

The reptile, bird and small mammal fauna of Dune Mallee Woodlands in south-western New South Wales

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ABSTRACT

Baseline surveys of reptiles, birds and small mammals that occur in Dune Mallee woodlands in the Lower Murray Darling catchment of south-western New South Wales were conducted at 60 sites between October 2007 and March 2008. These surveys comprise the first round of a catchment-wide monitoring programme to obtain a measure of the distribution and abundance of 21 priority threatened fauna species that inhabit Dune Mallee Woodlands. A total of 127 fauna species were recorded, which included 19 of the possible 21 threatened fauna species. The 127 species comprised 37 reptile species, 15 bat species, three small mammal species and 72 bird species. The mean species richness recorded at each three hectare survey site for birds was 14.7, reptiles 7.1, small ground dwelling mammals 0.5 and bats 3.0. Mean abundance for birds was 42.7, reptiles 13.1, small ground dwelling mammals 1.0 and microbats 3.7. These surveys represent the most comprehensive inventory of fauna of the Dune Mallee Woodlands of the Lower Murray Darling catchment. Furthermore, these surveys are a platform upon which to detect changes in abundance and persistence of priority threatened fauna species, as a way of measuring outcomes of property management agreements and offset reserves where land management has been enhanced by actions such as exotic herbivore removal and predator control.

Key words: Dune Mallee Woodlands; Spinifex; *Triodia*; Threatened species; Monitoring; Reserves; Species richness, Murray-Darling Depression Bioregion.

Introduction

Dune mallee woodlands of western New South Wales (NSW) are a vegetation class that typically grow on irregular, sub-parabolic to parabolic dunes on deep sandy red soils (Keith 2004). They include two described plant communities 'Deep Sand Mallee of Irregular Dunefields of the Semi-Arid (warm) Zone' and 'Spinifex Linear Dune Mallee mainly of the Murray-Darling Depression Bioregion (Benson *et al.* 2006). Dune mallee woodlands occur in two distinct areas in the far south west of NSW from Balranald to the South Australian border and in the Cobar Peneplain north of Griffith (Keith 2004).

In the Lower Murray Darling catchment of south-western NSW, some areas of Dune Mallee woodland have been cleared for dryland farming and irrigated horticulture, which has resulted in fragmentation and isolation of remnants. However, there are still large contiguous areas of this vegetation class in south-western NSW with an estimated $81 \pm 20\%$ of the community 'Spinifex Linear

Dune Mallee mainly of the Murray-Darling Depression Bioregion' and $99\% \pm 20\%$ of the community 'Deep Sand Mallee of Irregular Dunefields of the Semi-arid (warm) Zone' remaining (Benson *et al.* 2006). A significant proportion of the threatened fauna and flora of the Lower Murray Darling (LMD) catchment is restricted to Dune Mallee vegetation communities. The main threat to Dune Mallee fauna and their habitats is the ongoing degradation of the understorey and suppression of overstorey regeneration from feral and domestic herbivore grazing (Benson *et al.* 2006). To improve the status of the biodiversity in the LMD catchment, land management agreements on leasehold properties have been developed between landholders and the Lower Murray Darling Catchment Management Authority (LMDCMA) through various offsets and incentive mechanisms. The primary land management objective under these offsets and stewardship agreements is the reduction in total grazing pressure by exclusion of feral and domestic stock.

This paper presents the results of baseline fauna monitoring surveys between October 2007 and March 2008 in the LMD catchment of south-western NSW. The primary aim of this project was to select, establish and conduct the first round of fauna surveys at a network of 60 monitoring sites across the catchment. The condition of native vegetation at each site was also measured using a standardised method developed by the NSW Office of Environment and Heritage (OEH). Monitoring of the distribution, abundance and persistence of threatened and non-threatened fauna and their habitat condition across the study area will assist assessment of responses to current and future land use and climate change.

The fauna monitoring programme was also devised to provide advice to the LMD CMA on land management issues for which they have responsibility. One of the main biodiversity conservation mechanisms used in the catchment in the last decade has been the use of reserves to offset developments. Exclusion of domestic stock is also used to enhance the biodiversity value of landscapes. Hence, the establishment of monitoring sites within these areas was also considered by OEH and the LMD CMA to be a priority to detect long-term biodiversity outcomes in dune mallee woodland reserves where domestic stock grazing has been excluded.

Study Area

The LMD CMA area covers approximately 6.3 million ha and spans an area from the junction of the Murray and Murrumbidgee Rivers, west to the South Australian border, to Broken Hill in the north and east to Ivanhoe. Grazing is the dominant land-use on Western Lands leasehold properties in the LMD CMA area. In the south, dryland cropping and horticulture become more dominant. The LMD CMA area consists of three natural regions (IBRA Bioregions) (Morgan and Terry 1992); the Murray-Darling Depression Bioregion, which is dominated by dunes and sandplains and which is intersected by the Darling Riverine Plains Bioregion, which is characterised by alluvial deposits associated with the Darling River, and the Murray Riverine Plains Bioregion, which has extensive alluvial deposits associated with the Murray River (Morgan and Terry 1992). The Mallee overstorey is dominated by *Eucalyptus dumosa*, *Eucalyptus socialis*, *Eucalyptus gracilis*, *Eucalyptus leptophylla* and *Eucalyptus costata*. The shrub layer is highly variable with an understorey dominated by Spinifex *Triodia scariosa* subsp. *scariosa* (Figure 1).

Methods

Fauna surveys in the LMD CMA area have largely been confined to NSW National Parks and Wildlife Service (NPWS) Reserves (Ellis and Henle 1988, Ray Dayman pers. comm., NPWS), State Forests (Parson, 1993, Webster et al. 2003) and the Willandra World Heritage Area (Sadlier and Shea 1989, Boles and McAllan 1985, Tidemann 1988). A large number of surveys have been conducted to facilitate regional assessments (Brown et al. 2003) and regional planning (Mazzer et al. 1998). Few catchment wide surveys have been conducted apart from Val et al. (2001). Although Dune Mallee woodlands have



Figure 1. A characteristic image of Dune Mallee Woodland depicting a sparse mallee overstorey and a dense Spinifex (*Triodia scariosa* subsp. *scariosa*) understorey.

been frequently surveyed as part of on-park, property and regional surveys, this survey represents the most comprehensive fauna survey of a single vegetation class within the LMD CMA area. Notwithstanding the above, the survey methods were not tailored to sample invertebrates, fish, amphibians and medium to large mammals, although some species belonging to these groups were recorded through incidental observations. Vegetation dynamics and structural data were also collected at each survey site as part of the proposed long-term monitoring of the biotic responses to enhanced management at reserve sites.

Prioritisation of Threatened Species and Broad Vegetation Type

A total of 61 threatened fauna species listed on the schedules of the “NSW Threatened Species Conservation Act 1995” have been recorded in the LMD CMA area. Given budget and resource limitations, it is not possible to develop a monitoring programme for all of these species. A list of 37 high priority species was prepared by analysing fauna records in the Atlas of NSW Wildlife. Many of the high priority species were mallee vegetation specialists, or species that are known to inhabit vegetation that includes mallee environments (Sadlier et al. 1996; Val et al. 2001). Most of these ‘mallee’ species are known to select the broad vegetation type known as Dune Mallee Woodlands, especially with a Spinifex (*Triodia scariosa* subsp. *scariosa*) understorey (Table 1).

Of the 37 priority fauna species shown in Table 1, 26 species (70%) occur within Dune Mallee woodlands. The focus on Dune Mallee woodlands aligns closely with the high proportion of conservation and offset reserves in Dune Mallee Woodlands.

The remainder of the high priority taxa could not easily be incorporated into a catchment-wide monitoring programme because of their disparate habitat requirements, low number of records, or because they were insufficiently known. Alternatively, some species were not included as they were being systematically surveyed in separate projects.

Table 1. High priority threatened species in the LMD CMA, their preferred habitat, and if they were targeted in this monitoring project

Common name	Scientific name	Preferred habitat	Specifically Targeted
Gilberts Whistler	<i>Pachycephala inornata</i>	Includes mallee	Yes
Hooded Robin	<i>Melanodryas cucullata cucullata</i>	Includes mallee	Yes
Chestnut Quail Thrush	<i>Cinclosoma castanotum</i>	Mallee specialist	Yes
Shy Hylacola	<i>Sericornis cauta</i>	Mallee specialist	Yes
Southern Scrub Robin	<i>Drymodes brunneopygia</i>	Mallee specialist	Yes
Striated Grasswren	<i>Amytornis striatus</i>	Mallee specialist	Yes
Bolam's Mouse	<i>Pseudomys bolami</i>	Includes mallee	Yes
Eastern Long-eared Bat	<i>Nyctophilus corbeni</i>	Includes mallee	Yes
Inland Forest Bat	<i>Vespadelus baverstocki</i>	Mallee specialist	Yes
Little Pied Bat	<i>Chalinolobus picatus</i>	Includes mallee	Yes
Western Pygmy Possum	<i>Cercartetus concinnus</i>	Includes mallee	Yes
Southern Ningai	<i>Ningai yvonneae</i>	Mallee specialist	Yes
Crowned Gecko	<i>Diplodactylus stenodactylus</i>	Mallee	Yes
Ringed Brown Snake	<i>Pseudonaja modesta</i>	Mallee	Yes
Bardick	<i>Echiopsis curta</i>	Mallee specialist	Yes
Jewelled Gecko	<i>Strophurus elderi</i>	Mallee specialist	Yes
Mallee Worm-Lizard	<i>Aprasia inaurita</i>	Mallee specialist	Yes
Marbled-faced Delma	<i>Delma australis</i>	Mallee specialist	Yes
Slender Mallee Blue-tongue	<i>Cyclodomorphus melanops elongatus</i>	Mallee specialist	Yes
Western Blue-tongue	<i>Tiliqua occipitalis</i>	Mallee specialist	Yes
Yellow-tailed Plains Slider	<i>Lerista xanthura</i>	Mallee specialist	Yes
Regent Parrot	<i>Polytelis anthopeplus monarchoides</i>	Includes mallee	*Separate project
Black-eared Miner	<i>Manorina melanotis</i>	Mallee specialist	Separate project
Malleefowl	<i>Leipoa ocellata</i>	Mallee specialist	Separate project
Southern Bell Frog	<i>Litoria raniformis</i>	Riparian woodland	Separate project
Plains Wanderer	<i>Pedionomus torquatus</i>	Grasslands	Requires targeted surveys
Red-lored Whistler	<i>Pachycephala rufogularis</i>	Mallee specialist	Requires targeted surveys
Bush Stone Curlew	<i>Burhinus grallarius</i>	Riparian woodland, woodlands	Requires targeted surveys
Grey Falcon	<i>Falco hypoleucos</i>	Riparian woodlands, woodlands	Requires targeted surveys
Redthroat	<i>Pyrrholaemus brunneus</i>	Shrublands	Requires targeted surveys
Pink Cockatoo (breeding)	<i>Cacatua leadbeateri</i>	Woodland	Requires targeted surveys
Barking Owl	<i>Ninox connivens</i>	Woodlands	Requires targeted surveys
Black-breasted Buzzard	<i>Hamirostra melanosternon</i>	Woodlands	Requires targeted surveys
Painted Burrowing Frog	<i>Neobatrachus pictus</i>	Mallee and other habitats	Requires targeted surveys
Kultarr	<i>Antechinomys laniger</i>	Grasslands, shrublands	Requires targeted surveys
Australasian Bustard	<i>Ardeotis australis</i>	Grasslands, woodlands	Requires targeted surveys
Southern Hairy-nosed Wombat	<i>Lasiorhinus latifrons</i>	Woodlands	Requires targeted surveys

* Separate project (not included as these species were already being surveyed in separate species specific investigations with separate funding)

Site Selection

A stratified approach was applied to selecting survey sites across the LMD CMA area. The first criteria in selecting sites was to ensure that they covered a wide geographic range across the LMD CMA area to accommodate the extent of the known distribution of Dune Mallee woodland and the targeted priority threatened fauna species. This was achieved by overlaying the 1:100,000 map sheet templates over the catchment. The 10 map sheets chosen represented the distribution of

Dune Mallee Woodlands and a substantial proportion of the overall distribution and known records of most of the 26 priority threatened species (Table 2). Clusters of trapping sites were established on each of the 10 map sheets to achieve the desired geographic spread and allow adequate coverage of the distribution of the priority threatened fauna species. Within each of the 10 map sheets, the locations of six survey sites were established using known habitat requirements of the prioritised threatened species, the predicted distribution

Table 2. Number of high priority threatened species recorded in each of the 100,000 map sheet in the catchment. Highlighted rows indicate the map sheets selected to survey.

1:100,000 map sheet	No. of high priority Threatened species recorded (NSW NPWS Wildlife Atlas 2007)	1:100,000 map sheet	No. of high priority Threatened species recorded (NSW NPWS Wildlife Atlas 2007)
Scotia	25	Middle Camp	9
Mildura	21	Hatfield	9
Wild Dog	19	Lake Tandou	9
Popiltah	19	Bono	8
Turlee	15	Buckalow	8
Menindee	15	Nowingi	7
Para	14	Cuthero	7
Lake Victoria	13	Lindsay	5
Arumpo	12	Reden	5
Bidura	12	Broken Hill	4
Weimby	12	Boolabooka	3
Pooncarie	12	Nartooka	3
Bunnerungee	12	Darnick	3
Robinvale	11	Paika	2
Manfred	11	Culpataro	1
Wentworth	10	Balranald	1
Mulurulu	10		

of these species based on the Atlas of NSW Wildlife records, the extent of Dune Mallee Woodlands and land-use (pastoralism and conservation). To ensure independence, sites were at least two kilometres apart

and to standardise the influence of grazing pressure at least 2 km from watering points. Figure 2 illustrates the locations of all 60 survey sites across the 10 mapsheets. To standardise the influence of fire history on the

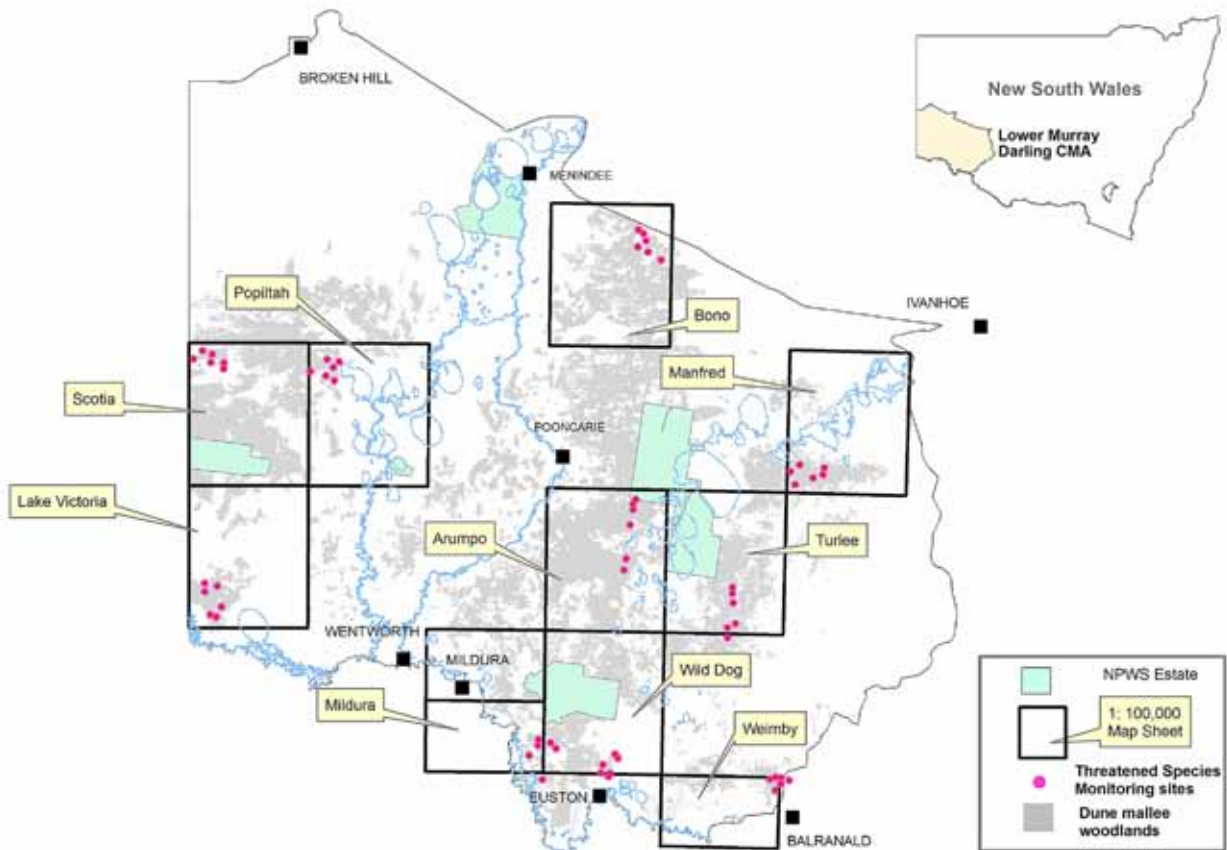


Figure 2. Location of the 60 monitoring sites, showing the distribution of Dune Mallee Woodlands in the Lower Murray Darling catchment and the chosen priority 1:100,000 map sheets.

surveys, sites of comparable fire history were chosen. Since a large proportion of the catchment was burnt in the 1974-75 fires most of the sites were selected in the age class >35 years post-fire. Survey sites were not selected within the nearby NPWS parks and reserves since benchmark data exists for these areas and they were part of an on-going fauna monitoring program (R. Dayman pers. comm. 2007).

Pitfall Trapping

Baseline fauna surveys were conducted at all 60 sites from December 2007 to March 2008. At each site reptiles and small mammals were sampled within a three hectare plot using two parallel pitfall line transects spaced approximately 50 m apart. Each pitfall line transect comprised six 20 litre plastic buckets (each 40 cm deep by 30 cm wide), spaced 5 m apart in a straight line, buried such that the top of each open bucket was flush with the ground. A fibreglass flywire drift fence (35 m x 30 cm) was erected, running over the centre of each trap and extending five metres beyond each end. Cardboard rolls or PVC tubing and leaf litter were placed in each pitfall to shelter and protect captured animals from predators and climatic extremes. At each site pitfalls were open for four consecutive nights so that each location surveyed had a total of 288 trap nights. Pitfall traps were checked early each morning and all captured animals marked with a non-permanent marker and released approximately 10 m from the point of capture.

Bird surveys

Bird surveys were conducted using a 30 min three hectare area based search, which is a 10 min and one hectare extension of the standard 20 min, two hectare area search technique described by Loyn (1986). This method was consistent with the bird survey technique utilised by Val *et al.* (2001), however it differs to most other long-term monitoring programmes (e.g. Birds Australia multi-regional monitoring project). To allow comparison of these data in the future, the data were collected over three adjacent one hectare sub-plots and then combined to give a total survey for the three hectare plot. Seven species of threatened mallee birds were targeted for surveys (Chestnut Quail-thrush, Striated Grasswren, Southern Scrub-robin, Gilbert's Whistler, Shy Heathwren, Malleefowl, and Regent Parrot). Each of the 60 sites was sampled twice on separate days in the early morning just after dawn till 930 h from late October – early December 2007.

Bat Surveys

Surveys for insectivorous microchiropteran bat species were undertaken at each of the 60 sites using harp traps (Tidemann and Woodside 1978), and Anabat recording an automatic ultrasonic echolocation call detection system (Corben 1989). One harp trap was set at each of the 60 sites and remained open for a minimum of two nights per site, a total effort of 120 harp trap nights or 12 harp-trap-nights per map sheet. Trapping was conducted

between December 2007 and March 2008. Anabat SD1 detectors were operated for one complete night at each site. All bat calls detected by the detectors were recorded to digital media (e.g. flash card). Calls were identified through comparison with calls in a reference library by a bat expert (Michael Pennay EPA or Craig Grabham GHD consulting).

Common names, scientific names and authorities for fauna follow Clayton *et al.* (2006).

Results

The baseline survey of the 60 monitoring sites represents a substantial addition to the fauna records for south-western NSW. A total of 4145 fauna records, including 334 threatened species records, was documented. Threatened species were recorded at 59 of the 60 sites. More specifically, threatened reptiles were recorded at 23 sites, threatened ground-dwelling mammals from 28 sites, threatened bats from 28 sites and threatened birds from 47 sites. Eighteen of the 21 targeted priority threatened species were recorded plus a number of non-target threatened species (Table 3).

Reptiles

A total of 37 species of reptiles were recorded from the 60 sites (Appendix 1). Thirteen species are thought to be 'common' in the study area (>20 captures per species), three species 'uncommon' (11-20 captures per species) and 21 species (≤ 10 captures) 'rare'. The skinks, *Ctenotus atlas* and *Lerista punctatovittata*, the Mallee Dragon *Ctenophorus fordi* and the Beaded Gecko, *Diplodactylus damaeus* accounted for the 46 % of 879 reptile captures.

The mean species richness (number of species trapped) per three hectare sampling site was 8.3 (SE 1.1) and the mean abundance (number of trapped individuals) was 13.1 (SE 1.7). Species richness and abundance of reptiles was highly variable across the geographic spread of trapping locations (Table 4, Figure 3). One hundred and fifty individuals from 19 species were captured at the six trapping sites from the northern most mapsheet (Bono), while as few as 50 animals from 13 species was recorded from the Wild Dog mapsheet in the south of the study area (Figure 3). Total captures also varied from December to March. In early December 150 captures were recorded from Bono map sheet sites, while in early March only 54 captures were recorded from the centrally located Arumpo map sheet sites, suggesting seasonal effects on reptile activity and trapability.

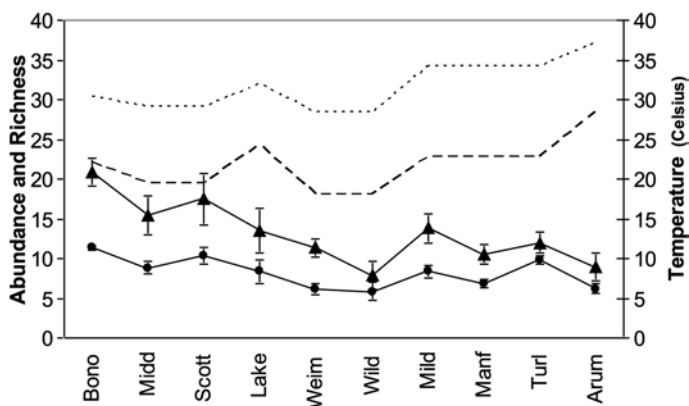
Annual breeding events were recorded during the survey period as reflected in the ratio of adult to juvenile pitfall captures. Nil juveniles were captured during the surveys in December, but from February onwards juveniles made up a varying percentage of the population. At the Mildura sites, surveyed in early March, juveniles made up 43 % of the captures (Table 6) and were also caught in large numbers at other map sheet sites. However, it was noticeable that no juveniles were captured from the Manfred and Weimby mapsheet sites despite being surveyed at the same period.

Table 3. Numbers of targeted Threatened fauna Species captured at 60 survey sites in the LMD CMA area of south-western NSW between October 2007 and March 2008

Common name	Species	Number of records	Targeted / Non Target
Mallee Worm Lizard	<i>Aprasia inaurita</i>	17	Targeted
Slender Mallee Blue-tongue	<i>Cyclodomorphus melanops elongatus</i>	1	Targeted
Marble-faced Delma	<i>Delma australis</i>	6	Targeted
Yellow-tailed Sand Slider	<i>Lerista xanthura</i>	10	Targeted
Ringed Brown Snake	<i>Pseudonaja modesta</i>	1	Targeted
Jellewed Gecko	<i>Strophurus elderi</i>	3	Targeted
Western Blue-tongue Lizard	<i>Tiliqua occipitalis</i>	1	Targeted
Mallee Ningauai	<i>Ningauai yvonneae</i>	58	Targeted
Bolam's Mouse	<i>Pseudomys bolami</i>	1	Targeted
Little Pied Bat	<i>Chalinolobus picatus</i>	18	Targeted
Greater Long-eared Bat	<i>Nyctophilus corbeni</i>	4	Targeted
Yellow-bellied Sheath-tailed Bat	<i>Saccolaimus flaviventris</i>	1	Non-target
Inland Forest Bat	<i>Vespadelus baverstocki</i>	23	Targeted
Chestnut Quail-thrush	<i>Cinlosoma castanotum</i>	121	Targeted
Gilbert's Whistler	<i>Pachycephala inornata</i>	11	Targeted
Hooded Robin	<i>Melanodryas cucullata cucullata</i>	6	Targeted
Pink Cockatoo	<i>Cacatua leadbeateri</i>	4	Non-target
Malleefowl	<i>Leipoa ocellata</i>	7	Non-target
Regent Parrot	<i>Polytelis anthopeplus monarchoides</i>	15	Non-target
Shy Heathwren	<i>Sericornis cauta</i>	6	Targeted
Southern Scrub Robin	<i>Drymodes brunneopygia</i>	5	Targeted
Striated Grasswren	<i>Amytornis striatus</i>	15	Targeted

Table 4. Comparative trapping success between the ten 1:100,000 map sheets surveyed in the LMD CMA area

Map Sheet	Reptiles		Mammals	
	Species	Numbers	Species	Numbers
Arumpo	15	54	1	2
Bono	19	150	2	7
Lake Victoria	18	87	2	10
Manfred	12	63	1	3
Popiltah	17	112	3	7
Mildura	16	89	1	4
Scotia	24	130	1	16
Turlee	20	74	1	8
Weimby	13	70	0	0
Wild Dog	13	50	2	7
Mean	16.7	87.9	1.4	6.4
Std	3.7	33.2	0.8	4.6

**Figure 3.** Number of captures and richness of reptiles from the ten map sheets throughout the trapping season (Dec 07 – Mar 08), dotted line represent day temperatures, dashed line represent night temperatures- source: NSW NPWS Weather Stations; triangles abundance (number of captures), circles richness (number of species).

Geckos

Eight species of gecko were recorded during the surveys, although most were infrequently captured. The Beaded Gecko *Diplodactylus damaeus* was the most frequently captured Gecko with 66 captures at 50 % of surveyed sites and at all but one of the surveyed map sheets (Table 5). The next most frequently recorded species

Table 5. Number of reptile captures across mapsheets (n=10) and sites (n=60) † = Mallee/Triodia dependent species (Sadler 1994).

Species	Number of captures	Number (%) of map sheets	Number (%) of sites	Abundance rating
Geckkonidae				
<i>Diplodactylus damaeus</i>	66	9 (90)	30 (50)	Common
<i>Diplodactylus vittatus</i>	3	2 (20)	3 (5)	Rare
<i>Gehyra variegata</i>	5	3 (30)	4 (6.7)	Rare
† <i>Strophurus elderi</i>	5	2 (20)	3 (5)	Rare
<i>Strophurus intermedius</i>	3	3 (30)	3 (5)	Rare
<i>Strophurus williamsi</i>	1	1 (10)	1 (1.7)	Rare
<i>Nephurus levis</i>	10	4 (40)	6 (10)	Rare
<i>Rhynchoedura ornata</i>	22	7 (70)	16 (26.7)	Common
Pygopodidae				
† <i>Aprasia inaurita</i>	17	6 (60)	12 (20)	Uncommon
† <i>Delma australis</i>	6	3 (30)	5 (8.3)	Rare
† <i>Delma butleri</i>	20	7 (70)	14 (23.3)	Uncommon
<i>Lialis burtonis</i>	7	3 (30)	6 (10)	Rare
<i>Pygopus schraderi</i>	2	1 (10)	1 (1.7)	Rare
Varanidae				
<i>Varanus gouldii</i>	1	1 (10)	1 (1.7)	Rare
Agamidae				
<i>Amphibolurus nobbi</i>	42	8 (80)	24 (40)	Common
† <i>Ctenophorus fordi</i>	148	10 (100)	43 (71.7)	Common
<i>Ctenophorus pictus</i>	3	2 (20)	3 (5)	Rare
<i>Pogona vitticeps</i>	12	7 (70)	11 (18.3)	Uncommon
Scincidae				
† <i>Ctenotus atlas</i>	110	10 (100)	45 (75)	Common
† <i>Ctenotus brachyonyx</i>	64	9 (90)	31 (51.7)	Common
<i>Ctenotus regius</i>	27	8 (80)	19 (31.7)	Common
<i>Ctenotus schomburgkii</i>	25	6 (60)	15 (25)	Common
† <i>Cyclodomorphus melanops elongatus</i>	1	1 (10)	1 (1.7)	Rare
<i>Cryptoblepharus carnabyi</i>	6	4 (40)	5 (8.3)	Rare
<i>Egernia inornata</i>	24	7 (70)	16 (26.7)	Common
<i>Lerista labialis</i>	51	2 (20)	10 (16.7)	Common
<i>Lerista muelleri</i>	46	6 (60)	20 (33.3)	Common
<i>Lerista punctatovittata</i>	84	10 (10)	44 (73.3)	Common
<i>Lerista xanthura</i>	10	3 (30)	6 (10)	Rare
<i>Menetia greyii</i>	42	8 (80)	28 (46.7)	Common
<i>Morethia boulengeri</i>	1	1 (10)	1 (1.7)	Rare
† <i>Morethia obscura</i>	6	4 (40)	5 (8.3)	Rare
† <i>Tiliqua occipitalis</i>	1	1 (10)	1 (1.7)	Rare
Elapidae				
<i>Brachyurophis australis</i>	2	1 (10)	1 (1.7)	Rare
<i>Parasuta nigriceps</i>	5	5 (50)	5 (8.3)	Rare
<i>Pseudonaja modesta</i>	1	1 (10)	1 (1.7)	Rare
<i>Pseudonaja nuchalis</i>	1	1 (10)	1 (1.7)	Rare
Terrestrial Mammals				
<i>Ningau yvonneae</i>	58	9 (90)	29 (48.3)	Common
<i>Pseudomys bolami</i>	1	1 (10)	1 (1.7)	Rare
<i>Sminthopsis murina</i>	5	4 (40)	4 (6.7)	Rare

was the Beaked Gecko *Rhynchoedura ornata* captured 22 times at 26 % of the sites. The threatened Jewelled Gecko *Strophurus elderi* was recorded five times at three sites.

Flap-Footed Lizards

Five species of Flap-footed Lizards of the family Pygopodidae were captured. The most frequently captured were Spinifex Snake-lizard *Delma butleri*, 20 captures at 23 % of the sites. Both of the threatened Flap-Footed Lizards known from the south west corner of NSW were captured. The Mallee Worm-Lizard *Aprasia inaurita* was captured at 20 % of sites and the Marble faced *Delma Delma australis* at 8% of sites.

Goannas

The Sand Goanna *Varanus gouldii* was captured only once (a juvenile), although its characteristic tracks and burrows were noted at most sites. The species is not frequently captured in pitfall traps as adult goannas are large enough to climb in and out of the buckets (J. Val pers. obs.).

Dragons

Four Dragon species were captured and all but the Painted Dragon *Ctenophorus pictus* were commonly encountered. The widespread *Ctenophorus fordi* was the most frequently captured vertebrate in this study, captured at every map sheet and at 71 % of sites.

Skinks

A total of 15 species of skink was captured across the sixty sites. The genus *Ctenotus* was represented by four species, the most frequently captured being *Ctenotus atlas* at 75 % of sites and *Ctenotus brachyonyx* at 51 % of sites. Four species of *Lerista* were captured, the most frequent and widespread being *Lerista punctatovittata*. *Lerista labialis* appeared to have a localised distribution with all the records from two map sheets (Scotia and Popiltah) in the western corner of the study area. The threatened Yellow-tailed Plains Slider *Lerista xanthura* was captured at six sites across three mapsheets and the secretive Spinifex Slender Blue-tongue *Cyclodomorphus melanops elongatus* only captured once in the extreme north of the study area.

Snakes (Elapids)

Four species of elapid were captured, all infrequently and at a low percentage of sites. The most frequently captured was *Parasuta nigriceps*, captured once at five different sites. The threatened Ringed Brown Snake *Pseudonaja modesta* was captured once from the western corner of the state. It would appear to have a very restricted distribution in the study area and perhaps NSW.

Threatened Reptiles

Seven of the nine threatened reptile species were recorded at sites from each map sheet with the exception of Turlee. A total of 41 captures of threatened species were recorded at 30 (50 %) of the 60 sites. The most frequently captured threatened reptile was Mallee Worm Lizard *Aprasia inaurita*. The two species not recorded were Crowned Gecko *Diplodactylus stenodactylus* and Bardick *Echiopsis*

curta. The main distribution of *Diplodactylus stenodactylus* is north of the study area with the bulk of the records from north-west corner of NSW (Atlas of NSW Wildlife, Swan et al. 2004). Despite surveying the property where the only previous record of the species in the LMDCMA was recorded (Atlas of NSW Wildlife), none were captured. *Echiopsis curta* is extremely rare, known only from three records in NSW, with only one recent record (Atlas of NSW Wildlife).

Small Ground-dwelling Mammals

Three native ground-dwelling small mammal species were trapped during the pitfall surveys (Appendix 1). Native mammal species richness and abundance per three hectare sampling site were both low at 0.5 and 1.0, respectively. The threatened Mallee Ningau *Ningau yvonneae* was the most frequently captured small mammal, recorded at 29 (48.3 %) of the 60 sites (Table 6). The capture of this species from the Lake Victoria mapsheet and the mallee woodlands south of the extensive Scotia mallee. The exotic House Mouse *Mus musculus* was captured at four sites. Three of these sites were recently burnt with one from a block of mallee adjoining dryland farming land. A single capture of the Threatened Bolam's Mouse *Pseudomys bolami* from the Popiltah mapsheet added little to our poor understanding of the species' distribution and habitat requirements. Also of concern was the lack of Western Pygmy Possum *Cercartetus concinnus* captures, despite deliberately sampling in areas where the species had previously been caught in relatively large numbers (Robertson and Sluiter 2003, R. Dayman, NPWS, pers. comm.).

Microchiropteran Bats

Two hundred microchiropteran bats were captured in harp traps, and the presence of 167 bats were identified by ultrasonic recordings across 10 trapping locations (Appendix 2). Problems associated with Anabat detectors and the analyses of calls meant that data from Mildura, Lake Victoria and Bono map sheets have been omitted. Fourteen species of micro-bat were recorded in total, 11 species were identified from call analysis (detected), and nine species were trapped. Six species could be considered 'common' (>20 records), two 'uncommon' (11-20 records) and six 'rare' (≤10 records). A number of calls were only identified to genus due to the similarity of their ultrasonic calls with other species from the same genus. Similarly, a large number of captured female *Vespadelus* could not be identified beyond genus, because the diagnostic characteristic for identification is based on shape of glans penis (Parnaby 1992). No bat species was recorded across all ten mapsheets, though the most widespread species, Gould's Wattled Bat *Chalinolobus gouldii*, was recorded from nine mapsheets. Bats were trapped at 37 of the 60 sites, with the Lesser Long-eared Bat *Nyctophilus geoffroyi* the most frequently caught species in harp traps. Four bat species *Chalinolobus morio*, *Tadarida australis*, *Saccolaimus flaviventris* and *Mormopterus planiceps* sp.4 were only recorded by the ultrasonic detectors.

Table 6. Number of juvenile reptiles captured at five of the ten mapsheets surveyed in the LMD CMA area between December 2007 and March 2008.

Map Sheet	Survey date	Numbers (%) of total captures	Number of species	Threatened Species
Lake Victoria	19/02/2008	29 (33)	10	1
Wild Dog	26/02/2008	7 (14)	3	
Mildura	04/03/2008	39 (43)	11	2
Turlee	04/03/2008	6 (12.9)	4	
Arumpo	11/03/2008	7 (8.1)	4	

Threatened Bats

All three of the priority threatened bat species were recorded during the surveys (Appendix 2). The most frequently recorded threatened bat species was the Inland Forest Bat *Vespadelus baverstocki*, with 23 records from 17 sites across six mapsheets. This is likely to be an underestimate given that many female *Vespadelus* not identified to species were probably *Vespadelus baverstocki*. Males of this species were recorded almost twice as often in the mallee than the similar Little Forest Bat *Vespadelus vulturinus*. The Southern forest bat *V. regulus* was not recorded. Eighteen records of the Little Pied Bat *Chalinobius picatus* came from 16 sites, while the Greater Long-eared Bat *Nyctophilus corbeni* was recorded four times from three (5 %) sites. This species may also have been under-recorded as anabat analysis does not allow the identification of *Nyctophilus* species. The high-flying Yellow-bellied Sheath-tailed Bat *Saccolaimus flaviventris* was detected at one site, but was not specifically targeted.

Birds

A total of 72 species of birds were recorded from the 60 survey sites (Appendix 3). Mean species richness per three hectare sampling site was 14.7 (SE 1.9) and the abundance (number of birds recorded) was 42.7 (SE 5.5). The most frequently recorded species were the Weebill *Smicromis brevirostris* and the Yellow-plumed Honeyeater *Lichenostomus ornatus* which together accounted for 723 records 28 % of the 2567 records. Eleven other species of bird were also frequently recorded (>50 % sites) and could be considered 'characteristic species' of Dune Mallee Woodland (Table 7). A further seven 'common' bird species were recorded at 20-50 % of sites. The remaining 58 species were 'uncommon' and recorded at less than 20 % of sites (Appendix 3). The 'uncommon' species were composed of generalists that make infrequent incursions into Dune Mallee Woodlands particularly where the landscape matrix is a mosaic of vegetation types. Other uncommon species included those that are nomadic,

Table 7. 'Characteristic' and 'Common' species in Dune Mallee Woodlands (characteristic species defined as those recorded >50% sites, common species recorded at 20-50% of sites).

Common name	Total Records	number of sites	% sites	Frequency
Weebill	319	55	91.7	Characteristic
Yellow-plumed Honeyeater	404	52	86.7	Characteristic
Grey Shrike-thrush	92	50	83.3	Characteristic
Crested Bellbird	89	48	80.0	Characteristic
Jacky Winter	132	48	80.0	Characteristic
Chestnut Quail-thrush	121	42	70.0	Characteristic
Spiny-cheeked Honeyeater	67	37	61.7	Characteristic
Yellow-rumped Pardalote	101	35	58.3	Characteristic
Grey Butcherbird	55	34	56.7	Characteristic
Rufous Whistler	49	31	51.7	Characteristic
Striated Pardalote	75	31	51.7	Characteristic
Australian Magpie	47	27	45.0	Common
Chestnut-rumped Thornbill	108	25	41.7	Common
Australian Ringneck	51	22	36.7	Common
Brown-headed Honeyeater	82	21	35.0	Common
Grey Currawong	25	20	33.3	Common
Rainbow Bee-eater	46	20	33.3	Common
Willy Wagtail	44	20	33.3	Common
Mulga Parrot	92	18	30.0	Common
White-eared Honeyeater	58	17	28.3	Common
White-fronted Honeyeater	41	14	23.3	Common
Black-faced Cuckoo shrike	16	13	21.7	Common

migratory or have restricted distributions (Appendix 3). Eight species were widespread across the study area and recorded at all ten survey locations (Appendix 3). The mean number of species recorded from each mapsheet was 32.5 (SE 10.280), which ranged from 16 at the Weimby mapsheet to 38 at Lake Victoria mapsheet (Figure 4). The mean number of species recorded per survey site ranged from only three species at the Weim1 site (Weimby mapsheet) to 23 species at Wild4 site (Wild Dog mapsheet) (Figure 4).

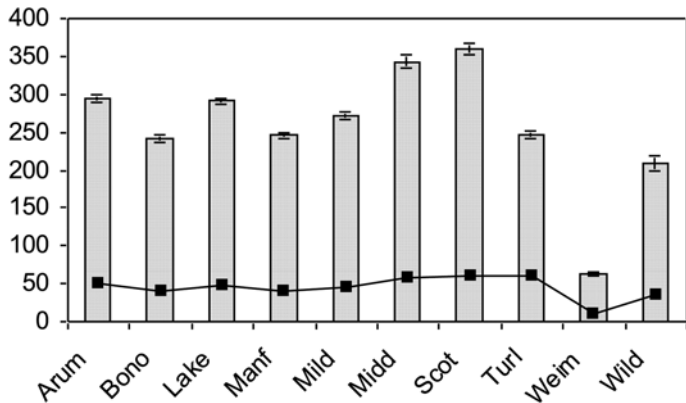


Figure 4. Number of bird species recorded at each location (map sheet), trend line showing the mean of the six survey sites for each map sheet.

Threatened Birds

Threatened bird species were recorded at 47 of the 60 monitoring sites. All high priority threatened birds were recorded during the surveys although most were recorded at less than 10 % of the sites and across 1-3 mapsheets. The most frequently encountered threatened bird species was the Chestnut Quail-thrush *Cinlosoma castanotum*, recorded at 42 sites and on every mapsheet (Table 8). A significant finding was the new record of the Southern Scrub Robin *Drymodes brunneopygia* in the south of the catchment on the Wild Dog mapsheet, approximately 5 km north of Euston (Appendix 3). The only previous confirmed records of this species come from the Scotia mallee in the western corner of the catchment, some 150 km northwest of this new record. The Striated Grasswren *Amytornis striatus* has a very restricted distribution in the LMD area and was recorded from only two sites on the Scotia mapsheet. The Shy Heathwren *Sericornis cauta* was recorded at three sites, but from across three different

Table 8. Numbers of threatened birds recorded during the bird surveys

Species	Records	Number of Sites (%)	Number of map sheets (%)
Chestnut Quail Thrush	121	42 (70)	10 (100)
Gilbert's Whistler	11	4 (6.7)	2 (20)
Hooded Robin	6	3 (5)	3 (30)
Major Mitchell Cockatoo	4	4 (6.7)	2 (20)
Malleefowl	7	6 (10)	3 (30)
Regent Parrot	15	2 (3.3)	1 (10)
Shy Heathwren	6	3 (5)	3 (30)
Southern Scrub Robin	5	2 (3.3)	1 (10)
Striated Grasswren	15	3 (5)	2 (20)

mapsheets. The Malleefowl *Leipoa ocellata* was noted at six sites across three map sheets. Foraging Regent Parrots *Polytelis anthopeplus monarchoides* were observed at two sites from the Wild Dog mapsheet. Although not a threatened species targeted in this monitoring program, the Regent Parrot is known to forage in mallee vegetation that occurs within 20 km of the River Murray. Pink Cockatoos *Cacatua leadbeateri*, Hooded Robins *Melanodryas cucullata cucullata* and the Gilbert's Whistler *Pachycephala inornata*, which are "vegetation generalists" rather than mallee specialists, were recorded at a small number of sites.

Discussion

This study provides a detailed systematic inventory of local occurrence of threatened and non-threatened terrestrial vertebrate fauna in Dune Mallee woodlands across the LMD CMA area. A network of 60 sites was established in Dune Mallee woodlands across a large area of the LMD CMA providing a framework for the long-term monitoring of threatened fauna.

We observed a diverse array of disturbances affecting the condition of Dune Mallee Woodlands; probably the most significant was the grazing by feral goats that affected all land tenures. Feral goats appear to favour these woodlands as they provide foraging habitat and dense vegetation cover to disappear into when disturbed. Furthermore, the private reserve fencing was ineffectual at excluding them with no differences in densities noted inside or outside the fences. The removal of domestic stock from reserves without adequately managing feral herbivore grazing appears to negate any gains in habitat improvement that may have been achieved (Read and Cunningham 2010). Adequate fencing and control of numbers of feral goats is considered to be a key management target to provide improvement in the status of local populations of many of the species we recorded in this study. In light of the above, we stress the importance of continuing to systematically monitor these sites every 3-5 years in order to observe trends and report on the outcomes of incentive measures.

Reptiles

The number of species of reptiles recorded during the surveys is comparable with other surveys of Spinifex dominated habitats. Hobbs *et al.* (1994) recorded 42 species and Masters (1996) recorded 40 species in

Spinifex grasslands in Central Australia. Ten of the 37 reptile species recorded during these surveys are regarded as Spinifex/Mallee specialists throughout NSW (Sadlier 1994), another two species *Egernia inornata* and *Nephrurus levis* are also predominately found in Spinifex/Mallee in the LMD. Masters (1996) identified eleven Spinifex dependent species from Central Australia, six of which were species from the genus *Ctenotus*. In comparison Spinifex/Mallee specialists in this study exhibit a greater diversity and are represented by two geckos, two legless lizards, one dragon, six skinks (of which only two were *Ctenotus* species) and one elapid *Echiopsis curta* (although not captured during these surveys). Spinifex grasslands are considered to contain the richest assemblage of reptile species (Pianka 1969, Pianka 1972). This high diversity is thought to be associated with the protective nature of Spinifex, the ever changing habitats provided by fire succession (Thompson *et al.* 2003) and a direct relationship with the abundance and richness of termites (Morton and James 1988). It is curious that almost half of this assemblage is listed as Threatened in NSW, yet both the plant communities that make up Dune Mallee Woodlands have not been cleared significantly, with 80-99 % remaining (Benson *et al.* 2006) and more than 15 % occurs in private and public reservation (RMAP 1999). The major threats influencing the status of these reptiles appear to be predators (foxes and cats) (Olsson *et al.* 2005), the influence of fire history (inappropriate fire regimes) (Bennett *et al.* 2006, Kelly *et al.* 2010) and the less documented impact of overgrazing (Castellano and Valone 2006) associated with feral goats and overgrazing by domestic stock. Despite the apparent intact nature of Dune Mallee Woodlands the simplification of habitat diversity, and the prevention of tree and shrub regeneration across landscape, as noted in other areas (Fischer *et al.* 2004) may have long term implications for reptile conservation.

Of greatest concern within the suite of threatened Spinifex/Mallee specialists in the region was the absence of records for *Echiopsis curta* and single records of Spinifex Slender Blue-tongue *Cyclodomorphus melanops elongatus* and Western Blue-tongue *Tiliqua occipitalis*. *Pseudonaja modesta* would appear to have a very restricted distribution in the LMD with the only records in Dune Mallee Woodlands that adjoin South Australia (Sadlier *et al.* 1996). In contrast, infrequently recorded species such as *Delma australis* and *Lerista xanthura* appear to have wide distribution in the LMD Murray Darling. *Lerista xanthura*, however, is thought to have a disjunct distribution in NSW with records from the northwest corner of the state near Tibooburra and from Dune Mallee Woodlands in the LMD (Sadlier 1994). The low number of records for *Strophurus elderi* in these surveys may not be an accurate reflection of its rarity as the species is more readily recorded in spotlighting surveys than in pitfall traps (Peter Robertson pers. comm.).

The high number of species identified as 'rare' (infrequently trapped) is partly explained by the relative ineffectiveness of pitfall trapping in capturing some groups of reptiles, in particular arboreal geckos and larger lizards and snakes. Minor adjustments to the monitoring program are likely to increase the detection rate of some threatened reptile

species, for example the incorporation of nocturnal searches particularly for *Strophurus elderi*. The inclusion of funnel traps is likely also to increase the capture rate of geckos that are able to climb out of pit falls and larger lizards and snakes (Thompson and Thompson 2007). This could be best done by incorporating a single entrance funnel trap on the ends and on both sides of the pitfall fences.

Breeding events were noted throughout the region from February onwards, although from some trapping locations no juvenile reptiles were recorded. Whether this indicates a lack or poor breeding event due to climatic or anthropogenic factors or a geographic influence is unknown.

Birds

The average number of bird species and density of birds per hectare measured in Dune Mallee woodlands was relatively low compared to more mesic woodlands and forest in south-eastern Australia. This is consistent with the assertion of Recher (1985) that avian richness is related to moisture, soil nutrients and foliar nutrients on which the productivity of a woody ecosystem depends. For example, Oliver *et al.* (1999) recorded, on average 9.7 species and 42.8 birds per hectare in temperate woodlands in northern NSW. A number of other studies in woodlands and forests have found between six and 18 species per survey site, though the size of each survey plot varied significantly from one to 50 hectares (Kavanagh *et al.* 1985, Loyn 1985, Milledge and Recher 1985, Recher *et al.* 1985, Shields *et al.* 1985). The density of birds recorded in temperate and mesic woodlands and forests is highly variable and ranges from 0.5 to 77 birds per hectare (Oliver *et al.* 1999) The highest average number of birds recorded in Australian wet sclerophyll forest vegetation was 54.5 birds per ha by Howe (1984), which is much higher than those recorded in Dune Mallee woodlands. A large number of bird species that were recorded in this study were 'uncommon' (i.e. recorded at less than 20 % of the 60 sites). Some of these species may have been recorded infrequently because of their habits and behaviour rather than their rarity. Indeed many of these species were generalists, open-country and edge users that only make infrequent incursions into Dune Mallee Woodland environments particularly in circumstances where sites were adjacent to a mosaic of vegetation types (Luck *et al.* 1999). For example, some of the species infrequently recorded include birds from the declining woodland bird group (Reid 1999; Bennett and Watson 2011), such as Red-capped Robin, White-browed Babbler, Varied Sittella, Dusky Woodswallow and White-browed Woodswallow). This is likely to be explained by the fact that Dune Mallee woodland is not the preferred habitat for these species. Others from this group of decliners, including Jacky Winter, Crested Bellbird, and Rufous Whistler, however, were widespread and abundant in this vegetation community in the catchment.

A large percentage of the uncommon bird species was nomadic or migratory and only appeared sporadically across the region during the surveys. Some species are not readily encountered using the standard sampling methods

as they are cryptic or nocturnal (Tawny Frogmouth, Spotted Nightjar) and hence the number of records of these species may not be a reflection of their abundance, but rather their detectability. Other components of the uncommon species group are the species of concern, with quite restricted distributions in the catchment, and species that are naturally rare. These include some of the threatened species which have specialised habitat requirements (e.g. Shy Heathwren, Southern Scrub-robin, Striated Grasswren, Gilbert's Whistler).

Some of the highlights of this study in terms of birds recorded, included the frequent recording of Malleefowl, Chestnut Quail-thrush and the discovery of a small population of Southern Scrub-robins near Euston. Of particular significance was the large number of records of the Chestnut Quail-thrush across the LMD area in sites with a wide range of ground cover condition. The relatively high recording rate of the species in the LMD CMA area compared to the highly cleared and fragmented mallee landscapes in central NSW suggests that the species is affected more by habitat loss and fragmentation than understorey degradation from grazing.

The very low number of records of species such as the Variegated and Splendid Fairy-wrens, which have a preference for a low shrub layer, is of concern. Shrubs were only abundant on the Scotia and Arumpo mapsheets. The low number of records of two sedentary Mallee specialists, the Grey-fronted Honeyeater and the White-eared Honeyeater, is worthy of further investigation, but possibly reflects the impacts of prolonged drought in southern NSW between 2002 and 2010 on resource availability such as nectar. The reasons for the low number of birds recorded on the Weimby map sheet (less than half the mean of other map sheets) is unclear but could be correlated with the high temperatures experienced during the survey in late November. As a footnote, a second round of surveys were conducted at the Weimby sites in February 2009 and the number of birds recorded was higher than in 2007, but still relatively low.

Notwithstanding the above, many of the species recorded infrequently may be a reflection of seasonal conditions and related movement patterns than actual rarity in the catchment. To counter this, it would be important to conduct future surveys not only in spring and summer, but also in other seasons to capture the full suite of species that may utilise Dune Mallee woodlands. It is also important to re-visit these sites in years of average or above average rainfall when habitat conditions are higher than during this study.

Small ground-dwelling mammals

The lack of captures of *Cercartetus concinnus*, despite selectively surveying in areas where the species had previously been recorded, is a concern. Between 2001 - 2004 large numbers of *C. concinnus* were caught in the LMD using similar trapping methods and time of survey to this study (Robertson and Sluiter 2003, R. Dayman, NPWS, pers. comm.). The survey results for *C. concinnus* over the last 15 years suggest that populations go through a crash and boom cycle, which is perhaps one reason why

the species was not recorded in NSW until 1994 (Mazzer *et al.* 1998). There is strong anecdotal evidence to suggest that rainfall is the primary factor influencing the large population fluctuations of this species. Clearly, many questions relating to Western Pygmy-possum autoecology in the LMD have yet to be answered.

Ningauai yvonneae was the most widespread and abundant small mammal encountered during the study, though it was not detected in mallee woodlands in the far south eastern corner of the study area. The species has not been recorded from the less contiguous and fragmented mallee woodland between the Darling and the Great Darling Anabranch. In the LMD *N. yvonneae* appears to be restricted to mallee with a spinifex understorey (Tidemann 1988, Dickman and Read 1992, Mazzer *et al.* 1998, Val *et al.* 2001, Webster *et al.* 2003). In this habitat the species is quite abundant with up to six individuals caught at a single three hectare site. These surveys increased our understanding of the species' distribution, revealing new populations in Mallee woodland south of Tarawi Nature Reserve and north of Lake Victoria.

Rodents occur throughout arid and semi-arid Australia at extremely low densities (Breed and Ford 2007). This was further highlighted with only a single capture of *Pseudomys bolami* from 2880 trap nights, adding little to our scant understanding of the species' biology and distribution in the study area. Ironically, the specimen was trapped at one of the most disturbed sites sampled, where heavy grazing by feral goats had greatly reduced the spinifex layer resulting in large areas of bare ground recently colonised by a native annual *Maireana pentatropis*. The species' main population appears to be associated with the immediate dune mallee woodlands surrounding Tarawi Nature Reserve and adjoining properties in South Australia (NPWS 2002). Another possibly smaller population occurs in woodlands around Wampo Station approximately 180 km to the east. In other regions, *Pseudomys bolami* feeds on *M. astrotricha* – spinifex provides cover on ridges and swales sources of feed plants (Moseby and Read 1999).

Microchiropteran bats

Several notable observations of microchiropteran bats were made during this survey; the diversity of the bat fauna in the NSW mallee areas appears particularly high in comparison with surrounding areas in Victoria and South Australia. Also of note was a number of uncommonly detected species that were recorded during this study. However, the overall capture rate of 1.6 bats per trap night during the survey was relatively low. Turbill and Ellis (2006), in a comparison of bat captures across 39 widespread study areas in semi-arid NSW, reported an average capture rate of 5.08 bats per trap night (8266 bats/ 1628 trap nights). However, the capture rate is comparable to the 0.99 bats per trap night (536 bats/539 trap nights) reported by Lumsden *et al.* (2008) in a survey of the mallee of north western Victoria.

Despite the relatively low capture rate and trapping effort, the species diversity (14 species) of bats is particularly high in comparison with surveys conducted in surrounding mallee areas of South Australia and Victoria. Lumsden

et al. (2008) recorded 12 species, earlier surveys of the Victorian mallee region by Lumsden and Bennett (1995) recorded 11 species, and a study in the South Australian Bookmark biosphere reserve by Dominelli (2000) recorded 9 species. The southern mallee region of NSW shares typical semi-arid species (*Nyctophilus corbeni*, *Vespadelus baverstocki*, *Scotorepens balstoni*, *Mormopterus* species) as well as more widespread 'generalist' species (*Chalinolobus gouldii*, *Nyctophilus geoffroyi*, *Tadarida australis*) with mallee regions in Victoria and South Australia. However, the high diversity of the NSW mallee areas is explained by the presence of typically temperate species (*Chalinolobus morio*, *Nyctophilus gouldii*, *Vespadelus vulturinus*) and a number of species that appear to reach the limits of their range in this region. For example, *Chalinolobus picatus* was recorded 15 times in this survey, yet it has never been recorded in Victoria despite extensive surveys. Likewise *Scotorepens greyi* was recorded 5 times in this survey and was only recently discovered for the first time in Victoria (Lumsden *et al.* 2008). The capture of 4 individuals of *Nyctophilus corbeni* (formerly *N. timoriensis* south-eastern form) is significant. The species is listed as vulnerable both nationally and in NSW. *N. corbeni* has a very patchy distribution, with some areas appearing as 'hot spots' for the species (Turbill and Ellis 2006). In addition to the box/ironbark/cypress forests of northern NSW where the highest densities of bats have been recorded (Turbill and Ellis 2006), the mallee areas of NSW and South Australia appear to represent an important habitat for this species. *N. corbeni* was recorded

in 3 % of trap nights, and made up 2.4 % of bat captures; comparable with previous surveys in NSW and South Australia mallee regions (Dominelli 2000, Turbill and Ellis 2006). Until 2007 there were only six records of *N. corbeni* in Victoria (Lumsden *et al.* 2008). Lumsden and Bennett (1995) only caught one *N. corbeni* in 595 trapnights (0.17%). However, a radio tracking study and survey of a long un-burnt area of Hattah-Kulkyne park in Victoria by Lumsden *et al.* (2008) caught 19 *N. corbeni* out of 963 bats (1.9%). Previous studies (Turbill and Ellis 2006, Lumsden *et al.* 2008) indicate the species has a strong preference for large contiguous areas of native vegetation and that the time since last fire is important. The record of *Saccolaimus flaviventris* is also significant, the species is very rarely reported in southern Australia, particularly in the mallee regions where it has been previously been recorded in Mildura in 1956 and Ouyen in 1934 (Lumsden and Bennett 1995).

Conclusions

This baseline study detected a significant number of both protected and threatened fauna that either permanently reside or frequent Dune Mallee Woodlands. Some of the fauna that inhabit these environments are abundant and widespread while others are uncommon and have very restricted distributions. Our work shows that a significant number of threatened species are found in Dune Mallee Woodlands and it could be feasible to monitor a large proportion of the threatened species known to occur in the LMD.

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APPENDIX I

Number of native reptiles and small mammal captures according to 1:100,000 map sheet. Threatened species are in bold

Species	Arumpo	Bono	Lake Victoria	Manfred	Popiltah	Mildura	Scotia	Turlee	Weimby	Wild Dog	Total
Reptiles											
<i>Diplodactylus damaeus</i>	2	22	7		3	8	13	2	8	1	66
<i>Diplodactylus vittatus</i>								2		1	3
<i>Gehyra variegata</i>		1	2		2						5
<i>Strophurus elderi</i>		4		1							5
<i>Strophurus intermedius</i>						1		1	1		3
<i>Strophurus williamsi</i>							1				1
<i>Nephrurus levis</i>	2	4			3		1				10
<i>Rhynchoedura ornata</i>	2	3	7	3			1	4		2	22
<i>Aprasia inaurita</i>	1		2			5	1		2	6	17
<i>Delma australis</i>			3				2			1	6
<i>Delma butleri</i>	2	6	2		3	3	3	1			20
<i>Lialis burtonis</i>	1	5					1				7
<i>Pygopus schraderi</i>			2								2
<i>Varanus gouldii</i>								1			1
<i>Amphibolurus nobbi</i>	8	11	3	4	2		1	6	7		42
<i>Ctenophorus fordi</i>	8	14	20	16	36	13	14	11	12	4	148
<i>Ctenophorus pictus</i>			1			1					2
<i>Pogona vitticeps</i>		1	2	1		1	2	2		3	12
<i>Ctenotus atlas</i>	6	26	9	7	7	11	15	11	6	12	110
<i>Ctenotus brachyonyx</i>	6	15	7	10	12	1	10	1	2		64
<i>Ctenotus regius</i>	2	9		1	6	1	2	3		3	27
<i>Ctenotus schomburgkii</i>			7		1	3	5	3	6		25
<i>Cyclodomorphus melanops elongatus</i>		1									1
<i>Cryptoblepharus carnabyi</i>		1	1		1		3				6
<i>Egernia inornata</i>	3	1	5	4	1		6	4			24
<i>Lerista labialis</i>					24		27				51

APPENDIX 1

Species	Arumpo	Bono	Lake Victoria	Manfred	Popiltah	Mildura	Scotia	Turlee	Weimby	Wild Dog	Total
<i>Lerista muelleri</i>	3			4		19		1	11	8	46
<i>Lerista punctatovittata</i>	6	17	6	9	2	13	12	7	5	7	84
<i>Lerista xanthura</i>					1	3	6				10
<i>Menetia greyii</i>	2	8	1	3	5	5		10	8		42
<i>Morethia boulengeri</i>								1			1
<i>Morethia obscura</i>					3		1		1	1	6
<i>Tiliqua occipitalis</i>		1									1
<i>Brachyuropis australis</i>								2			2
<i>Parasuta nigriceps</i>						1	1	1	1	1	5
<i>Pseudonaja modesta</i>							1				1
<i>Pseudonaja nuchalis</i>							1				1
Map sheet totals	54	150	87	63	112	89	130	74	70	50	879

Terrestrial Mammals											
<i>Ningaii yvonneae</i>	2	6	9	3	5	4	16	8		5	58
<i>Pseudomys bolami</i>					1						1
<i>Sminthopsis murina</i>		1	1		1					2	5
Map sheet totals	2	7	10	3	7	4	16	8	0	7	64

APPENDIX 2

Bat species recorded across the 10 map-sheet locations. Numbers inside the brackets refer to the number of bats trapped in harp traps, number outside the brackets refer to the number of sites at which the presence of bats were detected via Anabat. Single or multiple calls identified were recorded as a single record for a site. Grand total is the number animals trapped and detected. Threatened species in bold.

Name	Arumpo	Bono	Lake Victoria	Manfred	Popiltah	Mildura	Scotia	Turlee	Weimby	Wild Dog	Total
<i>Chalinolobus gouldii</i>	4[11]	[7]	[5]	4	6[7]		3[1]	2	1	5[5]	25[36]
<i>Chalinolobus morio</i>	2								1	2	5
<i>Chalinolobus picatus</i>	5[2]	[1]		2	5		1	1		1	15[3]
<i>Mormopterus planiceps</i> sp. 3	3[12]			3	6		3	3			18[12]
<i>Mormopterus planiceps</i> sp. 4	5			4	4			4	5	6	28
<i>Mormopterus</i> sp.		[3]			6		2				8[3]
<i>Nyctophilus geoffroyi</i>	[3]	[44]	[4]		[20]	[5]	[6]				[82]
<i>Nyctophilus gouldii</i>	[1]										[1]
<i>Nyctophilus</i> sp.					6		2				8
<i>Nyctophilus corbeni</i>	[2]			[2]							
<i>Saccolaimus flaviventris</i>									1		1
<i>Scotorepens balstoni</i>	5			4	6		3	3	2	6[1]	29[1]
<i>Scotorepens greyii</i>				1[1]	1					1[1]	3[2]
<i>Tadarida australis</i>					1			3	2		6
<i>Vespadelus baverstocki</i>		[2]	[1]		4[1]	[4]	3[3]			[5]	7
<i>Vespadelus</i> sp.	5[11]	[6]	[5]	1	[2]	[1]	[3]	2[1]		[4]	8
<i>Vespadelus vulturinus</i>	3		[1]					2[1]		1[4]	6[6]
Total	32 [42]	[63]	[16]	19 [4]	45 [30]	[10]	17 [13]	20 [2]	12	22 [20]	167 [200]

Birds recorded during bird surveys at each map sheet

N= Nomadic, M = Migratory, S= Sedentary (Schodde 1990) Bold= threatened species (NSW)

Common Name	status	Arumpo	Bono	Lake Victoria	Manfred	Mildura	Popiltah	Scotia	Turlee	Weimby	Wild Dog	Total	Number of sites	% sites
Dromaiidae														
Emu	N	1										1	1	1.7
Accipitridae														
Wedge-Tailed Eagle	N			1								1	1	1.7
Falconidae														
Brown Falcon	N	1										1	1	1.7
Megapodiidae														
Malleefowl	S			1				3			3	7	6	10.0
Podarigidae														
Tawny Frogmouth	S			3								3	1	1.7
Eurostopodidae														
Spotted Nightjar	S			1								1	1	1.7
Aegothelidae														
Australian Owlet Nightjar	S			2			1				1	4	4	6.7
Columbidae														
Common Bronzewing	S				2	2	2	6			1	13	8	13.3
Cacatuinae														
Major Mitchell's Cockatoo	N		3		1							4	4	6.7
Galah	N		7				2		3	6	4	22	11	18.3
Psittacidae														
Australian Ringneck	S	2	5	13	6		11	4	9	1		51	22	36.7
Budgerigar	N		10									10	3	5.0
Cockatiel	N		1									1	1	1.7
Mulga Parrot	S	8	22	3	7	2	46	2			2	92	18	30.0
Regent Parrot	N					15						15	2	3.3
Cuculidae														
Horsefield's Bronze-Cuckoo	N	1			3							4	3	5.0
Halcyonidae														
Red-Backed Kingfisher	M	1		3		1						5	4	6.7
Meropidae														
Rainbow Bee-Eater	M	1	11	16	3	8	1		4		2	46	20	33.3
Climacteridae														
Brown Treecreeper	S	3		10		12	3					28	8	13.3
Maluridae														
Splendid Fairy-Wren	S			3	4				4		1	12	5	8.3
Variiegated Fairy-Wren	S	5		2	9							16	5	8.3
Striated Grasswren	S							15				15	2	3.3
Acanthizidae														
Shy Heathwren	S	1						3			2	6	3	5.0
Weebill	S	55	17	26	57	38	38	27	20	16	25	319	55	91.7
Chestnut-Rumped Thornbill	S	36	2	9	29	5	6	13	2		6	108	25	41.7
Inland Thornbill	S		2		1			4				7	4	6.7

APPENDIX 3

Common Name	status	Arumpo	Bono	Lake Victoria	Manfred	Mildura	Popiltah	Scotia	Turlee	Weimby	Wild Dog	Total	Number of sites	% sites
Pardalotidae														
Striated Pardalote	S/N	1	4	20	1	1	11	4	21		12	75	31	51.7
Yellow-Rumped Pardalote	N	18		15	13	34	3	2	4	3	9	101	35	58.3
Meliphagidae														
Brown-Headed Honeyeater	N	26		2	8	12	2	10	4	3	15	82	21	35.0
Grey-Fronted Honeyeater	S	2										2	1	1.7
Red Wattlebird	N	1				7			7		1	16	7	11.7
Singing Honeyeater	S	6			2	1		1	4			14	11	18.3
Spiny-Cheeked Honeyeater	N	5	4	1	11	6	11	5	14		10	67	37	61.7
Striped Honeyeater	N		1		2		3	1				7	6	10.0
White-Eared Honeyeater	S	11			18			1	3	2	23	58	17	28.3
White-Fronted Honeyeater	N		1	3			3	10	11		13	41	14	23.3
Yellow-Plumed Honeyeater	S	22	44	41	9	25	66	126	49	4	18	404	52	86.7
Yellow-Throated Miner	S		3				6					9	4	6.7
Crimson Chat	M/N				2							2	1	1.7
Pomatostomidae														
Chestnut-Crowned Babbler	S						4					4	1	1.7
White-Browed Babbler	S			9			1	4			1	15	6	10.0
Eupetidae														
Chestnut Quail-Thrush	S	10	8	23	6	10	12	16	21	4	11	121	42	70.0
Neosittidae														
Varied Sittella	N			2		18						20	3	5.0
Campephagidae														
Black-Faced Cuckoo Shrike	N/M			1	1	4	4	3	1		2	16	13	21.7
White-Winged Triller	M		3						1		1	5	4	6.7
Pachycephalidae														
Gilbert's Whistler	S	5									6	11	4	6.7
Rufous Whistler	S	8	10	6	4	2	4	8	4		3	49	31	51.7
Grey Shrike-Thrush	S	9	11	10	7	7	14	13	10	6	5	92	50	83.3
Crested Bellbird	S	9	13	10	8	11	11	16	7	1	3	89	48	80.0
Artamidae														
Black-Faced Woodswallow	N	16										16	2	3.3
Dusky Woodswallow	N/M						9					9	3	5.0
Masked Woodswallow	M		2	4			3	20	4		1	34	10	16.7
White-Browed Woodswallow	M						4	1	9		3	17	4	6.7
Grey Butcherbird	S	2	10	5	4	5	10	6	11	1	1	55	34	56.7
Pied Butcherbird	S	3	2			1			1			7	7	11.7

APPENDIX 3

Common Name	status	Arumpo	Bono	Lake Victoria	Manfred	Mildura	Popiltah	Scotia	Turlee	Weimby	Wild Dog	Total	Number of sites	% sites
Grey Currawong	S	1		2	3	5	1	4	2	2	5	25	20	33.3
Australian Magpie	S	1	5	4	6	8	7	2	7	2	5	47	27	45.0
Rhipiduridae														
Restless Flycatcher	S			2		1						3	2	3.3
Willy Wagtail	S	6	3	5	3	4	17	5	1			44	20	33.3
Corvidae														
Australian Raven	S		2			2	3	1			3	11	9	15.0
Little Crow	N								1			1	1	1.7
Little Raven	N			7		1	2	2	1	7		20	9	15.0
Monarchidae														
Australian Magpie-Lark	S		1									1	1	1.7
Corcoracidae														
Apostlebird	S		2									2	1	1.7
White-Winged Chough	S			3		10		1		3		17	6	10.0
Petrociidae														
Jacky Winter	S	10	31	19	10	11	19	17	6	2	7	132	48	80.0
Hooded Robin	S		2		3			1				6	3	5.0
Red-Capped Robin	S	4		3	2	1			1			11	10	16.7
Southern Scrub-Robin	S							3			2	5	3	5.0
Hirundinidae														
Tree Martin	M	4		1		1	2				2	10	6	10.0
Nectariniidae														
Mistletoebird	N					1	1					2	2	3.3
Map Sheet Total		295	242	291	246	271	343	360	247	63	209	2567		
Mean Number Per Map Sheet		35	31	38	33	33	36	36	32	16	35			

APPENDIX 4



The Jewelled Gecko *Strophurus elderi*, this species was only captured at three of the sixty survey sites.

Photo, J.Val

APPENDIX 4



A juvenile Mallee Worm-Lizard *Aprasia inaurita*.
Photo, J.Val



The secretive Spinifex Slender Blue-tongue *Cyclodomorphus melanops elongatus*, this species was only captured once during the surveys.
Photo, J.Val



The threatened Mallee Ningai *Ningai yvonneae* was the most frequently captured small mammal.
Photo, J.Val



These surveys suggest that the Southern Scrub Robin *Drymodes brunneopygia* appears to be restricted to small disjunct populations in NSW.
Photo, J.Val