvus	**benp**,bu,da,dee,**dep**,**lnb**,**mtfcr**,**mtff**,**mtfm**,**tonp**,tr,**wnf**,**wng**, **wnlf**,**wnnu**,ya			6	11	5	
Cryptostylis ovata	23579,bu,co,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,di1,ke,**lnb**, lon,qui,**scnp**,**tonp**,**wch**,**wnf**,**wnlf**,**wnn**,**wnnu**			6	15	6	
Cyanicula deformis MS	chs,**tonp**,**wnnu**			2	2	1	
Cyanicula gemmata MS	chs,**dem**,**dep**,fg,**tonp**,**wch**,**wn**			4	5	2	
Cyanicula gertrudiae MS	**deb**,**dep**			1	2		
Cyanicula sericea MS	chs,fg,**lnb**,**lnh**,**lnl**,**scnp**,**snp**,**wch**,**wng**,**wnlf**			5	8	2	
Cyrtostylis huegelii	**benp**,**dec**,**dep**,**dey**,fg,go,**lnb**,**lny**,**mtfcr**,**mtfm**,na,**tonp**,**wbnp**, **wn**,**wnnu**			7	12	3	
Cyrtostylis robusta	col,fb,gr,gry,**mtfcr**,sw,**tonp**,**wch**			3	3	5	
Cyrtostylis tenuissima	**dep**			1	1		
Diuris aff amplissima	**dec**,**dep**,**lni**,**lnn**,**wbnp**,ye			3	5	1	
Diuris aff. corymbosa	chs,fg,me					2	
Diuris drummondii	**qunr**	R		1	1		
Diuris emarginata	**wnf**			1	1		
Diuris heberlei	**dem**	2		1	1		
Diuris laevis	**scnp**,**wnnu**			2	2		
Diuris laxiflora	chs,**wnf**,**wnt**			1	2	1	
Diuris longifolia	12951,23579,col,**dej**,**dem**,**dep**,gi,**lnb**,lon,**mtfcr**,**mtfs**,ro, **scnp**,st,**tonp**,tr,**wch**,**wnlf**,ye			7	10	7	
Diuris pauciflora	**qunr**,**wnf**			2	2		
Drakaea glyptodon	12951,bu,cl,crw,**dech**,**dej**,**dem**,**dep**,**dep/ls**,fg,ke,**lnb**,**lni**, **lnq**,**lnr**,**mtfo**,**scnp**,sh,st,th,**wng**,			6	13	8	
Drakaea livida	ca,**dech**,**dem**,**lnq**,**tonp**,**wch**,**wng**,**wnlf**			5	7	1	
Drakaea micrantha MS	lo/**mtfo**,**mtfo**	R		1	1	1	
Drakaea thynniphila	12951,ca,chl,col,**dech**,**dej**,**lnf**,**mtfo**,sto,th,**wbnp**,**wnf**,**wnlf**,**wnt**			5	8	5	
Elythranthera brunonis	12951,23579,chs,**dech**,**dej**,**dep**,**dey**,fg,**lnb**,**lnn**,lon,**mtfs**, **qunr**,**scnp**,st,**wch**,**wnf**,**wnlf**,w			7	13	4	
Elythranthera emarginata	23579,**deb**,**lnn**,lon,**scnp**,st,**tonp**,**wch**,**wnf**,**wnlf**			6	7	2	
Epiblema grandiflorum var. grandiflorum	23579,col,**dech**,**scnp**,**wch**,**wnf**,**wnlf**			4	5	1	
Eriochilus dilatatus	12951,br,bu,**deb**,**dec**,dee,**dep**,**dey**,**mtff**,**mtfm**,**qunr**,**scnp**,st, **tonp**,**wch**,**wnf**,**wng**,**wnlf**,			7	14	4	
Eriochilus dilatatus ssp. dilatatus MS	**dep**,**lnq**,**menr**,**tonp**,**wbnp**,wi,**wnf**,**wnnu**,**wnt**			6	8	1	
Eriochilus dilatatus ssp. magnus MS	bb,**dech**,**dep**,fg,go,**wnp**			2	3	3	
Eriochilus dilatatus ssp. multiflorus MS	ca,chs,**dep**,fg,qun6,**us**			2	2	4	
Eriochilus helonomos MS	chs,dee,**mtff**,**mtfj**,sh			1	2	3	
Eriochilus pulchellus MS	bu,**dech**,dee,**dep**,**menr**,**mtff**,**mtfj**,**sjm**,**tonp**,**us**,**us/sjm**,**wnf**, **wng**,wy			7	10	3	
Eriochilus scaber	**scnp**,**tonp**,**wch**,**wng**,**wnlf**			4	5		
Eriochilus scaber ssp. orbifolia MS	**wnnu**	1	E	1	1		
Eriochilus scaber ssp. scaber MS	**dem**,**wnf**,**wng**			2	3		
Eriochilus tenuis							
Eriochilus valens MS	bu,**dep**,**wng**,wy		C	2	2	2	
Gastrodia lacista	**mtfcr**,th,**wnlf**			2	2	1	
Leporella fimbriata	chs,fg,**scnp**,th,**tonp**,**wch**,**wnf**,**wnt**			4	5	3	
Leptoceras menziesii	br,chs,fg,**lnl**,**mtfcr**,na,**scnp**			3	3	4	
Lyperanthus serratus	**lnb**,**lnl**,me,**mtfm**,**scnp**,th,**wbnp**,**wch**,**wnf**,**wnnu**			6	8	1	
Microtis aff. alba (A.R.Annels 418)	**dej**,**dem**,**ginr**,**scnp**			3	4		
Microtis alba	12951,**dech**,**dep**,**dey**,lon,**scnp**,**tonp**,**wch**,**wng**,**wnlf**			5	8	1	
Microtis atrata	chs,**dech**,**dep**,**tonp**,**wch**,**wnlf**,**wnn**,wy,ye			4	6	3	
Microtis brownii	**dech**,**dep**,**ginr**,**us**,**wnlf**,**wnt**			4	6		
Microtis familiaris	**qunr**		E	1	1		
Microtis globula	**wnlf**	R	C	1	1		
Microtis media	12951,23579,chs,**dec**,**dech**,**dem**,**dey**,fg,**lnf**,**lnh**,**lni**,**mtfs**, **qunr**,**scnp**,**tonp**,**wch**,**wn**,**wnf**,**wng**,**wnlf**			8	16	2	
Microtis media ssp. densiflora	**dem**,**tonp**			2	2		
Microtis media ssp. media	**dech**,gry,li,**lnhv**,**scnp**,tr,**wbnp**,**wnnu**			5	5	3	
Microtis media ssp. quadrata	**dep**	4		1	1		
Microtis orbicularis	chs,**dep**,lon,**wch**			2	2	2	
Microtis pulchella	**dep**,**qunr**,**wch**,**wnlf**	4	C	4	4		

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
* Monadenia bracteata	**qunr,scnp,tonp,wch,wnnu**			5	5		
Paracaleana linearifolia MS	lon					1	
Paracaleana nigrita	cl,sto,**wnf,wng,wnlf**,wy			1	3	3	
Paracaleana triens MS	qui					1	
Praecoxanthus aphyllus MS	chs,**dech,dej,dep,scnp,tonp,wbnp,wch,wnf,wng,wnlf**,ye			6	10	2	
Prasophyllum aff. parvifolium (A.R. Annels 282)	23579,chs,**dej,dep,dey,qunr,scnp,tonp,wch,wnf,wng,wnn**			6	10	1	
Prasophyllum brownii	23579,da,dee,**dej,ginr**,lon,**mtfcr,mtfs,rrnr,scnp**,sh,**wng**			6	7	4	
Prasophyllum calcicola MS	**scnp**			1	1		
Prasophyllum cucullatum	**dep**			1	1		
Prasophyllum cyphochilum	lon					1	
Prasophyllum drummondii	**qunr,wch,wnf,wng,wnlf,wnn**			3	6		
Prasophyllum elatum	chs,**lnl,scnp,tonp,wch,wng**			5	5	1	
Prasophyllum fimbria	**tonp,wng,wnlf**			2	3		
Prasophyllum gibbosum	dor,**sjm/us**,th,**wng**			3	3	2	
Prasophyllum giganteum							
Prasophyllum gracile	chs,**scnp,wbnp**			2	2	1	
Prasophyllum hians	**lnh,scnp,wn,wng**			3	4		
Prasophyllum macrostachyum	**dep,scnp,tonp,wch**			4	4		
Prasophyllum odoratissimum	**dem,tonp,wbnp,wng**			4	4		
Prasophyllum parvifolium	**dep**,lnr,**scnp,tonp,wnf,wnn,wnnu**,ye			5	7	1	
Prasophyllum plumiforme	col,**tonp,wch**			2	2	1	
Prasophyllum regium	12951,**dep**,ro,**tonp,wnlf,wnn,wnt**			3	5	1	
Prasophyllum triangulare	**dec**			1	1		
Pterostylis aff. nana (A.R. Annels 1178)	ba,bu,bur,col,da,**deb,dec,dej,dep,dey**,di1,fg,**ginr**,if,ke,**lnb, lnf,lny**,lon,**ls,menr**,mos/**sjm,mtfcr,mtff,mtfm,mtfs**,pow,qun/**sjm,scnp**,sw,th,**tonp,wch,wnf,wng,wnnu**,wy			11	22	16	
Pterostylis aff. turfosa (W. Jackson BJ 360)	st,**wnt,wnlf**			2	3	1	
Pterostylis aspera	**dec,dep**			1	2		
Pterostylis barbata	**cs,dep**,fg,**lnb**,mos,**mtfs,scnp,sjm,snp,tonp,wnnu**,wy			8	9	3	
Pterostylis dilatata	**wch**			1	1		1
Pterostylis plumosa	bu,**wch**			1	1	1	
Pterostylis pyramidalis	br					1	
Pterostylis recurva	br,chs,col,**dej,dep**,fg,**lnb,lni,qunr**,ro,th,**tonp,wch,wng**			6	8	6	
Pterostylis rogersii	**dep,lny,tonp,wch**			4	4		
Pterostylis scabra	**wch**			1	1		
Pterostylis turfosa	bu,**dech,dej,dep,wch,wnnu**	1		2	6	1	
Pterostylis vittata	23579,br,bu,bur,chs,col,**deb,dech**,dee,**dep**,din,fg,gry,**lnb, lny**,lon,**mtfcr,mtff,mtfm,scnp**,sh,sw,**tonp**,tr,**wbnp,wch,wnf, wng,wnnu**			8	15	13	
Pyrorchis forrestii	12951,**dech**,fb,**scnp**			2	2	1	
Pyrorchis nigricans	br,chs,co,**deb,dep**,fg,**lnb,lnf,qunr,scnp**,sto,**tonp,wbnp,wch, wnf,wnlf,wnn**			8	12	5	
Thelymitra aff. holmsii (J.R. Wheeler 3399)	**dech,dem,dep**,fg,**ginr,qunr**,ro,**scnp**,st,wa,**wnf,wng,wnn, wnnu**			5	10	4	
Thelymitra aff. macrophylla (C.J. Robinson 201)	**lnl,scnp,wnp**,ye			3	3	1	
Thelymitra aff. pauciflora (G.J. Keighery 5271)	**lnh,tonp**			2	2		
Thelymitra antennifera	chs,lon,**mtfcr,qunr,tonp,wnf,wnnu,wnt**			4	6	2	
Thelymitra benthamiana	**dech,wch,wn,wnnu**			3	4		
Thelymitra canaliculata	chs,**glnr**,th,**wch**,we,**wnf,wnlf,wnnu**			3	5	3	
Thelymitra cornicina	**dej,scnp**,ye			2	2	1	
Thelymitra crinita	**dej,dey,ginr**,lon,**mtfcr,mtfs,qunr**,ro,**scnp**,th,**tonp,wch,wn, wng,wnlf,wnn**,ye			8	13	4	
Thelymitra cucullata	**tonp,wch,wnlf**			3	3		
Thelymitra flexuosa	12951,chs,**dech,dej,lnf,scnp,tonp,wch,wng,wnlf**			6	8	1	
Thelymitra fuscolutea	ce,chs,**dej**,ke,**lnl,lny,qunr,scnp,wnlf**			5	6	3	
Thelymitra granitora	**lnl,wch**			2	2		
Thelymitra jacksonii MS	dee,**dep**	3	E	1	1	1	
Thelymitra macrophylla	23579,bu,col,**dep**,lon,me,**mtfcr,mtfs,qunr**,st,th,tr,**wnf**			4	5	6	1
Thelymitra mucida	chs,**dey**,ye			1	1	2	
Thelymitra pauciflora	**dep,mtfcr,mtfm,qunr**,ro,**scnp**,st,th,**tonp,wch,wnf,wng,wnlf**			7	10	3	1

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Thelymitra spiralis							
Thelymitra tigrina	**dech**,lo,**wch**,**wng**,**wnlf**			3	4	1	
Thelymitra variegata	me						
Thelymitra villosa	chs					1	1
Orobanchaceae							
* Orobanche minor	**dep**,**dey**,**lne**,**lnf**,**lnh**,**lni**,**lnl**,**lnn**,**lnq**,**lny**,**lpnr**,me,**qunr**,**scnp**, **tonp**,**wbnp**,**wch**,wnn,wnnu			9	18		
Oxalidaceae							
* Oxalis corniculata	bb,chl,**dec**,**dej**,**dem**,**dep**,**lnb**,**lnh**,**lnl**,**lnn**,**lnq**,**lny**,**qunr**,**wnf**,**wng**			4	13	2	
* Oxalis corymbosa							
* Oxalis flava							1
* Oxalis glabra	fg,**wnf**			1	1	1	
* Oxalis incarnata	**wch**			1	1		
Oxalis perennans							1
* Oxalis pes-caprae	**lne**,**lnq**,me,**wch**			2	3		
* Oxalis purpurea	me,**qunr**			1	1		
Papaveraceae							
* Eschscholzia californica							
* Romneya coulteri							
Papilionaceae							
Aotus carinata	chs,**dej**,lon,**scnp**	4	ES	2	2	2	
Aotus cordifolia	**lnb**	3		1	1		
Aotus genistoides	**glnr**,lon,**mtfcr**,th,**wnf**,**wng**			3	4	2	
Aotus gracillima	**dej**			1	1		
Aotus intermedia	23579,bu,chs,co,**dec**,**dech**,**dej**,**dep**,**lni**,**lpnr**,**mtfo**,**mtfs**, **scnp**,**tonp**,**wch**			7	11	3	
Aotus passerinoides	col,**dech**,**dep**,ja,**mtfm**,**mtfm/mtfo**,wy			2	4	3	
Aotus phylicoides							
Aotus procumbens	me						
Aotus sp.Scott River (K.F.Kenneally 2371) PN	**dej**,**scnp**,**wnf**,**wnlf**		C	3	4		
Bossiaea aquifolium	an/ba,ba,ea,kea,le,**lne**,**lnq**			1	2	5	
Bossiaea aquifolium ssp. aquifolium	ba,be,ye					3	
Bossiaea aquifolium ssp. laidlawiana	bb,bb/co,**benp**,**brnp**,cha,di1,fb,go,le,li,ne,**wch**,wh/le, **wng**,**wnp**,ya			4	5	11	
Bossiaea dentata							
Bossiaea disticha	br,fg,**lnb**,**lne**,**lnf**,**lnh**,**lnhv**,**lnl**,**mtfs**	3	E	2	7	2	
Bossiaea eriocarpa	**lnf**,**lnl**,**lny**,**mtff**,**mtfm**,**mtfs**			2	6		
Bossiaea linophylla	23579,br,chs,co,col,**deb**,**dec**,**dech**,dee,**dej**,**dem**,**dep**,**dey**, di1,din,dor,fg,**glnr**,go,**lnb**,**lne**,**lnf**,**lnh**,**lnl**,**lnr**,**lny**,**ls**,me,mos/ **sjm**,**mtfcr**,**mtff**,**mtfo**,**qunr**,ro,**rrnr**,**scnp**,th,**tonp**,tr,**wbnp**,**wch**, wi,**wn**,**wnf**,**wnlf**,**wnn**,**wnnu**,wy			13	31	16	
Bossiaea ornata	bur,chs,col,**dep**,din,fg,**glnr**,if,**lne**,**lnl**,lon,me,**mtfcr**,**mtff**, **mtfo**,**mtfs**,na,ro,**scnp**,sh,st,th,wi,			6	10	13	
Bossiaea praetermissa	12951,**dech**,fg,ga/**dem**,**scnp**,**tonp**,**wbnp**,**wch**,**wnf**,**wnlf**			6	8	2	
Bossiaea rufa	br,chs,co,**dec**,**dech**,**dej**,**dem**,**dep**,dor,fg,**glnr**,ke,li,**lnb**,**lne**,**lnl**, lon,**mtfcr**,**mtfs**,no,**qunr**,ro,**scnp**,th,**tonp**,**wbnp**,**wch**,**wnf**,**wng**, **wnlf**,**wnnu**,**wnt**,wy			10	21	12	
Bossiaea webbii	bu,cha,col,da,dee,**dep**,**mtff**,**mtfo**,or,sh,sw,**wnf**,**wnlf**,**wnnu**,**wnt**			3	7	8	
Brachysema melanopetalum	ch,lon					2	
Brachysema minor	23579						
Brachysema praemorsum	**lny**			1	1		
Brachysema sericeum	23579,**tonp**,**wn**,**wnf**			2	3		
Callistachys lanceolata	23579,bb,br,co,**cs**,**cs/us**,**deb**,**dec**,**dech**,**dey**,din,ga/**dem**,go, ke,**lnb**,**lne**,**lnl**,**ls**,me,mos,na,po/**sjm**,**qunr**,**scnp**,**tonp**,**us**, **wbnp**,**wch**,**wnf**,**wnlf**,**wnn**,**wnnu**,**wnp**,**wnt**			10	23	10	
* Chamaecytisus palmensis							
Chorizema aciculare	me,**mtfs**			1	1		
Chorizema aciculare ssp. aciculare	me						
Chorizema carinatum	chs	3				1	1
Chorizema cordatum	fg,**lny**			1	1	1	
Chorizema diversifolium	bu,**deb**,**dech**,**dej**,**dep**,**dey**,if,li,**lnb**,**lne**,**lnf**,**lni**,**lnl**,**lny**,**qunr**, **scnp**,**wch**,**wnf**,**wnlf**,**wnn**,**wnnu**			6	19	3	

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Chorizema glycinifolium	ce,**dech**,**dem**,**tonp**,**wbnp**,**wch**,**wnf**			5	6	1	
Chorizema ilicifolium	br,chs,**dech**,**dem**,**dep**,fg,**lnh**,**mtff**,**qunr**,**scnp**,**tonp**,**wch**, **wnf**,**wnnu**,**wnt**			8	12	3	
Chorizema nanum	cha,**dep**,din,do,gry,**lnb**,**lnq**,**lny**,qun6,**us/cs/sjm**,wi,**wng**,**wnnu**			5	8	6	
Chorizema reticulatum	mcnr,me,th	3		1	1	1	
Chorizema retrorsum	bu,co,col,crw,**cs**,**cs**/ja,da,de,**dech**,dee,fb,**ls**,**mtfcr**,**mtff**,**mtfm**, **mtfo**,**mtfs**,na,**rrnr**,sh,st,sw,th,tr,**us**,**wnf**,**wng**,**wnlf**,**wnt**			5	15	14	
Chorizema rhombeum	col,**dej**,**dep**,**lnb**,**lnn**,**lny**,**ls**,me,**mtfcr**,**mtff**,**mtfs**,po/**sjm**,th, **tonp**,**us**,**wch**,wi,**wnf**,**wnlf**			8	15	4	
Chorizema spathulatum	**mtfcr**,st			1	1	1	
* Crotalaria agatiflora ssp. agatiflora							
Daviesia alternifolia	23579						
Daviesia anceps							
Daviesia angulata							
Daviesia cordata	bur,chs,col,fb,lon,me,**mtfcr**,**mtfs**,na,ro,**scnp**,st			2	3	8	
Daviesia decurrens	12951,**glnr**,**mtfcr**,**mtfm**,**mtfs**,**qunr**,**scnp**,th,**wnf**,**wng**			5	8	1	
Daviesia divaricata	**lnn**,**lnq**,**lny**,me			1	3		
Daviesia flexuosa	**glnr**,**mtfm**,**qunr**,**scnp**,th,**wnf**,**wnlf**			5	6	1	
Daviesia horrida	br,**lny**,me			1	1	1	
Daviesia inflata	23579,col,**dech**,fb,**ginr**,hi,if,ke,**lny**,**scnp**,sto,**tonp**,**wbnp**,**wnf**,ye			7	7	7	
Daviesia longifolia	me						
Daviesia preissii	be,**mtfcr**,**mtfs**,st,**wnf**,**wnlf**			2	4	2	
Dillwynia sp.A Perth Flora (R.Coveny 8036) PN	**dech**,**lnn**,lon,**mtfp**			3	3	1	
Dillwynia uncinata	ye					1	
Dillwynia uncinata var. Capel (R.D.Royce 4853) PN							
* Dipogon lignosus	fg					1	
Euchilopsis linearis	12951,**dej**,**glnr**,**lni**,**scnp**,sto,th,**wnnu**			5	5	2	
Eutaxia cuneata	**wch**,**wnlf**			2	2		
Eutaxia densifolia	col,**dech**,**dep**,**ls**,**mtfcr**,**mtfs**,**qunr**,th,tr,**wnf**,**wng**,**wnlf**,**wnnu**,**wnt**			5	11	3	
Eutaxia epacridoides	chs,**dech**,hi,**lnn**,me,**mtfo**,**scnp**,sh,st			4	4	4	
Eutaxia obovata	col,**dec**,**dech**,**dej**,ga,**ginr**,**lnh**,**lni**,**lnl**,**lnq**,**lny**,**ls**,me,**mtfm**,**mtfs**, po/ja,**scnp**,**sjm**,**snp**,**tonp**,**us/sjm**,**wbnp**,**wch**,**wnf**,**wng**,**wnlf**, **wnnu**,**wnt**			11	24	4	
Eutaxia parvifolia	th					1	
Eutaxia virgata	23579,br,bur,chs,**dej**,hi,**lnhv**,**lni**,**mtfm**,**scnp**,st,th,**wnnu**			5	6	6	
Gastrolobium bilobum	**dep**,fg,**lnh**,**lnl**,**tonp**,**wch**,**wnf**,**wnlf**,**wnnu**			5	8	1	
Gastrolobium brownii	lon,**mtfcr**,**mtff**,**mtfs**,**qunr**			2	4	1	
Gastrolobium forrestii	23579,lon,**mtfcr**,**mtff**,**scnp**,**wch**,**wnlf**			4	5	1	
Gastrolobium glabratum MS		4					
Gastrolobium microcarpum	**mtfs**			1	1		
Gastrolobium parviflorum							
Gastrolobium spinosum	me						1
* Genista linifolia							
* Genista monspessulana	**cs**			1	1		
Gompholobium amplexicaule	fg,**scnp**,sh,**wng**			2	2	2	
Gompholobium burtonioides	lon					1	
Gompholobium capitatum	chs,**dec**,**dem**,**ginr**,**glnr**,**mtfcr**,**mtfs**,**scnp**,th,**wnf**,ye			6	8	3	
Gompholobium confertum	chs,col,**dech**,**glnr**,ke,**lnn**,**mtfcr**,**mtff**,**mtfo**,**mtfs**,no,**qunr**,ro, **scnp**,th,**tonp**,**wbnp**,**wch**,**wnf**,**wng**,**wnlf**,wy,ye			10	15	8	
Gompholobium knightianum	fg,**lny**,lon,me,ro,**rrnr**,**scnp**,**tonp**,**wch**,ye			5	5	4	
Gompholobium marginatum	br,chs,**dep**,**lny**,me,**scnp**,**tonp**,**wch**,ye			5	5	3	
Gompholobium ovatum	bu,bur,chs,col,**dep**,di1,**glnr**,**lny**,lon,**menr**,mos/**sjm**,**mtfcr**, **mtff**,**mtfm**,**mtfo**,**mtfs**,na,**qunr**,ro,**rrnr**,st,th,wy			8	12	12	
Gompholobium polymorphum	23579,bu,chs,col,crw,**dep**,**lnf**,**lnl**,**ls**,me,**mtfcr**,**mtff**,na,**scnp**, st,**tonp**,**us**,**wch**,we,**wng**,wnlf,**wnnu**,wy,ye			8	13	9	
Gompholobium preissii	co,**dech**,**lni**,**lnn**,**lny**,me,**mtfcr**,**scnp**			4	6	1	
Gompholobium scabrum	dor,**glnr**,**scnp**,th,th/ra,**wch**,**wng**,ye			4	4	4	
Gompholobium tomentosum	co,**deb**,**dech**,**dej**,**dem**,**dep**,**lnf**,**lnn**,**lnq**,**lnr**,**lny**,**mtfcr**,**qunr**, **scnp**,st,sto,**tonp**,**wbnp**,**wch**,we,**wnf**,**wnn**,**wnnu**			9	19	4	
Gompholobium venustum	st						1
Gompholobium villosum	23579,**mtfs**,**wbnp**			2	2		

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Gompholobium viscidulum							
Goodia medicaginea							
Hardenbergia comptoniana	bb,br,bu,co,col,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,di1,din,fg,li,**lnb**,**lne**,**lnf**,**lnh**,**lni**,**lnl**,**lnn**,**lny**,**ls**,me,**qunr**,**scnp**,**tonp**,**wbnp**,**wch**,wi,**wnf**,**wnlf**,**wnn**,**wnnu**,**wnt**			9	26	10	
Hovea chorizemifolia	23579,ba,br,bur,col,**dech**,**dep**,do,**glnr**,**lnb**,**lnf**,**lnl**,**lnn**,**lnq**,**lnr**,lon,me,mos/**sjm**,**mtfcr**,**mtff**,**mtfm**,**mtfo**,**mtfs**,na,**qunr**,ro,**rrnr**,**scnp**,sh,st,th,we,**wnf**,**wng**,**wnlf**,wy			9	21	14	
Hovea elliptica	23579,ba,bb,**benp**,br,**brnp**,bu,cha,chs,co,col,crw,da,**dech**,dee,**dep**,di1,din,do,dor,fg,**glnr**,go,le,**lnb**,**lne**,**lnh**,**lnl**,**lny**,lon,**ls**,me,mos/**sjm**,**mtfcr**,**mtff**,**mtfm**,**mtfs**,na,ro,**rrnr**,**scnp**,sh,st,su/**us**,sw,th,tr,**wch**,wi,**wnf**,**wng**,**wnlf**,**wnnu**,**wnt**,wy			12	25	30	
Hovea pungens	**scnp**			1	1		
Hovea stricta	**scnp**,ye			1	1	1	
Hovea trisperma	23579,chs,**dej**,fg,**glnr**,**lnn**,lon,me,**mtfm**,ro,**scnp**,th,**tonp**,**wch**,**wnf**			8	8	5	
Isotropis cuneifolia	br,chs,co,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,fg,**lnb**,**lnf**,**lnh**,**lnl**,**mtff**,**mucp**,**qunr**,**scnp**,**sjm**,**tonp**,**wbnp**,**wch**,**wnf**,**wnn**,**wnnu**			11	21	4	
Jacksonia alata	st					1	
Jacksonia furcellata	chs,**lnn**,**lny**,**mtfs**,**scnp**,**wch**,**wnf**			5	6	1	
Jacksonia horrida	12951,chl,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,do,ke,**lne**,**lnf**,**lni**,**lnn**,**lnq**,**lnr**,**lny**,mos,**mtfs**,**qunr**,**scnp**,sto,to,**tonp**,**wbnp**,**wch**,**wnf**,**wnlf**,**wnn**,**wnnu**,**wnt**,wy,ye			9	25	7	
Jacksonia sparsa MS	bb	3				1	
Jacksonia spinosa	**glnr**,th			1	1	1	
Jacksonia sternbergiana							1
Jansonia formosa	br,chs,**dej**,**ginr**,**scnp**,**wnnu**	3	E	4	4	2	
Kennedia carinata	**bcp**/bo,br,chs,ke,**lnl**,me,qun6,**scnp**,**wnt**			4	4	5	
Kennedia coccinea	bu,chs,col,da,**dec**,**dech**,**dep**,di1,din,fg,**glnr**,gry,**lnb**,**lnh**,**lnhv**,**lnl**,**lny**,lon,mos,mos/**sjm**,**mtf**,cr,**mtff**,**mtfm**,**mtfs**,na,**qunr**,ro,**scnp**,sh,sw,th,**tonp**,**wbnp**,**wch**,**wnf**,**wng**,**wnlf**,**wnn**,**wn**			11	24	17	
Kennedia glabrata	**bcp**,bu,**dech**,**dep**,mos,**mucp**,**wbnp**,we	R	E	4	5	3	
Kennedia macrophylla	**lnl**	R	E	1	1		
Kennedia prostrata	chs,**dep**,din,**lnn**,lon,me			2	2	3	
* Lathyrus latifolius							
* Lathyrus tingitanus	fg					1	
Latrobea brunonis	**tonp**,**wch**			2	2		
Latrobea diosmifolia	12951,23579,**dech**,**dej**,**dep**,**mtfcr**,**mtfm**,**scnp**,**tonp**,**wch**,**wn**,**wnf**,wy			6	10	1	
Latrobea genistoides	23579,**glnr**,lo,**ls**,**mtfm**,**mtfs**,st,th,**us**/**sjm**			4	6	3	
Latrobea sp.South Coast (A.M.Ashby 1949) PN							
Latrobea tenella	**dej**,st			1	1	1	
Latrobea tenella var. grandiflora	**mtfcr**			1	1		
Latrobea tenella var. tenella	chs,**mtfcr**,th			1	1	2	
* Lotus angustissimus	me,**scnp**			1	1		
* Lotus suaveolens	12951,23579,**deb**,**dej**,**lnf**,**lnh**,**lni**,**wbnp**,**wch**,**wn**,**wnf**,**wnnu**			5	10		
* Lotus uliginosus	do,**lpnr**,**qunr**,**scnp**,**wng**,**wnlf**			4	5	1	
* Lupinus cosentinii							
* Lupinus luteus	**lny**			1	1		
* Medicago arabica							
* Medicago lupulina							
* Medicago polymorpha	**lnh**,**scnp**			2	2		
* Melilotus albus							
* Melilotus indicus	**lne**,**lnn**,**lny**,me,**tonp**			2	4		
Mirbelia dilatata	br,bur,**dep**,fg,ke,**lnb**,**lni**,lon,me,mos/**sjm**,**mtfcr**,**mtfo**,**rrnr**,**scnp**,sh,wi,**wnnu**,**wnt**,wy,wy/**dep**			7	10	10	
Mirbelia ovata							
Nemcia capitata	br,**lnn**			1	1	1	
Nemcia coriacea	**tonp**			1	1		
Nemcia crenulata	lon	2				1	1
Nemcia dilatata	**tonp**			1	1		1
* Ornithopus compressus	**scnp**			1	1		

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
* Ornithopus pinnatus	fg,**ginr**,**menr**,**qunr**,**tonp**,**wch**,**wnlf**			6	6	1	
Oxylobium lineare	**dej**,**scnp**,wi			2	2	1	
Oxylobium linearifolium	ra					1	
Phyllota barbata	lon,**mtfs**,th			1	1	2	
* Podalyria sericea							
* Psoralea pinnata	col,fg,**tonp**,**wch**			2	2	2	
Pultenaea aspalathoides	**wnf**			1	1		
Pultenaea barbata	**tonp**,**wch**			2	2		
Pultenaea drummondii	chs,**lnl**,**lny**,ye			1	2	2	
Pultenaea ericifolia	**menr**,**mtfs**,**qunr**			3	3		
Pultenaea obcordata	**tonp**,**wch**			2	2		
Pultenaea ochreata	chs,**dep**,hi,**tonp**			2	2	2	
Pultenaea pinifolia	ha,ye	3				2	
Pultenaea radiata		3					
Pultenaea reticulata	br,bu,bur,col,**deb**,**dec**,**dech**,dee,**dej**,**dem**,**dep**,dor,fb,fg, **glnr**,hi,ke,ki/dor,**lnn**,**lnq**,lon,mos/**sjm**,**mtfcr**,**mtff**,**mtfo**,**mtfs**, no,**qunr**,ro,**scnp**,sto,th,to,**tonp**,**us**,**wbnp**,**wch**,we,**wn**,**wnf**, **wng**,**wnlf**,**wnn**,**wnnu**,**wnt**			12	27	18	
Pultenaea skinneri		4					
Pultenaea tenuifolia	**tonp**,**wch**			2	2		1
Pultenaea verruculosa							
Sphaerolobium alatum	bu,co,col,**dep**,mos/**sjm**,**mtfcr**,**mtff**,**mtfo**,**mtfs**,ro,st,th,we, **wnf**,**wnlf**			4	8	8	
Sphaerolobium daviesioides							
Sphaerolobium drummondii							
Sphaerolobium fornicatum							
Sphaerolobium grandiflorum	23579,**dech**,**dej**,**dep**,**ginr**,**glnr**,**scnp**,th,**tonp**,tr,**wch**,**wnf**, **wng**,**wnlf**,**wnt**			7	12	2	
Sphaerolobium linophyllum	23579,chs,**tonp**			1	1	1	
Sphaerolobium macranthum	**dech**,**dep**,fg,**glnr**,ke,**lnb**,**lnn**,lon,**mtfcr**,**mtfs**,**qunr**,th,**wnf**,**wng**			6	10	4	
Sphaerolobium medium	23579,br,bu,bur,chs,col,da,**dech**,dee,**dep**,di1,din,fb,fg,**glnr**, **lnn**,**lny**,lon,**mtfcr**,**mtff**,**mtfm**,**mtfo**,**mtfs**,na,**qunr**,ro,**rrnr**,**scnp**, sh,st,th,**tonp**,tr,**wbnp**,**wch**,we,**wnf**,**wng**,**wnlf**,wy,ye			11	19	21	
Sphaerolobium nudiflorum	lo,**mtfcr**,**mtfs**,**scnp**,**wch**,**wnf**			4	5	1	
Sphaerolobium pubescens MS	**wch**,**wnf**			2	2		
Sphaerolobium racemulosum	fg,ro,**scnp**,th,**wnf**,ye			2	2	4	
Sphaerolobium rostratum MS	**wnlf**,**wnt**		C	1	2		
Sphaerolobium scabriusculum							
Sphaerolobium vimineum	12951,col,**dep**,ke,**scnp**,**us**,**wnf**			4	4	2	
* Sutherlandia frutescens	me						
Templetonia drummondii	**tonp**	4		1	1		
Templetonia retusa	br,**lnb**,**lne**,**lnf**,**lnh**,**lni**,**lnl**,**lnn**,**lnq**,**lny**,**tonp**,**wch**,**wnf**			4	12	1	
* Trifolium angustifolium var. angustifolium	**tonp**,**wch**			2	2		
* Trifolium arvense var. arvense							
* Trifolium campestre var. campestre	**deb**,fg,**lni**,**lnq**,me,**scnp**,**wnf**			4	5	1	
* Trifolium cernuum	**lnl**			1	1		
* Trifolium dubium	**ginr**,**qunr**,**wnf**,**wng**,**wnnu**			3	5		
* Trifolium fragiferum	**tonp**			1	1		
* Trifolium glomeratum	me,**scnp**,**wch**			2	2		
* Trifolium hirtum							
* Trifolium incarnatum var. incarnatum							
* Trifolium ligusticum							
* Trifolium repens var. repens	**wch**			1	1		
* Trifolium resupinatum var. resupinatum							
* Trifolium striatum							
* Trifolium subterraneum	**cs**,me,**scnp**,**wch**,**wng**			4	4		
* Trifolium suffocatum							
* Trifolium tomentosum var. tomentosum	**wch**			1	1		
* Ulex europaeus	**wch**			1	1		
* Vicia hirsuta	**wch**			1	1		
* Vicia sativa	**lnl**,**wch**			2	2		
* Vicia sativa ssp. nigra	fg,**wch**			1	1	1	
* Vicia sativa ssp. sativa	**lnl**			1	1		

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Viminaria juncea	23579,bur,chs,col,**dech**,ke,**lnb**,**lne**,**lnhv**,**lni**,**lnn**,**lnq**,**lny**,lon, me,**mtfm**,**scnp**,st,**wch**,**wnf**,**wnlf**			6	13	6	
Passifloraceae							
* Passiflora filamentosa							
Philydraceae							
Philydrella pygmaea	12951,chs,col,**dej**,**ginr**,lon,**qunr**,**scnp**,sto,**tonp**,**us/sjm**,**wch**			8	8	4	
Philydrella pygmaea ssp. minima	**scnp**	1	E	1	1		
Philydrella pygmaea ssp. pygmaea	**wnf**			1	1		
Phormiaceae							
Dianella brevicaulis	23579,**lne**,**lnf**,**lnh**,me,**tonp**,**wch**,**wnf**,**wnnu**			4	7		
Dianella revoluta	23579,**dej**,**dem**,**dep**,**ginr**,**lnb**,**lne**,**lnf**,**lni**,**lnl**,**lnn**,**lnq**,**lnr**,**lny**, me,**qunr**,**tonp**,**wch**,**wn**,**wnf**,**wn**			7	19		
Stypandra glauca	23579,**dec**,**dech**,**dep**,din,**lnb**,**lnh**,**lni**,**lnl**,**lnn**,**lnq**,**lny**,me,na, qui,**scnp**,**sjm**,**tonp**,**wch**,**wnnu**,			7	16	3	
Phytolaccaceae							
* Phytolacca octandra	fg,**tonp**,**wch**			2	2	1	
Pinaceae							
* Pinus palustris	bb					1	
* Pinus pinaster	**lnb**,**lne**			1	2		1
* Pinus radiata							1
Pittosporaceae							
Billardiera coriacea	**tonp**,**wbnp**			2	2		
Billardiera drummondiana	car,**tonp**			1	1	1	
Billardiera drummondiana var. collina	**lnl**			1	1		
Billardiera floribunda	23579,col,crw,**dech**,**dep**,di1,**lnl**,**lnn**,lon,mos/**sjm**,**mtfcr**, **mtff**,**mtfs**,sh,th,tr,**wng**,**wnlf**			5	10	8	
Billardiera laxiflora	br,**dec**,**dej**,din,dor,hi,**lnb**,**mtfs**,**wbnp**,**wch**,we,**wnlf**			6	7	5	
Billardiera parviflora	**lne**,**lnf**,**lnl**,**lnr**,**lny**,**tonp**			2	6		
Billardiera parviflora var. parviflora	**lnl**,**lnn**			1	2		
Billardiera sericea							
Billardiera sp.Walpole (A.R.Annels 277) PN	**dep**,ki/dor,**mtfo**,**wbnp**,**wnlf**	3		4	4	2	
Billardiera variifolia	23579,ba,br,bu,col,da,dee,**dej**,**dem**,**dep**,di1,**glnr**,**lnb**,**lnf**, **lnl**,lon,me,mos/**sjm**,**mtfcr**,**mtff**,**mtfm**,**mtfs**,**mtfw**,**mtsnr**,no, **qunr**,ro,**rrnr**,**scnp**,sh,st,sto,sw,th,th/**mtfs**,**tonp**,tr,**us**,**wch**,**wn**, **wnf**,**wng**,**wnlf**,**wnnu**,**wnt**,wy,ye			13	26	20	
Cheiranthera preissiana	ba,**scnp**,**wnlf**,ye			2	2	2	
Cheiranthera preissiana var. planifolia	**lnb**,**wnlf**			2	2		
Marianthus candidus	chs,**dej**,fg,**lnb**,**lnf**,**lnh**,**lni**,**lnl**,**lnn**,**lnr**,**lny**,**tonp**			3	10	2	
Marianthus coeruleo-punctatus	col,ea/ba,fg,**mtfs**			1	1	4	
Marianthus erubescens	**lny**			1	1		
Pittosporum phylliraeoides var. phylliraeoides	**lni**,**lnn**,me			1	2		
Pronaya fraseri	chs					1	1
Sollya drummondii	**mtfcr**	2		1	1		
Sollya heterophylla	23579,**deb**,**dec**,**dech**,**dej**,**dep**,**dey**,do,**lnb**,**lnf**,**lnh**,**lni**,**lnl**,**lnr**, **lny**,me,**qunr**,**tonp**,**wbnp**,**wch**,**wnf**,**wnlf**			7	19	1	
Plantaginaceae							
Plantago debilis	**lnf**,**lnq**,**wch**			2	3		
* Plantago lanceolata	**cs**,**dej**,**lne**,**lnh**,**lnl**,**lnq**,me,**tonp**,**wbnp**,**wch**,wi,**wn**,**wnf**			7	11	1	
* Plantago major	**dej**,**lne**,**lnq**,**wnf**,**wnn**			3	5		
Plumbaginaceae							
* Limonium companyonis	**wnf**			1	1		1
* Limonium sinuatum	**lnh**,**lny**			1	2		
Poaceae							
Agrostis avenacea	23579,chs,**dec**,**dech**,**lne**,**lnn**,**qunr**,**scnp**,**tonp**,**wch**,**wn**,**wnn**			7	10	1	
Agrostis avenacea var. avenacea	**dem**,			1	1		
* Agrostis capillaris var. aristata							
* Agrostis capillaris var. capillaris							
Agrostis drummondiana							1
* Agrostis gigantea							1
* Agrostis stolonifera							

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
* Aira caryophyllea	23579,chs,**dec**,fg,**ginr**,**lne**,**lni**,**lnl**,**lnn**,**lny**,lon,me,**qunr**,**scnp**,**tonp**,**us/sjm**,**wnn**			9	13	3	
* Aira cupaniana	**dec**,**dej**,**lnb**,**lnn**,me,**tonp**,**wch**			4	6		
* Aira praecox	**deb**,**dec**,**dej**,**dey**,**lnf**,**us/sjm**			4	7		
* Ammophila arenaria	**dec**,**dech**,**dep**,**dey**,**lne**,**lnl**,**lnn**,**tonp**,**wbnp**,**wch**,**wnf**			6	11		
Amphibromus nervosus	**qunr**,**us/sjm**			3	3		
Amphipogon amphipogonoides	23579,br,col,**dep**,**glnr**,**mtfcr**,**mtfm**,**mtfo**,**mtfs**,po/ja,**qunr**,**rrnr**,**sjm**/usc/csw,st,sto,th,tr,**wnf**,**wng**,**wnlf**,**wnt**,ye			8	13	9	
Amphipogon avenaceus	lon				1		1
Amphipogon debilis	chs,col,**ginr**,**mtfm**,**qunr**,**scnp**,st,th,**tonp**			5	5	4	
Amphipogon debilis var. debilis	sh,**wnf**			1	1	1	
Amphipogon debilis var. fallax	**qunr**			1	1		
Amphipogon laguroides	12951,col,di1,fg,ki/dor,**mtfcr**,**scnp**,sh,th,**wch**,wi,**wng**,**wnn**,**wnp**			4	6	8	
Amphipogon strictus	**lnb**,**lnhv**,**lni**,**lnl**,**lny**			1	5		
Amphipogon turbinatus	12951,chs,col,**dej**,**dem**,**dep**,**ginr**,**glnr**,**lnq**,lon,**mtfcr**,**mtfs**,**qunr**,ro,**scnp**,st,th,**tonp**,**wch**,**wnf**,**wnlf**,wy			10	14	7	
* Anthoxanthum odoratum	dee,fg,go,**lni**,**lnl**,**lnn**,**lny**,**wng**,**wnt**			2	6	3	
* Arrhenatherum bulbosum							
Austrodanthonia acerosa	**qunr**,**scnp**,**wng**			3	3		
Austrodanthonia caespitosa	br,**dep**,**lnh**,lon,**qunr**,st,**tonp**,**wch**,**wnf**,**wnt**			6	7	3	
Austrodanthonia occidentalis	br,**lnn**,me			1	1	1	
Austrodanthonia pilosa	**lnh**,**scnp**,**wnt**			3	3		
Austrodanthonia setacea	12951,chs,**deb**,**dej**,**dem**,**dep**,**dey**,fg,**lne**,**lnf**,**lnh**,**lni**,**lnl**,**lnn**,**lnq**,**lny**,me,**mtfj**,**qunr**,**scnp**,**tonp**,**wbnp**,**wch**,**wnf**,**wnlf**,**wnn**			9	22	2	
Austrofestuca pubinervis	23579,**dec**,**wch**	1		2	2		
Austrostipa acrociliata	**wch**			1	1		1
Austrostipa campylachne	**brnp**			1	1		
Austrostipa compressa	12951,chs,**deb**,**dej**,**dep**,**lne**,**lnf**,**lnl**,**lnr**,**lny**,**rrnr**,**scnp**,**wbnp**,**wch**,**wnf**,**wnn**			7	14	1	
Austrostipa drummondii	**tonp**			1	1		
Austrostipa elegantissima	**lnn**			1	1		1
Austrostipa flavescens	**dem**,**dep**,**lnb**,**lne**,**lnh**,**lni**,**lnl**,**lnn**,**lnq**,**lnr**,**lny**,me,**qunr**,**scnp**,**tonp**,**wbnp**,**wch**,**wn**,**wnf**,**wng**,**wnn**,**wnnu**			8	21		
Austrostipa macalpinei	**tonp**,**wch**			2	2		
Austrostipa mollis	**lny**,**mtfj**			2	2		
Austrostipa pycnostachya							
Austrostipa semibarbata	23579,lon,**qunr**,**scnp**,st,ye			2	2	3	
Austrostipa tenuifolia	**wn**,**wnf**			1	2		
Austrostipa variabilis	**wch**			1	1		1
* Avellinia michelii	**lnh**,**lnl**,**lnn**,**lny**,me,**scnp**,**tonp**,**wch**			4	7		
* Avena barbata	**lne**,**lnn**,me,**scnp**,**tonp**,**wch**,ye			4	5	1	
* Axonopus affinis							
* Briza maxima	23579,br,chs,**deb**,**dec**,**dech**,fg,**lne**,**lni**,**lnl**,**lnn**,**lnq**,**lny**,me,**qunr**,**scnp**,**tonp**,**wch**,**wnf**,**wnt**			7	15	3	
* Briza minor	12951,23579,chs,**dej**,**ginr**,**lnb**,**lnn**,**lny**,me,**qunr**,**scnp**,**tonp**,**wch**			7	9	1	
Bromus arenarius	**dec**,**lnn**,**lny**,**wch**			3	4		1
* Bromus catharticus							
* Bromus diandrus	**deb**,**dec**,**dej**,**lnh**,**lnl**,**lny**,**scnp**,**tonp**,**wch**			5	9		
* Bromus hordeaceus	br,**dep**,**sbnr**			2	2	1	
* Bromus madritensis							
* Cortaderia selloana	**tonp**			1	1		1
* Cynodon dactylon	**lni**,**scnp**,**wnf**			3	3		
* Cynosurus cristatus							1
* Cynosurus echinatus	din,**lne**,**lnh**,**wch**			2	3	1	
* Dactylis glomerata	**wch**			1	1		
* Desmazeria rigida	**lnh**,**lni**			1	2		
Deyeuxia inaequalis	li	1					1
Deyeuxia quadriseta	br,ca,gr,**lnb**,**lnh**,**lnl**,qui,**sbnr**,**scnp**,**wn**,**wnf**			4	7	4	
Deyeuxia quadriseta var. cylindrica	din					1	
Deyeuxia quadriseta var. quadriseta	**wnt**			1	1		

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Dichelachne crinita	br,chl,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,din,**ginr**,**lnf**,**lnh**,**lnl**, me,**qunr**,**tonp**,**wbnp**,**wch**,**wnf**,**wnn**,**wnnu**			8	18	3	
Dichelachne micrantha							
* Digitaria sanguinalis	**lnb**,**lnh**,**lni**,**lnl**			1	4		
Diplopogon setaceus	col,**deb**,**dech**,**dej**,**dep**,**ls**,**qunr**,**scnp**,th,**us**,**wbnp**,**wch**,we, **wnf**,**wnt**,wy			7	12	4	
* Echinochloa crusgalli							
Echinopogon ovatus	**lne**,**lni**,**wnlf**			2	3		
Echinopogon ovatus var. ovatus	din,do					2	
* Ehrharta calycina	**lne**,me,**wch**			2	2		
* Ehrharta erecta	**lnh**,**lnl**,**lnn**,**tonp**			2	4		
* Ehrharta longiflora	**lni**,**lnn**,me,**scnp**,**tonp**,**wch**			4	5		
* Ehrharta pusilla							
* Ehrharta villosa	**lne**,**lnl**,**lnr**,**wch**			2	4		
Elymus scaber	**lnl**,**lnn**,**lny**			1	3		
Eragrostis brownii							
* Eragrostis curvula	**wnf**			1	1		
* Festuca arundinacea	ya					1	
* Glyceria declinata	fg,**lne**,**lnq**,**wnt**			2	3	1	
* Glyceria maxima							
* Hainardia cylindrica	23579,**scnp**			1	1		1
Hemarthria uncinata var. uncinata	23579,**dec**,**lnh**,**qunr**,**wnn**			4	4		
* Holcus lanatus	**dech**,**lnb**,**lne**,**lni**,**lnq**,**lny**,**sbnr**,**scnp**,sw,**tonp**,**wch**,**wng**, **wnlf**,**wnnu**			7	13	1	
* Holcus setiger							
* Hordeum leporinum	me,**tonp**			1	1		
* Hyparrhenia hirta	**lnq**			1	1		
* Lagurus ovatus	**dec**,**dech**,**dep**,**lnb**,**lne**,**lnf**,**lnh**,**lni**,**lnl**,**lnn**,**lnq**,**lnr**,**lny**,me,**tonp**, **wbnp**,**wch**,**wnf**			6	17		
* Lolium multiflorum							
* Lolium perenne	23579,**dej**,**lnn**,**lny**,me,**wch**			3	4		
* Lolium rigidum	12951,**dej**,**lni**,**lny**,me,**tonp**,**wch**			4	5		
* Lolium temulentum	**lnh**,**lnl**			1	2		
* Lolium temulentum forma arvense							
* Melinis minutiflora							
Microlaena stipoides	bu,chs,**dem**,**dep**,**dey**,fg,**lnb**,**lne**,**lnh**,**lnl**,lon,**mtfcr**,**scnp**, **wng**,**wnlf**			5	11	4	1
Microlaena stipoides var. stipoides	cha,**dec**,**dep**,**dey**,do,**lne**,**lny**,**sbnr**,**scnp**,**wng**,**wnnu**			5	9	2	
Neurachne alopecuroidea	fg,**lne**,**lnq**,lon,me,**scnp**,th/ra,**wch**			3	4	4	
* Panicum capillare							1
* Panicum capillare var. capillare	**lnh**,**lnn**			1	2		1
* Panicum miliaceum							
* Parapholis incurva	**lne**,**wch**			2	2		
* Paspalum dilatatum	**ln**,**lnq**			1	2		
* Paspalum distichum	**lne**,**lni**			1	2		1
* Paspalum urvillei							
* Paspalum vaginatum	23579,**lne**,**lnl**,**lnn**,**lnr**			1	4		
* Pennisetum clandestinum	**lnb**,**tonp**,**wch**			3	3		
* Pennisetum villosum							
* Pentaschistis airoides	**lnb**,**lne**,**lnhv**,**lnl**,**lnn**			1	5		1
* Phalaris aquatica							
* Phalaris canariensis							
* Phalaris minor	**wch**			1	1		
* Phalaris paradoxa	**wnlf**			1	1		1
* Phleum arenarium	**lny**			1	1		
* Phleum pratense	**lne**			1	1		
* Phragmites australis							
* Piptatherum miliaceum							
* Poa annua	**deb**,**lnl**,**wch**,**wnlf**			4	4		
* Poa bulbosa							
Poa drummondiana	**deb**,**dech**,**dej**,**dem**,**dep**,**lnb**,**lnf**,**lnh**,**lnq**,**lny**,**qunr**,**scnp**,**tonp**, **wch**,**wnf**,**wnnu**			7	16		
Poa homomalla	**benp**			1	1		

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Poa poiformis	12951,bu,col,**deb,dec,dech,dej,dep,dey**,do,**ginr,lne,lnf,lnh,lni,lnl,lnq,lnr,lny,mtfcr,qunr,tonp,wbnp,wch,wnf,wnn,wnnu,wnt**			9	24	3	
Poa porphyroclados	car,**dec,dej,dem,dep,lnh,lnn,scnp,wch,wnf,wnlf,wnn,wnnu**			5	12	1	
* Poa pratensis							
Poa serpentum	br,**scnp,tonp**			2	2	1	
* Polypogon monspeliensis	**lne,lnq,wch**			2	3		
Polypogon tenellus	**deb,lnh,scnp,wch**			4	4		
* Polypogon viridis							
* Setaria gracilis							
* Setaria verticillata							
* Sorghum halepense							
Spinifex hirsutus	**dech,dej,lne,lnl,lnn,lnr,lny**,me,**tonp,wch,wnnu**			5	10		
Spinifex longifolius	**lne,lnn**,me			1	2		1
* Sporobolus indicus var. capensis	**lnb,lnh,lnl**,wa,**wch,wnlf**			3	5	1	
Sporobolus virginicus	**dec,dech,lne,lnf,lnh,lnl,lnq,scnp,tonp,wch,wn,wnf**			6	12		
* Stenotaphrum secundatum	**lne,lnh,lnl,lnq,tonp,wch**			3	6		
Tetrarrhena laevis	23579,**benp**,br,bu,chs,col,**cs**,da,**dec,dech**,dee,**dej,dep**,di1,din,do,fg,**lnb,lne,lnf,lnh,lni,lnl,lny**,lon,mos**sjm,mtfcr,mtff,mtfm,mtfs,mtsnr,qunr**,ro,**rrnr,scnp**,st,sw,th,**tonp**,tr,**wch**,we,wi,**wnf,wng,wnlf,wnnu,wnt**,wy,ye			13	29	21	
* Urochloa maxima							1
* Vulpia bromoides	chs,**us/sjm**			2	2	1	
* Vulpia fasciculata	**dec,lnh,tonp**			3	3		
* Vulpia myuros	**dech,ln,lne,lnn,lnr,lny,sbnr,tonp,wch**			5	9		
Podocarpaceae							
Podocarpus drouynianus	ba,br,bu,bur,chs,co,col,da,**dech**,dee,**dej,dep**,di,di1,din,dor,fb,fg,**glnr**,if,**lnb,lne,lnf,lnl,lnr**,lon,**ls,ls**/ba,me,mos**sjm,mtfcr,mtff,mtfm,mtfo,mtfs**,na,**qunr**,ro,**scnp**,sh,st,th,tr,we,wi,**wnf,wnlf**,wy			9	20	28	
Polygalaceae							
Comesperma calymega	col,**dec,dech,dep**,din,**glnr,lnf,lni,lnq,lnr**,lon,**ls,mtfcr,mtfs**,mur,**scnp**,st,th,**tonp,wbnp,wch**,we,**wnf,wng,wnlf,wnn**,wy,ye			10	19	9	
Comesperma ciliatum	**dech**,me,mo,**mtfs,scnp,wnf,wnlf**			4	5	1	
Comesperma confertum	23579,ba,bu,col,**cs,dech**,dee,**dej,dem,dep,dey**,fg,**ginr,glnr,lnb,lnf,lnh,lni,lnl,lnn,lnq,lny**,lon,me,**mtfcr,mtff,mtfm,mtfs,qunr**,ro,**rrnr,scnp**,sh,st,sw,th,**tonp,wbnp,wch,wnf,wng,wnlf,wnn,wnnu,wnt**,wy			13	32	12	
Comesperma flavum	bu,**dech,dep,glnr,mtfcr,mtfm,scnp**,st,th,**tonp,us,wch,wnf,wng**			8	11	3	
Comesperma nudiusculum	ca,**dej**,hi,**scnp,wch**,ye	C	3	3	3		
Comesperma virgatum	br,chs,**dech,dej,dep,lnl**,mos/**sjm,mtff,mtfo**,no,**scnp,tonp**,we,**wnf,wnlf,wnt**,ye			7	12	6	
Comesperma volubile	23579,col,**dej**,lon,**mtfs**,st,th,**wch,wnf**,ye			4	4	5	
* Polygala myrtifolia	bb,**tonp,wnf**			2	2	1	
* Polygala virgata	**wnt**			1	1		
Polygonaceae							
* Acetosella vulgaris	**dech,dem,scnp,wbnp,wch,wnf**			5	6		
* Emex australis	**lnn,lny**			1	2		
Muehlenbeckia adpressa	**deb,dec,dech,dej,dem,dep,dey**,do,**lne,lnf,lni,lnl,lnn,lnr,qunr,scnp,tonp,wbnp,wch,wnf,wnn,wnnu**			8	21	1	
Persicaria decipiens	do,dor,**lni,lnl,lnq,ls**/ba			2	4	3	
Persicaria hydropiper							
Persicaria prostrata	dor					1	
* Polygonum arenastrum							
* Rumex brownii							
* Rumex bucephalophorus	**wch**			1	1		
* Rumex conglomeratus	dor,**scnp,wch,wnf**			3	3	1	
* Rumex crispus	**lnq,scnp,tonp,wch,wnf**			5	5		
* Rumex frutescens	**wbnp**			1	1		
* Rumex obtusifolius							
* Rumex obtusifolius ssp. obtusifolius							
* Rumex pulcher subsp. pulcher							
* Rumex x schultzei							

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Portulacaceae							
Calandrinia brevipedata	**deb,dec,lnf,lnn,lny,qunr**,th,**wch,wnf,wnn,wnnu**			5	10	1	
Calandrinia calyptrata	**dech,dep,mtff,wbnp,wch,wnf,wnf/wnn,wnnu**			5	8		
Calandrinia corrigioloides	chs,fg,**scnp,tonp,wbnp,wch**			4	4	2	
Calandrinia granulifera	**mtfs,tonp,wnf,wnnu**			3	4		
Calandrinia liniflora	**dej,dep,wbnp,wch,wnf,wnn,wnnu**			4	7		
Posidoniaceae							
Posidonia angustifolia	**lnn,tonp**			2	2		
Posidonia australis							1
Posidonia denhartogii							1
Posidonia ostenfeldii							1
Posidonia sinuosa							1
Potamogetonaceae							
Potamogeton drummondii	**dem,dey,lnr**			2	3		
Potamogeton ochreatus	**qunr**			1	1		
Potamogeton pectinatus	sw,**wch**			1	1	1	
Ruppia megacarpa							
Ruppia polycarpa							1
Primulaceae							
* Anagallis arvensis	bb,**deb,dej,lne,lnf,lnl,lnn,lnq,lny**,me,**sbnr,scnp,tonp,wbnp, wch,wn,wnf,wnn,wnnu**			8	17	1	
* Anagallis arvensis var. arvensis	**wnnu,wnt**			1	2		1
* Anagallis arvensis var. caerulea	**qunr**			1	1		1
Samolus junceus	23579,**qunr,scnp,wch,wn,wnf,wnn,wnnu,wnt**			4	8		
Samolus repens	23579,**dech,dej,lne,lnf,lnh,lnl,lnq,qunr,scnp,tonp,wbnp, wch,wn,wnf,wnn,wnnu**			8	16		
Samolus repens var. floribundus							
Samolus repens var. repens	**lnh,lnq**			1	2		
* Samolus valerandi	**lne,lni,lnl,lnq,scnp**			2	5		
Proteaceae							
Acidonia microcarpa	12951,bu,**dech,dej,dep**,mos,**mtfcr**,ra/st,sh,th,**wch**,we,**wnf**			4	6	7	
Adenanthos barbiger ssp. intermedius MS	br,chs,fb,me,**mtfm,scnp**,sto/str			2	2	5	
Adenanthos cuneatus	**glnr**,lon,**mtfs,qunr**,th,**tonp,wbnp,wch,wnf,wng,wnlf**			7	9	2	
Adenanthos detmoldii	chs	4	E			1	
Adenanthos meisneri	**dech,dej,dep,lnn,lnq,lnr,lny,scnp**			3	8		
Adenanthos obovatus	12951,23579,bu,bur,chs,col,crw,**deb,dech**,dee,**dej,dem, dep**,fg,**ginr,glnr**,if,ke,**lnn**,lon,mos,**mtfcr,mtff,mtfm,mtfo, mtfs**,no,**qunr,scnp**,sto,th,**tonp,us,wbnp,wch**,wn,**wnf,wng, wnlf,wnn,wnnu,wnt**,wy			12	26	15	
Adenanthos sericeus ssp. sericeus	**tonp,wch**			2	2		
Banksia attenuata	col,**dej,dep,lne,lni,lnn,lnq,lnr,mtfcr,mtfs,qunr,scnp**,sto,th,			8	15	3	
Banksia brownii	**tonp,wch,wnf,wng**	R					
Banksia gardneri var. brevidentata	**mtfs**,ro			1	1	1	
Banksia goodii		R					
Banksia grandis	ba,br,bu,bur,chs,co,col,**deb,dec,dech,dej,dep**,di1,din,fg, **glnr,lnb,lnf,lnl**,lon,**ls**,mos/**sjm,mtfcr,mtff,mtfm,mtfo,mtfs**, na,**qunr**,ro,**rrnr,scnp**,sh,st,th,**tonp**,tr,**wbnp,wch**,we,**wnf, wnlf,wnn,wnnu**,wy			13	26	20	
Banksia ilicifolia	chs,col,**dech,dej,dem**,dor,**glnr,lne,lni,lnq,lnr,mtfcr,mtfs, qunr,scnp**,sto,th,to,**tonp,wbnp,wch,wnf,wng,wnlf,wnnu**,ye			10	19	6	
Banksia lemanniana	**mtfo**			1	1		
Banksia littoralis	23579,ba,br,chs,**deb,deb/ls,dech,dej,dep**,fg,ke,ki/dor,**lnb, lni**,lon,**mtfcr,mtfo**,ne,**qunr,scnp**sh,sw,th,**tonp,wbnp,wch, wnf,wng,wnnu**,ye			10	17	13	
Banksia meisneri ssp. ascendens	chs,**scnp**			1	1	1	
Banksia occidentalis ssp. formosa	**dej**		E	1	1		
Banksia occidentalis ssp. occidentalis	23579,**dec,dech,dej,ginr,lpnr,scnp**			4	6		
Banksia praemorsa	**tonp**			1	1		
Banksia quercifolia	23579,crw,**deb,dech,dem,dep,glnr**,ke,**ls,mtfcr,mtfm,mtfs**, no,**qunr**,ro,sw,th,**tonp,us,wbnp,wch**,we,**wnf,wng,wnn,wnnu**			9	18	7	
Banksia seminuda	23579,**dec**,dee,**dej,dep**,dor,fb,**wnf,wnlf,wnnu**			2	6	3	

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Banksia seminuda ssp. remanens	**deb,wnlf,wnn,wnnu,wnt**		E	2	5		
Banksia sphaerocarpa var. sphaerocarpa	**mtf,mtfs**,ro			1	2	1	
Banksia verticillata	**dep,tonp,wnnu**	R	E	3	3		
Conospermum acerosum ssp. acerosum	**lnl**			1	1		
Conospermum caeruleum	23579,**mtfcr,mtfs**,ro,**scnp**,th,**wch,wng**			4	5	2	
Conospermum caeruleum ssp. caeruleum	th,**wn**			1	1	1	
Conospermum caeruleum ssp. debile	12951,**scnp**			1	1		
Conospermum caeruleum ssp. marginatum	chs					1	
Conospermum caeruleum ssp. spathulatum	chs					1	
Conospermum capitatum	br,chs,**dep**,fg,**glnr,lnf,lnq,mtfs,qunr,scnp,tonp,wbnp,wch,wnf**			10	11	3	
Conospermum capitatum ssp. capitatum	br,**dep,scnp,tonp**		C	3	3	1	
Conospermum capitatum ssp. glabratum	**tonp**,ye			1	1	1	
Conospermum capitatum ssp. velutinum	**tonp**			1	1		
Conospermum flexuosum	col,dee,ha,**mtfcr**,th,**wnlf**			2	2	4	
Conospermum flexuosum ssp. flexuosum	**mtfo**,th/st			1	1	2	
Conospermum flexuosum ssp. laevigatum	chs,**scnp**			1	1	1	
Conospermum paniculatum	chs,**scnp**	3		1	1	1	
Conospermum petiolare	bu,**tonp**			1	1	1	
Conospermum quadripetalum	**scnp,tonp**	2	E	2	2		
Conospermum stoechadis	sto					1	
Conospermum teretifolium	**tonp,wnf**			2	2		
Dryandra armata var. armata	**mtfs,wnf**			2	2		
Dryandra bipinnatifida ssp. bipinnatifida	me						1
Dryandra formosa	le,**mtfcr**,ro,th,**tonp,wch**,wh			3	3	4	
Dryandra lindleyana	**lne,lnf,lnq,lny**,me,**mtfcr,mtfs,qunr**,ro,st,**tonp,wbnp,wch,wnf**			7	11	2	
Dryandra lindleyana ssp. sylvestris	**lnb**			1	1		
Dryandra lindleyana var. lindleyana	**lnf,lni,lnn,lnq,lnr,tonp**			2	6		
Dryandra mucronulata ssp. mucronulata							
Dryandra nivea ssp. uliginosa	**scnp**	R		1	1		
Dryandra serra	23579,ro,sh,st	4				3	
Dryandra sessilis	**dec,dech,dem,dep,dey,lne,lnf,lnl,lnn,lnr,lny,qunr,scnp, tonp,wbnp,wch,wnf,wnnu**			8	18		
Dryandra sessilis var. cordata	**dep,lnl,lnn,wnf,wnnu**	2	ES	3	5		
Dryandra sessilis var. sessilis	**dec,tonp**			2	2		
Franklandia fucifolia	**tonp,wbnp,wch,wng**			4	4		
Franklandia triaristata		4					
Grevillea brachystylis ssp. australis	**scnp**	R	E	1	1		
Grevillea centristigma	bur,**cs**,mi,**us**			1	2	2	
Grevillea depauperata				1	1		
Grevillea diversifolia	**scnp**			1	1		
Grevillea diversifolia ssp. diversifolia	ra			1			
Grevillea diversifolia ssp. subtersericata	chs,col,**deb/ls,dep**,lon,**mtff,mtfm**,ra/lo,st,th/ra,**wn,wnlf**			4	7	7	
Grevillea fasciculata	**rbnr**			1	1		
Grevillea manglesioides	chs,ra/lo,**wnnu**			1	1	3	
Grevillea occidentalis	col,dee,**dep,lpnr,mtfcr,mtff,mtfm,mtfs**,ro,sh,**srnr**,st,th,**wch, wng**			6	9	6	
Grevillea papillosa	12951,**dej,glnr**,ra/st,**scnp**	3	E	3	3	2	
Grevillea pulchella	23579,col,lon,**mtfcr,mtff,mtfs**,sh,st			1	3	4	
Grevillea pulchella ssp. ascendens	bur						1
Grevillea pulchella ssp. pulchella	**dep,mtff,srnr**			3	3		
Grevillea quercifolia	bur,chs,**lne,lnr**,me,**mtfcr,mtfo**,ro,**scnp,srnr**,tr,wy			4	6	5	
Grevillea sp.Scott River (G.J.Keighery 4070) PN	12951,**scnp**	1	E	1	1		
Grevillea trifida	23579,bu,chs,col,**dep,glnr**,if,lo,lon,**menr,mtfcr,mtff,mtfm, mtfs**,or,ro,sh,**srnr**,st,th,tr,**wbnp,wng,wnlf**,wy			7	11	13	
Grevillea vestita ssp. vestita	**lne,lnl,lnn**			1	3		
Hakea amplexicaulis	br,bu,bur,chs,col,**dech,dep**,di1,din,fg,**glnr**,le,**lnb,lne**,lon,**ls,** me,**mtfcr,mtff,mtfo,mtfs**,na,**qunr**,ro,**scnp**,sh,st,sw,th,tr,we, wi,**wnf,wng,wnlf**,wy			8	15	20	
Hakea ceratophylla	bur,chs,col,**dech,dej,dep,ginr,glnr,lne,lni**,lon,**mtff,mtfm**,ro, **scnp**,sh,th,**tonp,wch,wnf,wng,wnlf**,wy			9	15	8	

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Hakea cucullata							
Hakea cyclocarpa	ya						1
Hakea drupacea	**tonp,wch**			2	2		
Hakea elliptica	**tonp,wch,wnf**			3	3		
Hakea erinacea	me						1
Hakea falcata	chs,col,**dep**,hi,lon,**mtfs**,ro,**scnp**,th			3	3	6	
Hakea florida	bu,**dech,glnr,mtfcr,mtfs**,ro,**rrnr**,st,th,**tonp,wch,wnf,wng, wnlf,wnnu**			7	11	4	
Hakea lasianthoides	bur,chs,co,**cs,dech**,fg,lo,**mtfcr,mtff,mtfm,mtfo,mtfs**,sh,st,tr, wi,**wn,wng**,wy/bu,ye			4	9	12	
Hakea linearis	12951,br,chs,**deb,dej,dep,ginr,lnb,mtfs,scnp**,sh,**wbnp, wch,wnf,wng,wnlf,wnnu**			8	13	3	
Hakea lissocarpha	br,chs,me,**scnp**,wi			1	1	3	
Hakea nitida	**tonp**			1	1		
Hakea oleifolia	12951,23579,**deb,dec,dech,dej,dem,dep,dey**,din,**lnb,lnf, lnl,lnn,lnq,lnr,lny**,lo,me,qui,**qunr,scnp,tonp,wbnp,wch,wnf, wng,wnnu**			8	22	3	
Hakea prostrata	**deb,dec,dech,dej,dem,dep,dey,lne,lnf,lnl,lnn,lnq,lnr,lny, qunr,scnp**,to,**tonp,wbnp,wch,wnf,wnn,wnnu**			8	22		
Hakea ruscifolia	12951,br,ch,chs,**dech,dep**,fg,**lne,lnf,lnh,lnl,lnn,lnq,lnr, mtfcr,mtfo,mtfs,scnp**,to,**tonp,wch,wnf**,wy			7	16	5	
Hakea sulcata	12951,chs,**ginr,mtfm,qunr,scnp**			4	4	1	
Hakea trifurcata	br,col,**lnl,lny**,me,**tonp**			2	3	2	
Hakea tuberculata	12951,**ginr,scnp**	2	E	2	2		
Hakea varia	bu,bur,chs,col,**deb,dej,dep,ginr,lnl**,lon,**mtfcr,mtff,mtfm**,ro, **scnp**,sh,**tonp,wch,wnf**			8	12	7	
Isopogon attenuatus	23579,col,**dep**,st,th,tr,**wch,wnf**			3	3	4	
Isopogon axillaris	**dep,scnp**,th,**wch,wnf**			4	4	1	
Isopogon baxteri							
Isopogon buxifolius	**dech,wch**			2	2		
Isopogon buxifolius var. buxifolius	23579						
Isopogon cuneatus	**tonp**			1	1		
Isopogon formosus	**mtfs**,st,th,**tonp,wng**			3	3	2	
Isopogon formosus ssp. dasylepis	12951,**scnp**	3		1	1		
Isopogon formosus ssp. formosus	lon,**mtfs,tonp**			2	2	1	
Isopogon longifolius	**qunr**,th,**wch**,wy/bu			2	2	3	
Isopogon polycephalus	**wch**			1	1		1
Isopogon sphaerocephalus	bur,col,**dep**,go,**lny**,lo,**mtfcr,mtff,mtfm,mtfo,mtfs**,sh,th, **wnf,wnlf**			4	9	6	
Isopogon uncinatus	**tonp**	R		1	1		
Lambertia echinata ssp. citrina							
Lambertia orbifolia	**scnp**	R		1	1		
Lambertia rariflora ssp. lutea	**mtfm,mtfo**,sh,sh/**mtfm**,th,th/ra	3	E	1	2	4	
Lambertia uniflora							
Persoonia elliptica	chs,**lnf,lnn,lny,mtfcr,mtfm,mtfs,scnp**			3	7	1	
Persoonia graminea	chs,col,**dep,scnp,tonp**			3	3	2	
Persoonia hakeiformis		2					
Persoonia longifolia	23579,ba,br,bu,bur,chs,co,col,crw,da,**dec,dech**,dee,**dej, dep,dey**,di1,din,fb,fg,**glnr**,if,ke,**lnb,lnf,lnl,lnq,lnr**,lon,**ls**,me, mos/**sjm,mtfcr,mtff,mtfm,mtfo,mtfs**,na,no,**qunr**,ro,**scnp**,sh, st,sw,th,**wbnp,wch**,we,wi,**wnf,wng,wnlf,wnnu,wnt**,wy,ye			11	27	29	
Persoonia saccata	**dech**,fg,**wnf**			2	2	1	
Persoonia teretifolia	**scnp**			1	1		1
Petrophile acicularis	23579,**deb,scnp,tonp,wbnp,wch,wnf**			6	6		
Petrophile divaricata	**mtfcr**			1	1		1
Petrophile diversifolia	bb,br,bur,chs,col,**dech,dep**,fg,hi,if,**mtfcr,mtff,mtfm,mtfo, mtfs**,mur,na,ro,**rrnr,scnp**,sh,st,th,**tonp**,tr,**wch**,we,**wnf,wng, wnlf**,wy,ye			7	14	18	
Petrophile linearis	**dej**,gry,if,**lne,lnl,lnn,lnq,lnr,lny,scnp**,sto,**wnf**			4	9	3	
Petrophile longifolia	**dech,glnr**,lon,**mtfs,qunr**,th,**wnf,wng**			5	6	2	
Petrophile media	lon,**scnp,tonp,wbnp**			3	3	1	
Petrophile rigida	dor,to,**tonp,wbnp,wch,wnf**			4	4	1	
Petrophile serruriae	**lnf,lnh,lnq,scnp**			2	4		

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Petrophile squamata	12951,chs,col,**ginr**,**lpnr**,**scnp**,**tonp**			4	4	2	
Stirlingia divaricatissima	**mtfj**,**mtfo**,**mtfo/mtfj**,sh/**mtfo**,st	1		1	2	2	
Stirlingia latifolia	ye					1	
Stirlingia seselifolia	**scnp**			1	1		
Stirlingia tenuifolia	lon,**lpnr**,ra,st			1	1	3	
Strangea stenocarpoides	bu,bur,col,fb,**glnr**,**mtfcr**,**mtff**,**mtfm**,**mtfo**,**mtfs**,**mtfw**,po,th, **wn**,**wnf**,**wng**,**wnlf**			3	11	6	
Synaphea favosa	br,**scnp**,**tonp**			2	2	1	
Synaphea floribunda	**lny**			1	1		
Synaphea gracillima	ki/dor,**lnq**,**menr**,pow,**tonp**			3	3	3	
Synaphea incurva		1					
Synaphea intricata	lon,ra/lo,ra/th,ro,st,th	3	C			6	
Synaphea nexosa		1	E				
Synaphea obtusata	23579,**dep**,**mtfcr**,**mtfm**			2	3		
Synaphea otiostigma	kea	1				1	
Synaphea petiolaris	23579,**lne**,**lnn**,**lnq**,**lny**,me,**mtfcr**,**mtff**,st,**tonp**,**wnnu**,ye			4	8	2	
Synaphea petiolaris ssp. petiolaris	**tonp**			1	1		
Synaphea petiolaris ssp. triloba							
Synaphea polymorpha	lon,th					2	
Synaphea preissii	**tonp**,**wch**	3		2	2		
Synaphea reticulata	lon,ro,th,**tonp**			1	1	3	
Xylomelum occidentale	chs,fg,if,**lnb**,**lne**,**lny**,me,**scnp**,ya			2	4	4	
Pteridaceae							
Pteris vittata	**lne**,**lnh**,**lnr**,th			1	3	1	
Rafflesiaceae							
Pilostyles hamiltonii	br,me					1	
Ranunculaceae							
Clematis linearifolia	**lnn**,**lny**			1	2		
Clematis pubescens	ba,bb,br,bu,col,crw,**cs**,da,**dec**,**dech**,dee,**dej**,**dem**,**dep**,**dey**, di1,din,fg,**lnb**,**lnf**,**lnh**,**lni**,**lnl**,**lnn**,**ls**,me,**mtfcr**,**mtff**,**mtfm**, **mtfs**,**mtsnr**,na,**qunr**,**scnp**,st,sw,**tonp**,tr,**wbnp**,**wch**,wi,**wnf**, **wng**,**wnlf**,**wnn**,**wnnu**,**wnt**			11	30	16	
Ranunculus amphitrichus							1
Ranunculus colonorum	**benp**,chl,chs,**dech**,**dej**,din,**lnb**,**lne**,**lnf**,**lnh**,**lni**,**lnl**,**lny**,**scnp**, st,**tonp**,**wch**,**wnp**			7	14	4	
* Ranunculus muricatus	**lnh**,**lnl**,**wch**			2	3		
Ranunculus pumilio	**lny**			1	1		1
Ranunculus sessiliflorus var. sessiliflorus	**lnh**			1	1		
Resedaceae							
* Reseda lutea							
* Reseda luteola							
Restionaceae							
Alexgeorgea ganopoda	**dep**,**mtfcr**,**mtfm**,**mtfm**/sh,**mtfs**,ra/st,**scnp**,sh,st,st/ro,**wng**	2	E	4	6	5	
Anarthria gracilis	12951,br,bu,**dech**,**dej**,**dep**,dor,**ginr**,**lne**,**lnq**,**lnr**,**ls**,mos,**mtfcr**, **qunr**,**scnp**,st,th,**tonp**,**wbnp**,**wn**,**wnf**,**wng**,**wnnu**,wy,ye			10	17	8	
Anarthria humilis	**wch**			1	1		1
Anarthria laevis	23579,**qunr**,**wnf**			2	2		
Anarthria prolifera	12951,23579,bu,chl,chs,col,**deb**,**dech**,dee,**dej**,**dem**,**dep**, fg,**ginr**,**glnr**,if,ke,ki/dor,**lne**,**lnr**,**ls**,mos,**mtfcr**,**mtff**,**mtfm**,**mtfs**, no,qui/to,**qunr**,ro,**rrnr**,**scnp**,st,sto,th,to,**tonp**,tr,**us**,**wbnp**,wch, we,**wnf**,**wng**,**wnlf**,**wnn**,**wnnu**,**wnt**,wy			13	27	21	
Anarthria scabra	23579,bu,chs,col,**dech**,**dej**,**dem**,**dep**,do,fg,**glnr**,ke,**lnb**,**lne**, **lnf**,**lnh**,**lni**,**lnl**,**lnn**,lon,**ls**,me,mos,mos/**sjm**,**mtfcr**,**mtff**,**mtfm**, **mtfo**,**mtfs**,no,**qunr**,ro,**scnp**,st,sto,th,to,**tonp**,**wbnp**,**wch**,we, **wnf**,**wng**,**wnlf**,**wnn**,**wnnu**,**wnt**,wy			12	30	16	
Chaetanthus aristatus MS	23579,**dep**,**glnr**,lo,lon,**mtfcr**,**mtfm**,**mtfs**,th,**wn**,**wnf**,**wng**,**wnlf**			4	9	3	
Chaetanthus leptocarpoides	chs,**dej**,**ginr**,lon,**mtfm**,**scnp**,**wnf**			5	5	2	
Chaetanthus tenellus	23579,**dep**,lon,**qunr**,**scnp**,**wch**,ye			4	4	2	
Chordifex amblycoleus	chs,**dej**,**dem**,**ginr**,hi,**scnp**,sto		C	3	4	3	
Chordifex gracilior	chs,**scnp**	3		1	1	1	
Chordifex isomorphus	12951	2	E				
Chordifex jacksonii MS	**dech**,**dej**,**dep**,lon,th,wy	1	C	1	3	3	
Chordifex laxus	col,**dep**,**tonp**,**wch**			3	3	1	

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Chordifex serialis MS	**mtff**			1	1		
Chordifex sphacelatus	**wch**			1	1		1
Cytogonidium leptocarpoides	12951,**scnp**			1	1		
Desmocladus castaneus MS	12951,**scnp**			1	1		
Desmocladus fasciculatus MS	12951,23579,br,bu,bur,chs,co,col,**dech**,**dep**,di1,din,fg,**ginr**,**glnr**,**lnb**,**lnn**,**lnq**,lon,mos/**sjm**,**mtfcr**,**mtff**,**mtfm**,**mtfo**,**mtfs**,**qunr**,ro,**rrnr**,**scnp**,sh,st,th,tr,**wbnp**,**wch**,we,**wnf**,**wnf/wnn**,**wng**,**wnlf**,**wnn**,wy,ye			12	22	19	
Desmocladus flexuosus MS	27398,br,bu,col,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,do,fg,**glnr**,ke,**lnb**,**lne**,**lnf**,**lnh**,**lni**,**lnl**,**lnn**,**lnq**,**lnr**,**lny**,lon,me,**mtfcr**,**mtff**,**mtfm**,**mtfs**,qui/to,**qunr**,ro,**scnp**,sto,**tonp**,tr,**wbnp**,**wch**,**wnf**,**wng**,**wnlf**,**wnn**,**wnnu**,**wnt**,wy			11	34	13	
Empodisma gracillimum	chs,col,**dech**,**dej**,**dep**,**dey**,fg,**lnb**,**mtff**,**scnp**,th,**tonp**,**wch**,**wnlf**,**wnn**,**wnt**,wy,ye			7	12	6	
Hypolaena caespitosa MS	12951,chs,**scnp**			1	1	1	
Hypolaena exsulca	12951,23579,br,chs,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**,din,fg,**ginr**,ke,**lnb**,**lne**,**lnf**,**lni**,**lnq**,**lnr**,**mtfcr**,**mtfm**,**mtfo**,**qunr**,**scnp**,sto,th,to,**tonp**,**wbnp**,**wch**,**wnf**,**wng**,**wnlf**,**wnn**,**wnt**,wy,wy/de			10	26	10	
Hypolaena fastigiata	12951,23579,col,**dep**,ke,ro,**tonp**,**us**,**wch**,**wnf**,wy			5	5	4	
Hypolaena macrotepala MS	**us**	E	1	1			
Hypolaena pubescens	12951,bu,**deb**,**dech**,**dej**,**ginr**,**lnl**,**scnp**,**wbnp**,**wnf**			6	8	1	
Hypolaena viridis MS	br,chs,**mtff**,**scnp**	C	2	2	2		
Lepidobolus preissianus	chs					1	1
Leptocarpus diffusus MS	**dej**,**dem**,**dep**,hi,**ls**,**qunr**,**scnp**,**wnnu**			5	7	1	
Leptocarpus elegans MS	chs,**ls**,sh			1	1	2	
Leptocarpus tenax	23579,bu,chs,col,**dech**,**dej**,**dep**,**dey**,**ginr**,**glnr**,lo,**ls**,**mtff**,**qunr**,ro,**scnp**,th,**tonp**,**us**,**wbnp**,**wch**,**wnf**,**wng**,**wnlf**,**wnnu**,**wnt**,wy,ye			11	19	8	
Lepyrodia drummondiana	car,chs,col,**ginr**,**mtfm**			2	2	3	
Lepyrodia extensa MS	**mtfcr**			1	1		
Lepyrodia glauca	br					1	
Lepyrodia heleocharoides	chs,**scnp**,ye	3		1	1	2	
Lepyrodia hermaphrodita	12951,bur,**ginr**,**menr**,ra/th/st,**sjm**/usc/csw,st			4	4	4	
Lepyrodia macra							
Lepyrodia monoica	**us**,we,**wnf**			2	2	1	
Lepyrodia muirii	**dech**,**dej**,**us**,**wnf**			3	4		
Lepyrodia porterae MS	12951,**scnp**,wi		C	1	1	1	
Loxocarya cinerea	ba,chs,co,**dech**,**dej**,**dep**,fg,ga/**dem**,**ginr**,**lne**,**lnf**,mos/**sjm**,**mtff**,**mtfo**,**qunr**,to,**tonp**,**wch**,wi,**wnf**,ye			9	14	8	
Loxocarya magna	12951,**scnp**	3		1	1		
Loxocarya striata MS							
Lyginia barbata	12951,23579,chs,col,**dec**,**dech**,**dej**,**dem**,**dep**,**ginr**,**glnr**,ki/dor,**lne**,**lnq**,**lnr**,lo,lon,**mtfcr**,**mtfs**,**qunr**,**scnp**,sto,th,to,**tonp**,**wbnp**,**wch**,**wn**,**wnf**,**wng**,**wnlf**,**wnn**,wy			11	22	9	
Meeboldina cana MS	bu,**dep**,ke,**lnb**,ro,**tonp**,**wnf**			4	4	3	1
Meeboldina coangustata MS	chs,**dech**,**dej**,**lnb**,**mtfm**,**scnp**,**wch**,**wnf**			6	7	1	
Meeboldina crassipes MS	**dech**,**dep**,**ls**,sto,th,wy	3	E	2	3	3	
Meeboldina crebriculmis MS	car,**dej**,**lnb**,**scnp**			3	3	1	
Meeboldina denmarkica	chs,col,**dech**,**dej**,**dep**,**ginr**,**glnr**,ja,**lnf**,lon,**mtfcr**,**mtfm**,**qunr**,**scnp**,sto,th,**us**,**wnnu**,wy,wy/**dep**			9	12	8	
Meeboldina kraussii MS							
Meeboldina roycei MS	br,**ginr**,ja,**scnp**,**us**			3	3	2	
Meeboldina scariosa MS	br,chs,**deb**,**dech**,**dej**,**dem**,**dep**,ga,**ginr**,**lnb**,**mtfm**,**qunr**,**scnp**,**sjm**,sto,**tonp**,**wbnp**,**wnf**,**wnnu**,**wnt**,wy,wy/**dep**			10	16	6	
Meeboldina tephrina MS	chs,**dej**,**dem**,**ginr**,hi,**mtfm**,**qunr**,**scnp**,wy			5	6	3	
Meeboldina thysanantha MS	**scnp**,wi	3		1	1	1	
Melanostachya ustulata	12951,col,ja,**lnl**,lon,**mtfcr**,**mtfm**,**mtfm**/sh,**mtfs**,**scnp**,sh,st/ra,ye			3	5	8	
Platychorda applanata	chs,**dech**,**dej**,**dem**,**dep**,**ginr**,hi,ke,**scnp**,wy,wy/**dep**		C	3	6	5	
Sporadanthus rivularis MS	crw,**dec**,**dej**,**scnp**,**sjm**/**us**,tr,**us**/**cs**/**sjm**,**wnlf**,wy/**dep**,ye	3		5	8	4	
Sporadanthus strictus MS	12951,chs,col,**dech**,**dej**,**dep**,**ginr**,**glnr**,**lnb**,**mtfcr**,**mtfm**,**scnp**,wi,**wnf**,**wnt**,wy			7	11	4	

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Stenotalis ramosissima	23579,col,**dec,dech,dej,ginr**,ja,**lnl,mtfo/mtfj,qunr,us, wch,wnf**			8	11	2	
Taraxis grossa	car,chs,cl,**cs/ls,dec,dej,dep,dep/ls**,fb,fg,ga,ga/**dem**,ke,**ls, menr**,ra,ra/st,**scnp**,st,tr,**wbnp,wch,wnf,wnlf,wnt**			7	13	11	
Tremulina cracens MS	bo,chl,**cs,cs/ls,dej,dep**,ga,ja,lo,**ls,mtfo,scnp**,we,**wnf**		C	5	7	6	
Tremulina tremula	12951,23579,chs,**dej,ginr**,ra/st,**scnp**,st,sto,**wch**			4	4	4	
Tyrbastes glaucescens	ba,chs,dee/or/sh,**dej,dep**,ga,**ginr**,ja,lo/**mtfj,mtff**,ra/st,**scnp**, sh,st/ro,th/ra,**wch,wng,wnlf**	4	E	6	9	12	
Rhamnaceae							
Cryptandra arbutiflora	**mtfp**			1	1		
Cryptandra arbutiflora var. arbutiflora	br					1	
Cryptandra arbutiflora var. tubulosa	**lni,lnn,lnq,lnr,lny**,me,**wnnu**			2	6		
Pomaderris myrtilloides	**tonp**			1	1		
Spyridium globulosum	chl,**dec,dech,dej,dem,dep,dey**,ec,**lnb,lne,lnf,lnh,lnhv,lni,lnl, lnn,lnq,lnr,lny,qunr,scnp**,tonp,**wbnp,wch,wnf,wnn,wnnu**			8	25	2	
Spyridium majoranifolium	**tonp,wch**			2	2		
Spyridium riparium	th/st	1				2	
Spyridium spadiceum	12951,**tonp**	2		1	1		
Trymalium floribundum	bu,chs,col,da,**dep,lnb,lnl,mtfcr,mtff,mtfm,mtfs,mtsnr,rrnr, scnp**,st,sw,**tonp,wch**,wi,**wnf,wng,wnlf,wnt**			9	16	7	
Trymalium floribundum ssp. floribundum	ke					1	
Trymalium floribundum ssp. trifidum	bb,crw,**cs**,fb,ke,**lnb,mtfcr,rrnr**,wa,**wbnp**,wi,**wnf,wng,wnlf, wnp,wnt**			6	10	6	
Trymalium ledifolium	me,**scnp**			1	1		1
Trymalium ledifolium var. ledifolium	lon,ro,st				3		1
Trymalium ledifolium var. rosmarinifolium	br,**lnf,lny**,me,**mtff,mtfm**/sh,**scnp**,st,**tonp**			4	6	3	
Trymalium venustum	**qunr,us,wnlf**		C	3	3		
Rosaceae							
* Acaena echinata	**lnb,lnl,lnn**,me			1	3		1
Acaena echinata var. retrorsumpilosa							
* Acaena novae-zelandiae	bb					1	
* Aphanes arvensis							
* Cottoneaster glaucophyllus	**tonp**			1	1		
* Rosa canina							
* Rosa rubiginosa							1
* Rubus discolor	dor,**lnq,scnp,tonp,wnp**			4	4	1	
* Rubus fruticosus	**wch**			1	1		1
* Rubus selmeri	co,**lnb,lnh**			1	2	1	
* Rubus ulmifolius	**lnhv,lnl**			1	2		
* Rubus ursinus							
* Sanguisorba minor ssp. muricata							
Rubiaceae							
* Galium divaricatum	**lnl,wch**			2	2		
Galium migrans	**lnb,lnhv,wch**	3		2	3		
* Galium murale	**lnh,lnhv,lnl,lnn,lnq,lny**,me			1	6		
Opercularia apiciflora	bur,**dep,lnf,lny,scnp**,ye			3	4	2	
Opercularia echinocephala	fg,**lnb,scnp**			2	2	1	
Opercularia hispidula	23579,ba,bb,bo,br,bu,chl,chs,co,col,da,**deb,dec,dech**,dee, **dej,dem,dep,dey**,di1,din,fg,**glnr,lnb,lne,lnf,lnh,lni,lnl**,lon,**ls, mtfcr,mtff,mtfj/mtfw,mtfm,mtfo,mtfs,mtsnr**,na,no,**qunr**,ro, **rrnr,scnp**,sh,st,sw,th,**tonp**,tr,**us/cs/sjm,wbnp,wch,wnf,wng, wnlf,wnn,wnnu,wnp,**			14	38	24	
Opercularia hispidula var. pauciflora	**mtfcr**			1	1		
Opercularia spermacocea	**tonp,wch,wnp**			3	3		
Opercularia vaginata	12951,chs,**deb,dej,dem,dep,lne,lnf,lnh,lnn,lnq,lnr,lny**,lon, me,**qunr,scnp,tonp,wbnp**,wch,**wn,wnf,wnn**			8	19	2	
Opercularia volubilis	bb,br,bu,col,**cs**,da,**dec,dep,lnb,mtfcr,mtff,mtfj/mtfw,mtfs, mtfw**,po/ja,**qunr,rrnr,scnp**,sw,**wch**,wi,**wn,wng,wnlf,wnn, wnp,wnt**			9	19	9	
* Sherardia arvensis	**lnb,lnh**,ye			1	2	1	
Rutaceae							
Asterolasia pallida							
Asterolasia squamuligera	chs						1

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Boronia alata	**dech,lnb,lnf,lnh,lni,lnl,lnn,tonp,wch,wnf,wnnu**			5	11		
Boronia albiflora	**tonp**			1	1		
Boronia anceps	12951,**lnn,scnp**	3	C	2	2		
Boronia capitata ssp. gracilis	ye	2					1
Boronia coerulescens ssp. spinescens							
Boronia crassipes	3						
Boronia crenulata	23579,br,chl,**deb,dech,dej,dem,dey,ginr,lnb,lnf,lnr**,no,**qunr,scnp**,to,**tonp,wbnp,wch,wnf,wng,wnlf,wnn,wnnu,wnt**,ye			9	20	4	
Boronia crenulata ssp. pubescens	12951,**lnn,lnq**,ye			1	2	1	
Boronia crenulata var. crenulata	col,**dej,dep**,dor,fb,**glnr,mtfcr,mtfm,mtfo,qunr,scnp**,st,th,**tonp,wnf,wng,wnlf**			7	12	5	
Boronia defoliata	ye					1	
Boronia denticulata	23579,chs,fg,**scnp**			1	1	2	
Boronia dichotoma	**lnn**			1	1		
Boronia exilis	chs,**scnp**	R	E	1	1	1	
Boronia fastigiata ssp. tenuior	12951,ea,if,**scnp**			1	1	2	
Boronia gracilipes	ba,br,bu,col,crw,**cs**,da,**dech**,dee,**dem,dep**,do,fg,le,lon,mos/**sjm,mtfcr,mtff,mtfm,mtfo,mtfs,mtsnr**,na,**qunr**,ro,**rrnr**,sh,st,sw,th,tr,**us,wbnp**,we,wi,**wnf,wng,wnlf,wnnu,wnt**,ye		C	9	20	22	
Boronia heterophylla	an,th,**wch**			1	1	2	
Boronia juncea	chs,**dej,dep,ginr**,ja,**mtfm,qunr,scnp**,th,**us**,wa,**wbnp,wch,wnf**,wy			9	10	5	
Boronia juncea ssp. laniflora	**wnf**		C	1	1		
Boronia juncea ssp. micrantha	**deb/ls,dep,scnp,wnf,wng**		C	4	6		
Boronia juncea ssp. minima	chs,**dech,dej,dem,dey,ginr**,hi,**scnp,wnlf**		C	4	7	2	
Boronia megastigma	bur,col,**dech,dej**,mos/**sjm,mtff,mtfo,scnp**,sh,we,**wn,wnf**			5	8	5	
Boronia molloyae	br,bu,ke,**lnb,scnp**,su/**us,wn,wnlf,wnn**			4	6	4	
Boronia nematophylla	**mtfs**			1	1		
Boronia pulchella	**benp,wng,wnlf,wnn**			2	4		
Boronia ramosa ssp. anethifolia	**dej**,ye			1	1	1	
Boronia spathulata	12951,bur,chs,crw,**dech,glnr**,ke,ki/dor,lon,**mtfcr,mtfo,mtfs**,ro,**scnp**,st,sto,th,**tonp,wnf,wng,wnlf**,wy			6	10	12	
Boronia stricta	br,bu,**dech,dej,dep,dey**,dor,ke,**lnq**,lon,**ls**,mos,mos/**sjm,mtfcr,mtfo**,po/ja,sw,**us,wbnp,wnf,wng,wnlf,wnnu,wnt**,ye			7	16	11	
Boronia subsessilis	bur,pow,th					3	
Boronia tenuis	me	4					
Boronia tetrandra	th,**tonp**			1	1	1	
Boronia virgata	lon,**mtfcr,mtfm**,sh,st,**wbnp,wnf,wnlf**	3	E	3	5	3	
Chorilaena quercifolia	bb,**benp**,bu,col,crw,**cs,dech,dem,dep,lnb,lnf,lni,lnl,lnq,mtff,mtsnr,rrnr,scnp**,sw,**tonp,us**,wa,**wch,wnf,wng,wnlf,wnnu,wnp,wnt**			11	23	6	
Crowea angustifolia	**cs,dep**,do,**ls,mtfo,sjm,tonp,wch,wng,wnlf,wnp**,wnt			7	11	1	
Crowea angustifolia var. angustifolia	gi,lon,**mtfcr**,ro,**wnlf**		C	2	2	3	
Crowea angustifolia var. platyphylla	bu,col,da,dee,**dep**,do,lo,**ls**,mos/**sjm,mtfcr,mtff,mtfm,mtfs**,na,**sjm**,sw,th,tr,**us/sjm,wnf,wng,wnlf,wnp,wnt**			5	13	11	
Diplolaena dampieri	**lnf,lnh,lni,lnl,lnn,lny**,me			1	6		
Diplolaena drummondii							
Diplolaena microcephala	**lnl**,su			1	1	1	
Phebalium anceps	**dec,dej,ginr,lnhv,lnl,scnp**,st,**tonp,wch,wnf,wnlf,wnn,wnnu**,			7	12	1	
Phebalium rude	**tonp,wch**			2	2		
Phebalium rude ssp. rude	**tonp**			1	1		
Philotheca nodiflora ssp. lasiocalyx							
Philotheca spicata	12951,br,chs,**deb,dech,dej**,fb,fg,if,**lnf,lnhv,lnl,lny,scnp**,sto			3	8	6	
Salicaceae							
* Populus albus	**cs/us**			1	2		
Santalaceae							
Choretrum lateriflorum	**dem,wbnp,wch,wn,wnf**		E	4	5		
Exocarpos odoratus	**dec,dech,dep,dey,lnh,lnl,qunr,tonp,wbnp,wch,wnf,wnnu**			7	12		
Exocarpos sparteus	**dec,dech,dej,dem,dep,lnb,lne,lnh,lni,lnn**,me,**qunr,tonp,wbnp,wch,wnf,wnn**			7	16		
Leptomeria cunninghamii	bu,co,col,**glnr,mtfcr,mtff,mtfs**,qui,th,**wnf,wng,wnlf,wnnu,wnt**,wy,ye			3	9	7	
Leptomeria dielsiana		R					

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Leptomeria ellytes MS	**mtfcr,mtfs,wch**			2	3		
Leptomeria furtiva MS	**scnp**	2		1	1		
Leptomeria pauciflora	**hrnr,mtfs,scnp,tonp,wch,wng**			6	6		
Leptomeria scrobiculata	bur,chs,col,**dej,dep**,fb,ga/**dem,ginr,glnr,lnh**,lon,**ls,ls/dep, mtfo,mtfs**,no,**qunr,scnp**,th,**tonp,wch**,we,**wnf,wnlf,wnn, wnnu,wnt**			11	18	9	
Leptomeria squarrulosa	23579,br,**brnp**,bur,chs,**cs,dech,dej,dep,hrnr**,fg,**ginr,lnf, lnhv,lnl**,lon,mos/**sjm,mtfo,scnp**,st,th,**tonp**,we,**wn,wnf,wnnu**			11	17	9	
Santalum acuminatum	**lne,lnq,lnr,lny**			1	4		1
Sapindaceae							
Dodonaea aptera	**lni,lnn,lnq,lny,wnnu**			2	5		
Dodonaea ceratocarpa	bea,**dech**,dee,**dej,dep,lni,lnl,lnq**,lny,me,**mtfcr,mtfm,tonp, wch,wnlf,wnnu,wnt**			6	14	2	
Dodonaea viscosa	bea,**dey**,ye			1	1	2	
Dodonaea viscosa ssp. angustissima	col,**mtfcr,scnp**,st,**wnlf**			3	3	2	
Schizaeaceae							
Schizaea fistulosa	bab,**cs/ls,dej,dep**,fb,**lnl,ls,wch,wnlf**			5	7	2	
Schizaea rupestris	ro,**wch,wnlf**	2		2	2	1	
Scrophulariaceae							
* Bartsia trixago	**deb,dep,dey,lnh,lni,lnn,lny**,me,**qunr,scnp,tonp,wbnp,wch, wnf,wnn,wnnu**			8	15		
* Dischisma arenarium	**dec,dech,dej,dey,lnh,lnn,lny,qunr,wbnp,wch**			5	10		
Euphrasia collina	**tonp,wch,wnf**			3	3		
Euphrasia collina ssp. tetragona	**tonp,wch**			2	2		
Glossostigma drummondii							1
Gratiola pubescens	crw,hi,**lnb,lne,lnq,ls**,me,**mtfp**,po/**sjm,qunr,scnp**,th,**wbnp, wch,wn,wnf,wnlf,wnnu,wnt**			9	15	4	
* Parentucellia latifolia	**lnh,lnr**,lon,**scnp,tonp,wch,wnf**			5	6	1	
* Parentucellia viscosa	12951,bu,**deb,dec,dem,dep,dey**,go,**lnq,ls**,me,**sbnr,tonp, wbnp,wch,wn,wnf,wnn**			8	14	2	
* Verbascum virgatum	**lnb,lne**,tb			1	2	1	
* Veronica arvensis	**lne**			1	1		
Veronica calycina	**scnp,wch**			2	2		1
Veronica distans	**dech,dej,dep,dey,lnb,lnf,lnh,lni,lny,qunr,tonp,wnnu**			5	12		
* Veronica persica							
Veronica plebeia	**lnl,lnn/lny,tonp,wch**,wi,ya			3	5	2	
Selaginellaceae							
Selaginella gracillima	chs,**dep,lne,lnh,lni,lnl,scnp,us/sjm,wch**			6	9	1	
Solanaceae							
Anthocercis littorea	**lnb,lnh,lnl,scnp,tonp,wch,wn,wnf**			5	8		
Anthocercis sylvicola	**wnt**	2	E	1	1		
Anthocercis viscosa	**tonp,wch,wnf**			3	3		
Anthocercis viscosa ssp. caudata	**dep,wn,wnnu**			2	3		
Anthocercis viscosa ssp. viscosa	**tonp,wch**			2	2		
* Datura stramonium							
* Lycium ferocissimum							1
* Nicandra physalodes							
* Physalis peruviana	**lnb,lne,tonp**			2	3		
* Solanum americanum	chl,**lne,lnl,tonp**			2	3	1	
* Solanum laciniatum	do,**tonp,wch**			2	2	1	
* Solanum linnaeanum	**lnl**			1	1		
* Solanum nigrum	**lnb,lne**,me,**scnp,tonp,wch,wnlf**			5	6		
Solanum symonii	**lnb,lnl,tonp,wch,wnf**			4	5		
Stackhousiaceae							
Stackhousia monogyna	col,**deb,dec,dech,dej,dem,dep**,di1,do,gry,**lnf,lnn,lnq,lny**, lon,**ls**,mos/**sjm,mtfcr,mtfs**,na,**qunr,scnp**,th,**tonp,wbnp,wch, wnf,wng,wnnu,wnt**			11	23	8	
Tripterococcus brachylobus MS	chs,**dej,scnp**,ye		E	2	2	2	
Tripterococcus brunonis	23579,chs,**cs,dech,dep**,fg,**lnb,lnf,lnn,lnr**,me,**mtfcr,scnp, tonp,us/sjm**,ye			7	12	3	
Tripterococcus paniculatus MS	chs	1				1	
Sterculiaceae							
Guichenotia ledifolia	**lni,lnn**			1	2		

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Lasiopetalum cordifolium ssp. acuminatum MS	**mtfcr,mtfs**	2		1	2		
Lasiopetalum floribundum	ba,bu,col,crw,**cs**,da,**dech**,dee,**dep**,fg,ga/**dem**,gry,if,**lnb,ls**, **mtfcr,mtff,mtfs,mtsnr,qunr**,rorrnr,st,su/**us**,sw,tr,**wbnp,wch**, wi,**wnf,wng,wnlf,wnnu,wnt**,ye			10	20	17	
Rulingia corylifolia	**dep**,ha,**lnl**,lon,**scnp,tonp,wch**,wn,**wnf,wnlf,wnnu**			6	9	2	
Rulingia cygnorum	**dep**,me,or,**tonp,wch,wnnu**			4	4	1	
Rulingia grandiflora	**lnhv,tonp,wnnu,wnt**			3	4		
Rulingia rotundifolia	**tonp**			1	1		
Thomasia brachystachys	bb	1				1	
Thomasia cognata	**lnn,lny**			1	2		
Thomasia discolor		3					
Thomasia foliosa							
Thomasia grandiflora	if					1	
Thomasia heterophylla MS	an/ba,ba,bu,cha,**cs,cs**/po,**dech**,ja,**lnb**,lon,**ls,menr**, **mtfj/mtfw**,po,su/**us**,sw,**wnf,wng,wnlf**,wy/bu		E	6	11	11	
Thomasia laxiflora	**dej**	1		1	1		
Thomasia macrocarpa	ye					1	
Thomasia multiflora		1					
Thomasia paniculata	an/ba,ba,bu,**cs/ls,dech**,ga/**dem**,or,po,we,**wng,wnlf**, **wnnu,wnt**,wy/bu			3	8	8	
Thomasia pauciflora	ba,bur,ca,car,**dech,dej,dem**,fg,ke,lon,ro,**scnp,us**,wi,**wng**, **wnt**,ye			4	7	10	
Thomasia purpurea	**lni,wbnp,wch**			3	3		
Thomasia quercifolia	bu,col,dee,lon,**mtfcr,mtff,mtfm,mtfs,rrnr**,st,sw,**tonp**,tr,**wch**, **wnf,wng,wnlf,wnt**	2	E	5	11	7	
Thomasia rhynchocarpa	chl,**cs/ls**,sw,**us**			1	3	2	
Thomasia solanacea	**dep**	3		1	1		
Thomasia sp.Big Brook (M.Koch 2373) PN	do						1
Thomasia stelligera	po/**sjm**				1	1	1
Thomasia triloba	12951,bur,ca,crw,**cs/us**,ke,mat,**wbnp,wng,wnlf,wnnu**, **wnp,wnt**	1		3	8	5	
Thomasia triphylla	**dej,dem,lne,lnf,lnh,lni,lnl,lnn,lnq,lny,tonp**			3	11		
Stylidiaceae							
Levenhookia dubia	12951,**menr,qunr,scnp,tonp,wnf**			5	5		
Levenhookia pauciflora	**lnb,scnp,tonp**			3	3		
Levenhookia preissii	chs,**dej**,fg,**lny**,ra/st,**scnp**,ye			3	3	5	
Levenhookia pusilla	23579,bu,chs,**deb,dec,dech,dej,dem,dep,dey**,fg,**lnb,lnf**, **lni,lnl,lnn,lnq,lnr,lny**,lon,me,**mtfcr,mtfs,qunr,scnp**,st,th, **tonp,us/sjm,wbnp,wch,wn,wnf,wnlf,wnn,wnnu**,wy			11	29	7	
Levenhookia stipitata	**lnn,lny**,me,**wch**			2	3		
Stylidium adnatum	an/ba,**benp**,br,col,da,**dec,dech,dej,dey**,fg,**lnb,lnh,lni,lnn**, **lny**,me,**mtff,mtfs,scnp**,sh,sw,**tonp,wbnp,wch,wn,wnf,wnlf,wnt**			9	20	8	
Stylidium adnatum var. abbreviatum							
Stylidium adnatum var. adnatum	**dem,lni**			2	2		
Stylidium affine	me						
Stylidium amoenum	12951,23579,bu,ca,chs,co,col,cou,**cs**,da,**deb,dech,dej**, **dem,dep**,di1,din,fg,**lni,lnl,lny**,lonmo,**mtfcr,mtff,mtfm,mtfo**, **mtfs**,na,ro,**rrnr,scnp**,sh,st,th,**tonp,wch,wn,wnlf,wnnu**,wy			9	21	18	
Stylidium amoenum var. amoenum							
Stylidium amoenum var. caulescens							
Stylidium assimile	ke,**mtfcr**,th,**wch**			2	2	2	
Stylidium barleei	chs	3				1	
Stylidium beaugleholei							
Stylidium breviscapum	lon,**mtff**,ye			1	1	2	
Stylidium breviscapum var. breviscapum	lon,**mtff**,ye			1	1	2	
Stylidium brunonianum	**lny,scnp,wch,wng,wnnu**			4	5		
Stylidium brunonianum ssp. minor							
Stylidium bulbiferum	12951,**lnq,lny**,me,**scnp**			2	3		
Stylidium caespitosum	23579,br,**dej**,lon,**mtfs,qunr**,th,**tonp,wnf,wng,wnlf,wnn**			5	8	3	
Stylidium calcaratum	**benp**,bu,cha,col,**deb,dec,dech,dej,dep,dey**,fg,**lnb,lnn,lnr**, lon,**mtfs,qunr,scnp,snp**,st,th,**tonp,wbnp,wch,wnf,wnn,wnnu**			11	20	7	
Stylidium carnosum							

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Stylidium ciliatum	bu,**glnr**,**qunr**,ro,th,**wnf**			3	3	3	
Stylidium corymbosum	chs,**wch**			1	1	1	
Stylidium corymbosum var. corymbosum	**wch**			1	1		
Stylidium crassifolium	**ginr**,**lni**,**lnl**,**scnp**,**wn**,**wnf**,**wng**,**wnlf**			4	8		
Stylidium despectum	**dech**,**wnt**			2	2		
Stylidium dichotomum							
Stylidium diversifolium	**dech**,**dep**,**lnn**,lon,**mtfs**,ro,**scnp**,th,**tonp**,tr,**wbnp**,**wch**,**wng**, **wnlf**,**wnnu**,**wnt**,wy			8	12	5	
Stylidium ecorne	12951,**lne**,**lnf**,me,**scnp**			2	3		
Stylidium emarginatum	**dep**,**lnb**,**qunr**,**wnf**,**wng**,**wnnu**			4	6		
Stylidium falcatum	lo,**scnp**,**us**			2	2	1	
Stylidium fasciculatum	br,**deb**,**dem**,**dep**,do,**lnf**,**lnh**,**lnl**,**lnq**,**lnr**,po,po/ja,po/**sjm**, **qunr**,ra/st,**scnp**,**tonp**,**wch**,**wnf**,wnnu			8	15	7	
Stylidium glaucum	col,**dem**,**lnq**,**ls**,**scnp**,sw,**tonp**,wch,*wn*,**wnf**			7	8	2	
Stylidium glaucum ssp. angustifolium	12951,**dech**,**dej**,**scnp**,**wch**,**wnt**		E	4	5		
Stylidium glaucum ssp. glaucum	**dech**,lon			1	1	1	
Stylidium guttatum	chs,**dej**,**dep**,**glnr**,**lni**,**mtfcr**,**mtfo**,**qunr**,**scnp**,th,**us**,**wbnp**,**wch**,ya			9	11	3	
Stylidium hirsutum	**tonp**			1	1		
Stylidium inundatum	12951,**dep**,**ginr**,**scnp**,**tonp**,**wch**,**wng**,**wnlf**			6	7		
Stylidium junceum	12951,an,bu,chs,**deb**,**dep**,**ginr**,**lnb**,**lne**,**lnf**,**lnn**,**lnq**,**lny**,**mtfcr**, **mtfs**,**qunr**,**scnp**,**tonp**,**us**,**wbnp**,**wnf**,**wnlf**,wy			10	18	4	
Stylidium junceum ssp. brevius	23579,**dep**,**lnf**,po/ja,**wnf**,**wnnu**,ye			3	4	3	
Stylidium junceum ssp. junceum							
Stylidium laciniatum	**cs**/**ls**,ga/**dem**,**lnf**,**ls**,mos/**sjm**,**mtfcr**,**us**/**sjm**,**wnf**,**wng**,**wnlf**		E	6	10	2	
Stylidium leeuwinense	12951,chs,**dech**,**dep**,fg,**ginr**,**scnp**,th,**wn**,**wnf**,**wnt**	3	E	4	7	3	
Stylidium lepidum	**mtfs**	3		1	1		
Stylidium leptophyllum							
Stylidium lowrieanum	**lne**,**lnf**,**lnh**,**lni**,**lnr**,**lny**		ES	1	6		
Stylidium luteum	23579,bu,chs,**dech**,**dej**,**ginr**,**glnr**,**lnq**,**mtfcr**,**mtfm**,**mtfs**,st, sto,th,th/ra,**wch**,**wn**,**wnf**,**wnlf**,			7	13	6	
Stylidium luteum ssp. glaucifolium	12951,chs,col,**dech**,**dem**,dor,lon,**qunr**,**scnp**,sh,th,**us**,**wch**,**wnf**			6	7	6	
Stylidium luteum ssp. luteum							
Stylidium mimeticum	12951,col,**dej**,**ginr**,**scnp**,st,**tonp**	3		4	4	2	
Stylidium periscelianthum							
Stylidium perpusillum	12951,bu,**dech**,**scnp**,th/tr/mfs,**tonp**,**wch**			5	4	3	
Stylidium petiolare	ke,**lnn**			1	1	1	
Stylidium piliferum	bu,**deb**,**glnr**,**lnn**,**lnq**,lon,**mtfcr**,**mtff**,**mtfo**,**qunr**,**scnp**,th,**tonp**, **wbnp**,**wch**,**wng**,**wnlf**,**wnnu**,			10	15	4	
Stylidium piliferum ssp. minor	23579,**lnn**,**wn**,**wnlf**			2	3		
Stylidium preissii	**dech**			1	1		
Stylidium pritzelianum	bu,col,**glnr**,**mtfm**,**mtfs**,**rrnr**,st		C	3	4	3	
Stylidium pulchellum	12951,**dech**,**dej**,**scnp**,**wnlf**			3	4		
Stylidium pygmaeum	23579,**dech**,**ls**/ba,**us**/**sjm**,**wbnp**,**wch**			5	6	1	
Stylidium repens	23579,bu,chs,**dec**,**dech**,**dej**,**dem**,**ginr**,**glnr**,ki/dor,**lnq**,**lnr**,me, **mtfcr**,**mtfs**,no,**qunr**,**scnp**,sto,th,**tonp**,**us**,**wbnp**,**wch**,**wnf**, **wng**,**wnlf**			12	19	7	
Stylidium rhynchocarpum	ba,**benp**,**brnp**,bu,cha,col,**cs**,dee,**dep**,di1,**lnb**,**lni**,**lnl**,lon,**mtfcr**, **mtff**,**mtfm**,**mtfs**,na,or,**qunr**,th,**tonp**,tr,**us**,**wbnp**,**wch**,**wn**,**wnlf**			11	18	11	
Stylidium roseo-alatum							1
Stylidium rupestre	**mtfs**,**qunr**,**wng**,**wnt**			3	4		
Stylidium scandens	12951,bu,ca,chs,col,**cs**,**dech**,**dej**,**dep**,dor,**ginr**,ke,**lnb**,**lnl**, **mtfcr**,**mtff**,**mtfm**,**mtfs**,no,po,**qunr**,ro,**scnp**,sto,th,**us**,**wbnp**, **wch**,**wnf**,**wng**,**wnlf**,**wnt**,wy,ye			10	20	13	
Stylidium schoenoides	23579,co,**dej**,**dem**,**dep**,fg,**glnr**,**lni**,**lny**,**mtfs**,**qunr**,**rrnr**,**scnp**, th,**tonp**,**wch**,**wnf**,**wng**,**wnlf**,**wnnu**,**wnt**			10	17	3	
Stylidium spathulatum	23579,br,bu,**deb**,**dej**,**dep**,fg,**lnn**,mos/**sjm**,**mtff**,**mtfo**,**qunr**, ra/st,ro,**scnp**,th,**tonp**,**wbnp**,**wch**,we,**wnf**,**wnlf**,**wnn**,**wnnu**,**wnt**			10	17	9	
Stylidium spathulatum ssp. acuminatum	**mtfcr**,**mtfs**,**wnlf**,wy			2	3	1	
Stylidium spathulatum ssp. spathulatum	col,**dep**,**glnr**,**mtfcr**,**mtfs**,ro,st,**us**/**sjm**,wy			5	6	4	
Stylidium spinulosum	**mtfm**,**mtfo**			1	2		
Stylidium spinulosum ssp. spinulosum	no					1	
Stylidium squamellosum	**tonp**			1	1		
Stylidium squamosotuberosum	br,col,**dech**,**dej**,**scnp**,**tonp**,**wbnp**,**wch**,**wnf**,wy			6	7	3	

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
Stylidium striatum	**lny**,ye			1	1	1	
Stylidium uniflorum							
Stylidium violaceum	**dech**,**dej**,**glnr**,**mtfs**,**scnp**,th,**tonp**,tr,**wch**,**wn**,**wnf**,**wng**,**wnlf**			7	11	2	
Taxodiaceae							
* Sequoia sempervirens	bb					1	
Thymelaeaceae							
Pimelea angustifolia	12951,23579,chs,**lni**,**scnp**,**tonp**,**wng**,**wnlf**			4	5	1	
Pimelea argentea	**lnb**,**lnh**,**lnhv**			1	3		
Pimelea ciliata ssp. ciliata							
Pimelea ciliata ssp. longituba	**lnhv**,ye			1	1	1	
Pimelea clavata	bb,**dec**,**dech**,**dej**,**dem**,**dep**,**dey**,dor,dor/su,**lnb**,**lnh**,**lnl**,**mtff**, **qunr**,tb,**tonp**,wa,**wbnp**,**wch**,**wnf**,**wnnu**,**wnp**,**wnt**			8	18	5	
Pimelea erecta	23579						
Pimelea ferruginea	**dej**,**dem**,**dep**,**lnb**,**lne**,**lnf**,**lnh**,**lni**,**lnl**,**lnq**,**lnr**,**lny**,me,**qunr**, **scnp**,**tonp**,**wch**,**wnf**			7	17		
Pimelea hispida	23579,br,chs,col,**cs/ls**,**dej**,**dem**,**dep**,fg,**ginr**,**lnb**,**lnl**,**mtfs**, **scnp**,th,**tonp**,tr,**wch**,wi,**wn**,**wnf**,**wng**,**wnlf**,**wnnu**,**wnt**,ye			9	18	8	
Pimelea imbricata	23579,**dech**,lon,**ls**,**mtfcr**,**mtfm**,**tonp**,**wbnp**,**wch**,**wnf**, **wnnu**,**wnt**,ya			7	10	2	
Pimelea imbricata var. imbricata	de,**dech**,dee,**wnf**			2	3	1	
Pimelea imbricata var. piligera	**lne**			1	1		
Pimelea lanata	23579,chs,**dech**,**dej**,**ginr**,hi,**lni**,**scnp**			4	5	2	
Pimelea lehmanniana ssp. lehmanniana							
Pimelea lehmanniana ssp. nervosa	**mtfcr**,ye			1	1	1	
Pimelea longiflora ssp. longiflora	12951,bu,chs,col,crw,**dech**,**dej**,**dem**,**dep**,dor,**glnr**,ja,ke,**lnf**, **lni**,**mtfcr**,**mtff**,**mtfm**,**mtfs**,**qunr**,**scnp**,sh,th,**tonp**,**wbnp**,**wch**, we,**wnf**,**wng**,**wnlf**,**wnnu**			10	20	10	
Pimelea preissii	**lnl**,**lnn**,me,**mtfcr**,**mtff**,**scnp**,th,ye			3	5	2	
Pimelea rosea	12951,23579,chl,**deb**,**dec**,**dech**,**dem**,**dep**,**dey**,fg,**lnf**,**lnl**, **lnn**,**lnr**,**lny**,**mtfcr**,**qunr**,ro,**scnp**,**tonp**,**wbnp**,**wch**,**wnf**,**wng**, **wnlf**,**wnn**,**wnnu**			9	22	3	
Pimelea rosea ssp. annelsii MS							
Pimelea rosea ssp. rosea	**dech**,**dej**,**dey**,**lnf**,**lnn**,**tonp**,wi			3	6	1	
Pimelea spectabilis	bu,col,**cs**,da,dee,**dej**,fg,**lnl**,**lnn**,lon,me,**mtfcr**,**mtff**,**mtfs**,**rrnr**, sh,st,sw,**us**,wi,**wng**,**wnlf**			6	11	10	
Pimelea suaveolens ssp. suaveolens	br,bu,**lny**,me,**mtfcr**,**mtfs**,**rrnr**,**tonp**,**wch**,wy,ya,ye			5	6	5	
Pimelea sulphurea	**mtfs**			1	1		
Pimelea sylvestris	chs,col,**dep**,fg,**lnb**,**lne**,**lnf**,**lnh**,**lnhv**,**lnl**,lon,**mtfcr**,**mtfs**,we, **wn**,**wnf**,**wnn**,**wnnu**,ye			4	13	6	
Pimelea tinctoria	**mtfs**			1	1		
Tremandraceae							
Platytheca galioides	23579,co,**dej**,fb,lo,me,**mtfj**,**scnp**,**wch**			4	4	3	
Tetratheca affinis	col,**lni**,**lnn**,**lnq**,lon,**mtfcr**,**mtfs**,ro,**rrnr**,sh,st,th,ya			3	6	7	
Tetratheca filiformis	bu,**cs**,**dep**,dor,ga/**dem**,ke,**lnb**,**lnf**,lon,po/ja,th,wi,**wnf**, **wnlf**,**wnt**,ya		E	4	8	10	
Tetratheca hirsuta	br,bu,col,**cs**,da,dee,**dep**,fg,**lnf**,**lnn**,**lnr**,**lny**,me,**mtfcr**,**mtff**, **mtfm**,**mtfs**,sh,st,sw,th,we/mo,**wnf**,**wnlf**,wy,ya			5	12	14	
Tetratheca hispidissima	**cs**,**cs/ls**,**dep**,**mtff**,**mtfm**/sh,we,**wng**,**wnlf**,**wnt**			4	8	2	
Tetratheca setigera	**dec**,**ginr**,**glnr**,**lne**,**lni**,**lnn**,**lnq**,**lnr**,lo,me,**mtfcr**,**mtff**,**mtfo**, **mtfs**,ra/lo,**scnp**,sh,st,th,th/ra,**tonp**,**wch**,**wn**,**wng**,**wnlf**,ya			9	18	6	
Tremandra diffusa	ba,**bcp**/bo,br,bu,co,col,**cs**/po,**dej**,di1,din,dor,ga/**dem**,**lnb**, **lnf**,**lnl**,lon,**ls**,**mtfcr**,**mtff**,**mtfm**,**mtfs**,na,**sbnr**,**scnp**,st,sw,th, **tonp**,tr,**us**,**wch**,wi,**wnlf**,**wnt**			10	19	18	
Tremandra stelligera	ba,bab,bb,br,bu,chl,co,col,crw,**cs**,da,**dech**,dee,**dej**,**dep**,di1, dor,fg,**ginr**,ke,le,**lnb**,**lne**,**lnl**,lon,**ls**,**menr**,**mtfcr**,**mtff**,**mtfm**, **mtfs**,**mtsnr**,na,po/**sjm**,**rrnr**,**scnp**,st,su/**us**,sw,th,**tonp**,**wbnp**, **wch**,wi,**wn**,**wnf**,**wng**,**wnlf**,**wnn**,**wnnu**,**wnp**,**wnt**,ye			14	30	25	
Typhaceae							
Typha domingensis	**dec**,**dey**,**scnp**			2	3		
* Typha orientalis	**lne**,**lnl**,**lnq**,**wch**			2	4		
Urticaceae							
Parietaria debilis	**dec**,**dep**,**dey**,**lnb**,**lnf**,**lnh**,**lnhv**,**lni**,**lnl**,**lnn**,**lnq**,**lny**,me,**qunr**, **tonp**,**wbnp**,**wch**			6	16		

Family/Taxon	*Block codes*	Conservation code	Endemic taxa code	Number of reserves	Number of reserve blocks	Number of forest blocks	No Warren voucher
* Soleirolia soleirolii	**lnhv**			1	1		1
* Urtica urens							1
Valerianaceae							
* Centranthus ruber							
Verbenaceae							
* Verbena bonariensis							
Violaceae							
Hybanthus calycinus	**lnn**,**lnq**,**lny**,me			1	3		
Hybanthus debilissimus	ba,bu,col,**cs**,da,di1,din,fg,**lnb**,**lnl**,lon,**mtfcr**,**mtff**,**mtfm**,**mtfs**, st,sw,th,**wng**,**wnlf**,ye			4	9	12	
Hybanthus floribundus ssp. floribundus							
Hybanthus volubilis	lo,lo/**mtfo**/**mtfj**,**scnp**	2		2	2	2	
* Viola odorata	**lnb**			1	1		
Xanthorrhoeaceae							
Xanthorrhoea brunonis	**scnp**			1	1		
Xanthorrhoea brunonis ssp. brunonis	**scnp**			1	1		
Xanthorrhoea brunonis ssp. semibarbata							
Xanthorrhoea gracilis	bu,bur,cha,co,col,**dep**,di1,fg,**glnr**,ke,**lne**,lon,me,mos/**sjm**, **mtfcr**,**mtff**,**mtfm**,**mtfs**,ro,**rrnr**,**scnp**,st,th,we,**wn**,**wng**,wy			8	12	15	
Xanthorrhoea platyphylla	**tonp**,**wch**			2	2		
Xanthorrhoea preissii	12951,23579,br,bu,chs,co,col,**deb**,**dec**,**dech**,**dej**,**dem**,**dep**, fg,**ginr**,**glnr**,ke,**lnb**,**lne**,**lnf**,**lnh**,**lni**,**lnl**,**lnq**,**lnr**,**lny**,lon,me, **mtfcr**,**mtff**,**mtfm**,**mtfo**,**mtfs**,no,**qunr**,ro,**scnp**,sh,st,sto,th, **tonp**,tr,**wch**,**wn**,**wnf**,**wng**,**wnlf**,**wnn**,**wnnu**,**wnt**,wy			10	33	16	
Xyridaceae							
Xyris flexifolia	or/bu,ra/st,**tonp**,tr,**wnf**,**wnlf**			2	3	5	
Xyris gracillima	fg,**lnb**,**scnp**,**wch**			3	3	1	
Xyris inaequalis	br					1	
Xyris indivisa	cl,**dej**,**mtff**			2	2	1	
Xyris lacera	**dech**,**dej**,**dep**,**dey**,**scnp**,**tonp**,**wch**			4	7		
Xyris lanata	col,**dech**,**dej**,**dep**,**ginr**,**glnr**,ja,ke,**ls**,mos,**mtfcr**,**mtfm**,**mtfm**/sh, **mtfo**,**qunr**,**scnp**,sh,sto,th,**tonp**,**us**,**wch**,we,**wnf**,**wnlf**,wy			10	16	10	
Xyris laxiflora	**dech**,**dej**,**scnp**,wy			2	3	1	
Xyris roycei	**dep**,**ls**,**scnp**		C	3	3		
Zamiaceae							
Macrozamia riedlei	ba,bb,br,bu,chs,co,col,da,**dec**,**dech**,dee,**dej**,**dem**,**dep**,**dey**, di1,din,fg,**lnb**,**lne**,**lnf**,**lnh**,**lni**,**lnl**,**lnn**,**lnq**,**lnr**,**lny**,lon,**ls**,me, mos/**sjm**,**mtfcr**,**mtff**,**mtfm**,**mtfo**,**mtfs**,na,no,ro,**scnp**,sh,st,sw, th,**tonp**,tr,**wch**,we,wi,**wnf**,**wng**,**wnlf**,**wnnu**,**wnt**,wy			9	31	25	
Zannichelliaceae							
Lepilaena bilocularis							1
Lepilaena cylindrocarpa	**scnp**			1	1		
Lepilaena preissii							1
Zygophyllaceae							
Nitraria billardierei	**lnh**,**lnhv**			1	2		1

APPENDIX 2

Listing of block codes by tenure type.

TENURE/BLOCK	CODES
NATIONAL PARKS	
Beedalup	benp
Brockman	brnp
D'Entrecasteaux	de
broke	deb
callcup	dec
chudalup	dech
jasper	dej
maringup	dem
pingerup	dep
yeagarup	dey
Leeuwin-Naturaliste	ln
boranup	lnb
ellensbrook	lne
freyinet	lnf
hamelin	lnh
hillview	lnhv
injudup	lni
leeuwin	lnl
naturaliste	lnn
quinninup	lnq
redgate	lnr
yallingup	lny
Mount Frankland	mtf
crossing	mtfcr
frankland	mtff
johnston	mtfj
mitchell	mtfm
o'donnell	mtfo
peak	mtfp
soho	mtfs
thompson	mtft
wattle	mtfw
Scott River	scnp
Shannon	snp
central shannon	cs
lower shannon	ls
upper shannon	us
Sir James Mitchell	sjm
Torndirrup	tonp
Walpole – Nornalup	wn
ficifolia	wnf
giants	wng
lower frankland	wnlf
nornalup	wnn
nuyts	wnnu
tinglewood	wnt
Warren	wnp
West Cape Howe	wch
William Bay	wbnp
NATURE RESERVES	
Gingilup	ginr
Gum Link	glnr
Hunwick Road 1998	hrnr
Lake Powell	lpnr
Mehinup Hill	mhnr
Mount Shaster	mtsnr
Quarram	qunr
Rudyard Beach	rbnr
Redmond Road	rrnr
Smith Brook	sbnr
CONSERVATION PARKS	
Boorara	bcp
Muirillup	mucp
FOREST BLOCKS	
Andrew	an
Babbington	bab
Balban	bal
Barlee	ba
Beaton	be
Beavis	bea
Big Brook	bb
Boorara	bo
Bramley	br
Burnett	bu
Burnside	bur
Carey	ca
Carter	car
Central	ce
Challar	ch
Channybearup	cha
Charley	chl
Chesapeake	che
Chester	chs
Cleave	cl
Collins	co
Collis	col
Court	cou
Crowea	crw
Curtin	cu
Dawson	da
Deep	dee
Diamond	di
Diamond 1	di1
Diamond 2	di2
Dingup	din
Dixie	ls
Dombarkup	do
Dordagup	dor
Easter	ea
Eclipse	ec
Fly Brook	fb
Forest Grove	fg
Frankland	fr
Gardner	ga
Giblett	gi
Gordon	go
Graphite	gr
Gray	gry
Hawke	ha
Hilliger	hi
Iffley	if
Jane	ja
Kearney	kea
Keystone	ke
Keystone-31501	ke
Kinkin	ki
Lewin	le
Lindsay	li
Lochart	lo
London	lon
Mack	ma
Mattaband	ma
Mindanup	mi
Mooralup	mo
Mossop	mos
Muirillup	mu
Murtin	mur
Nairn	na

Netic	ne
Northcliffe	no
Northcliffe (12915)	no
O'Sullivan	cs
Ordnance	or
Poole	po
Powley	pow
Quillben	qui
Topanup	to
Quininup Cpt6	qun6
Quininup	qun
Rate	ra
Romance	ro
Sharpe	sh
Solai	sol
Storry	sto
Strickland	str
Styx	st
Styx /Fr 214-25	st
Styx/29660	st
Sutton	su
Swarbrick	sw
Thames	th
Thames/Fr 179-25	th
Thompson	to
Thornton	tho
Treen Brook	tb
Trent	tr
Trent/Fr 193-25	tr
Warren	wa
Weld	we
Wheatley	wh
Witchcliffe	wi
Wye	wy
Yanmah	ya
Yelverton	ye

MISCELLANEOUS	
12951	12951
23579	23579
Meelup (21629)	me

APPENDIX 3

Taxa recorded from the study area not recorded from within the Warren boundary.

Anthericaceae
- Johnsonia inconspicua

Apiaceae
- Xanthosia ciliata

Asteraceae
- * Cotula bipinnata
- Gnephosis tenuissima
- Leptinella drummondii
- Millotia tenuifolia var. laevis
- Millotia tenuifolia var. tenuifolia
- Myriocephalus helichrysoides
- * Urospermum picroides

Brassicaceae
- * Brassica napus

Caryophyllaceae
- * Spergula arvensis

Chenopodiaceae
- Rhagodia baccata ssp. dioica

Colchicaceae
- Wurmbea calcicola

Cyperaceae
- * Carex divisa
- Mesomelaena preissii
- Schoenus grammatophyllus

Dilleniaceae
- Hibbertia polystachya
- Hibbertia spicata

Droseraceae
- Drosera gigantea ssp. gigantea
- Drosera rosulata
- Drosera stricticaulis
- Drosera tubaestylis

Epacridaceae
- Andersonia annelsii MS
- Conostephium pendulum
- Leucopogon cymbiformis

Euphorbiaceae
- Adriana quadripartita

Goodeniaceae
- Dampiera scaevolina

Haemodoraceae
- Haemodorum discolor

Iridaceae
- Sisyrhyncium sp. (B.M.J. Hussey s.n.)

Linaceae
- * Linum usitatissimum

Mimosaceae
- * Acacia dealbata
- Acacia ligulata
- Acacia nervosa
- Acacia paradoxa

Myrtaceae
- Calytrix pulchella
- Chamelaucium forrestii ssp. forrestii MS
- Eucalyptus decipiens ssp. chalara
- Eucalyptus phylacis

Orchidaceae
- Caladenia caesarea ssp. maritima MS
- Caladenia longicauda ssp. clivicola MS
- Caladenia viridescens MS
- Paracaleana triens MS
- Thelymitra variegata

Papilionaceae
- Daviesia angulata
- Daviesia longifolia
- Gastrolobium parviflorum
- Gastrolobium spinosum
- Oxylobium linearifolium

Poaceae
- Austrostipa elegantissima
- Deyeuxia quadriseta var. cylindrica
- * Holcus setiger
- * Phalaris aquatica
- * Phragmites australis

Polygonaceae
- * Polygonum arenastrum

Proteaceae
- Banksia goodii
- Conospermum stoechadis
- Dryandra bipinnatifida ssp. bipinnatifida
- Dryandra mucronulata ssp. mucronulata
- Hakea erinacea
- Stirlingia latifolia

Rhamnaceae
- Cryptandra arbutiflora

Rutaceae
- Boronia capitata ssp. gracilis
- Boronia tenuis

Sterculiaceae
- Thomasia macrocarpa

APPENDIX 4

Hybrid taxa recorded from the study area. Codes refer to CALM's priority list. (see Appendix 1). The presumed parentage of named hybrids appears in parentheses.

Aizoaceae
* Carpobrotus edulis x virescens

Asteraceae
* Arctotheca calendula x populiifolia

Cyperaceae
Isolepis congrua x prolifera

Haemodoraceae
Anigozanthos flavidus x viridis
Anigozanthos manglesii x viridis

Iridaceae
* Crocosmia x crocosmiiflora
* Freesia alba x leichtlinii
* Gladiolus cardinalis x tristis

Lamiaceae
* Mentha x piperita
* Mentha x piperita nothov. piperita
* Mentha x piperita var. x citrata

Myrtaceae
Agonis ?linearifolia x parviceps
Eucalyptus calophylla x ficifolia
Eucalyptus angulosa x cornuta
Kunzea ericifolia x recurva
Kunzea recurva x sulphurea

Orchidaceae
Caladenia applanata x latifolia
Caladenia christiniae x latifolia
Caladenia huegelii x paludosa
Caladenia paludosa x serotina
Caladenia citrina x viridescens
Caladenia x aestantha ms (C. corynophora x C. serotina)
Caladenia x cala ms (C. dilatata x all members of C. longicauda/C. patersonii complex)
Caladenia x ericksoniae ms (C. cairnsiana x C. filamentosa complex)
Caladenia x erminea ms (C. flava x C. marginata)
Caladenia x exserta ms (C. longicauda x C. uliginosa)
Caladenia x idiastes ms (C. latifolia x C. longicauda/C. patersonii/C. huegelii complexes)
Caladenia x spectabilis ms (C. flava x C. latifolia, C. reptans, or C. nana)
Caladenia ?granitora x longicauda
Cyanicula gemmata x gertrudiae
Drakaea elastica x thynniphila
Drakaea glyptodon x thynniphila
Elythranthera brunonis x emarginata
Microtis alba x media
Prasophyllum drummondii x regium

Poaceae
* Lolium multiflorum x perenne
Spinifex x alterniflorus

Polygonaceae
* Rumex x muretii
* Rumex x pseudopulcher

Proteaceae
Adenanthos x cunninghamii (A. cuneatus x A. sericeus ssp. sericeus) R
Adenanthos x pamela (A.detmoldii x A. obovatus) P4

Sterculiaceae
Thomasia heterophylla x paniculata
Thomasia purpurea x solanacea P1

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Behaviour and some impacts of a large wildfire in the Gnangara maritime pine (*Pinus pinaster*) plantation, Western Australia

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ABSTRACT

One of the largest and most intense softwood plantation wildfires in Western Australia burnt 850 ha of the Gnangara maritime pine (*Pinus pinaster)* plantation and 365 ha of banksia woodland in less than 12 hours. The fire started on private property adjacent to the plantation and appeared to have been lit by children. It threatened nearby homes and properties, cost in excess of $300 000 to suppress and resulted in a major operation to salvage more than 100 000 m^3 of logs. Burning under hot, dry weather conditions in December 1994, the wildfire spread 2–3 times faster than predicted. Over-prediction of fuel moisture content and under-prediction of wind speeds in the plantation contributed to the under-prediction of headfire rates of spread, which exceeded 2000 m h^{-1}. The quantity of fuel burnt directly affected fire intensity and flame height but appeared to have little affect on rate of spread. All *P. pinaster* trees that were defoliated or fully scorched by the fire died, but trees with more than 2 m of green crown tip survived. In stands that carried heavy needlebed fuel loads, low intensity backfires killed large mature trees by girdling the stems near ground level. Conditions of weather, fuel and fire behaviour experienced during the wildfire are presented and discussed and some fire management recommendations are made.

INTRODUCTION

Softwood plantations in the south-west of Western Australia (WA) provide an important timber resource, supplementing timber production from native hardwood forests. The total area of State-owned softwood plantations is about 72 000 ha of which about 45 000 ha is *Pinus radiata* and about 27 000 ha is *P. pinaster* (De Braganca 1987; and Moore *et al.* 1987). Currently, most of the State's *P. pinaster* plantations are grown on the poor sandy soils of the coastal plain from Harvey in the south to Wanneroo in the north and are managed by the Western Australian Department of Conservation and Land Management (CALM). Each year about 190 000 m^3 of sawlogs, veneer logs and other timber products are harvested from these plantations (CALM 1998). The 23 000 ha Gnangara maritime pine plantation (*P. pinaster*), about 10 km east and north of the city of Wanneroo, was first established in the 1930s, but most planting was undertaken between 1951 and 1975 following the clearing of banksia woodlands and heathlands. The region experiences a strongly Mediterranean-type climate with an average annual rainfall of 750 mm, of which about 90 per cent falls during the cooler months from April to October. While the winter months are cool and moist, the summer months are warm to hot and dry. Early morning and evening easterly land breezes and strong afternoon south-westerly sea breezes are common over the summer/autumn months. The 'fire season', or the period of the year when fuels within the plantations are dry enough to sustain fire, can extend from September to May, with peak fire weather conditions (hot, dry and windy weather) usually experienced over the period December to March.

An increase in the frequency of wildfires in the plantation over the last 20 years has been associated with increased urbanization, which has encroached on the plantation. Today, almost all wildfires are human-caused and most of these can be attributed to arson. Over the last five years, CALM has attended 222 wildfires in the plantation of which156 were suspected arson. The plantation's wildfire protection is based on rapid detection and dispatch of suppression crews and strategic fuel reduction burning. This strategy has been highly successful, with 98 per cent of wildfires being quickly suppressed and the median wildfire size restricted to 0.1 ha. Occasionally, when fuel and weather conditions are such that fires develop rapidly, early suppression may fail, resulting in wildfires that can be costly to suppress, can cause significant timber losses and disruption to supply and can threaten lives and nearby property. Such a wildfire occurred in the Gnangara plantation on 30 December 1994. The fire burnt about 850 ha of *P. pinaster* plantation and about 365 ha of banksia woodland in 12 hours before it was finally contained, making it one of the largest wildfires in the history of the Gnangara maritime pine plantation and one of the largest in softwood plantations in WA.

This paper reports on the cause of the fire, observed fire behaviour, fuel and weather conditions, and the impact

of the fire on *P. pinaster* trees. Some fire management implications of these observations are also discussed.

IGNITION CAUSE AND DETECTION

The wildfire (No. P58) was first detected and reported at 1407 hours (Western Standard Time) on 30 December 1994 by an observer on CALM's Pinjar fire lookout tower located about 6.5 km north-east of the ignition point. The fire originated on private property (location number 1882) on the south-western corner of the plantation and about 8 km east of Wanneroo. Initially, the fire was thought to have been caused either by a faulty transformer or an electric stock fence near the fire origin. However, subsequent investigation and reconstruction of the fire revealed that it was most likely caused by children playing in a horse paddock on private property adjacent to the plantation. The following evidence led to this conclusion.

(1) The pole-mounted transformer near the ignition point was functioning normally when inspected a day after the fire and there was no evidence of previous shorting or malfunction. The overhead high voltage power lines showed no evidence of flashover, and power problems were not reported or experienced by nearby residents. The ground around the transformer was clear of any flammable material for a distance of about 5 m.

(2) Reconstruction of the fire revealed that it actually back-burned (burned into the wind) towards, rather than away from, the transformer. This was ascertained from the low (10–20 cm) defoliation height to vegetation within 20 m of the down-wind side of the transformer. From the freeze direction of the vegetation, the fire burnt under the influence of a south-west wind, which is consistent with weather observations. Freeze is a term used to describe the live (green), fine vegetation which has been killed but not consumed by the fire and which becomes supple owing to heat and bends under the influence of the prevailing wind. When the vegetation cools after the passage of the flames, it stiffens and remains fixed (frozen) in the wind-bent orientation. This indicates the direction of the wind, hence the direction of headfire spread at the time of the passage of flames. The height of scorch, char and defoliation provide additional clues as to the intensity of the fire and whether a particular location experienced a headfire, flankfire or a backfire.

(3) The fire had back-burned towards, rather than away from, the electric stock fence, thus eliminating this as a possible ignition cause.

(4) The north-west corner of the horse paddock was burned. If the fire started at the transformer or the stock fence, it is highly unlikely that it would have been able to back-burn through the very short sparse grass covering the paddock and cross a 3 m mineral earth break surrounding the paddock. The most likely scenario is that the fire started in grass in the horse paddock and the headfire, under the influence of a south-west sea breeze, was driven across the sparse grass and the mineral earth break. Such a scenario is consistent with the field evidence described above.

(5) Two fresh sets of small (children's) footprints (track shoes) were observed in sand near the estimated ignition source in the horse paddock.

INITIAL SUPPRESSION RESPONSE

Two heavy-duty fire fighting units and two officers were immediately dispatched from CALM's Wanneroo office, arriving at the fire at about 1420 hours. The fire was burning in light (3–4t ha^{-1}) dry grass and needlebed fuels beneath open, mature *P. pinaster* plantation on flat sandy soil. When the crews arrived they estimated the fire to be about 2 ha with a headfire rate of spread of about 500 m h^{-1} and headfire flame heights averaging 1.5–2 m. An initial attempt at direct suppression almost succeeded, but the mobility of the suppression vehicles heavily laden with water was hampered by the very dry and therefore boggy sand. By the time additional suppression forces had arrived at the fire (about 1430 hours), the headfire was too intense and moving too fast to attempt a direct headfire attack (see Tables 1 and 4). The wind was forecast to shift to the south-east later in the day, blowing the fire towards homes and farms. Consequently, the suppression strategy was to concentrate resources along the western flank of the fire, to bring this flank under control, then attack the eastern flank, pinching the headfire off. Eventually this tactic was successful and running fire was stopped at 0200 hours the following day (31 December 1994). Mop-up was completed by 1500 hours the same day. Resources committed to the fire during the peak of suppression activity included about 120 firefighters, 32 pumpers (fire fighting units), 6 earth moving machines and spotter (reconnaissance) aircraft. Agencies involved included CALM, Bush Fires Board, State Emergency Services, volunteer bush fire brigades, Royal Australian Air Force, and local government officers. The total area burnt was 1215 ha (850 ha *P. pinaster* plantation, 365 ha banksia woodland). Other damage caused by the fire included the loss of two light duty fire fighting units (burnt) and 105 000 m^3 of sawlog that needed to be salvaged.

WEATHER

The months leading up to the time of the fire were very dry with only 0.8 mm and 4.6 mm of rain being recorded at CALM's Wanneroo office (Wanneroo) on 25 and 27 November respectively. This is well below the average for November, which is about 16 mm. The average rainfall for December is about 10 mm, but no rain was recorded for December 1994. The mean maximum daily temperatures for November and December 1994 were 25.6 °C and 31.2 °C respectively which is about average for this time of year (Fig. 1). As a result of well below average spring

rainfall, the Soil Dryness Index (SDI) (Mount 1972; Burrows 1987), a measure of drought and of the general moisture status of heavy fuels and vegetation, climbed rapidly and was 1753 on 30 December, the day of the wildfire (Fig. 1). The SDI ranges from 0, when the upper soil profile and heavy forest fuels are saturated, to 2000, when the upper soil profile and surface fuels are dry. Ambient temperature and relative humidity (measured at the Perth office of the Bureau of Meteorology some 25 km south of the fire) before and during the wildfire are shown in Figure 2. Continuous open (tower) wind speed and direction (recorded at the Perth office of the Bureau of Meteorology) for the day of the fire are shown in Figure 3. Tower wind speed observations were also made at 2 hourly intervals at the CALM Wanneroo office (Wanneroo) and are shown in Table 1.

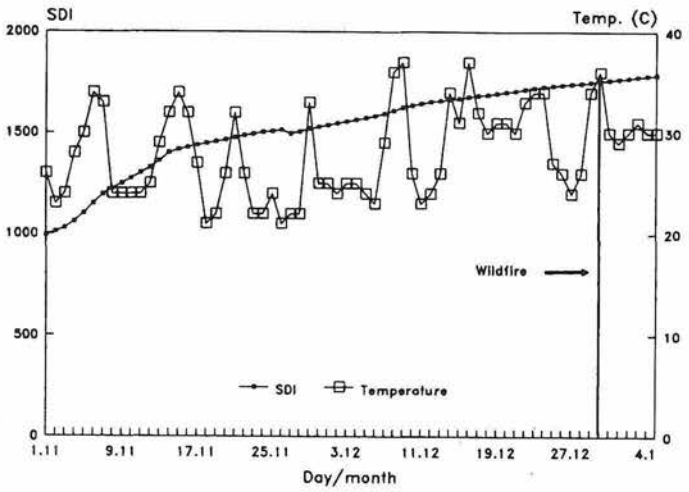


Figure 1. Daily maximum temperatures and Soil Dryness Index (Mount 1972) for Wanneroo near the Gnangara pine plantation leading up to and during the wildfire period.

FUELS

The Gnangara plantation was established over the period 1951 to 1975 and in each planting year, up to 20 cells each about 20 ha were planted in a block. Generally, the plantation was established from south to north. Seven fuel types were recognized within the plantation affected by the wildfire. Native vegetation (banksia woodland) comprised an eighth type (Table 2). Each plantation fuel type was associated with plantation cells and blocks of cells with similar histories of silvicultural treatment (including year planted) and fire. The fuels were measured and described several days after the wildfire by matching, as far as possible, burnt cells with unburnt cells across the fire boundary, then sampling the adjacent unburnt cells. Detailed plantation maps showing each cell and the year of planting were used to match burnt and unburnt cells. The plantation fuel types were either needlebed, needlebed and short grass or needlebed and thinning slash (red tops) resulting from silvicultural operations 3–6 months prior to the fire (see Table 2). The banksia woodland fuel consisted of a shallow surface litter and low woody shrubs (Burrows and McCaw 1990).

In each fuel type except the red tops, the quantity of needlebed and fine litter fuel (< 6 mm diameter) was estimated by collecting all material in 20 randomly located quadrats each 0.125 m^2. The material was oven dried and the fuel weight expressed in t ha^{-1}. Mean fuel weights for each type are shown in Table 2. Stand characteristics such as stocking, basal area, height to crown base and mean top height were measured in the vicinity of the fuel samples. These data are summarized in Table 2 and fuel types are mapped in relation to the area burned in Figure 4.

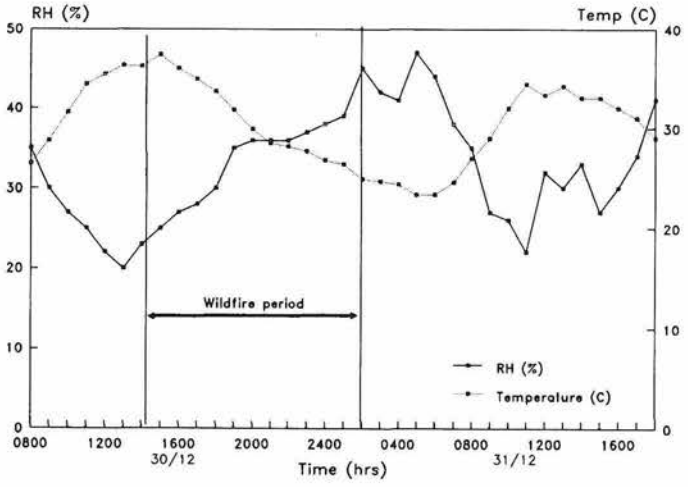


Figure 2. Hourly relative humidity and temperature observations made at Wanneroo near the Gnangara pine plantation wildfire.

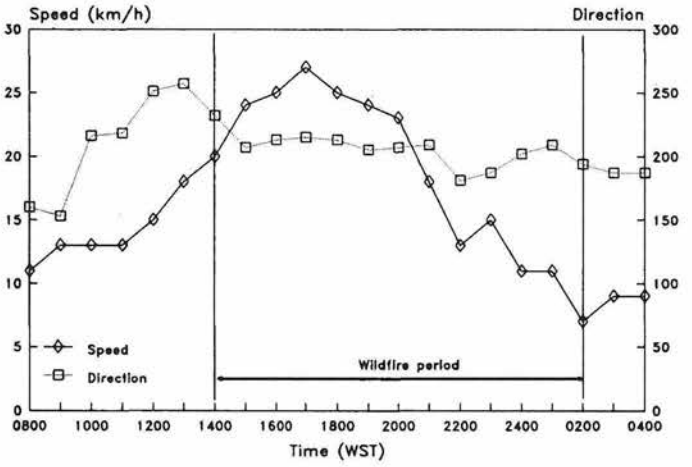


Figure 3. Wind speed and direction recorded at Perth, some 25 km south of the Gnangara pine plantation wildfire locality.

FUEL MOISTURE CONTENT

The moisture content of the various fuel types involved in the wildfire was not measured during the wildfire (30 December 1994) but was measured the following day (31 December 94) (Table 3). No rain fell over the period and diurnal temperature and relative humidity trends were

TABLE 1. Weather forecast issued at 1000 hours and observed weather conditions (CALM Wanneroo office) from 1100 hours – 1700 hours on the 30 December 1994. Tower wind speed observations are 10 minute averages taken on the hour. Overnight winds were forecast to be SE at 8 km h^{-1}.

WEATHER VARIABLE	FORECAST	OBSERVED
Max. Temp (°C)	37	37
Min. RH (%)	19	20
Tower wind speed (km h^{-1}) & direction Time (hours)		
1100	ENE12	SW12
1300	SW18	SW12
1500	SW25	SSW24
1700	SW15	SSW24
1900	Overnight–SE8	SSW24
2100		SSW16
2300		SW16

similar (Fig. 2) so it is reasonable to assume that fuel moisture contents on the day of the wildfire were similar to those measured the following day. Actual fuel moisture contents for each fuel type shown in Table 2 were determined by oven drying 7–10 samples (about 60 g each). Fuel moisture content predictions were made using the Forest Fire Behaviour Tables for Western Australia (Sneeuwjagt and Peet 1985) and are shown in Table 3.

FIRE BEHAVIOUR

The fire perimeter was mapped at regular intervals during the fire either from the air during daylight hours or from the ground. These maps were checked against observations made by fire control officers who submitted regular fire situation reports via radio to the control point at CALM's Wanneroo office. These reports described the position of the fire in relation to features such as roads and plantation cells and provided fire behaviour information including an estimate of headfire rate of spread and flame height. A composite map of the fire perimeter at various time intervals was constructed from these sources (Fig. 4) and used to calculate headfire rate of spread, fire perimeter and area (see Table 4).

Aided by moderate to fresh winds and dry fine fuels, the fire accelerated quickly through the open 43-year-old cells (planted 1951) and through relatively light fuels (4–6 t ha^{-1}). The quantity of needlebed and grass fuel was low in these cells as a consequence of prescribed burning which had been carried out some two years earlier. Tracks and mineral earth firebreaks throughout the plantation, some up to 30 m wide, were ineffective at stopping or significantly slowing the fire. Numerous spot fires developed 50–100 m downwind of the main fire front with a few developing 200–400 m downwind. These were usually over-run by the headfire before they developed to any significant size. While largely confined to the surface fuels, there were bursts of sustained crown fire spread (50–100 m) particularly in well stocked stands (about 600 stems ha^{-1}) with moderate to heavy surface fuel loads (> 8 t ha^{-1}). Headfire rates of spread and flame heights at various intervals during the wildfire run are shown in Table 4. There was no obvious or significant variation in headfire rate of spread associated with the different fuel types under these dry and windy conditions. However, flame height, therefore fire intensity, varied significantly with the taller flames being associated with the heavier fuels (Table 4). Headfire intensity varied from about 1500 kW m^{-1} to about 18 000 kW m^{-1}. The unusually long and narrow shape of the fire (Fig. 4) was largely owing to suppression action, which concentrated on the flanks of the fire, distorting the fire's shape and restricting the area burnt. A more-or-less constant wind direction during the fire run also contributed to the elongated shape. Fanned by moderate wind speeds, headfire behaviour was quite active, even during the relative cool of evening (Table 4), and was finally suppressed in the banksia woodlands in the cool early hours (0200) of 31 December 1994 when the wind speed fell to below about 10 km h^{-1}.

Observed rates of spread were generally higher than expected and higher than predicted by the Forest Fire Behaviour Tables for Western Australia (FFBT) (Sneeuwjagt and Peet 1985). Below is a worked example of predicting rate of spread during the period from about 1400–1500 hours when the fire was burning in cells containing the fuel code 2 (see Table 2).

Inputs for predicting rate of spread using FFBT:

Litter depth	= 10 mm
Total litter quantity	= 4.9 t ha^{-1}
Surface (fuel) moisture content (SMC)	= 7%
Profile (fuel) moisture content (PMC)	= 7%
Available fuel factor	= 1.0
Tower wind speed	= 25 km h^{-1}; 4:1 ratio
Slope	= 0°

Calculating predicted rate of spread:

Available litter quantity	= 4.9 x 1.0 = 4.9 t ha^{-1}
Rate of Spread Index	= 160
Fuel correction factor	= 2.7
Slope correction factor	= 1.0
Predicted rate of spread	= 160 x 2.7 x 1.0 = 432 m h^{-1}

The predicted rate of spread for this stage of the wildfire was 432 m h^{-1} compared with the actual rate of spread of 790–945 m h^{-1}. One of the factors contributing to the under prediction is that actual surface fuel moisture content (SMC) in these open cells was lower than that predicted by about 2 per cent. If the actual SMC is used in the calculations (4.9 per cent), then the predicted rate of spread is about 650 m h^{-1}. It is also possible that the wind ratio of 4:1 (tower wind speed: wind speed at 1.5 m) used in the prediction is too high for these open stands (about 175 stems ha^{-1}). Burrows *et al.* (1988) reported a wind

TABLE 2. Major fuel types and associated stand characteristics for *P. pinaster* plantation and banksia woodland burnt by wildfire. Approximate distribution of each fuel type is shown in Figure 4.

FUEL CODE	YEAR PLANTED	STOCKING (STEMS (per ha^{-1})	BASAL AREA (m^2ha^{-1})	HEIGHT TO CANOPY BASE (m)	TOP HEIGHT (m)	DOMINANT FUEL TYPE	MEAN FUEL LOAD ($t\ ha^{-1}$)
1	1951	175	35.4	12.6	22.3 long unburnt	Needlebed	37.4
2	1951	175	34.8	12.8	22.9	Needlebed and grass recently prescribed burnt	3.8
3	1953	600	25.0	10.6	17.3	Needlebed long unburnt	22.8
4	1953	200	25.3	10.8	18.7	Red tops and needlebed	40
5	1957	350	28.1	10.2	18.9	Needlebed	15.6
6	1961	600	27.1	7.9	16.8	Needlebed	11.4
7	1965	400	26.4	8.6	16.3	Needlebed	8.6
8	Banksia woodland					Shallow litter and live shrubs 20 years since last fire	7

TABLE 3. Predicted and actual mean fuel moisture contents. Predictions were made using the Forest Fire Behaviour Tables for Western Australia (Sneeuwjagt and Peet 1985) for the day of the wildfire (30 December 94). Actual moisture contents were determined from samples taken the day after the wildfire (31 December 94). SMC = needlebed surface moisture content, PMC = needlebed profile moisture content and red tops = aerated red needles in debris resulting from thinning operations. Standard error in parentheses.

TIME (hours)	PREDICTED SMC 30/12/94 (%)	ACTUAL SMC 31/12/94 THINNED STAND (%)	ACTUAL SMC 31/12/94 UNTHINNED STAND	ACTUAL PMC 31/12/94 UNTHINNED STAND (%)	ACTUAL RED TOPS 31/12/94 (%)	ACTUAL LIVE NEEDLES 31/12/94 (%)
1500	7	4.9 (0.84)	6.5 (0.61)	7.4 (0.82)	6.8 (0.52)	162.3 (8.9)
1800	9	6.3 (0.66)	7.2 (0.63)	8.0 (0.72)	7.9 (0.55)	not sampled

speed ratio of about 6:1 for a heavily stocked (2000 stems ha^{-1}), unpruned stand of 17-year-old *P. pinaster*. Fire behaviour is highly sensitive to wind speed, particularly under hot, dry conditions and uncertainty about the most appropriate wind speed ratio to choose when predicting rate of spread is one of the major limitations of the FFBT system.

TREE MORTALITY AND DAMAGE

P. pinaster, like other introduced conifers, is not as well adapted to fire as native tree species such as jarrah (*Eucalyptus marginata*) and marri (*Corymbia calophylla*). While mature *P. pinaster* has thick protective bark which enables it to withstand low intensity fire (Fig. 5), it does not have the capacity to re-sprout following fires that kill

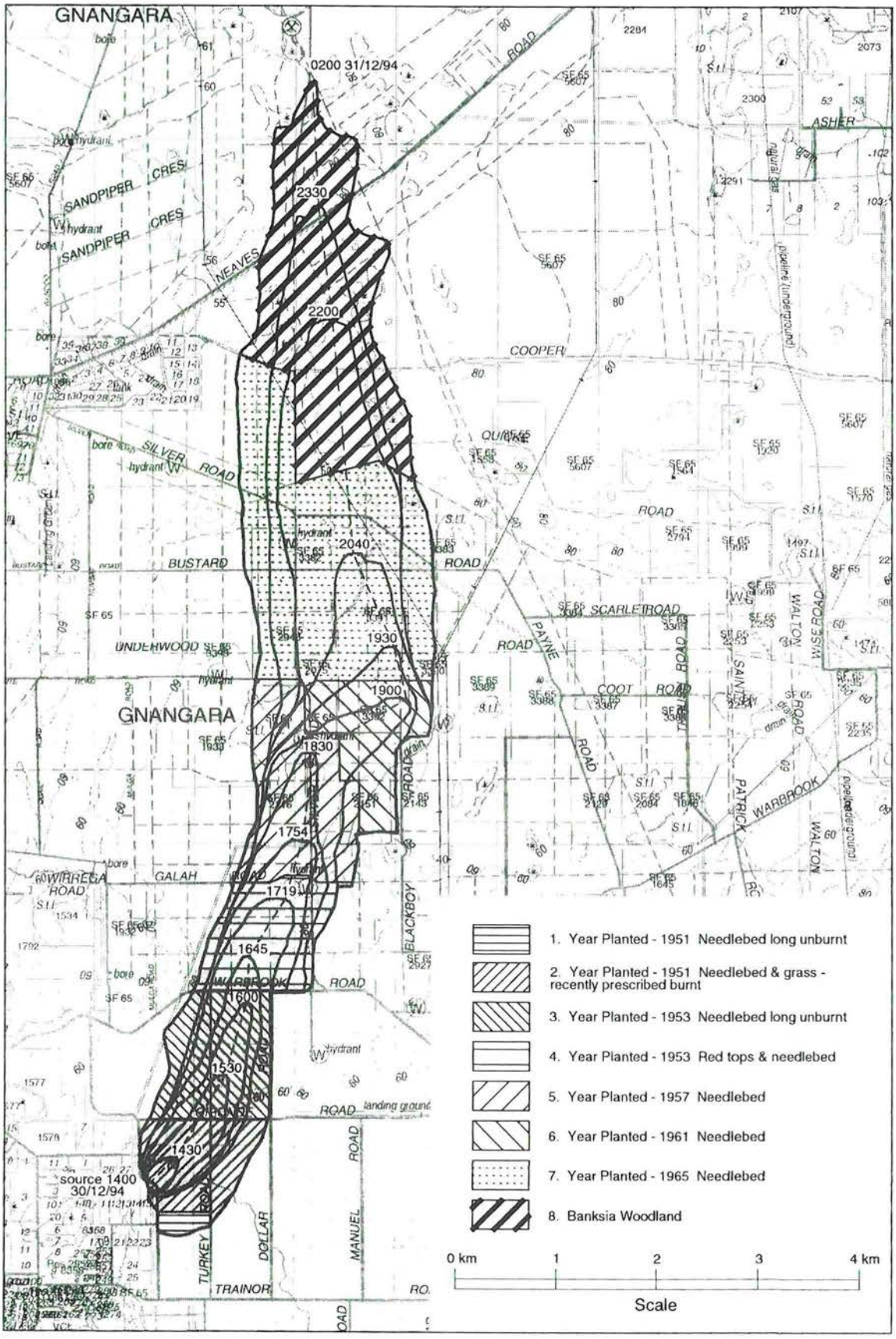


Figure 4. Wildfire perimeter with time.

TABLE 4. The behaviour and size of the Gnangara pine plantation wildfire at various time periods. The estimated ignition time was 1400 hours on December 30th 1994. See Table 2 for fuel code descriptions.

TIME (hours)	FUEL CODE BURNING	HEADFIRE RATE OF SPREAD (m h^{-1})	HEADFIRE FLAME HEIGHT (m)	FIRE AREA (ha)	FIREPERIMETER (m)
1400–1430	2	790	1–2	7	1 007
1430–1530	2&3	945	3–4	42	3 037
1530–1600	3	1 480	3–5	86	4 642
1600–1645	3&4	620	2–4	130	5 620
1645–1719	4	913	6–8	254	7 858
1719–1754	5&6	1 044	4–6	307	9 190
1754–1830	5&6	1 463	4–6	367	10 996
1830–1900	5&6	2 144	8–10	462	13 067
1900–1930	7	1 078	3–5	557	14 167
1930–2040	7	869	3–5	650	16 148
2040–2200	7&8	1 746	6–8	924	20 808
2200–2330	8	753	4–6	1077	22 897
2330–0200	8	490	1–2	1444	26 055

the crown or the bole. Thus, the extent of fire-caused damage to the plantation is of concern to plantation managers. It has ramifications for post-fire salvage operations and for the short and long term economics of the plantation. There is no information available for *P. pinaster* to allow the extent of fire-caused damage and mortality to be forecast or predicted. If managers could predict the fate of trees and cells after a wildfire, then they would be able to plan which trees or cells to salvage log and what the salvaging priority should be. That is, which trees are dead or will die and therefore should be salvaged immediately before they are affected by wood-degrading insects and fungi, and which trees, although damaged, are alive or likely to live and can either be salvaged later or left to grow.

To estimate the extent of canopy scorch and tree mortality, and to develop a relationship between crown damage (extent of scorch and defoliation) and mortality, a series of sample lines were placed across the width of the burned area. Seven lines were used to sample the most common age classes burned (Table 5). Four days after the wildfire, 30–34 trees were selected along each transect by selecting the tree nearest the line at 20–30 m intervals. Another ten trees per line were selected in adjacent unburnt cells as controls. Each tree was numbered and measured for d.b.h.o.b. (diameter at breast height over bark), bark thickness, total height, height to the base of the canopy, scorch height and stem char height (windward side). The site was re-visited some 3 months after the wildfire to assess whether the marked trees were alive or dead. This was ascertained by both visual assessment and by taking four cambial core samples from the stem at about 20 cm above ground. Live cambium is white in colour, whereas dead cambium is a brown-yellow colour. Without exception, trees that were deemed to be dead by visual inspection showed no signs of live cambium.

Trees were killed either by crown damage (crown scorch or defoliation) or by stem girdling, with the former being the most common cause of death. A summary of the mortality rate and of the extent of crown scorch among the sample trees is shown in Table 5 for each of major tree/cell ages affected by the wildfire. The highly stocked 1953 plantings suffered the highest mortality rate with 91 per cent of sampled trees being killed by the fire. This was probably owing to the combination of intense fire behaviour, moderate to heavy fuel loads (needlebed and red tops, see Table 2 above), and the relatively small height and d.b.h.o.b. of the trees. The mortality rate in other cells was between 50 and 60 per cent.

All trees whose crowns were either fully scorched or defoliated, died and, with the exception of those trees which were killed by stem girdling, 90 per cent of trees which retained more than 2 m of green crown, survived (Fig. 5). As expected, none of the trees in the unburnt cells had died when assessed three months after the wildfire.

Low intensity backfire (about 350 kW m^{-1}) burning in heavy needlebed fuels (fuel code 1, Table 2) killed about 50 per cent of large trees (planted in 1951), even though the scorch and stem char heights were relatively low (see Table 5). Inspection of these trees, whose crowns were mostly undamaged, or slightly damaged, revealed that the trees had been killed by stem girdling. These cells, which had not been burnt before the wildfire, carried deep and heavy needlebed fuel (fuel code 1, Table 2) which, under the very dry conditions, burnt completely. Consequently, the bark on the trees was burned down to the cambium,

TABLE 5. Damage to *P. pinaster* trees burnt during the Gnangara pine plantation wildfire. A total of 238 trees were sampled (30–34 trees per line). Standard errors are shown in parentheses.

LINE NUMBER & YEAR PLANTED	TOP HEIGHT (m)	HEIGHT TO CANOPY BASE (m)	d.b.h.o.b. (cm)	SCORCH HEIGHT (m)	STEM CHAR HEIGHT (m)	MORTALITY RATE – CROWN SCORCH (%)	MORTALITY RATE – STEM GIRDLING (%)
L1 1951	23.3 (0.32)	11.6 (0.25)	49.1 (0.96)	21.0 (0.55)	5.22 (0.59)	53	0
L2 1953	17.2 (0.47)	10.6 (0.26)	22.5 (1.31)	16.9 (0.50)	6.9 (0.61)	91	0
L3 1957	18.9 (0.54)	10.2 (0.43)	32.0 (1.26)	16.6 (0.66)	3.2 (0.16)	56	0
L4 1965	16.8 (0.34)	8.6 (0.34)	26.1 (1.30)	14.8 (0.44)	3.0 (0.56)	54	0
L5 1965	17.5 (0.27)	8.9 (0.33)	33.6 (1.21)	14.5 (0.44)	5.2 (0.55)	30	0
L6 1965	16.2 (0.34)	8.5 (0.47)	28.1 (1.67)	14.2 (0.65)	5.9 (0.73)	47	0
L7 1951	22.6 (0.34)	13.8 (0.31)	51.3 (1.24)	14.3 (0.65)	3.8 (0.31)	7	46

TABLE 6. A comparison of bark thickness on burned and unburned *Pinus pinaster* trees in the Gnangara pine plantation. Standard errors in parentheses.

	BURNT TREES (N = 153)	UNBURNT TREES (N = 70)
Mean bark thickness (mm)	19.5 (0.53)	29.7 (0.79)
Mean d.b.h.o.b. (cm)	30.4 (0.81)	30.3 (1.31)

Note: d.b.h.o.b. = stem diameter at breast height over bark.

from ground level to the height of the needlebed (40–80 mm), effectively girdling the trees. These trees could have been saved had the low intensity backfire been suppressed.

The wildfire significantly reduced bark thickness by about 30 per cent on all burned trees measured at breast height (1.5 m). The moisture content of the outer 5 mm of bark measured one day after the wildfire was about 10 per cent, so it is not surprising that during the wildfire a significant proportion of bark was burned (Table 6). The relationship between bark thickness measured at breast height and d.b.h.o.b. for unburned *P. pinaster* and *P. radiata* is shown in Figure 6. The *P. radiata* data are from Blackwood Valley plantations near Nannup and Kirup (Burrows 1985) and are included to show that *P. pinaster* develops thicker bark, which probably helps to explain its observed greater fire resistance.

CONCLUDING DISCUSSION AND MANAGEMENT IMPLICATIONS

The increasing level of arson in the Gnangara pine plantation and surrounds is a serious land management issue, not only for the plantations but also for other land uses in the region. Early detection and a rapid suppression response have been highly successful in limiting the size and impact of most wildfires, but situations will arise when this will not be the case, and large and damaging wildfires will result.

In the absence of management intervention, the fuels beneath *P. pinaster* plantations accumulate to very high levels. Wildfires in these heavy fuels can be difficult, dangerous and expensive to suppress. Heavy surface fuels are also conducive to the development of crown fires (Burrows *et al.* 1988). Reducing fuel loads by prescribed burning reduces the potential fire intensity, therefore the suppression difficulty and damage potential of wildfires. However, the introduction of prescribed fire into mature open stands encourages the growth of ephemeral grasses and other weeds, which support a fast spreading wildfire under dry, windy conditions. This is not an issue in stands

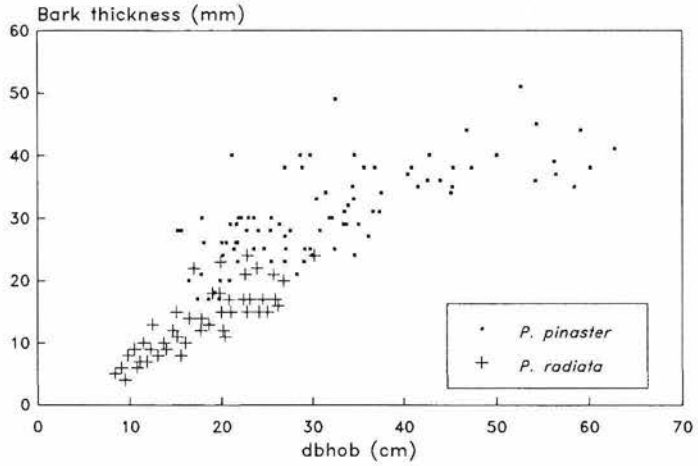


Figure 5. Relationship between bark thickness and stem diameter at breast height over bark (d.b.h.o.b.) for unburned Pinus pinaster *and* P. radiata *trees (Burrows 1985).*

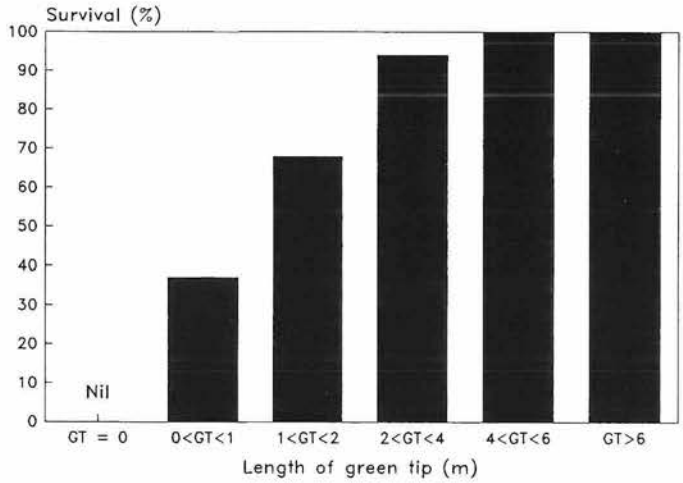


Figure 6. Probability of survival and length of green tip (unscorched crown) for Pinus pinaster *following the Gnangara pine plantation wildfire. This relationship applies to trees whose stems were not girdled by fire.*

with closed or near-closed canopies. The rate of spread of the wildfire described in this paper appeared to be unaffected by fuel load but affected by wind speed. However, fire intensity, flame dimensions, suppression difficulty and tree damage levels were significantly greater in those cells carrying heavier fuel loads. Trees that were defoliated or fully scorched by the wildfire, died, whereas more than 90 per cent of trees that retained more than 2 m of green tip, survived. The headfire spread significantly faster than predicted by the Forest Fire Behaviour Tables for Western Australia (Sneeuwjagt and Peet 1985) largely because the Tables over-predicted the moisture content of the fuel (i.e. fuels were drier than predicted) and wind speed through the stand was probably under estimated.

This wildfire provided an opportunity to evaluate, and where necessary, refine the existing fire management prescriptions. Many of the following management recommendations arising from this investigation are, to varying degrees, already incorporated in existing fire management plans. This case study serves to reinforce management practices.

(1) Further studies are needed to improve prediction of wind speeds in various plantation structures. Maps showing wind speed ratios that should apply when predicting fire behaviour in various parts of the plantation would be of assistance in forecasting fire danger and rate of spread. In the interim, predictions could be improved by using a wind ratio of 3:1 for mature (15–20 m) open stands (<250 stems ha^{-1}), a ratio of 4:1 for mature, moderately stocked stands (250–750 stems ha^{-1}) and 5:1 for mature, heavily stocked stands (750–1250 stems ha^{-1}).

(2) Regular (weekly) field checks of surface fuel moisture content should be made during the fire season to correct predictions.

(3) Detailed and up-to-date records and maps of all silviculture and fire management activities (including fuel maps) within plantations should be maintained to improve fire behaviour predictions. Ideally, these records should be maintained in a geographic information system (GIS).

(4) Weather equipment in Stevenson's screens should be maintained and calibrated regularly. Both the humidity and temperature sensors on thermohydrographs should be operational and accurate.

(5) The Soil Dryness Index (SDI) should be maintained and the current year SDI should be graphed with that of previous years and displayed in a prominent place so that fire managers can be appraised of the severity of the impending fire season.

(6) Rather than prescribe burning cells on a mosaic throughout the plantation, a series of wide, long fuel reduced buffers should be installed and maintained. If practical, the buffers should run east-west across the width of the plantation (perpendicular to prevailing winds), they should be 500–1000 m deep, be placed at about 3 km intervals and be burnt every 2–3 years to maintain fuel loads below about 6 t ha^{-1}. The purpose of these buffers is to reduce the potential for large intense wildfires to develop. In open areas within the buffers, grasses and other weeds should be managed to reduce the potential for fast spreading headfires to develop.

(7) During post-wildfire salvage operations, cells in which the trees have been defoliated or fully scorched should be removed first as these trees have been killed and the wood quality will deteriorate quickly. Trees with more than 2 m of green crown are expected to survive and need not be salvaged, or can be salvaged later if necessary.

ACKNOWLEDGEMENTS

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Mountain bike rider preferences and perceptions in the south-west of Western Australia

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ABSTRACT

A mail-back survey of mountain bike riders in the south-west of Western Australia revealed that riders prefer natural settings and trails with a firm surface. Riders support a code of conduct and are aware of environmental and management issues associated with trail use. Differences between racing and recreation riders' preferences for trail features and facilities were detected. Riders who race prefer technically challenging trails with downhill sections, curves and jumps, whereas recreation riders prefer trails that are less challenging, but well marked and have drinking water provided.

The issue of riders spreading dieback needs more attention. There is some evidence of spread of dieback by recreation, however, the spread between locations by mountain bikes may be limited since the majority of riders clean their bikes regularly, some clean their equipment after every ride. Many respondents revealed a poor understanding of dieback and where dieback risk areas are located. There is a need for raising rider awareness and understanding of this disease.

Several respondents indicated that a bike trail similar to the Bibbulmun Track walking trail should be established in Western Australia. The development of long distance mountain bike trails would provide tourism opportunities. All riders agreed that more mountain bike trails are needed in the south-west of Western Australia.

INTRODUCTION

An increase in leisure has seen a corresponding increase in outdoor pursuits as part of nature based tourism world-wide. In Western Australia (WA), nature based tourism has increased annually by 25 to 30 per cent (Western Australian Tourism Commission 1997). Mountain bike riding is an outdoor pursuit that is also growing in popularity, especially in natural settings. Between 1984 and 1989, the number of mountain bikes in the United States of America increased from 200 000 to 5 million (Blahna *et al.* n.d.) and mountain bike riding is the eighth most popular outdoor activity there (SGMA 1997). According to CALM (1999b), over 90 per cent of all bikes currently sold in WA are mountain bikes.

Corresponding with the increasing popularity of mountain biking is a growing demand for new trails and an expansion of existing trail systems. Meeting this demand is not easy since most trails throughout the world are established and maintained by agencies and organisations with insufficient resources. WA is no exception to this and the managing agencies, Trailswest and the Department of Conservation and Land Management (CALM), plan to expand the trail system in the State. This expansion will mean an investment of public funds in the establishment of trails and their ongoing maintenance. It is important that both mountain bike specific and multiple use trails are environmentally sustainable, and meet the needs of users (Goeft and Alder, submitted).

In the case of mountain biking, meeting rider needs helps to ensure, firstly, that trails are used and therefore public money to meet the demand is well spent and, secondly, that trails are less likely to be modified by riders, or informal tracks established. In Marin County, California, only wide trails and fire tracks were open to mountain bike riders who subsequently established illegal trails that suited their preferences (Edger 1997). Obtaining information on rider preferences is an integral part of locating, establishing and managing sustainable trails. Such information, however, is often not readily available for trail designers and managers owing to a lack of resources or time constraints: a situation existing in WA where the only study on rider preferences was an unpublished study undertaken by Brindal and CALM (1995) that examined some aspects of trail design (such as encounters with other trail users, amenities and trail surface) in relation to a long distance mountain bike trail. Clearly there was a need to gather more specific information on rider preferences in WA.

Managers need to integrate information on the trail features and settings that mountain bike riders actually want if mountain biking is to continue to grow in an environmentally sustainable manner. Until recently little information was available on rider preferences and none of this related to Australia. This paper presents the findings of a mail-out survey designed to determine preferences and

perceptions of mountain bike riders in the Perth metropolitan area and the south-west of WA in 1998/99. Specific information on rider demographics, preferred trail features and facilities, and perceptions of trail management and environmental issues was collated and analysed. This information is used to provide broad recommendations for trail designers and managers on the location, design and management of trails in the south-west of WA.

RIDER PREFERENCES AND PERCEPTIONS

Overseas research on the impacts and design of mountain bike trails has been of limited relevance to WA because of differences in the environments studied. The same may be true for user expectations, preferences and perceptions, hence local investigation was needed (MacGregor[1], personal communication, 13 August 1998). Nevertheless, the overseas studies provide a useful framework for designing mountain bike research programs in WA.

Research to explore various aspects of mountain bike rider behaviour, preferences, perceptions and demography was undertaken in the United Kingdom by Ruff and Mellors (1993) and in New Zealand by Cessford (1995c). In the United States of America Watson *et al.* (1991), Chavez (1993, 1996), Blahna *et al.* (1994), Blahna, *et al.* (n.d.) and Hollenhorst *et al.* (1995) investigated the same aspects. In Germany Wöhrstein (1998) carried out an extensive survey of mountain bikers through a mountain bike magazine.

Results of these studies found that males around the age of 30 years dominated mountain biking, with slightly younger participants in New Zealand and Germany compared with those in the USA and the UK. This reflects the image of mountain biking as adventure recreation (Priest and Dixon 1990) where participants look for a certain element of risk, excitement and peak experiences (Ewert 1989; Hollenhorst *et al.* 1995). Cessford (1995b) points out that trail design that takes into account surroundings, incline, and length of a trail, as well as difficulty and variation of a course, plays an integral part in satisfying these user expectations.

Cessford (1995c) found a variety of preferences that were important to riders of all levels, such as exploration of new areas, scenery and nature (including native forest and undulating terrain), speed and excitement, as well as socializing. Preferences for other features depended on the level of experience where technical challenges of speed, racing, single track, fast difficult downhills and long steep uphills with rough hard surfaces became more important to more experienced riders. Obstacles and difficulties on the tracks were also preferred by these riders. All riders preferred natural settings for riding, but more experienced riders were more tolerant of pine forest and farmland than new riders were. Racing was not very important to most riders in Cessford's study, while many experienced riders had done overnight tours.

[1] Ewen MacGregor, Trailswest, Perth, Australia.

Cessford (1995c) found that overall riders did not like to meet motorized vehicles and had a somewhat negative attitude towards meeting walkers. More experienced riders were more accepting of other mountain bikers than were less experienced riders. When the attitudes of riders toward management issues were explored, riders believed that most walking trails should be available for riding and that damage done by mountain biking is overrated. Voluntary codes of conduct were seen as a preferred management option.

Chavez (1993) found that most respondents to a mountain bike rider survey in the San Jacinto region (USA) were riding with friends and fewer rode alone or with family. On average, mountain bikers had been riding a mountain bike for 4.6 years, had ridden 42 times in the previous year, and their rides averaged 14.2 miles (22.7 km). Membership with various mountain bike organisations was low. Opinions on trails and trail use were also explored, with most riders agreeing with the need for trail etiquette and environmentally responsible behaviour. When asked about the desirability of various items at the trailhead, riders indicated that a map of the trail showing distances, signs showing permitted and prohibited trail uses and drinking water were the most desired items. Toilets and parking facilities were of medium importance.

Hollenhorst *et al.* (1995) also found that most mountain bikers in his survey of five USA National Forests rode with friends and that they preferred trails to roads. Average riding experience in years was 3.75 and in the previous 12 months they rode a mountain bike on average 67 times for about 15 miles (24 km) per ride. Reasons for riding a mountain bike were given as enjoyment/fun (30.5 per cent), exercise (23 per cent) and being in nature (10.8 per cent).

Wöhrstein (1998) found that only 15 per cent of mountain bikers in Germany were club members. The bikers rode their bikes on average about four times a week and close to 3500 km a year. The average ride distance was calculated as 16.5 km. Forty-three per cent of the riders indicated that they did tours and close to 37 per cent used their bikes to ride around the city or to work. Ninety-six per cent of the respondents used their mountain bike for rides in the countryside. Gravel roads were most frequented, followed by trails between 1 and 2 m wide. Sealed roads and footpaths less than 1 m width followed this. Very few mountain bikers did not ride on trails. Overall, riders experienced few problems with walkers, although women had slightly more problems than men did and young riders had more problems than older ones. When asked to compare the impacts of mountain bikes with those of hiking, mountain bikers estimated the impacts to be the same.

MOUNTAIN BIKE RIDING IN WESTERN AUSTRALIA

Western Australia's first mountain bike club, the Perth Mountain Bike Club, was formed in 1989. Membership

increased rapidly and now totals over 200 (Gaull[2], personal communication, 1998). Other clubs were formed. In 1995 the Western Australian Mountain Bike Association (WAMBA) was founded, which incorporates 10 Western Australian mountain bike clubs. In the last two years membership of WAMBA has stabilized at about 400 members (Ahrens[3], personal communication, 20 August 1998), with not all mountain bike club members being WAMBA members and vice versa (Gaull, personal communication, 14 December 1998). Most clubs are racing orientated, catering mainly for the racing community. Many mountain bike riders who pursue the sport only recreationally do not appear to be affiliated with any clubs, making it difficult to estimate the total number of mountain bikers.

The two major forms of mountain biking are recreational riding and racing. The most popular forms of mountain bike racing in WA are cross country and downhill. In cross country racing an undulating course with obstacles is ridden repeatedly; downhill racing entails racing down a course with obstacles. Other forms of mountain bike racing are dual slalom, where two riders race down a hill on parallel tracks; hill climb, where riders race uphill; observed trials, involving the negotiation of a natural or constructed obstacle course without setting a foot on the ground or leaving the course; and stage races, which are held over two or more days (UCI, 1998–1999).

In WA, most mountain bike racing trails are also used for recreational riding: they are cordoned off for racing events. There are few 'mountain bikes only' trails in WA and these are mainly confined to the south-west of the State (Fig. 1). Most of the mountain bike trails can be used by other types of recreationists and few of the trails that are used by mountain bikers are marked as such. John Forrest National Park has produced a leaflet describing the appropriate use of mountain bikes in the Park (CALM n.d.).

[2] Peter Gaull, former President, Perth Mountain Bike Club, Perth, Australia.
[3] Mick Ahrens, former Secretary, Western Australian Mountain Bike Association, Perth, Australia.

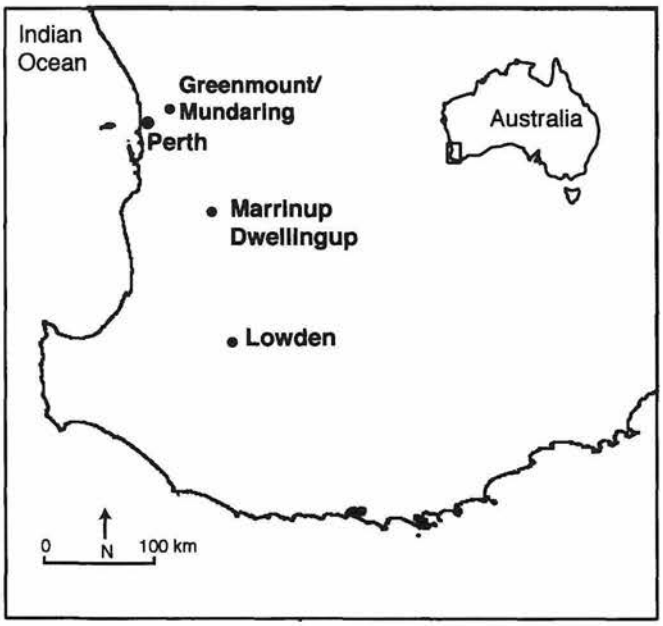


Figure 1. Locations of research sites and popular mountain biking trails.

RESEARCH METHODS

A mail-back questionnaire was used, with questions based on a review of similar studies as discussed above (see Appendix). Interviews with trail managers on the nature of information they sought for designing trails were also taken into consideration. The survey was pilot-tested by 15 mountain bike riders to identify problems with the design and delivery of the questionnaire, and any ambiguity over the questions' response clarity. Appropriate changes in wording and sequencing were made to the survey instrument prior to commencement of the survey.

Nine-hundred-and-eighty questionnaires were distributed during the period December 1998 and February 1999. Two hundred of these were distributed through a mailing list (Western Australian Mountain Bike Association), and the remainder through bike shops, CALM offices and personal contact with riders. The respondents either returned the completed form to the researcher in person or posted it in a reply paid envelope. The managers of shops and offices were asked to collate the questionnaires and either send them back in the reply paid envelopes provided or to await collection by the researcher. All shops and offices were reminded in early February to send the forms back by 15 February 1999.

The questionnaire was designed for easy and quick completion (8–10 minutes) and contained a mix of open, closed and Likert scale questions. It comprised four parts.

The first part provided a profile of riders: information was collected on rider participation in mountain bike clubs, reasons for undertaking the sport, equipment used, rider experience, frequency and length of rides, and favourite trails.

The second part of the survey, which was the primary focus of the study, explored rider preferences for trail features (e.g. downhills, curves, surfaces, logs, etc.), trail facilities (e.g. drinking water, trail markers, brochures, etc.), settings (natural and built), demand for touring trails, and encounters (e.g. wildlife, other trail users). In this section respondents assigned an importance rating to each item in a list of trail features, facilities and settings. Items relating to encounters were assigned a level of amenity (love it to hate it) by respondents. These items are of particular interest to trail managers.

The third section of the survey was used to examine rider perceptions of a range of statements on mountain bike management (e.g. the need for more trails, multiple-use trails, trail damage, rider techniques, bike cleaning) and environmental awareness (e.g. dieback, soil erosion). Dieback is a disease that attacks and kills many plants in the forests and heathlands of south-west WA (CALM 1999a). The disease can be spread by vehicles, such as logging machinery (Batini 1973), and some evidence exists

that recreationists can also spread the disease (Wills 1993). The bike cleaning practices of riders were explored as mountain biking may contribute to the spread of dieback. This section also queried respondents' attitudes towards a voluntary code of conduct.

Part four gathered basic demographic information (e.g. age, gender and place of residency) of respondents.

Survey data were collated and analysed using SPSS (7.5 for Windows) for non-parametric statistics appropriate to the style of question. Percentages were used for closed questions, means and modes for Likert scale questions and counts for the open questions. In some cases, cross tabulations with Chi squared tests were conducted. Specific comments made by respondents were typed out in full and collated. Some adjustments in the data analysis were made when respondents did not answer a question or when they answered single-answer questions twice. Analysis focused on general statistics such as rider profiles, rider preferences for trail features and facilities as well as the perceptions of riders towards management of environmental issues.

RESULTS

Response Rate

The survey response rate was 18.7 per cent (183 people). The response rate of the mail-out to the WAMBA members was over 50 per cent. The high response rate for WAMBA members was achieved because forms were mailed to individuals with reply paid envelopes attached. The response rate for questionnaires from bike shops and CALM offices was lower because some of these shops and offices were frequented by few mountain bike riders or the questionnaires were given out to riders but were not returned to the shops. Consequently, some responses may be biased and represent the views of people who belong to clubs more so than those of the general mountain bike population. Nevertheless sufficient information was obtained to compare the findings with those of other studies and to examine the implications of this study on trail design, especially in the south-west of WA.

Rider Profile

The majority of respondents were male (88 per cent) aged between 25 and 39 years (39 per cent), resident within the Perth metropolitan region (77 per cent) and had an average of 6 years of riding experience. Many of the respondents (72 per cent) were members of a mountain bike club. Most respondents ride mountain bikes for enjoyment and fun (91 per cent), followed by fitness and training (81 per cent). Many respondents (77 per cent) also indicated that they raced. This may be an overestimate since many respondents were mountain bike club members and racing is a major activity in many clubs. Five respondents specified 'adrenaline rush' as a reason for riding.

Most respondents (84 per cent) ride at least two to three times per week and their rides are at least 20 to 50 km long (46 per cent). More than half of the respondents (68 per cent) indicated that they had never participated in overnight tours, but more than half of these respondents (59 per cent) were interested in overnight touring. The respondents (30 per cent) who had toured, averaged 2.6 tours with four nights per tour. The most popular destinations for riding among the respondents were Mundaring, Dwellingup, Greenmount, Kalamunda and Helena Valley, which are mostly State forest settings (Fig. 1). A general trend of riders preferring to ride close to their place of residence was detected in the study ($p = 0.03$). Riders from the Perth metropolitan area prefer to ride close to Perth and respondents from country centres prefer to ride there.

Rider Preferences

Downhill (long, medium or short) sections, curves, short uphill sections, jumps, logs and slopes (moderate or steep) were the trail features that riders considered most desirable (Table 1). Respondents indicated that drinking water, route markers and parking facilities were highly preferred trail facilities (Table 1).

Respondents preferred single track, native bush or forest settings for riding (Table 2). Other settings such as plantation forests (mode = 2) and farmland (mode = 2) were tolerated by riders but built environments, urban areas (mode = 4) and sealed roads (mode = 3) were not desired (Table 2).

The preferences for trail features and facilities varied with the type of rider (recreational only, or a mix of racing/recreation). A majority of racing/recreation riders indicated that trail features such as downhill sections, curves and jumps were essential in trail design, whereas recreation riders indicated trail facilities such as drinking water and route markers were essential (Table 3). Recreation riders considered the above trail features to be good, except jumps, which they clearly dislike and avoid. The preferred setting also varied with the type of rider (Table 4). Recreation riders rated gravel roads and plantations essential or good, whereas racing/recreational riders considered single tracks as essential and were neutral towards or disliked gravel and sealed roads.

Rider Perceptions

Most respondents answered the questions relating to their perceptions of the environmental damage caused by mountain biking (Table 5). Most riders (mode = 4) disagreed with the statement that mountain biking damaged trails. Many respondents (mode = 1) indicated that 'trail damage by mountain bikes is overrated'. Respondents' awareness of specific environmental issues was weak as indicated by the number of 'don't know' responses (Table 5). Few respondents were sure whether trail damage varied with soil type (15 don't know responses) or with downhill curves (22 don't know responses), and whether mountain bike racing has more impact than touring (22 don't know responses).

Even fewer respondents were knowledgeable about dieback (37 don't know responses) and how it is spread

TABLE 1

Respondents' preferences for trail features and facilities (1 = essential, 2 = good, 3 = neutral, 4 = don't like and 5 = total rejection).

FEATURE	MEAN	MODE
Long downhills	1.47	1
Medium length downhills	1.56	1
Long curves	1.71*	1
Tight curves	1.75	1
Short downhills	1.92	1
Short uphills	1.93	2
Jumps	1.96	1
Moderate slopes	1.99	2
Steep slopes	2.06	1
Rocks/logs	2.10	1
Firm surface	2.14	2
Straight stretches	2.16	2
Setting up area	2.17	2
Easy slopes	2.20	2
Rough surface	2.25	2
Medium length uphills	2.34	2
Ditches	2.54	2
Long uphills	2.67	2
Smooth surface	2.87	3
Overhanging branches	3.07	3
Muddy/boggy areas	3.09	3
Loose sand/gravel	3.10	3
FACILITY		
Drinking water	1.81	2
Route markers	1.90	1
Parking facilities	2.08	2
Toilet facilities	2.12	2
Brochures	2.25	2
Interpretive signs	2.30	3
Information shelters	2.32	3

TABLE 2

Respondents' preferences for trail settings (1 = essential, 2 = desirable, 3 = okay, 4 = try to avoid and 5 = total rejection).

SETTING	MEAN	MODE
Native bush/forest	1.59	1
Plantation forest	2.32	2
Wide trail	2.54	2
Gravel road	2.72	3
Farmland	2.73	3
Sealed road	3.55	3
Built up areas/suburbs	3.62	4

(38 don't know responses). Nevertheless, 59 per cent of respondents indicated that they were aware of dieback risk areas and 85 per cent of these respondents could either define a dieback risk area or identify where they are found. Many respondents (40 per cent) indicated that they clean their bike after every race or ride and another 15 per cent indicated that they clean their bikes at least once per week.

Perceptions of mountain bike management issues were varied among respondents. There was agreement with the issues related to reducing trail damage such as good riding technique, trail design and education (Table 5). The mean response and mode was approximately 2 for these statements. There was less agreement on management issues relating to riders accessing all trails. Although the mode equalled 1, the mean score was 2.2. Respondents also indicated that they were satisfied with using trails repeatedly (mode = 2), but they did not agree with the statement that there are enough trails (mode = 4) (Table 5).

Respondents' perceptions of trail damage and riding technique varied with the type of rider (Table 6). Racing/recreational riders disagreed more strongly ($p = 0.018$) that mountain bike riding causes trail damage than recreational riders who tended to agree. Similarly racing/recreational riders in contrast to recreational riders strongly agreed ($p = 0.000$) that trail damage by mountain biking was overrated . Overall, there was agreement that good riding technique can reduce trail damage, with stronger agreement from racing/recreational riders ($p = 0.035$).

Ninety-one per cent of respondents indicated that they would be prepared to accept a voluntary code of conduct or trail etiquette. These respondents also indicated that concepts such as 'respecting other trail users', 'safety', 'respect for the environment', and 'minimizing damage' should be included in the code. Reasons for rejecting the code were loss of freedom or no need (4 respondents).

DISCUSSION

The preferences of mountain bike riders in terms of trail design and setting, as well as their awareness of mountain bike management issues, are important for the appropriate management of mountain biking and the design of mountain bike trails (Cessford 1995a).

The profile of mountain bike riders in this study coincides with that of other studies, that is, young males seeking fun and adventure with a high level of excitement and risk (Ewert 1989; Priest and Dixon 1990; Hollenhorst *et al.* 1995; Cessford 1995c). They ride at least two to three times per week and travel at least 10 km each ride. These findings compare with those of Wöhrstein (1998) who found that German mountain bikers rode their bikes on average four times a week and for 16.5 km. Hollenhorst *et al.* (1995) also noted that riders in their survey travelled an average of 15 miles (24 km). Mountain biking also has female participants (11 per cent in this study) and riders range from the very young to 60+ years who ride for fitness and enjoyment. Riders also tend to ride near their place of residence and, as in this study, they often live in urban centres (Horn *et al.* 1994).

TABLE 3

Significant ($p < 0.5$) cross tabulations of rider motivation with trail features.

TRAIL FEATURE	CATEGORY	RECREATION ONLY RIDERS	RACING AND RECREATION RIDERS
		n=38	n=128
Long downhills	essential	39.5%	72.7%
	good	44.7%	18.8%
	neutral to dislike	15.8%	8.6%
Medium downhills	essential	39.5%	62.5%
	good	47.4%	28.1%
	neutral to dislike	12.8%	9.4%
		n=39	n=129
Long curves	essential	30.8%	49.6%
	good	56.4%	34.9%
	neutral to dislike	12.8%	15.5%
Tight curves	essential	30.8%	57.4%
	good	30.8%	30.2%
	neutral to dislike	38.4%	12.4%
Water	essential	41.0%	37.2%
	good	53.8%	38.8%
	neutral to dislike	5.1%	24.0%
Route markers	essential	51.3%	30.2%
	good	35.9%	41.1%
	neutral to dislike	12.8%	28.7%
Short uphills	essential	25.6%	35.7%
	good	66.7%	41.9%
	neutral to dislike	7.7%	22.5%
Jumps	essential	28.2%	49.6%
	good	10.3%	34.9%
	neutral to dislike	61.5%	15.5%
		n=39	n=128
Short downhills	essential	20.5%	46.1%
	good	51.3%	32.0%
	neutral to dislike	28.2%	21.9%

TABLE 4

Significant ($p < .05$) cross tabulations of rider motivation with settings.

SETTING	CATEGORY	RECREATION ONLY RIDERS	RACING AND RECREATION RIDERS
		n=39	n=128
Single trail	essential	25.6%	70.3%
	good	35.9%	25.0%
	neutral to dislike	38.5%	4.7%
Gravel road	essential to good	51.3%	34.4%
	neutral to dislike	48.7%	65.6%
		n=39	n=129
Plantation	essential to good	46.2%	66.7%
	neutral	41%	26.4%
	avoid to dislike	12.8%	6.9%
		n=39	n=127
Sealed road	essential to good	17.9%	9.4%
	neutral	59.0%	32.3%
	avoid to dislike	23.1%	58.3%

TABLE 5

Respondents' perceptions of environmental and mountain bike management issues (1 = agree strongly, 2 = agree, 3 = neutral, 4 = disagree and 5 = strongly disagree, N = 183).

STATEMENT	MEAN	MODE	DON'T KNOW
ENVIRONMENTAL ISSUES			
Mountain bike riding damages trails	3.82	4	6
Trail damage by mountain bikes is overrated	1.73	1	19
Trail damage varies with soil type	1.94	2	15
Mountain bike racing has more impact than touring	2.34	2	22
Dieback is an environmental problem in WA	2.03*	2	37
Mountain bikes can spread dieback disease	2.75	2	38
Most trail damage occurs in downhill curves	2.46	2	22
MANAGEMENT ISSUES			
Good riding technique reduces trail damage	1.86*	2	7
Good trail design can reduce trail damage	1.75*	2	9
Rider education could reduce trail damage	1.92*	2	3
Mountain bikes should be allowed on all trails	2.20	1	2
It is enjoyable to ride the same trail repeatedly	2.48	2	1
There are enough mountain bike trails	4.05	4	3

Racing, and therefore speed and excitement, is also a popular reason for mountain biking in the south-west of WA. This study, and those of Cessford (1995c) and Ruff and Mellors (1993), noted that racers are often associated with clubs. The level of membership with a mountain bike club in this study was much higher than that found in studies in Germany (Wöhrstein 1998) and the United States (Chavez 1993). In Germany only 15 per cent of respondents were club members. The higher level of membership in this study may be attributed to the good response rate from mountain bike club members compared with that of non-members.

Nearly 30 per cent of respondents had done overnight tours and another 30 per cent were interested in doing these tours. In Wöhrstein's (1998) survey, 43 per cent of the riders indicated that they had done tours. Cessford (1995c) found a relationship of greater rider experience with number of overnight tours, which is comparable to the findings of this study, with more racers than recreational riders participating in overnight tours. This is reinforced by specific comments for the provision of mountain bike touring trails like the Bibbulmun Track walking trail in the south-west of WA.

Mountain bike riders in this study prefer to encounter wildlife and other cyclists on their rides. Cessford (1995c) found a similar preference of more experienced riders for meeting other cyclists. Respondents in this survey were neutral towards walkers and horses, which is not directly comparable with the findings of Watson *et al.* (1991) who found that few mountain bikers disliked hikers, and Wöhrstein (1998) who noted that few mountain bikers experienced problems with walkers. Cessford (1995c), however, found that riders were tolerant-to-negative towards walkers. Brindal and CALM (1995) found a mixed response by mountain bike riders towards walkers. Many respondents of their survey were happy to meet walkers on bush tracks but not horses.

Riders in Cessford's (1995c) study and in this study disliked motorized vehicles. Brindal and CALM (1995) also found that riders did not want to share trails with trail bikes. This concurs with Devall and Harry (1981, p. 399) who stated that: 'Users of less obtrusive technologies seem to dislike the more obtrusive much more than the latter dislike the former'. Mountain bike riders dislike trail bikes. This may be owing to competition for trails, since trail bikes can use narrow mountain bike trails, and to their potential to physically impact the trail (Weaver and Dale 1978; Wilson and Seney 1994).

Long and medium length downhill sections were the most preferred trail features in this study. They were closely followed by long as well as tight curves. These features create a challenging and technically demanding trail for riders, especially racers. Short downhill sections, jumps, steep slopes and short uphill sections are features that racers want, but recreational riders did not see these as important features in this study. Cessford (1995c) found essentially the same trends, with more experienced riders being more interested in technical difficulties, fast downhill sections and steep slopes as well as in racing.

Recreation-only riders in this study and in that of Brindal and CALM's (1995) study preferred drinking water and route markers. Chavez (1993) also found that riders wanted to have drinking water available at the trailhead. In addition, Chavez (1993) found that toilets and parking were amenities that were of medium importance to riders as did Brindal and CALM (1995), which is comparable to results of this study.

Overall, respondents in this study and in that of Cessford (1995c) did not like smooth surfaces, overhanging branches, muddy or boggy areas and loose

TABLE 6
Significant ($p < .05$) cross tabulations of rider motivation with opinion statements.

STATEMENT	CATEGORY	RECREATION ONLY RIDERS	RACING AND RECREATION RIDERS
		n = 35	n = 128
Mountain bike riding damages trails	strongly agree – neutral	51.4%	28.8%
	disagree to strongly disagree	48.6%	71.2%
		n = 36	n = 126
Good riding technique reduces trail damage	strongly agree	33.3%	36.5%
	agree	36.1%	50.8%
	neutral – strongly disagree	30.6%	12.7%
		n = 28	n = 119
Trail damage by mountain bikes is overrated	strongly agree	28.2%	53.2%
	agree	18.0%	34.1%
	neutral – strongly disagree	53.8%	12.7%

sand or gravel surfaces. For smooth surface, Cessford (1995c) found differences in opinion and many riders actually preferred this condition. In this study, some respondents remarked that a 'good' mountain bike trail has to have a variety of features to be interesting to ride.

In terms of settings, respondents clearly preferred single tracks and native bush or forest with a lesser preference for plantation forest and wide trails. Farmland and gravel roads were more acceptable than sealed road. Most respondents avoid built up areas or suburbs. Similar preferences for natural settings were found by others (Ruff and Mellors 1993; Cessford 1995c; Hollenhorst *et al.* 1995). By contrast with these studies, respondents in the Brindal and CALM (1995) study preferred compacted or hard soils over gravel, sealed and rock surfaces.

Interestingly, racing riders rate plantation forests quite highly as a setting in contrast to recreational riders: this was also noted by Cessford (1995c). A possible explanation for this could be that racers ride mainly for sport and not for sightseeing and as long as the requirements for a 'good' mountain bike trail (see above) are fulfilled, racers do not care as much as recreational riders do about the surroundings.

The statement that mountain biking should be allowed on all trails attracted a range of responses from strong agreement to disagreement. This same wide spread in opinion was observed by Cessford (1995c). Respondents were quite united in their disagreement with the statement that there are enough mountain bike trails, especially overnight touring trails. Locally, there is an order of magnitude between the length of dedicated walking trails (1000s of kilometres) and dedicated mountain bike trails (a few hundred kilometres). Meeting this shortfall is important in minimizing environmental impacts and reducing trail user conflicts. Bjorkman (1996) implied that more mountain bike trails would disperse riders over a greater area and result in less damage to trails in Wisconsin.

Both this and Cessford's (1995c) studies noted that riders do not agree that mountain bike riding damages trails and that they agree that trail damage by mountain bikes is overrated. An experimental study by Wilson and Seney (1994) in the USA and a three-year study by Wöhrstein (1998) in Germany both found little damage by mountain bikes. Keller (1990, cited in Cessford 1995b) associated mountain bikes with trail damage, although he conceded that the extent of damage depended on riding technique.

Good trail design, as well as good riding technique, was seen by respondents as a way to reduce trail damage. Chavez *et al.* (1993) found that trail erosion depended on site conditions and rider behaviour. Riders in this survey saw rider education as a means to reduce trail damage. These findings suggest awareness by mountain bikers of these issues in accordance with the findings of various researchers. Widmer (1997) points to the importance of education to reduce trail damage because aware riders ride more responsibly. He recommends a code of conduct.

Nearly all respondents in this survey supported a code of conduct. The most important aspects of such a code were cited as respect for other trail users, safety, respect for the environment and respect for the trail. Chavez (1993) also found that most riders supported trail etiquette and environmentally responsible behaviour, and Cessford (1995c) found that voluntary codes of conduct were seen as the preferred management option for mountain biking by riders.

Dieback was acknowledged as a serious environmental problem in WA, but mountain bikers were not as readily accepting of the notion that their bicycles are potential disease carriers. Many respondents pointed out that walkers and wildlife are also potential carriers of the disease. Under the existing management guidelines of CALM, given the limited knowledge and lack of research into the potential spread of dieback by mountain bikes, walkers or wildlife, a change in the current situation seems unlikely.

The notion that trail damage by mountain bikes is overrated found greater support among racers than among recreational riders in this study. Racers also disagreed more with the statement that mountain bikes cause trail

damage. This difference was not found by Cessford (1995c). Factors leading to these differences in opinion may be owing to racers riding more often than recreational riders and racers observing how little the trails change over time. Alternatively, racers may be accustomed to the impacts of mountain bikes, not noticing them any more or accepting them as part of the sport. For an occasional recreational rider a worn curve, an eroded downhill section or skid marks may be more noticeable.

The statement that good riding technique reduces trail damage was strongly supported by both groups of mountain bikers, with racers agreeing more strongly than recreational riders. This discrepancy may reflect the greater knowledge of riding techniques and the better riding skills of racing riders. Observations at racing events support this statement. Riders who appeared to have great mastery over their bicycles were skidding very little in or before curves, thus reducing damage to the trail surface.

Among the racing community there seems to be more support for the notion that all trails should be open to mountain bikes whereas among recreational riders many disagree with the idea. This may reflect the perception by racers that mountain bikes do little damage to trails especially when good riding technique is employed. Furthermore, racers would like access to walking trails because they often meet racers' preferences for narrow single tracks.

Since the majority of riders clean their bicycles at least monthly and 40 per cent of riders indicated that they clean their bikes after every race or ride, the risk of the spread of dieback by mountain bikes between areas is perceived to be low. Riders also remarked that they clean their bikes after muddy rides: wet conditions are conducive to the spread of *Phytophthora* spores (Shearer and Tippet 1989). However, it is likely that mountain bikes can spread dieback along tracks, similar to the spread of the disease observed on recreational (walking) tracks in the Stirling Range National Park (Wills 1993). Clearly this subject needs further investigation.

Over half of the survey respondents indicated that they were aware of dieback risk areas (DRA), however, they also indicated a lack of knowledge and information, as well as confusion over the DRA system. This lack of understanding is supported by the high number of 'don't know' answers, especially among young respondents, to the statements that related to dieback.

MOUNTAIN BIKE MANAGEMENT IMPLICATIONS

Trail Development

The survey has clearly shown that riders want more trails. These should be provided in close proximity to where riders live, especially within the Perth metropolitan area. This would meet the needs of young riders who have limited access to the trails.

A long distance trail may provide tourism opportunities. Overnight mountain bike touring through natural settings is limited in Europe despite the high demand (Wöhrstein[4] personal communication, 1999) and the provision of long distance trails would greatly add to the already substantial attractiveness of Australia to European and especially German tourists. Mountain bike tours are popular with visitors to New Zealand. Their availability in the south-west of WA could provide substantial economic gains for local communities.

Trail Design

Trails need to have a variety of features, be of varying distances and in a range of natural settings. Riders who use trails are seeking different experiences that range from adrenaline rush to a peaceful ride in the bush. Racers seek single tracks that are technically challenging with steep downhill sections of varying lengths and short uphill sections. Although recreational riders enjoy some of these features, other features favoured by racers such as jumps and tights curves are not desired.

Ideally, an interconnected system of mountain bike circuits or loops of differing length and difficulty with obstacles and difficult trail sections reserved for the trail loops should be developed for WA. The main trail should be of a difficulty level that allows for relaxed riding and is suitable for riders with relatively little experience. The trail(s) should be clearly marked and the level of difficulty (rating) and the presence of obstacles should be clearly stated at the trailhead. A rating system could be based on the length of trail, technical difficulty including obstacles, and the number of steep slopes. The provision of trail markers and drinking water is important to recreational riders. Adequate access to drinking water, parking facilities and setting-up areas, toilets and shelters as well as emergency access should be considered when siting a trail.

Mountain bike riders indicated a willingness to share trails. Other users, especially walkers, may be reluctant to do so. This survey and other studies also clearly show that riders do not want to share the trail with motorized vehicles. Conflict with other users can be avoided if the trail system consists of mountain bike only trails. This is highly unlikely given the limited resources of most agencies responsible for trails. Nevertheless, some of the problems of sharing trails can be addressed through rider education and awareness (Moore 1994). A code of conduct for mountain bike riders can also add to an improved understanding between trail users.

Practices

The support of a code of conduct was clearly indicated by the vast majority of respondents and should be developed as planned by WAMBA (Machin[5], personal communication, 1998). The code should include aspects of safety, respect for other users and respect for the environment. Low impact riding behaviour should also be included. Riders also expressed confusion about right of

[4] Dr Thomas Wöhrstein, An der Steige 132, 78713 Schramberg, Germany.
[5] Les Machin, former Trails Coordinator, WAMBA, Perth, Australia.

way issues. Rules that are acceptable to the majority of trail users could reduce conflict and increase safety. Irrespective of a code of conduct, riders should be encouraged to wash their bikes after every ride to reduce the potential to spread dieback.

Information

Signs at the trailhead should show a map of the trail, state the length of the trail as well as its difficulty rating. The signs should also clearly state the users allowed on the trail (preferably explaining why use is restricted if it is) and state whether it is a one-way track. Especially at multiple-use trails the appropriate trail etiquette should be stated. Trail markers should be clearly visible along trails. Warning signs should be placed at road crossings or other features that require extra caution.

Off the trail, maps and brochures can be used to disseminate information through bicycle retail outlets, mountain bike clubs and appropriate agencies (Trailswest, Bikewest, CALM). The maps should contain information about the trail (length, difficulty) and how to access it as well as the location of telephones and the nearest bicycle shops. These publications should contain a code of conduct and information on low impact mountain biking.

Many respondents were not aware that dieback is a major environmental problem in WA. There is a need for more information about dieback and dieback risk areas, in particular what a DRA is and why they are there. Mountain bike specific publications could be used to disseminate information about DRAs and why mountain bikes are not allowed in these areas. Awareness programs should increase the understanding of dieback among riders including the younger riders.

Education

High schools, technical and further education colleges and universities could provide courses for the public on mountain bike riding. These should include aspects of rider safety, trail etiquette, riding techniques, dieback awareness and bicycle maintenance. The courses could be tailored to suit the skill levels of participants and the capability of their bicycles. Some educational institutions provide courses for their students but these are not open to the public. These institutions could consider providing public courses, utilizing their resources and knowledge base during holiday periods. Some operators conduct mountain bike tours but these allow for limited instruction only. However, as a service to customers they could consider specific courses. Bike shops could hold workshops or sponsor such events.

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APPENDIX - *Questionnaire*

Dear Mountain Bike Rider,

This questionnaire is part of a research project designed to help improve mountain bike trails and facilities in Western Australia.

The project is run by Ute Goeft, an Environmental Management honours student at Edith Cowan University in Joondalup. The research will help Trailswest, the Department of Conservation and Land Management (CALM) and Western Australian mountain bike clubs to locate, construct and maintain better and environmentally sound mountain bike trails and facilities. To achieve this aim it is important to know what mountain bike riders actually want in a trail and therefore **we need your help !**

The information you provide will be completely confidential.

Please take a few minutes and **fill in this form. Thank you.** ✍

◀ ◀ ◀ ❖ ▶ ▶ ▶

1. **Do you belong to a mountain bike club?** ❑ Yes ❑ No

2. **Why do you ride a mountain bike?** (tick as many boxes as you like)
   - ❑ enjoyment/fun
   - ❑ relaxation
   - ❑ exercise/training
   - ❑ to appreciate nature
   - ❑ to be with friends
   - ❑ family outing
   - ❑ for a challenge
   - ❑ racing ➪ DH ❑; XC ❑; DS ❑; Trials ❑
   - ❑ transport
   - ❑ other (please specify).....

3. **How often do you ride a mountain bike?** (please tick one box only)
   - ❑ once a day
   - ❑ 2 - 3 times a week
   - ❑ once a week
   - ❑ 2 - 3 times a month
   - ❑ once a month
   - ❑ other (specify).....

4. **In what year did you start to ride a mountain bike?** (please specify) 19.....

5. **How long are your rides on average?** (please tick one box only)
   - ❑ under 2 km
   - ❑ 2 - 5 km
   - ❑ 5 - 10 km
   - ❑ 10 - 20 km
   - ❑ 20 - 50 km
   - ❑ over 50 km

6. **Have you done tours that included over night stays?**
   - ❑ Yes ➪ how many tours have you done? Please specify number of tours.....
     ➪ how many nights did you stay away on your last trip? Please specify number of nights.....
   - ❑ No ➪ are you thinking of doing overnight tours? ❑ Yes ❑ No

7. **Where do you like to ride?** (please list your 3 favourite areas/trails according to preference)

   a. ..... b. ..... c. .....

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8. Do you mind if you encounter: (please circle 1 number per row)

	love it	quite good	neutral	don't like	hate it
cars/4WDs	1	2	3	4	5
motor bikes	1	2	3	4	5
horses	1	2	3	4	5
wildlife	1	2	3	4	5
walkers	1	2	3	4	5
other cyclists	1	2	3	4	5

9. How important are the following features for you when riding? (circle 1 no. per row)

	essential	would be good	neutral	don't like it	don't want at all
smooth surface	1	2	3	4	5
rough surface	1	2	3	4	5
loose sand/gravel	1	2	3	4	5
firm surface	1	2	3	4	5
muddy/boggy areas	1	2	3	4	5
easy slopes	1	2	3	4	5
moderate slopes	1	2	3	4	5
steep slopes	1	2	3	4	5
short uphills	1	2	3	4	5
long uphills	1	2	3	4	5
medium length uphills	1	2	3	4	5
short downhills	1	2	3	4	5
long downhills	1	2	3	4	5
medium length downhills	1	2	3	4	5
tight curves	1	2	3	4	5
long curves	1	2	3	4	5
straight stretches	1	2	3	4	5
jumps	1	2	3	4	5
rocks/logs	1	2	3	4	5
overhanging branches	1	2	3	4	5
ditches	1	2	3	4	5
parking facilities	1	2	3	4	5
setting up area	1	2	3	4	5
drinking water (tap/tank)	1	2	3	4	5
toilet facilities	1	2	3	4	5
route markers	1	2	3	4	5
information shelters	1	2	3	4	5
brochures	1	2	3	4	5
interpretive signs	1	2	3	4	5
other (specify)	1	2	3	4	5

10. How important are the following settings for you when riding? (circle 1 number per row)

	essential	desirable	okay	try to avoid	don't want at all
native bush/forest	1	2	3	4	5
plantation forest	1	2	3	4	5
farmland/meadows	1	2	3	4	5
built up areas/suburbs	1	2	3	4	5
sealed road	1	2	3	4	5
gravel road	1	2	3	4	5
wide trail	1	2	3	4	5
single track	1	2	3	4	5

11. Do you agree that: (circle one number per row)

	strongly agree	agree	neutral	strongly disagree	disagree	don't know
- there are enough mountain bike trails	1	2	3	4	5	6
- mountain bikes should be allowed on all trails	1	2	3	4	5	6
- mountain bike riding damages trails	1	2	3	4	5	6
- good riding technique reduces trail damage	1	2	3	4	5	6
- rider education could reduce trail damage	1	2	3	4	5	6
- mountain bikes can spread dieback disease	1	2	3	4	5	6
- trail damage varies with soil type	1	2	3	4	5	6
- most trail damage occurs in downhill curves	1	2	3	4	5	6
- trail damage by mountain bikes is overrated	1	2	3	4	5	6
- it is enjoyable to ride the same trail repeatedly	1	2	3	4	5	6
- mtb racing has more impact than touring	1	2	3	4	5	6
- good trail design can reduce trail damage	1	2	3	4	5	6
- dieback is a big environmental problem in WA	1	2	3	4	5	6

12. Would you be prepared to accept a voluntary code of conduct/trail etiquette?

❑ Yes ➪ What would be important to you (e.g. safety, respect other trail users)?

(please specify) .....

.....

.....

❑ No ➪ Why not? (please specify).....

.....

13. What type of mountain bike do you ride?

❑ no suspension

❑ front suspension ❑ dual suspension ❑ other.....

14. How often do you clean your bike (including tyres and treads)? (tick **one** box only)

❑ once a week ❑ once a fortnight ❑ once a month

❑ every 3 months ❑ every six months ❑ once a year

❑ after every race/ride ❑ never ❑ other .....

15. Are you aware of dieback risk areas? ❑ No ❑ Yes ⇨ see below

If yes, please specify below what a dieback risk area is and where they are found

.....

.....

16. What age group do you belong to?

❑ under 15 ❑ 15 - 24 ❑ 25 - 39 ❑ 40 - 59 ❑ 60 & over

17. Are you female or male? ❑ female ❑ male

18. Please tell us your post code ❑❑❑❑

if you are visiting Australia please tell us your home country .....

19. Is there anything else you would like to tell us? Please do ! .....

.....

.....

.....

.....

Please **return this form** to the person who gave it to you or

mail it in the reply paid envelope provided **as soon as possible** (latest by 15 February, 1999).

Thank you very much for your time & happy riding ! ☺

✂----------

Trailswest are currently developing a network of recreation trails around the State, for information please contact Ewen MacGregor at Trailswest: ∋ 9387 9700; FAX 9387 9726;
email: emacgregor@wamsr.ausport.gov.au or visit the Trailswest website: www.msr.gov.au

For information on the project please contact Ute Goeft: ph. 9400 5058; email: u.goeft@cowan.edu.au

If you want more questionnaires please contact Ute or Ewen.

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