



# The Vertebrate Fauna of Manobalai Nature Reserve and adjacent Crown lands

Project funded under the Central Branch Parks and Wildlife Division  
Biodiversity Survey Priorities Program

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*Cover Photos*

Front cover

Feature Photo (Spotted Gum Woodland, DEC)  
*Mormopterus* sp. 3 (short penis form) (Narawan Williams)  
Spotted Gum (Elizabeth Magarey)  
Nobbi Lashtail (Narawan Williams)  
Grey Gum (Daniel Connolly)  
Squirrel Glider (Narawan Williams)

Back cover

Red-crowned Toadlet (Dave Hunter)  
Woodland in Yengo National Park (Narawan Williams)  
Tawny Frogmouth (Narawan Williams)  
Escarpment Slopes Woodland in North-east Wollemi National Park

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# OVERVIEW

Manobalai Nature Reserve comprises 3 800 hectares of a dissected sandstone plateau within the catchment of the Goulburn River. It is bordered to the south and east by three parcels of Crown Land, which together encompass 7800 hectares of native vegetation. These 'adjacent Crown Lands' have been proposed as additions to the Nature Reserve, and in conjunction with the Reserve form the focus of this report (the study area). The area is characterised by sandstone peaks and mesas, with benches and slopes dropping to deep narrow gorges. Broader alluvial valleys feature in the southern area of the Nature Reserve and also the southern portion of Crown Land. The study area lies at the convergence of a number of environmental and climatic influences, as illustrated by the diversity and pattern of vegetation communities. These range from grassy alluvial woodlands, dry woodlands and forests on sandstone slopes and ridges, and rocky heath to taller Spotted Gum-Ironbark forests. The diverse range of environments provides a rich assemblage of habitats for fauna.

This report compiles and reviews Atlas of NSW Wildlife data on terrestrial vertebrate fauna and documents the extensive systematic surveys undertaken by the Department of Environment and Conservation in 1997 and during the spring, summer and autumn of 2004-05. A total of 88 systematic survey sites have sampled the birds, frogs, bats, reptiles and arboreal mammals. Terrestrial mammals have been sampled opportunistically, while fish have not been included in this study. The 2004-05 surveys were undertaken to provide a more accurate inventory of fauna across the range of habitats present and enable a more reliable assessment of importance of the Reserve and Crown Lands to the protection of threatened species at a local, regional and state level. The report finds that:

- Two-hundred and fourteen (214) species of native vertebrate fauna are known to inhabit the study area, including 166 in the Nature Reserve and 201 in the Crown Lands. This includes 120 species of diurnal birds, eight nocturnal birds, five arboreal mammals, sixteen bats, eleven ground mammals, 30 reptiles and 14 frogs.
- The composition of fauna is strongly influenced by the central western slope environments, including species such as Grey-crowned Babbler, Black-chinned Honeyeater, Inland Broad-nosed Bat and South-eastern Morethia Skink. It also includes species typical of drier Sydney sandstone environments such as White-eared Honeyeater, Rockwarbler, Eastern Freetail-bat (*Mormopterus* species 2) and Whites Rock-skink, and species more typical of the north coast including Robust Velvet Gecko, Eastern Ranges Rock-skink and Two-clawed Worm-skink. A number of animals found lie near the limit of their known range and ecological tolerance.
- Manobalai Nature Reserve supports habitat for at least fourteen species listed as threatened on the Threatened Species Conservation Act (1995), while the southern Crown Land supports at least twenty. Three of these threatened species are widespread across the study area, including the Powerful Owl, Glossy Black-cockatoo and Large-eared Pied Bat.
- Fourteen threatened species have the greatest area of their preferred habitat located in the southern Crown Land, including Black-chinned Honeyeater, Grey-crowned Babbler, Speckled Warbler, Turquoise Parrot, Brown Treecreeper, Painted Honeyeater, Hooded Robin, Diamond Firetail, Gang-gang Cockatoo, Barking Owl, Squirrel Glider, Greater Long-eared Bat, Koala and Eastern Cave Bat.
- The Spotted Gum – Ironbark Forests provide quality habitat for the Regent Honeyeater and Swift Parrot, though these birds have not been recorded within the park to date. Targeted surveys for these species are recommended.
- Three threatened species appear rare within the study area, the Yellow-bellied Sheath-tail-bat, East-coast Freetail-bat and Eastern Bent-wing Bat while a further three species are considered likely to persist but have not been recently confirmed, including Masked Owl, Spotted-tailed Quoll, Brush-tailed Rock-wallaby.
- Feral animals including Rabbits, Foxes and Wild Dogs are present, with highest densities recorded near the boundaries of the study area. Foxes pose the greatest threat to native wildlife through predation. Initiatives that prevent expansion of these animals are warranted.

The report highlights that Manobalai Nature Reserve and the adjacent Crown Lands support different assemblages of fauna, driven by the habitats contained therein. The southern portion of Crown Land contains habitats of particular conservation significance within the Hunter region given the extent of clearing and the fact that such habitats are currently poorly protected in the reserve system.

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# 1 INTRODUCTION

## 1.1 PROJECT AIMS

The Central Branch Parks and Wildlife Division (PWD) of the NSW Department of Environment and Conservation (DEC, formerly NSW National Parks and Wildlife Service (NPWS)) has established a Biodiversity Survey Priorities (BSP) program for DEC managed estate within the Branch. This program recognises that information that documents the range of biodiversity values held within reserves is fundamental to successful reserve management and to generating an improved understanding of the contribution reserves make to the protection of vegetation communities, plant and animal populations and their habitats. Currently there is only sparse and incomplete information that describes the role reserves play in ensuring the viability of fauna species across large regions and local areas.

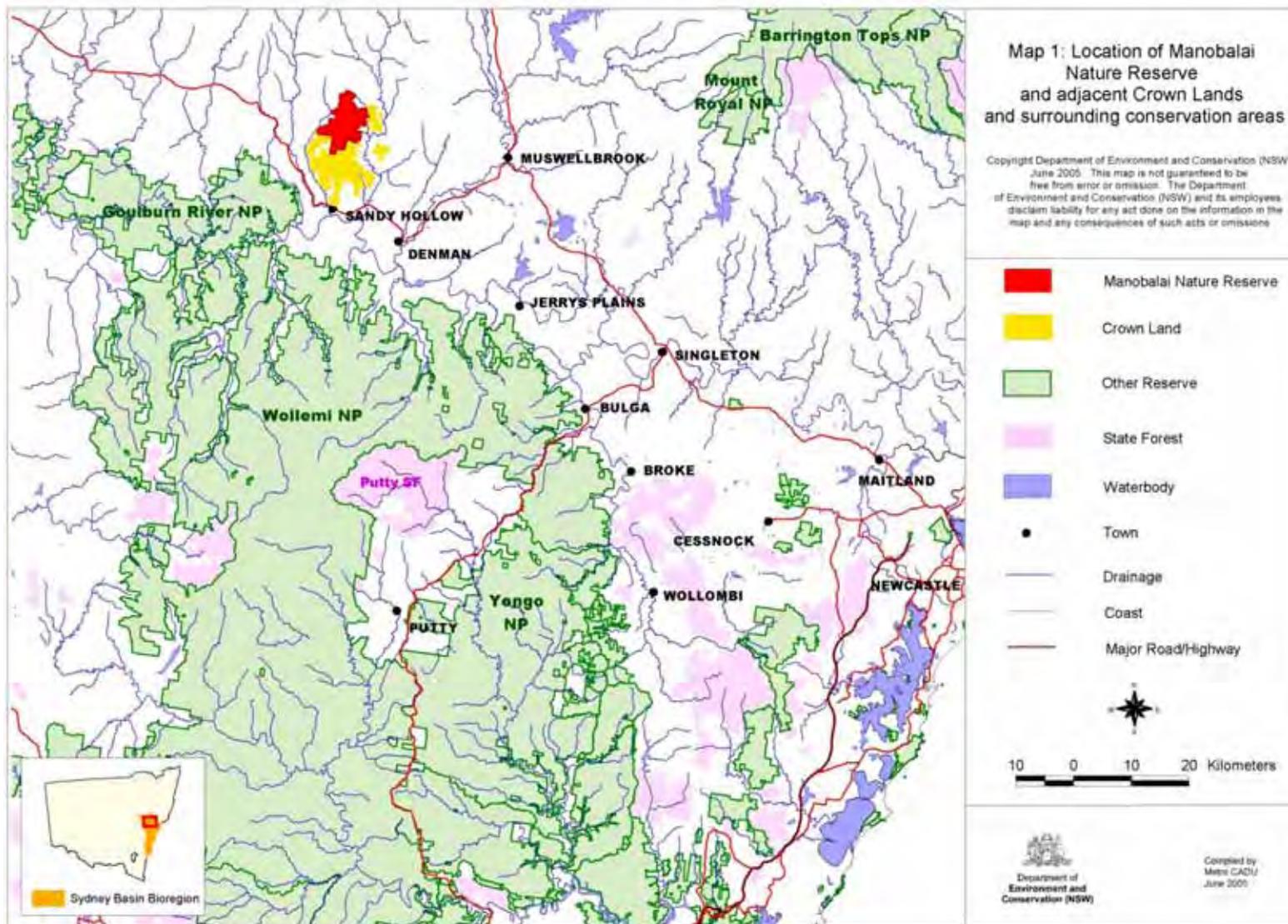
Typically the largest reserves, which potentially offer a significant contribution to biodiversity conservation, are the most poorly understood and the most deficient in data quality and quantity. The BSP program goes some way towards addressing this information shortfall by addressing the most poorly known reserves first and combining this work with larger regional conservation assessment projects.

Currently the Hunter region is the focus of considerable biodiversity assessment and environmental planning investigation. In terms of human population it represents one of the fastest growing regions in the state and extreme pressures are being placed on many of the habitats of the Central Coast and Lower Hunter as a result of urban expansion. Knowledge of the values of the sandstone reserves that fringe the southern Hunter Valley is fundamental to understanding the conservation priorities for many species in the region. Manobalai Nature Reserve is characterised by low levels of information on its fauna values (NPWS 2003a). Consequently this reserve was identified as a survey priority. The parcels of Crown Land to the south and east are being considered as additions to the reserve, so surveys were concurrently undertaken here to assist with conservation assessment and facilitate planning. The specific objectives of this project are to:

1. Document, review and collate existing terrestrial vertebrate fauna data.
2. Carry out systematic field sampling of all terrestrial vertebrate fauna groups to establish baseline data for future conservation assessment and monitoring works.
3. Identify and profile threatened fauna species and other regionally significant fauna that are known or likely to occur.
4. Identify broad-scale patterns in fauna occurrence and habitat use across the study area and identify habitats of particular conservation significance.

## 1.2 BACKGROUND

Manobalai Nature Reserve (NR) is located approximately 30 kilometres west of Muswellbrook and approximately 200 kilometres north-west of the Sydney metropolitan area (Map 1). The reserve encompasses approximately 3800 hectares of land, and is bordered to the north, west and south-east by partially cleared private lands, predominantly used for grazing, and to the south and north-east by Crown Lands covered by native vegetation. The Crown Lands comprise approximately 7800 hectares and are divided into three portions: the largest between Manobalai Nature Reserve and the township of Sandy Hollow (called the southern Crown Land hereinafter); the remaining two to the east (called the north-eastern Crown Land hereinafter) and south-east (called the south-eastern Crown Land hereinafter) of Manobalai Nature Reserve (Map 1). The Reserve, as well as the southern portion and north-eastern portion of Crown Land, form the divide between the catchments of Wybong Creek to the east and Giants Creek to the west, each of which flow south into the Goulburn River. The south-eastern portion of Crown Land lies to the east of Wybong Creek, encompassing a small section of its eastern catchment. Manobalai Nature Reserve was dedicated as a reserve in 1967 because of the association of Spotted Gum (*Corymbia maculata*), Ironbark and Grey Gum (*E. punctata*), which represents the most northerly and westerly example of this vegetation community in NSW. It forms the northern-most reserve in the PWD Hunter Range Area. It lies just over ten kilometres north-east of Goulburn River National Park and just under 20 kilometres north of Wollemi National Park (Map 1). It forms an important link in the string of parks that connect the Sydney, Hunter and Central West regions of New South Wales.



**Map 1: Location of Manobalai Nature Reserve and adjacent Crown Lands and surrounding conservation areas**

## 1.3 HISTORY OF LAND USE

The Wonarua Aboriginal people have strong connections with the land in the Manobalai area, believing that it is inhabited by Bai-ame, a powerful Dreamtime creator (Bilton 1990). There are at least two Aboriginal sites recorded within the Crown Lands, though the actual number is expected to be far greater.

Europeans settled the area in the mid 1820s (Visser 1997), gradually clearing the widest valley floors throughout the Hunter area for agriculture, settlement and mining. The rugged landscape, low nutrient soils and dry climate of the majority of the study area, however, prevented its use for settlement or primary industry. As a result, the rolling hills, steep mountains, sandstone cliffs, stony plateau and deep gorges that comprise the majority of the reserve and Crown Lands have remained largely unoccupied and relatively undisturbed. The exception is areas of higher soil fertility, such as the basalt-influenced soils that lie at the northern edge of the southern portion of Crown Land, which have been cleared and used for agriculture and currently remain as inholdings. Some of the wider valleys within the study area have in the past been cleared for grazing or selectively logged for fence post material, particularly along Coffin Arm, Walters Arm, Webbs Arm, Reedy Creek, Melon Creek (each in the Crown Land) as well as Long Arm, Shingle Arm and Wybong Arm (each in the Nature Reserve). Ironbark eucalypts have been collected for fence posts extensively in the central part of the study area, the outer layer of rough bark having been removed and left in piles *in situ*. The majority of Ironbark trees in the central valleys of the study area today are regenerated, with very little old growth remaining. Finally, these cleared or logged valleys have been used in the past, and some continue to be used today, for low to moderate intensity cattle grazing.

## 1.4 ENVIRONMENT

### 1.4.1 Biogeography

The study area occurs at the biological interchange between coastal and western slope environments. It lies at the northern boundary of the Sydney Basin Bioregion (Thackway and Cresswell 1995), which extends from just north of Batemans Bay to Nelson Bay on the central coast, and almost as far west as Mudgee (Map 1). This Bioregion is characterised by a temperate climate with warm summers and no dry season (NPWS 2003b). Approximately 40 percent of the Bioregion is reserved for conservation, largely as National Parks and Nature Reserves (NPWS 2003b). The Brigalow Belt South Bioregion lies immediately to the north of Manobalai Nature Reserve, extending from south of Dubbo north to the mid-Queensland coast. The south-eastern section of the Brigalow Belt South Bioregion is characterised by a subhumid climate, with no dry season and a hot summer (NPWS 2003b). Less than three per cent of this bioregion is currently conserved (NPWS 2003b), though a significant extension to the reserve system has recently been announced.

### 1.4.2 Geomorphology

Manobalai Nature Reserve is situated on a dissected plateau of Triassic Narrabeen Sandstones and Conglomerate (Story *et al.* 1963). This plateau forms an amalgam of residual sandstone peaks and mesas that break from northern Baerami and Hungerford Ranges to the south. The geology and derived soil landscapes (Kovac and Lawrie 1991) have been coarsely mapped, but the local vegetation patterns suggest that greater diversity than is described lies above the three significant alluvial valleys of the Goulburn River, Wybong Creek and Giants Creek. Sandstone ridges are characterised by shallow sandy soils with considerable areas of bare outcropping rock (Bilton 1990). Sandstone benches are associated with steeper slopes, which drop to deep narrow gorges in the east of the Nature Reserve. The depth of dissection is not as pronounced, however, as that of the adjoining plateaus of Goulburn River and Wolllemi National Parks. Steep sandstone scarps form a rim around the plateau as it rises from the surrounding alluvial valleys. A narrow peninsula of Crown Land also runs parallel to Giants Creek just to the west of the reserve that is also characterised by steep rocky escarpments.

Recently deposited alluviums characterise the broad valley floors to the east, west and south. These alluviums comprise a mix of eroded sandstone material as well as richer clays and silts derived from the basalt substrates. These alluviums formed floodplain terraces following major depositional phases. The headwaters of these expansive valleys are present in the Reserve and particularly the adjoining Crown Lands.

Small areas of Tertiary basalt are known from Healys Arm and Forest Gully catchments and from Gulf Sugarloaf. The basalt flows that are thought to have in-filled some valleys are now much eroded away, leaving vestigial igneous landscapes. Basalt landscapes dominate the Merriwa Plateau less than 10 kilometres to the west. A small section in the north-west corner of Portion 175 is capped by Tertiary basalt.

### 1.4.3 Elevation

The entire study area lies below 500 metres above sea level (asl), reaching a maximum of 499 metres on Gulf Sugarloaf in the north of Manobalai Nature Reserve. The majority of Manobalai Nature Reserve lies between 300 and 400 metres asl, with the exception of the Oaky Arm, Forest Gully, Cockatoo Arm and Gulf Creek valley systems, which reach a minimum of 190 metres at the eastern boundary of the reserve. The Manobalai Crown Lands are generally at lower elevation, though rise sharply from the river flats that surround them to the east, south and west. The Crown Lands are comprised of valley systems that range between 100 and 300 metres asl, divided by ridges that reach up to 400 metres asl. The landscape rises above 400 metres at only one point in the Crown Lands, at a peak south of Reedy Creek.

### 1.4.4 Climate

Long term climate patterns across the study area are directly related to topography. The following information is derived from GIS layers of modelled climate patterns. Generally, ridges above 350 metres asl have a mean annual temperature of between fifteen and sixteen degrees, with a maximum of approximately 29 degrees and a minimum of 1.5 degrees Celsius. Manobalai Nature Reserve is generally cooler than the Crown Lands, due to its higher elevation. Slopes within the study area have an average annual temperature of sixteen degrees (minimum of two and maximum of 30 degrees), while the major creeklines, including Reedy Creek, Melon Creek, Gulf Creek, Cockatoo Arm and Forest Gully, maintain a more moderate average of approximately seventeen degrees (with a minimum of two and a maximum of 31 degrees).

The annual rainfall data for the study area follows a similar pattern. Peaks above 400 metres asl in Manobalai Nature Reserve on average receives between 675 and 710 millimetres of rain per year. Upper slopes receive between 645 and 675 millimetres of rain per year, while the lower slopes and drainage systems receive an average of between 615 and 645 millimetres of rain per year. These climate patterns illustrate the semi-arid nature of the study area.

## 1.5 VEGETATION

While the Reserve and the adjoining Crown Lands lie within the Sydney Basin Bioregion the floristic assemblages are characteristic of the central western slopes (Harden 1999). The vegetation has been mapped and described by Bell (1997) and Peake (1999). The following summarises the findings of these studies.

The uniquely identifying feature of Manobalai Nature Reserve and the two small portions of Crown Land to the east is the presence of Spotted Gum forests growing on sandstone soils (Plate 1). This is unusual for two



Plate 1: Spotted Gum Ironbark Forest in Nature Reserve © E. Magarey /DEC

reasons. Firstly, the species is more often associated with more fertile though well drained loams rather than the siliceous shallow material of the Manobalai Plateau. Secondly, the location

approaches the north-western limit of the species range, known mostly along the foothills and valleys of the east coast of NSW.

Other tree species found in the Manobalai Spotted Gum community include Red Ironbark, Grey Gum, Brown Bloodwood (*Corymbia trachyphloia*) and Black Cypress (*Callitris endlicheri*). The understorey of this vegetation reflects the influence of the sandstone parent material with shrubs such as Narrow-leaved Geebung (*Persoonia linearis*), Prickly Shaggy Pea (*Podolobium ilicifolium*) and Blunt Beard-heath (*Leucopogon muticus*) common. However, other components of the understorey are grassier and more open than the



Plate 2: Exposed Woodland on ridgeline in Nature Reserve © H. Achurch/DEC

surrounding Ironbark woodlands and include the prominent cycad *Macrozamia communis*. Many of the ground cover grasses and herbs are shared with the Box woodlands growing on basalt suggesting that the soil on which the Spotted Gum grows has been enriched in some manner by igneous material. Stands of Spotted Gum range from an open grassy forest (about 25 metres tall) in deeper soils in the Reserve proper, to mixed stands with other eucalypts and cypress above sandstone heath understorey on narrow ridges with shallow soils in the eastern Crown Lands.

The remainder of the sandstone plateau supports a combination of open dry sclerophyll forests and woodlands. The species composition is closely aligned to the adjoining sandstone ranges in north-western Wollemi National Park, Goulburn River National Park and Myambat defence lands. Primarily ridges and upper slopes comprise a low growing open tree layer above a sparse shrub layer (Plate 2). Tree species are most commonly Ironbarks (*Eucalyptus fibrosa*, *E. caleyi*, *E. nubila*, *E. crebra* and *E. beyeriana*), Grey Gum and Narrow-leaved Stringybark (*E. sparsifolia*). The abundance of Ironbarks in the canopy varies, probably in response to subtle changes in soil fertility. Understorey includes Tea Trees (*Leptospermum* spp.), Blunt Beard-heath and Blackthorn (*Bursaria* spp.).

Rocky sites with skeletal soils may include dense stands of Currawang (*Acacia doratoxylon*) and



Plate 3: Heath on ridgetop in south-eastern portion of Crown Land © E. Magarey/DEC

Brown Bloodwood. Black Cypress stands are prominent, particularly in sites of disturbance or in areas that have excluded fire. Ground cover is typically very open with scattered rocks and dense litter commonly encountered. These sites have been mapped as Acacia Woodland and are most prominent in the southern portion of Crown Land.

Many exposed rock plates and benches carry a heath community (Plate 3) comprising Common Fringe-myrtle (*Calytrix tetragona*), *Micromyrtus sessilis* and Broombush (*Melaleuca uncinata*). Small mallees of

Dwyers Red Gum (*E.dwyeri*) grow amongst the heath sometimes amongst scattered Black Cypress and Currawang. Some sites also contain dense scrubs of *Allocasuarina gymnanthera*.



Plate 4: Dry Sheltered Forest in southern Crown Land  
© E. Magarey/DEC

north-east of the southern portion of Crown Land. The fertile soil provides a good cover of grass and herbs, while shrub layers are generally sparse to absent. The majority of this woodland has been disturbed in the past, leaving few very old-growth Ironbark trees. On sandier alluviums, such as along Reedy Creek, Rough-barked Apple (*Angophora floribunda*) is dominant often in association with Red Gums (*E. blakelyii*/ *E. tereticornis*) and Grey Gum (Plate 6). A grassy ground cover is present although Bracken Fern (*Pteridium esculentum*) is also often present. Some sites may have impeded drainage and as a result a dense cover of water tolerant vegetation flourishes. These minor swamp-like depressions feature sedges and rushes such as *Carex* spp. and *Juncus* spp. Clearing for agriculture has depleted the original extent of these alluvial vegetation communities. Small tongues are found as remnant forests in small valleys of the Manobalai area, Goulburn River NP and northern Wollemi NP.

Clearing has also affected vegetation growing on small basalt caps and diatremes found in the north of the reserve. These small isolated richer soils support White Box-Ironbark Woodlands that are open and grassy. These communities are closely related to those that were once extensive across the basalt of the Merriwa Plateau. Some regenerating shrubs such as Native Olive (*Notelaea microcarpa*) are present.

Many of the sheltered slopes and gullies on Narrabeen sandstone geology (Plate 4) feature a taller forest (to 20 metres) dominated by Grey Gum, Ironbarks and Narrow-leaved Stringybark. Shrub layers tend to be denser than in exposed woodlands and the ground cover has a greater cover of herbs and grasses. Rock outcropping and boulders are present on steeper slopes. In only the most sheltered sites do mesic shrubs and ground covers become abundant, such as the deep gorges at the south-eastern corner of the study area. Emergent trees common to the surrounding slopes sit above a low dry rainforest assemblage dominated by Grey Myrtle (*Backhousia myrtifolia*), Port Jackson Fig (*Ficus rubiginosa*) and Red Ash (*Alphitonia excelsa*). Rainforest is restricted to deeper, richer soils within Reedy Creek catchment.

Small areas of alluvial woodland are present along low-lying areas of major watercourses. There are two different types of alluvial community that are found. The first of these is dominated by open Narrow-leaved Ironbark (*E. crebra*) and Grey Box (*E. molucana*) (Plate 5), occurring for example along Walters Arm in the



Plate 5: Alluvial Ironbark Woodland in the southern portion of Crown Land © E. Magarey/DEC

## 1.6 FIRE

Fire is a natural component of the Manobalai ecosystem and the area is characterised by a highly flammable mix of fire adapted flora. Little is known about traditional Aboriginal burning practices in the area and knowledge of the fire regime since European settlement is also sparse. Landholders who have lived in the area since the 1930s do not recall a wild fire ever burning through Manobalai Nature Reserve (W. Constable pers. comm.). Records indicate that the most recent extensive wildfire in the Crown Lands occurred in 1979/80, covering the south-western half, but not burning Manobalai Nature Reserve proper. Control burns have been undertaken to a limited extent, including during 1992/93, when a fire burnt the area between Clay Hole Arm Road and 'Fern Valley'.



Plate 6: Alluvial Red Gum Woodland along Melon Creek  
© E. Magarey/DEC

## 2 METHODS

### 2.1 EXISTING FAUNA DATA

Prior to the current study, knowledge of the terrestrial vertebrate fauna of Manobalai Nature Reserve and Crown Lands was very limited. Some of this knowledge had not been stored in the Atlas of NSW Wildlife, the states major fauna database, so was entered by the Information and Assessment Section during the current study. This database was the primary resource used to access existing data on the fauna of the study area. The majority of records within the Atlas prior to the summer of 2004-05 derived from the licensed data sets of Birds Australia (Blakers *et al.* 1984 and Barrett *et al.* 2003). These records were collected in two stages. The first period was prior to 1984 (primarily 1977-1981) when a large number of records were gathered as part of the Bird Atlas published by the Royal Australasian Ornithologists Union (RAOU) (Blakers *et al.* 1984). The method used by Birds Australia at this time involved designating a ten-minute spatial grid, based on easting and northing lines, and attributing all sightings within that grid to the coordinates at the centre of the grid. One such grid centre lies within the southern portion of Crown Land. This data is spatially inaccurate and there is no guarantee that all or even any of these sightings actually occurred at the given AMG coordinate. The second period of Birds Australia data collection occurred between 1998 and 2002 for the second Bird Atlas (Barrett *et al.* 2003). Records collected during this period have a higher degree of spatial accuracy. Observations were made at two points, one at the eastern edge of the Nature Reserve on Dry Creek Road and the other in the southern portion of Crown Land near Melon Creek.

The second largest number of records within the Atlas of NSW Wildlife prior to 2004 derive from systematic surveys undertaken as part of the NSW Comprehensive Regional Assessment (CRA) process, which sought to provide a broad overview of the conservation value of public lands in eastern NSW. Work was undertaken over the spring and summer of 1997 and 1998 and centred on major roads including Clayhole Arm Firetrail, Reedy and Melon Creek Roads. These surveys were undertaken by NPWS using the systematic techniques described below. The Upper Hunter District of NPWS undertook surveys in the southern Crown Land in early 1997 (Visser 1997), also using these systematic techniques, at four sites near Reedy and Melon Creek. In 2000, NPWS commissioned systematic surveys in the Nature Reserve, resulting in nine sites located on Clayhole Arm and Diamond Ridge Firetrails (Stauber & Thumm 2000). However, data from these surveys was not entered into the Atlas of NSW Wildlife at the time and could only be entered at point localities during the current study.

A number of records derive from the specimen register of the Australian Museum, primarily collected in the 1960s, 70s and 80s. The spatial accuracy of these records is low, with all data attributed to two point localities, one in the centre of the reserve and one in the southern Crown Land. Remaining records within the Atlas derive from observations made by: park rangers and field officers; neighbouring landholders; bushwalkers and naturalists; scientific researchers and consultants working in the area. These records have various levels of reliability depending on the type of observation, as well as the certainty and experience of the observer.

### 2.2 SURVEY STRATIFICATION AND SITE SELECTION

The aim of the survey stratification and site selection process was to proportionately sample the range of habitat types contained within Manobalai Nature Reserve and Crown Lands. Prior to the commencement of the 2004-05 DEC Biodiversity Survey Priority surveys, three systematic fauna survey sites had been established within the reserve as part of the CRA program. In addition, four sites were sampled for nocturnal animals only in the Crown Land. The CRA sites were concentrated along the easily accessible major trails, leaving large portions of the study area unsurveyed. The site selection process undertaken for the 2004-05 survey season ensured that the data collected would complement, rather than replicate, work that has previously been undertaken within the study area.

The primary stratum used for site selection was vegetation community, using the vegetation mapping prepared by Peake (1999) for the Nature Reserve and Bell (1997) for the southern Crown Land. The first step undertaken was a gap analysis to identify the previous systematic fauna survey effort completed within each vegetation community across the Nature Reserve and Crown Lands. Vegetation communities that had not previously been sampled or had been under-sampled (where the amount of previous survey effort was less than that predicted by the proportional size of the community) were prioritised for sampling.

Sites were then selected using Arcview, with information gained from vegetation maps and topographic maps. Sites were primarily positioned on or close to access trails to facilitate spotlighting and harp trapping and to maximise the number of sites that could be accessed during the limited survey period. In the field, the proposed site locations were ground-truthed to ensure that they were representative of the intended stratum, had been minimally effected by recent burning or other habitat modification, and comprised a single vegetation community. If these criteria were not met, an alternative location was found. Systematic survey sites were 100 by 200 metres in area, and where possible were spaced a minimum of one kilometre from each other (two kilometres for nocturnal call playback surveys). An effort was made to cover spatial gaps in fauna information and where vegetation communities or large spatial gaps were located only in remote sections of the reserve an effort was made to reach them for diurnal surveys. In some cases during hikes, due to the terrain and the time taken to walk between sites, survey sites were placed closer than one kilometre. In this case, care was taken to ensure that adjacent sites sampled different habitats and that animals were never double counted. The north-eastern and south-eastern portions of Crown Land have not been mapped in detail, so sites here were selected on the basis of topography, aspect and maximising spatial coverage.

The location of access trails and the large amount of travelling time between areas (especially when walking in difficult terrain) limited the selection of survey sites. The extreme weather conditions (over 40°C most days) and the total fire ban imposed during the first week of summer survey, meant that for safety reasons surveyors were restricted to working from roads and undertook less hiking to remote survey sites than was originally planned. Consequently, some difficulties were met in sampling survey sites that proportionately sampled the full range of strata, maintained sufficient distance between sites to ensure they were independent from one another, and could be accessed with a reasonable degree of efficiency. For these reasons, vegetation types that were located far from roads (such as Narrabeen Acacia Woodland) were slightly under-sampled whereas vegetation types that were easily accessible (including Ironbark Woodland on Alluvium) were slightly over-sampled. As this latter habitat type is in a more productive environment, the return on time spent surveying is high, somewhat justifying the amount of time spent there. In addition, a small spatial gap in the east of the Nature Reserve could not be filled, however this area does not house any unique habitats that were not sampled elsewhere.

Table 1 presents the area of vegetation types categorised into broad classes and the corresponding survey effort for each fauna survey technique. Appendix A provides the specific AMG and survey techniques undertaken at each survey site. The tables include all systematic surveys undertaken within the study area by DEC between 1997 and 2005 (i.e. during both CRA and BSP programs).

## 2.3 SURVEY METHODS

The systematic fauna survey methods used were based on those developed by the NPWS Biodiversity Survey Coordination Unit (NPWS 1997). The techniques were used to sample the following vertebrate fauna groups: diurnal and nocturnal birds, diurnal and nocturnal reptiles, bats, arboreal mammals, amphibians, and terrestrial mammals. Consistency in the use of these techniques allows comparison between fauna species detected across different vegetation types and environments within the study area. Furthermore, it will allow future comparisons with consistent surveys of environments elsewhere.

Field survey teams were supplied with field proformas to facilitate comprehensive, consistent recording of field data and to increase accuracy and efficiency of data entry into the DEC Biodiversity Subsystem (BSS) of the Atlas of NSW Wildlife computer database. The names of observers and recorders were noted on every data sheet to aid data verification and entry.

### 2.3.1 Systematic site-based methods

#### *Site attributes*

A site attribute form, aiming to characterise fauna habitat, was filled out at every systematic site where survey techniques were conducted. A 20 by 20 metre quadrat typical of the overall 100 by 200 metre site was used for the assessment. The site attribute locates and describes the site in a format that is comparable to other sites. Data relating to physio-geographic, disturbance, structural and floristic, microhabitat and stream categories were recorded for the site. Standard codes provided by the Australian Soil and Land Survey Handbook (McDonald *et al.* 1990), particularly for vegetation (i.e. Walker and Hopkins 1990) were used wherever possible.

### *Diurnal bird survey*

Diurnal bird censuses comprised a twenty minute observation and listening search within a two hectare (100 by 200 metre) area, conducted by an experienced bird surveyor. Censuses were conducted only during periods of relatively high bird activity (in the early morning) and reasonable detectability (e.g. low wind and cicada activity). All surveys were undertaken in spring or summer. All bird species and abundance of individuals seen or heard were recorded. Individuals were scored as on-site if they were detected within the one hectare plot. Individuals recorded outside the plot, in adjacent vegetation types or flying overhead were recorded as off-site.

### *Diurnal herpetofauna search*

A standard half-hectare area (50 by 100 metres) was searched for one person-hour at each site (standardised regardless of the number of persons searching). Censuses were restricted to spring and summer during the period between mid-morning to late afternoon, when temperature and insolation are sufficient to ensure maximum reptile activity. Surveying was not conducted on overcast or rainy days or in extreme heat.

This census technique entailed active searching of potential reptile and frog microhabitats within the half-hectare area. Active or basking reptiles were identified by sight or captured and identified by the use of keys. Sheltering or cryptic species were detected by searching around, under and within fallen logs, litter, decorticating and fallen bark, rock outcrops and other likely shelter sites. Incidental observations of other fauna were also recorded.

### *Nocturnal site spotlighting survey*

This census comprised searching for arboreal mammals along a 200 metre transect within a site for half a person hour. Fifty-watt spotlights were used to scan the vegetation for animals and enable detection of reflected eye shine. Surveyors also listen intently for fauna calls during the survey period. All fauna observed within the census period were recorded, noting whether they were on or off site.

### *Harp trapping*

While ultrasonic recorders were used principally to detect high flying bat species, collapsible bat traps, known as harp traps (Tidemann and Woodside 1978), captured low flying species. Two nights of trapping were conducted at each bat trap site, between spring and summer. Sites were selected for their perceived potential to interrupt bats along their flight paths, and were usually along tracks or creeklines or in gaps between trees where adjacent vegetation might 'funnel' flying bats.

Traps were checked each morning. Captured bats were identified by external morphology, forearm measurement and body weight, and keyed out where necessary using Parnaby (1992a) and Churchill (1998). Animals were released on the following night at the point of capture.

### *Bat ultrasonic ('Anabat') call recording*

Ultrasonic recorders (Corben 1989) are particularly useful for detection of high-flying species, which often comprise more than one third of an area's bat species (Parnaby 1992b), yet are under sampled by harp trapping (Richards 1992). Additionally, ultrasonic detectors also record low-flying species. The method requires the recording and identification of high frequency, echo-location "calls" made by bats, which, except for one or two species, are ultrasonic, that is, inaudible to humans. All recordings were made during spring and summer, when bat activity is highest.

### CRA

The recording equipment for the surveys consisted of an Anabat II<sup>®</sup> detector and a tape recorder. Census duration was 30 minutes. Censuses began at or soon after dusk, and were conducted between then and up to two hours after dusk, a peak activity period for microchiropteran bats. A 40-kilohertz calibration tone was recorded for a few seconds at the start and end of each recording session and sometimes at intervals during the recording period.

Vegetation community	Mapped area of vegetation community in study area (hectares)	Proportion of study area occupied by vegetation community (%)	No. of diurnal bird surveys	No. of diurnal reptile surveys	No. of site spotlight surveys*	No. of harp trapping bat sites	No. of ultrasonic bat detector sites	No. of nocturnal streamside searches for frogs	No. of owl call broadcast sites	No. of Elliott trap sites	No. of hairtube sites
Narrabeen Exposed Woodland	4458	38.86	10	9	5	3	2	0	4	1	0
Narrabeen Sheltered Dry Forest	3162	27.56	9	8	3	2	2	1	5	0	0
Spotted Gum Open Forest Complex on Sandstone	1525	13.29	13	14	4	1	1	0	2	0	1
Narrabeen Acacia Woodland	967	8.43	3	2	1	0	1	0	1	0	0
Ironbark Woodland on Alluvium	532	4.64	8	6	5	5	1	0	4	1	0
Cleared Land	360	3.14	0	0	0	1	1	0	1	0	0
Red Gum Swamp Open Forest on Alluvium	141	1.23	3	3	2	0	0	0	1	0	1
Narrabeen Rocky Heath	129	1.13	1	0	0	0	0	0	1	0	0
Angophora Woodland on Alluvium	95	0.83	2	1	2	6	2	2	2	1	0
Dry Rainforest on Alluvium	46	0.40	1	1	0	0	0	0	0	0	0
Box Woodland	23	0.20	2	2	2	1	1	0	0	0	0
Disturbed Pasture with Native Olive on Basalt	20	0.18	0	0	0	0	0	0	0	0	0
Spotted Gum Grassy Woodland on Sandstone	8	0.07	0	0	0	0	0	0	0	0	0
Allocasuarina Scrub Forest Complex on Sandstone	3	0.03	0	0	0	0	0	0	0	0	0
Native Olive Vine Thicket	1	0.01	0	0	0	0	0	0	0	0	0
Spotted Gum Open Forest Complex on Basalt	1	0.01	0	0	0	0	0	0	0	0	0
Grand Total	11472	100	52	46	24	19	11	3	21	3	2

**Table 1: Areas of mapped vegetation communities within Manobalai Nature Reserve and southern portion of Crown Land and allocation of systematic survey methods (includes systematic survey sites from CRA and Biodiversity Survey Priorities projects). Vegetation communities derived from Bell (1997) and Peake (1999).**

<sup>1</sup> area based on GIS data layers does not equal gazetted area of reserve. Note also that mapped vegetation unit as presented here does not necessary equal vegetation community in the field.

## BSP

The recording equipment for the surveys consisted of an Anabat II<sup>®</sup> detector and digital flash card recorder, housed within a tupperware box for weather protection. The box was set up in locations where bats were expected to fly, such as over water bodies, at cave entrances and along tracks. The Anabat was set to commence detection at dusk and turn off at dawn. During the night, a delay switch operated to turn on the recording device when bat activity was detected and then de-activate the device while no bat activity was occurring. The equipment was left in each location for one night only, then moved elsewhere. A 40-kilohertz calibration tone was recorded for a few seconds at the start and end of each recording session.

Anabat recordings were transferred onto computer and analysed by Narawan Williams, a recognised expert in this field. Identification was designated as either definite, probable or possible, following the methodology of Parnaby (1992b) and Pennay *et al.* (2004).

### *Nocturnal streamside search*

Streamside searches for frogs were undertaken for half a person hour in one of two ways: in stream or gully habitats a 200 metre stretch was searched; at standing water bodies a half-hectare (50 by 100 metre) area was surveyed. The searches were only conducted on warm, dark, humid and wet nights within two days of rain. All frogs, and other animals, identified visually or by call within the time period were recorded, together with the weather conditions at the time of the survey.

### *Nocturnal call playback*

Nocturnal birds and mammals are often detected only when they vocalise for territory or social contact, behaviour which can be elicited by broadcasting specific calls. A standard survey census involved broadcasting the calls of each of the four large forest owls - Powerful Owl (*Ninox strenua*), Masked Owl (*Tyto novaehollandiae*) Sooty Owl (*T. tenebricosa*) and Barking Owl (*N. connivens*) - from the centre of a site. Prior to call broadcasts, on arrival at the site, the surrounding area was searched by spotlight for five minutes to detect any fauna in the immediate vicinity and then a ten minute period of listening was undertaken.

A pre-recorded compact disc of each species' call series was played, amplified through a megaphone. Calls of each species were played for five minutes, followed by a five minute listening period. The surrounding area was again searched by spotlight after a final ten minute listening period. After the census, the response or presence of any fauna, date and time that response occurred, and weather details such as amount of cloud cover was recorded. Very windy and rainy periods were avoided where possible. Censuses conducted in poor weather were noted. Censuses were undertaken in autumn and winter.

### *Elliott trapping*

This technique involved setting ten Elliott B traps at twenty metre intervals along a 200 metre transect through a site. Traps were baited with a mixture of peanut butter, oats and honey. Traps were left in place for four nights, checked and emptied every morning soon after dawn. Any animals captured within the traps were identified, sexed if possible, and released.

### *Hair tube sampling*

During CRA, twenty large hair-sampling tubes (nine centimetre diameter, after Scotts and Craig 1988) were placed at 100 metres intervals along a two kilometre transect. During Biodiversity Survey Priorities ten large hair-sampling tubes were placed at approximately twenty metre intervals along a 200 metre transect. In both cases alternative tubes were baited with meat or a mixture of peanut butter, honey and rolled oats. Each tube was fitted with adhesive paper to collect hairs of small and medium sized mammals that were attracted to the bait. Tubes were left on site for a minimum of ten nights. Hair samples were identified using the techniques described by Brunner and Coman (1974) by an expert in the field, Barbara Triggs. Identifications were classified into three levels of reliability: definite, probable and possible.

## **2.3.2 Transect based methods**

### *Transect spotlighting survey*

The method employed varied on a site by site basis, and was only undertaken during the CRA surveys. A team of two surveyors walked or drove along a transect, varying between 300 metres and eight kilometres in length, searching for arboreal mammals with 50 watt spotlights. An AMG was calculated for each sighting along the transect and entered into the data sheet.

### 2.3.3 Opportunistic methods

#### *Predator and herbivore scat and pellet collection*

The presence of hairs, and occasionally skeletal remains, in predator scats and owl pellets can result in the identification of prey species at a high level of confidence and is hence an efficient sampling technique for prey animals. In addition, the recording of predator or non-predator scats constitutes records for the species that deposits the scat, providing locality records for species such as the Spotted-tailed Quoll (*Dasyurus maculatus*), Fox (*Vulpes vulpes*), Dingo (*Canis lupus dingo*), Dog (*C. lupus familiaris*) and Pig (*Sus scrofa*). Due to the unmeasurable time delay between prey ingestion and defecation, the location in which the prey animals lived cannot be accurately known, so this technique is useful only for detecting the species presence within a general area. Lunney *et al.* (2002) has shown, however, that predators defecate an average of two kilometres from the point of prey ingestion.

Predator scats were collected, placed in paper envelopes, labelled and sent to specialist Barbara Triggs for analysis. Hair samples were identified using the techniques described by Brunner and Coman (1974). Identifications were classified into three levels of reliability: definite, probable and possible.

The location of herbivore scats was also noted on an opportunistic basis to indicate the presence of an animal. If there was any doubt in herbivore scat identification in the field, samples were brought back for identification by an expert.

#### *Searches of caves and overhangs*

When come across, caves and overhangs were thoroughly searched with a headtorch for animals such as cave-roosting bats, geckos and nesting birds.

#### *Incidental records*

Surveyors driving or walking through the study area recorded the location of interesting fauna when it was seen or heard. Particular animals targeted by this technique were those undersampled by systematic surveys, including large ground mammals, non-vocalising birds, and secretive, shy and/or rare animals. The date, time, map grid location (usually obtained from a GPS) and microhabitat of the animal were recorded on a data sheet.

## 2.4 SURVEY TIMING

As summarised above, systematic field surveys have been undertaken within Manobalai Nature Reserve and Crown Lands over a number of years. Table 2 summarises the timing of these surveys and the techniques that were undertaken in each period.

Survey program	Area	Timing	Techniques employed
Comprehensive Regional Assessment (CRA)	Nature Reserve	February 1998	Diurnal bird census, reptile search, transect spotlighting, 30 minute bat call detection, harp trapping, nocturnal call playback, nocturnal streamside search, opportunistic methods
	Southern Crown Land	September 1997	Nocturnal call playback, nocturnal streamside search
Biodiversity Survey Priorities (BSP)	Nature Reserve and Crown Lands	November - December 2004	Diurnal bird census, reptile search, site spotlighting, harp trapping, all night bat call detection, nocturnal streamside search, Elliott trapping, opportunistic methods
	Nature Reserve and Crown Lands	April – June 2005	Nocturnal call playback, hair tubes, opportunistic methods

**Table 2: Timing of DEC systematic fauna surveys within Manobalai Nature Reserve and Crown Lands**

# 3 RESULTS AND DISCUSSION

## 3.1 OVERVIEW

DEC has established and surveyed a total of 88 systematic fauna survey sites, including 33 within Manobalai Nature Reserve and 55 within the Crown Lands, of which 82 were surveyed in 2004-05 as part of the Biodiversity Survey Priorities fauna survey program (Map 2). These sites cover the dominant habitats and landscapes present within the study area, and have been surveyed during spring, summer and autumn. In addition to these surveys, records have been collected by Visser (1997), Stauber & Thumm (2000), members of Birds Australia, numerous DEC staff, scientific researchers, and dedicated members of the public.

A total of 214 species are now known to occur in the study area. Table 3 presents a summary of the numbers of vertebrate fauna known within the Nature Reserve and Crown Lands, including the number of threatened species.

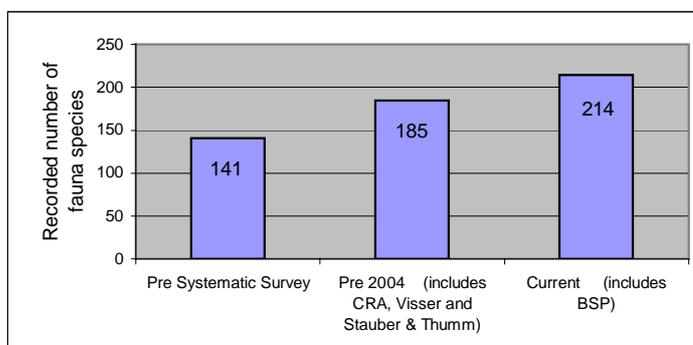
	Manobalai Nature Reserve	Crown Lands
Total no. native vertebrate fauna species known to occur	166	201
No. native species recorded during 2004-05 Biodiversity Survey Priorities surveys	136	168
No. species listed as threatened on TSC Act (1995)	14	20
No. species listed as threatened on EPBC Act (1999)	4	4
No. introduced mammals	7	7
No. introduced birds	1	1

**Table 3: Numbers of vertebrate fauna recorded in Manobalai Nature Reserve and Crown Lands**

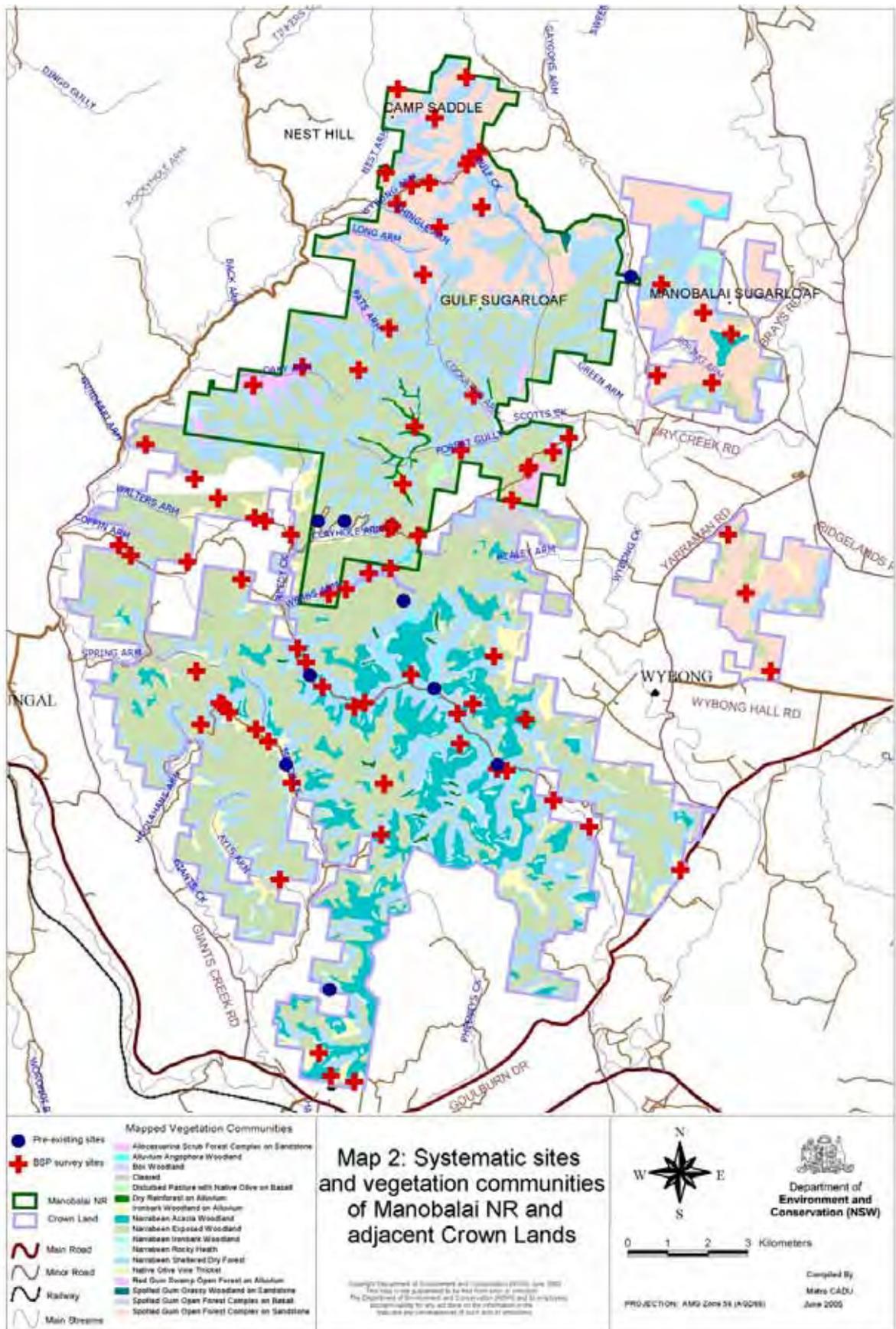
An additional 21 native and two introduced species have been recorded on the Atlas of NSW Wildlife for which there is some doubt regarding their occurrence in the park proper, as will be discussed below. A complete species list for all fauna groups is provided in Appendix B for the Nature Reserve and Appendix C for the Crown Lands.

In addition to the above fauna, 28 species have been recorded within a five kilometre radius of the study area boundary (see Appendix D). This includes two additional threatened species, of which one is considered to have the potential to also occur within the park.

The value of systematic fauna survey is apparent in the contribution it has made to the knowledge of fauna within the study area and the building of a species inventory. The Comprehensive Regional Assessment (CRA) surveys, undertaken in 1997-98, together with the work of Visser (1997) and Stauber & Thumm (2000) added 44 species to the list of known fauna within Manobalai Nature Reserve and Crown Lands, and the Biodiversity Survey Priorities (BSP) program, undertaken in 2004-05, added a further 29 species to the study area database. Figure 1 indicates the increase in the known number of fauna species within the study area over time, primarily as a result of dedicated systematic fauna survey. Furthermore, the BSP surveys increased the number of fauna records within the park more than three-fold, from 1021 to 3963.



**Figure 1: Number of fauna species recorded within Manobalai Nature Reserve and Crown Lands following systematic fauna survey**



Map 2: Systematic sites and vegetation communities of Manobalai NR and Crown Lands

## 3.2 NATIVE DIURNAL BIRDS

A total of 136 native diurnal bird species are recorded on the Atlas of NSW Wildlife as occurring within Manobalai Nature Reserve and Crown Lands. The DEC surveys undertaken in 2004-05 confirmed the presence of 99 species, including 18 species of diurnal bird not previously known to occur in the Nature Reserve and 15 new species for the Crown Lands. The close examination of all diurnal bird records in the Atlas of NSW Wildlife that was undertaken for this report (see below) led to a revision of the number of species that occur within the study area, with a total of 120 diurnal bird species now considered to occur. The Manobalai Nature Reserve supports 91 species while the Crown Lands support 117. Scientific names for birds discussed within this section are located in Appendix B and C.

### 3.2.1 Results of surveys

Eight species listed as threatened under the NSW Threatened Species Conservation Act (TSC Act) (1995) have been recorded in the study area: Gang-gang Cockatoo, Glossy Black-cockatoo, Turquoise Parrot, Brown Treecreeper (south-eastern subspecies), Speckled Warbler, Painted Honeyeater, Black-chinned Honeyeater (south-eastern subspecies) and Grey-crowned Babbler (south-eastern subspecies). In addition three threatened species, the Hooded Robin (south-eastern subspecies), Diamond Firetail and Regent Honeyeater have been recorded within two kilometres of the study area and as potential habitat is present, it is considered likely that these species utilise the area, at least on occasion. All of these species, with the exception of the Gang-gang and Glossy Black-cockatoo, are closely tied to alluvial dry open woodlands, a vegetation type that has been heavily cleared throughout the state. These threatened species will be discussed further in Section 5.

Also of conservation significance is the presence of a number of species that are thought to be in decline, though they have not yet been listed on either the TSC Act (1995) or the federal Environmental Protection and Biodiversity Conservation Act (EPBC Act) (1999). A recent review of bird records across the nation identified numerous species that appear to have declined in numbers in recent years (Barrett *et al.* 2003). Of the species identified, the following occur within the study area (followed by the number of times they have been recorded to date): Rockwarbler (31); White-winged Chough (19) and Spotted Quail-thrush (7). The Rock Warbler is of particular interest because it is endemic to NSW and its distribution pattern is very closely linked to the Sydney sandstone environments. The sightings made in Manobalai Nature Reserve and Crown Lands constitute the most northerly cluster of records for the species, and together with Goulburn River and Wollemi National Parks, the area is vital to the continued survival of the species at its distributional extremity. This small ground dwelling bird is moderately common amongst the outcropping rocks and boulders of the gullies and slopes of Manobalai.

In addition, a number of species that have been located are thought to have declined within the Sydney Basin Bioregion in recent years (Barrett *et al.* 2003). These include the Jacky Winter (14, Plate 7), Wedge-tailed Eagle (14), Nankeen Kestrel (6), Dusky Woodswallow (10), Brown Falcon (3), Australian Pipit (3), White-winged Triller (6) and White-throated Needletail (3). The presence of these species suggests that the study area, together with the neighbouring national parks of the Blue Mountains and Hunter Range, play an important role in their ongoing regional conservation.



Plate 7: Jacky Winter © Rebecca Allport/DEC

The systematic diurnal bird surveys undertaken in 2004 have yielded valuable information on the relative abundance of species and allow comparisons of the distribution of bird species across different habitats. Eighty-three diurnal bird species were recorded during the 52 systematic diurnal bird censuses. The most commonly encountered species was the White-throated Treecreeper, recorded at 49 (94% of) sites. This small bird with a distinctive, high-pitched piping call utilises a wide range of habitats, from moist gully forest to dry woodlands and rocky heaths, and was detected within all of the major habitats sampled in the study area. Also frequently recorded were the Noisy Friarbird (86% of sites), Rufous Whistler (78%), Sulphur-crested Cockatoo

(76%) and Spotted Pardalote (70%). These birds are all commonly recorded in dry woodland and forest in reserved areas throughout the region, particularly as they are highly vocal and visible.

The composition and richness of bird species is a reflection of the habitat types present. Woodlands on exposed sandstone ridges and slopes occupy the greatest area of Manobalai Nature Reserve and Crown Lands. These support bird species common to the drier Sydney sandstone environments, including White-eared Honeyeater, Yellow-faced Honeyeater, Brown Thornbill, Silveryeye, Cicadabird, White-throated Treecreeper, Rufous Whistler and Spotted Pardalote. The dry grassy woodlands that occupy the alluvial creeklines in the Crown Lands and south-east of the Nature Reserve support a suite of birds that are characteristic of the dry woodlands of the Hunter Valley and the central western slopes. These include the Brown Treecreeper, White-browed Babbler, Striped Honeyeater, Grey-crowned Babbler, Turquoise Parrot, Jacky Winter, Black-chinned Honeyeater, White-plumed Honeyeater, White-winged Chough, White-winged Triller, Eastern Shrike-tit and Noisy Miner. Due to the extent of clearing of alluvial woodlands in the Hunter Valley, many of these birds are locally or regionally threatened. Noticeably absent from the species list of the study area are birds that require moist coastal gully forests, though these birds are present within sections of the adjacent Goulburn River and north-eastern Wollemi National Parks (NPWS 2001a; DEC 2005b). The small patches of dry rainforest and sheltered forest in the incised gorges in the south-east of the Nature Reserve provide habitat for a few more adaptable moist forest species, most notably the Golden Whistler, which was only recorded here. There is potential for the Satin Bowerbird to also occur here, alongside more habitat-generalist species such as the Bell Miner, Superb Lyrebird, Crimson Rosella and White-browed Scrubwren.

The number of Honeyeater species within the study area is lower than other reserves in the region (DEC 2005b, 2005c and 2005d), largely due to the absence of moist coastal forest species such as Lewin's Honeyeater. Never the less, the group is a fairly dominant feature of the bird assemblage, with sixteen species recorded. This includes common and widespread species like the Noisy Friarbird, Yellow-faced Honeyeater, Noisy Miner, White-naped Honeyeater and Brown-headed Honeyeater which have the propensity to inhabit a large range of environments and whose distribution is dependent on the location of flowering trees and shrubs. Also common are the White-eared Honeyeater, Eastern Spinebill, Yellow-tufted, Scarlet and Striped Honeyeaters, while the Red Wattlebird, Bell Miner, Little Friarbird, Painted, White-plumed and Spiny-cheeked Honeyeaters are relatively rare.

Birds of prey are another well-represented group, with eight species known to inhabit the study area, including (in order of frequency detected) Wedge-tailed Eagle, Nankeen Kestrel, Brown Goshawk, Black-shouldered Kite, Brown Falcon, Little Eagle, Australian Hobby and Peregrine Falcon. In addition, the Spotted Harrier occurs in the cleared grasslands and very open woodlands just outside the boundary of the study area. The Brown Falcon and Black-shouldered Kite have been reported by Birds Australia to have declined in numbers in the Sydney Basin Bioregion since the 1980s (Barrett *et al.* 2003), so their occurrence has conservation significance. The Brown Falcon, Black-shouldered Kite and Nankeen Kestrel utilise cleared lands adjacent to the park for foraging, where they hunt reptiles, rodents and insects (N. Williams pers. comm.). In contrast, the Brown Goshawk forages largely within forests and woodlands, and is therefore likely to be more widespread within the interior of the study area. The Peregrine Falcon is also likely to be more common towards the northern perimeter of the park, as it would nest and roost in caves and cliff edges along the sandstone escarpments, foraging for smaller birds within both cleared and forested lands.

Two of the most widely recognised groups of birds in eastern Australia are the parrots and cockatoos. Eight species of parrot have been recorded in the study area, the most common being the Australian King-parrot (recorded at 42 locations) followed by the Eastern Rosella (35 locations) and Little Lorikeet (26 locations). These birds feed on fruit and seeds in tree foliage and often on the ground. Less common parrots include Musk Lorikeet (8), Red-rumped Parrot (6), Crimson Rosella (5), Turquoise Parrot (2) and Rainbow Lorikeet (1). Red-rumped Parrots are known to prefer open country and have only been recorded near the perimeter of the park. The Sulphur-crested Cockatoo is a dominant feature of the Nature Reserve and Crown Lands, their loud harsh call heard echoing through all of the major vegetation types. These large charismatic birds are particularly abundant in the Spotted Gum Forest in the northern half of the study area, often making it challenging to decipher other bird calls during surveys. The Galah is also a common sight, though as it prefers open country it is most frequently recorded at the edge of the park or in the alluvial woodlands. Other species are the Glossy Black-cockatoo, Gang-gang Cockatoo and Yellow-tailed Black-cockatoo.

Seven species of Cuckoo occur within the Nature Reserve and Crown Lands, all of which are widespread in the region and have been recorded in the neighbouring reserves. The Brush Cuckoo

and Channel-billed Cuckoo are most frequently encountered. The pigeons and doves are a less well represented group, with only one common resident species, the Common Bronzewing. The Crested Pigeon and Peaceful Dove are infrequently encountered, the former being largely restricted to the interface between cleared and wooded land. The Bar-shouldered Dove is very rare, having only been recorded on one occasion in the southern Crown Lands.

The Swift Parrot (*Lathamus discolor*) has not been recorded within the study area to date, however potential winter habitat for the species is extensive. During the summer it breeds in Tasmania, but during the non-breeding season it is nomadic and migrates to the mainland, with small to large flocks congregating at suitable food sources. Favoured food trees in NSW include Mugga Ironbark (*E. sideroxylon*) and Spotted Gum (*Corymbia maculata*) (Higgins 1999), which are both widespread in the study area. The species is a regular visitor to a number of sites in the lower Hunter Valley, including the Hunter Employment Zone (Saunders 2002) and Werakata National Park (DEC 2005d). It is recommended that targeted winter surveys be undertaken for the species within habitats that include the favoured tree species, particularly in the north of the Nature Reserve and the small portions of Crown Land to the east. Any sightings should be reported to the Swift Parrot Recovery Team and managed in accordance with the national Recovery Plan.

### 3.2.2 Revision of diurnal bird species list

A large proportion of the bird records for the study area in the Atlas of NSW Wildlife are derived from Birds Australia data sets. As mentioned above, records collected for Birds Australia prior to 1998 have a very low degree of spatial accuracy and there is no guarantee that any of the sightings attributed to a certain point actually occurred at that location. Indeed, eight species have not been recorded by any other method. A further seven species have only been recorded on the very edge or immediately outside the boundary of the park, either by Birds Australia, private landholders or other surveyors. Table 4 presents a summary of these species and comments regarding whether the bird is actually likely to occur within the study area proper. The bird list for the study area is artificially elevated by the inclusion of the first 13 species in Table 4, which is misleading as to the fauna values held within Manobalai Nature Reserve and Crown Lands. Therefore, these 13 species will not be included within the species totals presented in this report. The latter fifteen species are known or considered likely to utilise habitats present within the park proper and so have been included in the species list. However, they are likely to be most abundant at the interface between cleared and wooded lands.

Species common name	Last recorded	Comment
Stubble Quail	1999 by BA on Dry Creek Road	Likely to occur in grassy paddocks at boundary of the park. Unlikely to utilise habitats in the park proper.
Australasian Grebe	1978	May occur on boundary of the park in dams on private lands. Unlikely to utilise habitats in the park proper.
White-necked Heron	1979	May occur on boundary of park in dams and paddocks; may fly over the park. Unlikely to utilise habitats in the park proper.
Black-fronted Dotterel	1978	May occur at sandy waterholes near boundary of the park or in dams on private lands. Unlikely to utilise habitats in the park proper.
Golden-headed Cisticola	1997 by Visser in southern Crown Land	Possible mis-identification or spatial inaccuracy. Prefers wetlands, swamps, tall wet grass or irrigated pasture. May occur on park boundary but is unlikely to utilise habitats in the park proper.
Straw-necked Ibis	1979	May occur in cleared lands on surrounding valley floors but is unlikely to enter the park except to fly over it.
Spotted Harrier	2003 by landowner on Wybong Hall Road	Likely to occur in grasslands and very open woodlands at the

Species common name	Last recorded	Comment
		boundary of the park, but unlikely to utilise habitats in the park proper.
Black Falcon	2003 by landowner on Wybong Hall Road	Possible misidentification. Unlikely to utilise habitats in the park proper.
Varied Triller	1978	Possibly a vagrant or misidentification. Unlikely to utilise habitats in the park proper.
Horsfield's Bushlark	1999 by BA on Dry Creek Road	Known to prefer grasslands and crops and is unlikely to inhabit the park proper.
Australian Pipit	1999 by BA on Dry Creek Road	Known to prefer grasslands and crops and is unlikely to inhabit the park proper.
White-backed Swallow	1981	Known to occur in cleared lands in the surrounding river valleys. May utilise the edge of the park along watercourses and foothills but is unlikely to inhabit the park proper.
Lewin's Honeyeater	1995 by consultant in the vicinity of the western boundary of southern Crown Land	Prefers moist coastal forest and is unlikely to occur in the park due to lack of potential habitat.
White-faced Heron	1999 by BA on Dry Creek Road	May utilise ephemeral creeklines or occur on boundary of park in dams and paddocks; may fly over the park.
Pacific Black Duck	1999 by BA on Dry Creek Road	Known to occur in cleared lands on the surrounding valley floors. May utilise ephemeral creeklines at the edge of the park or fly over it.
Black-shouldered Kite	2003 by landowner on Wybong Hall Road	May utilise open grassy woodlands near the perimeter of the park.
Little Eagle	1979	May utilise open woodlands on watercourses and slopes on the perimeter of the park, where open country intermixes with wooded hills.
Brown Falcon	2003 by landowner on Wybong Hall Road	May utilise open woodlands on watercourses and slopes on the perimeter of the park.
Australian Hobby	2003 by landowner on Wybong Hall Road	May utilise woodlands and open forests near the perimeter of the park.
Peregrine Falcon	1978	May utilise a variety of habitats in the park proper, but particularly near the perimeter.
Red-rumped Parrot	2004 by DEC on Coffin Arm near western boundary of southern Crown Land	Known to prefer pastoral country but may utilise the open grassy woodlands around the perimeter of the park.
Horsfield's Bronze-cuckoo	1999 by BA on Dry Creek Road	Likely to utilise woodlands and open forests in the park, particularly near the perimeter.
Painted Honeyeater	2002 by landowner on Wybong Hall Road	Likely to be an occasional visitor to the alluvial woodlands.
Hooded Robin	1979	Known to occur in cleared lands on the surrounding valley floors, likely to also utilise dry open woodlands along creeklines near the boundary

Species common name	Last recorded	Comment
		of the park.
Red-capped Robin	1979	May occur in dry woodlands and open forests, particularly near the boundary of the park.
Rose Robin	2003 by landowner on Wybong Hall Road	May occur in open grassy woodlands in the park in autumn and winter (migrating to highlands in the summer)
Diamond Firetail	1978	Known to occur in cleared lands on the surrounding valley floors, likely to also utilise dry open woodlands along creeklines near the boundary of the park.
Tree Martin	2004 by DEC on northern edge of southern Crown Land	Possibly an occasional visitor to the park. May occur in woodlands and open forests, particularly near the boundary of the park.
Rufous Songlark	2004 by DEC on northern edge of southern Crown Land	Known to occur in cleared lands on the surrounding valley floors, may also utilise dry grassy woodlands along creeklines near the boundary of the park.

**Table 4: Native bird species recorded only by Birds Australia or only on the perimeter of the study area**

An eighth threatened species, the Bush Stone-curlew, listed as Endangered under the TSC Act (1995), was recorded in the southern Crown Lands in 1978. However, the spatial accuracy of this record is very low and it is not known where the bird was actually seen. It is possible that this species occurred within the study area in the past, as they are known to occupy open woodlands with a ground-cover of short, sparse grass and few shrubs (NPWS 2003c), as occurs along some of the alluvial valley systems. It also requires abundant leaf litter and fallen debris for foraging and roosting. The species is now considered very rare east of the Great Dividing Range in NSW (Garnett & Crowley 2000). Predation by the Fox, together with habitat loss or degradation, is thought to be the major factors causing its decline (NPWS 2003c). It is unlikely that the Bush Stone-curlew exists within the study area today and therefore it has not been included in the species totals presented in this report, or afforded a threatened species profile.

Finally, two species of bird, the Brush Bronzewing and Azure Kingfisher, have also been removed from the species list for the Nature Reserve and Crown Lands as they are considered highly unlikely to occur, representing spatial or identification inaccuracies.

### 3.3 NOCTURNAL BIRDS

Eight species of nocturnal bird inhabit the study area, including five owls: the Southern Boobook (*Ninox boobook*, 22 locations), Barn Owl (*Tyto alba*, 13), Masked Owl (2), Powerful Owl (6) and Barking Owl (4). The latter three species are listed as Vulnerable under the TSC Act (1995), and together with the Sooty Owl, were the subject of the 21 nocturnal call playback surveys that were undertaken in 1997 and 2004-05. The response rate obtained during the call playback surveys was moderately low, with Barking Owl responding at 14 percent of sites and Powerful Owl at five per cent. Masked Owls were not detected by DEC, but have been heard



Plate 8: Southern Boobook © N. Williams

calling once in the Nature Reserve and once in the Crown Lands during other surveys (Stauber & Thumm 2000; Visser 1997). Sooty Owls are not present as they require extensive areas of tall mesic gully forest and rainforest, habitats which are very restricted within the study area. The density of these threatened owls is markedly different from that recorded in the southern Sydney region where systematic surveys have recently been undertaken by DEC. In southern Sydney, Powerful Owls were located at over twenty percent of owl censuses, Sooty Owls at nine percent, Masked Owls at three percent and Barking Owls at less than one percent (DEC 2005e). The threatened owls will be discussed further in Section 5.

The Southern Boobook (Plate 8) and Barn Owl are widespread and abundant within the Sydney Basin Bioregion, and indeed across the eastern half of the state. However reporting rates of the Southern Boobook have declined within the Bioregion in recent years (Barrett *et al.* 2003), making its abundance in reserves, such as Manobalai and the surrounding national parks, important. The Southern Boobook is the most commonly encountered owl in the study area, having been recorded at 22 widely spread locations. Records are concentrated along roads, however this is an artefact of nocturnal survey effort and the species is likely to occur within all the major habitat types where sufficient hollows or wood debris are available for nesting. Barn Owls are also widespread in both the Crown Lands and Nature Reserve, and are particularly common in the Spotted Gum - Ironbark forests and adjacent to cleared lands in the north. This typical habitat for these birds, which depend on open grassy country for foraging and large tree hollows, caves or overhangs for roosting (Pizzey & Knight 1999). A young Barn Owl was seen in a Spotted Gum hollow in December 2004, calling out to its parent which was not far away, possibly collecting food for the baby. An owl, presumably one of the same ones, was then heard calling from the same tree in May 2005.

The other species of nocturnal bird detected are the Australian Owlet-nightjar (*Aegotheles cristatus*), Tawny Frogmouth (*Podargus strigoides*) and White-throated Nightjar (*Eurostopodus mystacalis*). Systematic surveys have provided some insight into these species relative abundance and habitat preferences. The small Australian Owlet-nightjar is widespread and abundant, its variety of calls having been heard at 31 locations during the DEC surveys, while individuals were spotted at a further two locations. The Tawny Frogmouth is also widespread, recorded at 19 locations, including within both the Nature Reserve and Crown Lands. Both of these birds are common throughout forests and woodlands of the greater Blue Mountains and Hunter Range regions, where they inhabit a wide range of habitats. Within the study area, the majority of records come from the alluvial woodlands, though they are also common on sheltered slopes and in the Spotted Gum - Ironbark forests in the north. The White-throated Nightjar is much less common in the study area, recorded at eight locations, of which only one is in the Nature Reserve near the southern boundary. This medium-sized bird is relatively easy to detect when present, either by site or by its distinctive rising and accelerating whooping call. It appears to be absent from the Spotted Gum forests in the north and east of the study area, though the reasons for this are not known. The White-throated Nightjar was only recorded during the summer and autumn months, as the species migrates north for winter.

### 3.4 ARBOREAL MAMMALS

The systematic surveys confirmed the presence of four species of arboreal mammal in the study area, of which two species were not previously known to occur. One of these, the Squirrel Glider (*Petaurus norfolcensis*) is listed as Vulnerable under the TSC Act (1995) as its preferred habitats in open forests and woodlands growing on relatively fertile soils on gentle topography (Lunney & Leary 1988) have been extensively cleared. Habitat for this species is preserved in the alluvial woodlands and forests in the southern portion of Crown Land and the south eastern quarter of the Nature Reserve, which has high conservation significance. A fifth species, the Vulnerable Koala (*Phascolarctos cinereus*), has been heard calling twice in the Nature Reserve and detected by



Plate 9: Common Brushtail Possum © N. Williams/DEC

scratchings and a hair sample in the southern Crown Lands, though no individuals have been directly encountered. These threatened species will be discussed further in Section 5.

By far the most frequently encountered arboreal mammal is the Common Brushtail Possum (*Trichosurus vulpecula*, Plate 9) recorded at 26 locations in the Nature Reserve and over 40 points in the Crown Lands. A total of 24 systematic site spotlighting surveys were undertaken over the summer of 2004-05. This large possum was observed during 66% of these surveys and 81% of nocturnal call playback surveys. It has most frequently been observed in the Red Gum – Rough-barked Apple – Ironbark alluvial woodlands, particularly along Reedy Creek and Melon Creek, but is also common in the Spotted Gum Forests and on exposed and sheltered slopes. Across NSW, the Common Brushtail Possum has been shown to prefer drier open forests and woodlands (Kavanagh 2004), explaining its abundance in the study area. As large areas of these dry woodlands have been cleared or modified, the species is thought to be declining on the western slopes and plains of NSW (Kerle 2004).

The Sugar Glider is relatively uncommon, recorded at six locations in the Crown Lands and three in the Nature Reserve. Interestingly, this small glider was not detected during spotlighting surveys, but was heard calling during 24% of nocturnal call playback surveys, and seen or heard five times opportunistically. The Sugar Glider uses a variety of habitats, but requires suitable trees with hollows for nesting and sufficient foraging material, particularly nectar and pollen, *Acacia* gum, the sap of certain eucalypts and invertebrates (Suckling 1995a). Within the study area it has been recorded most frequently in alluvial woodlands, but also in Spotted Gum-Ironbark Forest and on exposed and sheltered slopes. This species smaller body size, lower energy demands, and more diverse diet enable it to occupy many environments not inhabited by the closely related Squirrel Glider (Quin 1995).

The Common Ringtail Possum (*Pseudocheirus peregrinus*) has been recorded on just one occasion, in the far south of the southern Crown Lands near Sandy Hollow Caravan Park. This individual was located right at the boundary between cleared and forested land, in a Narrow-leaved Stringybark tree. This small possum has not been located within dry grassy woodland habitats in either Goulburn River or north-eastern Wollemi National Parks, and is rare in Yengo NP (NPWS 2001a; DEC 2005b; DEC 2005c), which is consistent with its scarcity within the current study area and suggests that the species is not common in the region. The Common Ringtail Possum is more abundant in NSW in coastal woodlands and forests, particularly in habitats with a well developed mid-stratum or shrub layer (Kerle 2004). They obtain their food (leaves and fruit) and nesting material from the sub-canopy and shrub layers and do not come to the ground to feed (Kavanagh 2004). Within the study area this species is likely to be restricted to small patches that retain a relatively dense understorey.

A sixth species of arboreal mammal, the Yellow-bellied Glider (*Petaurus australis*), listed as Vulnerable under the TSC Act (1995), has been recorded once within the Nature Reserve. Stauber & Thumm (2000) heard two calls, which were identified as those of Yellow-bellied Glider, in Spotted Gum Open Forest on the Diamond Ridge Firetrail. Extensive surveys undertaken in the area since, however, have not identified the species, though it is usually easy to detect either by its loud call (often emitted in response to owl call playback), the distinctive incisions it leaves on feed trees, or by its eye-shine. The call can sometimes be confused with that of the Common Brushtail Possum, and there is therefore doubt about the occurrence of the glider in the reserve. The Yellow-bellied Glider is associated with tall mature forests in regions of higher rainfall (NPWS 1999a), however it has recently been detected within drier gullies in the north of Wollemi National Park (DEC 2005b), an area with a similar average annual rainfall as Manobalai Nature Reserve. Grey Gums, a favoured feed tree, are prevalent in northern Wollemi NP, however, yet absent from the Spotted Gum Forests in northern Manobalai. The Yellow-bellied Glider is known to feed on Spotted Gum in other parts of its range, however and Grey Gum does occur further south in the Crown Lands. Thus, while it is possible that the glider exists within the study area, the fact it has not been detected during systematic surveys indicates that it either does not occur or does so only in very low numbers. Further surveys are warranted to clarify this issue. Due to the doubt surrounding its occurrence, a profile has not been generated for this species and it has not been included in species totals.

### 3.5 BATS

The Microchiroptera, or microbats, are a sub-order of bats that are generally small, feed on insects and navigate using echolocation (Churchill 1998). Sixteen species of microbat are known to occur within the study area, including both tree and cave-roosting species. A total of fourteen bat species occur within the Nature Reserve, of which seven were not known to occur prior to systematic surveys. A different set of thirteen species occurs within the Crown Lands, of which eight were not known prior to the current surveys. The systematic surveys have thus greatly increased our understanding of the

bat fauna within the study area, and indeed within the region. Six of the microbat species are listed as Vulnerable under the TSC Act (1995), including Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*), East-coast Freetail-bat (*Mormopterus norfolkensis*), Large-eared Pied Bat (*Chalinolobus dwyeri*), Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*), Greater Long-eared Bat (*Nyctophilus timoriensis*) and Eastern Cave Bat (*Vespadelus troughtoni*). The occurrence of the Eastern Cave Bat has particular conservation significance as a maternity roost site was located in the southern Crown Lands in December 2004, contributing vital information to our knowledge of this very poorly understood species. All of these threatened species will each be discussed further in Section 5.

The study area supports a diversity of microbat species due to the large range of microhabitats, environments and landscape features present within the park. The extent of this abundance and diversity is exemplified by the data collected when an ultrasonic call detector was placed facing over a dam on the edge of the southern Crown Land. The temperature during the previous day had exceeded 43 degrees Celsius and not fallen below 30 degrees during the night. Hence an extremely large number of bats came to the dam to drink and to forage over the water, as very little standing water was available elsewhere within the area. The calls of at least eight species were recorded on the detector, including the White-striped Freetail-bat (*Nyctinomus australis*), Little Forest Bat (*Vespadelus vulturnus*), Chocolate Wattled Bat (*Chalinolobus morio*), Eastern Bent-wing Bat, Inland Broad-nosed Bat (*Scotorepens balstoni*), Large-eared Pied Bat, Southern Freetail-bat (*Mormopterus* sp. 4, long penis form), Gould's Wattled Bat (*Chalinolobus gouldii*) and at least one species of Long-eared Bat (*Nyctophilus* spp.). These bat species each roost in different microhabitats and environments.

A total of nineteen harp trap and eleven ultrasonic detector sites were set up, yielding information regarding the composition and distribution of the bat fauna. Tree-roosting microbat species, which shelter in hollows and under exfoliating bark, are the most abundant bat group within the study area, with twelve species recorded. These animals have a broad range of homes available to them, which may account for the greater diversity of species and abundance of this group. Records for all of these bat species within the study area are concentrated along major access trails, however this is an artefact of sampling as it was not logistically possible to undertake harp trapping in the more remote sections of the park. By far the most frequently detected bat species in the study area was the Little Forest Bat, captured at 95 % of harp traps sites. This tiny bat, weighing as little as three grams is common across south-eastern Australia and its high abundance is typical in the forests and woodlands of the Sydney Basin. The Lesser Long-eared Bat (*Nyctophilus geoffroyi*), Chocolate Wattled Bat, Gould's Long-eared Bat (*Nyctophilus gouldii*) and Inland Broad-nosed Bat are also common (captured in 68%, 47%, 42% and 42% of harp trap sites respectively). The first three of these small microbats each occupy a wide range of habitats across their distribution, from dry woodland and mallee to wet sclerophyll forest (Churchill 1998). These species are likely to be widespread in all major habitats across the study area. The Inland Broad-nosed Bat is typical of the arid and semi-arid regions of inland Australia, and approaches the eastern edge of its distribution in the study area, occurring here because of the dry climate that exists within the Hunter Valley. This species is widespread throughout the study area, though it would not occur within the dry rainforests or mesic gully systems. Gould's Wattled Bat is also common, recorded at 37% of harp trap locations. This relatively large bat is highly adaptable and is found in virtually all habitats throughout Australia (Churchill 1998); hence in the study area it was recorded within all sampled environments.

The remaining tree-roosting microbat species were recorded at lower frequency, either because they are less abundant or because their habit of flying higher than harp traps can be set (that is more than four metres from the ground) prevents them from being captured. The Freetail-bats are of particular interest, as this group comprises species characteristic of both eastern and western environments. The very low relief of the Great Dividing Range in the Hunter catchment facilitates this co-occurrence of coastal and inland fauna species. The East-coast Freetail-bat and Eastern Freetail-bat (*Mormopterus* sp. 2; (Plate 10) are typically eastern Australia



Plate 10: Eastern Freetail-bat © N. Williams/DEC

animals, occurring along and to the east of the Great Dividing Range (Churchill 1998). The Southern Freetail-bat (*Mormopterus* sp. 4, long penis form) generally occurs inland of the Great Dividing Range in dry open forest and woodland habitats (Churchill 1998). The fact that the study area is dominated by environments characteristic of the central western slopes is reflected in the scarcity of East-coast Freetail-bat and Eastern Freetail-bat (recorded once and three times respectively) and the relative abundance of the Southern Freetail-bat (recorded on 17 occasions). There is also a possibility that the Inland Freetail-bat (*Mormopterus* sp. 3, small penis form) occurs within the study area. It has recently been detected within similar environments in north-eastern Wollemi National Park (DEC 2005b) and was twice identified with very low reliability (possible identification only) by ultrasonic call in the southern Crown Lands in December 2004. This species is common in open woodlands and shrublands in the more arid parts of Australia (Churchill 1998). The CRA surveys undertaken in 1997 captured *Mormopterus planiceps*, the taxon previously used to describe both *Mormopterus* species 3 and *Mormopterus* species 4, but unfortunately did not record whether they were short or long penis form.

The navigation calls of only two species of bat that occur in central NSW whose are audible to humans, the White-striped Freetail-bat and the Yellow-bellied Sheath-tail-bat. Both of these are fast-flying species that do not manoeuvre very well and tend to forage in open areas or above the tree canopy (Churchill 1998). They are therefore rarely captured in harp traps, and were not detected by this method in the study area. However, the White-striped Freetail-bat has been detected aurally during a range of survey techniques including at ten spotlighting sites, one nocturnal call playback site and sixteen times opportunistically, as well as five times using the ultrasonic call detection system. Records have been collected in all the major habitats in both the Nature Reserve and Crown Lands, and the species is now known to be common and widespread. The White-striped Freetail-bat is distributed across all of southern Australia, on both sides of the Great Dividing Range (DEC 2005a) and is common across the sandstone environments of the Sydney Basin and Brigalow Belt South. In contrast, the Yellow-bellied Sheath-tail-bat has a disjunct distribution, with the greatest number of records located in the Brigalow Belt South Bioregion (DEC 2005a). They are thought to migrate north from the Sydney Basin for winter. This threatened species was confirmed to occur within Manobalai Nature Reserve in December 2004, and will be discussed further in Section 5.

The Long-eared Bats have only been detected by harp trapping, as the species of this genus cannot be reliably distinguished by their ultrasonic call using standard parameters (Pennay *et al.* 2004). These bats can orientate and forage without using echolocation (Churchill 1998), such that very short quiet calls are often all that is recorded by ultrasound recording devices. Their abundance and distribution is therefore underestimated across the study area in comparison to bat species that can be detected using both techniques. It is clear from harp-trapping results, however, that the Greater Long-eared Bat is less abundant than its congeners, having been captured in 32% of harp traps. As will be discussed in Section 5, this species primarily occurs west of the Great Dividing Range, and is abundant in the Brigalow Belt South Bioregion (DEC 2005a). The species only occurs in the far north-west of the Sydney Basin Bioregion, where dry environments occur in the Goulburn and Hunter River Valleys (DEC 2005a). This species has not been detected in Spotted Gum Forests in the north of the study area, but only in the Red Gum-Ironbark-Roughbarked Apple Woodlands in the south of the Nature Reserve and Crown Lands.

Four cave-roosting bat species have been recorded within the study area, including the Large-eared Pied Bat (recorded at 10 locations), Eastern Bent-wing Bat (five locations), Eastern Cave Bat (two locations), and Eastern Horseshoe-bat (one location). Cave roosting bats are often particular about the kind of cave they choose to roost in, especially when raising young (Churchill 1998). The abundance of cave-roosting bats in Manobalai Nature Reserve and Crown Lands is markedly lower than in



Plate 11: Eastern Cave Bat maternity roost near Melon Creek  
© N. Williams/DEC

north-eastern Wollemi National Park (DEC 2005b), but similar to the numbers recorded in northern Yengo NP (DEC 2005c). In particular, the number of Eastern Bent-wing Bats is low; the species was not captured at all in harp traps but detected only by its ultrasonic calls, though two specimens from the Sandy Hollow area were submitted to the Australian Museum in 1980. This suggests that the species does not have a permanent roost or maternity roost within the study area, though the area may provide important foraging habitat. The closest known roost site is located in the disused oil shale mines in the Baerami Valley in north-eastern Wollemi National Park, which is within the possible travelling distance for the species. The Eastern Cave Bat is known to roost in the study area, as a maternity roost housing at least fifty adults, some with young, was discovered near Melon Creek. The DEC surveys undertaken in 2004-05 have revealed the Hunter region to be a stronghold for this species. The other two species, Eastern Horseshoe-bat and Large-eared Pied Bat, are also thought to roost within the study area, as they have a more limited foraging range than the Eastern Bent-wing Bat and have less stringent roost site requirements, often utilising smaller, shallower caves that are not necessarily in complete darkness (Churchill 1998). The Eastern Horseshoe Bat is apparently rare, while the Large-eared Pied Bat is relatively common, having been recorded flying through Spotted Gum forest, dry forest on sheltered slopes and most frequently in the alluvial woodlands.

The 2004-05 surveys of the Hunter Range reserves have revealed an interesting pattern in the occurrence of bat species across the area. The composition of bat species supported within each park is directly related to the habitat types located therein, with a clear change in assemblages from the moist coastal environments to the dry western-influenced environments. The bat fauna of Werakata National Park is dominated by coastal species including Eastern Broad-nosed Bat (*Scotorepens orion*), Large Forest Bat (*Vespadelus darlingtoni*) and Little Bent-wing Bat (*Miniopterus australis*) (DEC 2005d). Northern Yengo National Park primarily supports species that prefer higher rainfall environments, but also contains a single western species, Southern Freetail-bat (*Mormopterus* sp. 4, long penis form) in very low numbers (DEC 2005c). A diverse mix of bats inhabit Wollemi National Park, including species typical of both eastern and western environments. The Eastern Broad-nosed Bat is present in conjunction with the Inland Broad-nosed Bat, while the coastal Eastern Freetail-bat (*Mormopterus* sp. 2), East-coast Freetail-bat and Large Forest Bat exist alongside the western Southern Freetail-bat, Greater Long-eared Bat, and Inland Freetail-bat (*Mormopterus* sp. 3, short penis form). The bat fauna of Manobalai Nature Reserve is less diverse and is characterised by species typical of the western slopes, including the Yellow-bellied Sheathtail-bat, Greater Long-eared Bat, Southern Freetail-bat and possibly the Inland Freetail-bat. The environment is too dry for the coastal species to exist here.

It is possible that three further microbat species occur within the study area. Stauber & Thumm (2000) identified the Little Broad-nosed Bat (*Scotorepens greyii*) from ultrasonic call in the south of the Nature Reserve. There is doubt about this record, however, as the species has only been identified from call once and has never been captured. The existence of the Little Broad-nosed Bat in the study area would constitute a 100 kilometre range extension from other known records. This species has only elsewhere been recorded east of the Great Dividing Range in the Clarence River Valley. In order to confirm a range extension like this, an individual would need to be captured in the hand and identified anatomically. Until the presence of this species is confirmed by capture, it will not be included in the species totals for this report.

The Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) has been recorded at Anvil Hill, just under two kilometres to the east of the southern Crown Land boundary. The species has also been trapped in north-eastern Wollemi National Park and detected by ultrasonic call in northern Yengo National Park, though records are sporadic and low in density (DEC 2005b, DEC 2005c). The Eastern False Pipistrelle is thought to be uncommon or localised across its range (Parnaby 1992a), which appears to be the case in the Hunter Range area. The bat is most common at higher elevations on the Great Dividing Range, and the study area is therefore not considered to constitute high quality habitat for the species.

A single record of the Eastern Forest Bat (*Vespadelus pumilus*), exists for the study area within the Atlas of NSW Wildlife, however there is uncertainty regarding the accuracy of this record, as the individual may have been confused with the Eastern Cave Bat. The Eastern Forest Bat is generally a more coastal species, and the study area is not considered to provide quality habitat for the species.

Though no species of Megachiroptera (commonly known as fruit bats) are recorded on the Atlas of NSW Wildlife, the Grey-headed Flying-fox (*Pteropus poliocephalus*) is known from local reports. The Grey-headed Flying-fox is a spirit of the Wonarua people, and considered a highly important component of the community of animals in the Manobalai area (Bilton 1990). The Grey-headed Flying-fox probably only visits Manobalai Nature Reserve and Crown Lands during times of abundant

flowering or when food resources are limited in other areas. Spotted Gum is a known food resource for this species and therefore constitutes high quality habitat. The area may form an important component of the foraging habitats on which Grey-headed Flying-foxes in the Hunter Valley depend. The Hunter Valley and Newcastle area provide highly significant habitat for the species between spring and autumn, estimated to support a large proportion of the Grey-headed Flying-fox population at certain times of the year (N. Williams pers. comm.).

### 3.6 NATIVE GROUND MAMMALS

Ground mammals are difficult to sample adequately as they either require a large, labour intensive trapping effort (e.g. Dasyurid and *Rattus* species), are large bodied, wide-ranging habitat-generalists (e.g. Wombats, wallabies, kangaroos), or they prefer inaccessible and precarious habitats (e.g. Brush-tailed Rock-wallabies (*Petrogale penicillata*)). The majority of records for large ground mammals, such as wombats and macropods, have come from opportunistic sightings, while a number of small ground mammal records have come from predator scat analyses, Elliott trapping and hair tube surveys.

The 2004-05 DEC surveys confirmed the presence of eight species of native ground mammal, including the Short-beaked Echidna (*Tachyglossus aculeatus*), Yellow-footed Antechinus (*Antechinus flavipes*), Brown Antechinus (*Antechinus stuartii*), Common Wombat (*Vombatus ursinus*), Eastern Grey Kangaroo (*Macropus giganteus*), Common Wallaroo (*Macropus robustus*), Red-necked Wallaby (*Macropus rufogriseus*) and Swamp Wallaby (*Wallabia bicolor*). A ninth species, the Common Dunnart (*Sminthopsis murina*), has been identified from remains in 1982 and 1997. It is possible that two threatened species occur within the study area, though unfortunately recent sightings have not been confirmed. The Brush-tailed Rock-wallaby, listed as Endangered under the TSC Act (1995), has possibly been seen in the Nature Reserve and surrounding the Crown Lands. The Spotted-tailed Quoll was once abundant in the Nature Reserve (C. Daniels pers. comm.), however it has not been positively identified here for a number of years. However, potential habitat for both of these species remains within the Nature Reserve and Crown Lands and they may still persist, as will be discussed in Section 5 of this report.

By far the most commonly recorded ground mammal is the Common Wombat, detected at 60 locations by direct observation, burrow entrances, or their distinctive, often prominently placed scats. These large marsupials have been recorded in all major habitats, though they are rarely detected on exposed rocky ridges and most frequently along valley floors, where alluvial soils provide good material for burrow construction. The Common Wombat is widespread across the reserves in the Hunter Range and the feature of large sandstone reserves across the Sydney Basin Bioregion.

The next most abundant ground mammal is the Swamp Wallaby, recorded at almost 40 locations either by direct observation or by remains identified from predator scats. There is evidence that both Foxes and Dogs/Dingos prey on these large marsupials, however this does not seem to be threatening the persistence of the Swamp Wallaby in the area. Eastern Grey Kangaroo and Red-necked Wallaby are also widespread, each recorded at approximately twenty locations. Both of these macropods are most frequently encountered near the junction of the Nature Reserve and southern Crown Lands, presumably because the matrix of cleared grassland, open woodland on alluvial soils and shrubby woodland on slopes provides good foraging and shelter sites. The Common Wallaroo is more sparsely distributed, detected at thirteen locations ranging from the alluvial woodlands and lower slopes to exposed rocky ridges. The majority of macropod records are concentrated along roads and walking trails, as this is where surveyors have spent most time and the species are most visible.

One species of monotreme occurs within the study area, the Short-beaked Echidna (*Tachyglossus aculeatus*). This unmistakable animal has been directly observed on only four occasions: three times in the Nature Reserve and once in the southern Crown Lands. However, the species often leaves distinctive traces where it has been, such as diggings in the side of ant nests and termite mounds, or long, smooth, cylindrical-shaped scats. Such traces of the Echidna have been



Plate 12: Common Dunnart © N. Williams

found frequently, indicating that the species is in fact widespread, though very cryptic. The records are widespread through a diverse range of environments, as is typical of the species.

The three species of small dasyurid marsupials that occur within the park, have each been detected in low numbers. The Yellow-footed Antechinus appears to be the most common, seen in five widely spaced locations, including four times on rocky lower slopes and once in dry rainforest where it was spotted running along a fallen log early in the morning. This species is likely to be more abundant than records indicate, because as it is difficult to detect and capable of inhabiting a wide range of habitats. The Brown Antechinus has not been recorded in the study area since 1982 and all three of the records are spatially inaccurate, leaving uncertainty as to the status of the species. The species approaches the western limit of its distribution near the study area, being more common in coastal hinterland forest with thick ground cover and abundant fallen debris (Braithwaite 1995). The Brown and Yellow-footed Antechinus have elsewhere been reported to partition habitat, with Yellow-footed Antechinus occurring in more open forests while Brown Antechinus occur in wetter denser forests (Braithwaite 1995). The Brown Antechinus is therefore most likely to occur only at low density in the area, restricted to the most moist environments, or may not even be present at all. As mentioned above, the Common Dunnart (Plate 12) has only been detected by remains, once identified from a predator scat and once from a hair sample found on the ground. This species is notoriously difficult to capture in Elliott traps, and is therefore likely to be more widespread than records currently indicate. Elsewhere the Common Dunnart is known to occur within a wide variety of dry habitats (Menkhorst & Knight 2001) as is likely to be the case in the study area.

The absence of native rodents is worthy of mention, as the Bush Rat (*Rattus fuscipes*) and New Holland Mouse (*Pseudomys novaehollandiae*) occur in neighbouring areas such as Goulburn River National Park, north-eastern Wollemi National Park and the Bush Rat at Anvil Hill, less than four kilometres east of the study area (DEC 2005a). A possible New Holland Mouse was trapped in the north of the study area in 2000 but the identification could not be confirmed (Stauber & Thumm 2000). Both of these species would be near the western limit of their distribution in the study area, as they are tied to coastal environments. It may be that these species occur at very low density and have yet to be detected, or that the habitats are too dry for them and they do not occur at all.

There is no direct evidence currently available regarding the extent to which Dogs within the study area have Dingo heritage. Currently, all of the wild Dogs recorded have been entered into the Atlas of NSW Wildlife under the name 'Dingo/domestic Dog' as it is not possible to ascertain the ancestry of individuals without DNA testing. However, it is possible that Dogs in the core of the park have a high degree of Dingo heritage, and may therefore be worthy of appropriate management. It is recommended that the Dog/Dingo research program currently being undertaken in Yengo National Park (T. Horwood pers. comm.) be expanded to cover the whole Hunter Range region. This research should aim to ascertain patterns in the heritage of Dogs/Dingoes across the region, identify key areas of Dingo purity and Wild Dog invasion, understand the dynamics of social, territorial and foraging behaviour, understanding the interaction between Dingo/Dog packs and other predators, and hence inform management strategies. Ideally, this research should be undertaken before broad-scale Dog control programs are implemented or continued.

### 3.7 REPTILES

The 2004-05 DEC surveys confirmed the presence of 27 species of reptiles, including one turtle, five geckos, one legless lizard, two dragons, two monitors, 14 skinks and two snakes. Twenty-three species were detected in the Nature Reserve, of which nine were not known to occur prior to systematic surveys, and 27 were observed in the Crown Lands, of which 15 had not previously been recorded. Two additional species, the Diamond/Carpet Python (*Morelia spilota*) and Yellow-faced Whipsnake (*Demansia psammophis*), were detected in the Nature Reserve in 1978, however the spatial accuracy of these records is very low and it is not known which section of the study area they were sighted in. In addition to this, three species have been recorded near the boundary of the southern Crown Lands: the Dark-flecked Sun-skink (*Lampropholis delicata*), Yellow-bellied Three-toed Skink (*Saiphos equalis*, record has very low spatial accuracy) and Brown-snouted Blind Snake (*Ramphotyphlops wiedii*). It is considered unlikely that the first two of these species occur within the study area, as they were not detected during any of the 46 systematic herpetofauna searches and the environments are largely too dry for them. Blind Snakes, however, are notoriously difficult to survey, and could easily have gone undetected in the DEC surveys. This latter species is therefore considered likely to occur. Thus in total, 30 species of reptile are considered to currently inhabit Manobalai Nature Reserve and Crown Lands.

The systematic diurnal herpetofauna searches detected 21 of the reptile species and yielded information regarding their comparative abundance and distribution. Lesueur's Velvet Gecko (*Oedura lesueurii*) is the most widespread and abundant gecko species, having been recorded during 48% of diurnal herpetofauna searches as well as during 20% of site spotlighting surveys and numerous times opportunistically. It has been detected in all of the major habitats in the Nature Reserve and all pockets of Crown Land, from the dry rainforest and alluvial woodlands to the rocky heath. The major determinant of its presence is the availability of shelter sites; it is most frequently detected underneath exfoliating rock, as well as in crevices and under bark. Its reaches its greatest density around rock outcrops and would be expected to occur on all of the rocky ridges and slope in the study area. The Broad-tailed Gecko (*Phyllurus platurus*, also known as Southern Leaf-tail Gecko) is also widespread, and though only detected during six per cent of herpetofauna searches and one spotlighting search, it has been observed 27 times opportunistically. This species appears to be present wherever rock cracks and crevices provide suitable shelter, detected most frequently in the alluvial valleys in the southern Crown Land, but also on rocky slopes and ridges in Spotted Gum forest and in the dry rainforest gorges in the Nature Reserve. Thick-tailed Geckos (*Underwoodisaurus milii*) are infrequently detected during diurnal herpetofauna searches as they shelter during the day in microhabitats that are hard to survey, such as leaf litter, deep crevices or even in burrows (Swan *et al.* 2004). Nine individuals were observed opportunistically during surveys at night, however, particularly on the roads during the very hot weather experienced in December 2004. An additional seven records for the species were collected prior to systematic surveys. The two remaining geckos are less common in the study area and were not known to occur prior to the systematic BSP surveys. The Eastern Stone Gecko (*Diplodactylus vittatus*) is never-the-less widespread and has been detected in 15% of diurnal herpetofauna searches, once during spotlighting and once opportunistically, in a variety of habitat types. The Robust Velvet Gecko (*Oedura robusta*) is much more restricted in its habitat choice and has only been detected in the Ironbark and Red Gum alluvial woodlands in the southern Crown Lands. This species has the north coast at the centre of its distribution, where it inhabits dry sclerophyll forests and woodlands, particularly around rock outcrops. This species reaches the southern limit of its distribution in the Hunter Valley, and recent surveys have found it to be reasonably widespread in the region (DEC 2005b, DEC 2005c).



Plate 13: Lace Monitor © N. Williams

Legless lizards are rare within the study area, with only one individual of one species, the Burton's Snake-lizard (*Lialis burtonis*), recorded. This individual was spotted basking on a rock outcrop along a tributary of Reedy Creek in the southern Crown Lands, during a diurnal herpetofauna search in December 2004. The cryptic nature of legless lizards means they are rarely encountered, even where they do occur. There is therefore a possibility that further species occur at low density, but have yet to be detected. Based on the recent findings in similar environments in north-eastern Wollemi National Park, there is considered to be high potential for the Leaden Delma (*Delma plebeia*) to occur.

Only two species of dragon have been recorded in the study area. The Eastern Bearded Dragon (*Pogona barbata*) is common and widespread, recorded at sixteen locations, though never during a systematic herpetofauna search. The Nobbi Lashtail (*Amphibolurus nobbi*) is also common, recorded at 14 locations including during fifteen per cent of systematic reptile surveys. It has been recorded in a range of environments, from alluvial gullies to rocky ridges, but appears most common in the Spotted Gum forests and woodlands in the north of the study area. The Nobbi Lashtail ranges from the coast and ranges of Queensland and far northern New South Wales around to the western slopes of the Great Dividing Range and into South Australia (Wilson & Swan 2003). Manobalai Nature Reserve and Crown Lands lie at the south-eastern extent of the species distribution. It also occurs in Goulburn River National Park and is one of the most abundant dragons in the Brigalow Belt South Bioregion (NPWS 2001a).

The Lace Monitor (*Varanus varius*, Plate 13) is a common sight in both the Nature Reserve and southern Crown Lands. This species has been spotted on over 20 occasions during the two weeks of survey undertaken in November and December 2004, and was one of the few animals to remain

active during the extremely hot weather conditions. It was seen in a variety of habitats, though most frequently encountered in the alluvial woodlands. The Sand Monitor (*Varanus gouldii*) is less common, encountered on seven occasions during the summer 2004 surveys. Like the Lace Monitor it was most recently seen in the alluvial woodlands, though this is likely to be because surveyors spent a large amount of time in this area. The Sand Monitor is primarily a species of western NSW, occurring east of the ranges only in the Hunter Valley and Clarence River Valleys, where dry environments reach through the gap in the ranges.

Skinks are the most diverse group of reptiles in the study area. This group is comprised of species typical of drier Sydney sandstone environments, species typical of the central western slopes environments, and species whose range is centred on the NSW north coast. A number of the skink species are tied to sandstone outcrops, which provide shelter, basking sites and foraging areas. The most frequently encountered reptile is the Copper-tailed Ctenotus (*Ctenotus taeniolatus*), recorded during 57% of diurnal herpetofauna searches and 30 times opportunistically. This species has been recorded in all of the major habitat types but is most common on ridges and slopes where it is usually located in rocky areas under rock slabs. The White's Rock-skink (*Egernia whiti*) and Cream-striped Shinning-skink (*Cryptoblepharus virgatus*) are also widespread (recorded at 27 and 11 locations respectively), both also primarily occurring on slopes and ridges, where they are usually seen around rock outcrops. The Cunningham's Spiny-tailed Skink (*Egernia cunninghamii*) is less common, though still widespread, recorded at eight locations, in both the Nature Reserve and Crown Lands. This large distinctive lizard was observed either on rock or in rock crevices on every occasion it was seen. Cunningham's Spiny-tailed Skink is a species complex that is subject to considerable variation in colour and pattern across its range (Cogger 1996). All of the individuals seen during the surveys had an appearance typical of the group that occurs on Sydney Sandstone.

The Barred-sided Skink (*Eulamprus tenuis*), has been recorded across the study area, though at relatively low density (a total of 14 locations). This species is capable of inhabiting a wide variety of habitats (Swan *et al.* 2004), and being a largely arboreal lizard would be expected to occur anywhere in the study area where suitable trees or rock outcrops provide shelter (e.g. hollows or crevices), basking sites and foraging areas. The Robust Ctenotus (*Ctenotus robustus*) is also widespread, but has only been recorded at eight locations. This species shelters under rocks, logs and in ground litter (Swan *et al.* 2004) and has been detected in a range of habitats but not in the Spotted Gum forests and woodlands in the north of the study area. Both the Barred-sided Skink and Robust Ctenotus occur at moderate density in forests and woodlands across the Sydney sandstone environments.

The Punctate Worm-skink (*Anomalopus swansonii*) has been recorded at eleven widely spaced locations, in well-drained sandy sites on ridges, slopes and alluvial gullies in the Nature Reserve and southern Crown Lands. This species has a very restricted distribution, occurring only in the northern half of the Sydney Basin Bioregion from just north of Sydney to the Hunter Valley (DEC 2005a). The 2004-05 DEC surveys in the Hunter Range area have increased the number of records for this species on the Atlas of NSW Wildlife eight fold, and found the lizard to be abundant in the Upper Hunter. The species reaches its most north-westerly extent within Manobalai Nature Reserve. The Upper Hunter region appears to be the stronghold for the Punctate Worm-skink and hence the reserves in this area (including Wollemi and Yengo National Parks and Manobalai Nature Reserve) are very important for the conservation of this species.

Several skink species that are characteristic of central western slopes environments occur within Manobalai Nature Reserve and Crown Lands. These include the South-eastern Slider (*Lerista bougainvillii*, recorded at 12 locations), Southern Rainbow-skink (*Carlia tetradactyla*, 8) (Plate 14), South-eastern Morethia Skink (*Morethia boulengeri*, 9) and Tree-crevice Skink (*Egernia striolata*, 5). These species all usually occur on and to the west of the Great Dividing Range, extending towards the coast only where a low relief in the Range allows drier habitats to occur, such as in the Hunter Valley and Clarence Valley (DEC 2005a). The first three are litter dwelling species that have been recorded in a range of habitats within the study area, including Spotted Gum forests and woodlands



Plate 14: Southern Rainbow-skink © N. Williams

in the north, Box woodlands on basalt in the north-west corner, Ironbark-Callitris woodlands on exposed slopes and ridges, and alluvial woodlands in the south and west, but are not expected to occur within the moister incised gullies in the east. The Tree-crevice Skink has only been located in the alluvial woodlands and the Box woodland on basalt at Camp Saddle, though elsewhere it has been found to inhabit a wide range of environments, from creek flats to rocky ridges (DEC 2005b).

The second most frequently encountered skink species in the study area is the Tree-base Litter-skink (*Lygisaurus foliorum*, recently revised taxonomically to *Carlia foliorum*), detected during 70% of systematic diurnal reptile surveys and 24 times opportunistically. It has been located in all of the major habitats, including dry rainforest, alluvial woodland, Spotted Gum Forest, and Ironbark woodlands on slopes and ridges. This skink is common in drier woodland environments on the central and north coasts of NSW, and is particularly abundant in the Upper Hunter region, including within north-eastern Wollemi National Park (DEC 2005b) and Goulburn River National Park (NPWS 2001a). Both the Eastern Ranges Rock-skink (*Egernia modesta*) and the Two-clawed Worm-skink (*Anomalopus leuckartii*) reach the southern edge of their range within the Hunter Valley. These species have only been recorded in the dry alluvial Box-Ironbark-Red Gum woodlands that occur on the major valley systems in the southern Crown Lands and the west of the Nature Reserve.

It is important to note that Manobalai Nature Reserve and Crown Lands do not support a suite of species that are typical of more moist coastal hinterland environments. This suite, which has been recorded in eastern Wollemi National Park, northern Yengo National Park and most species in eastern Goulburn River National Park, includes the Eastern Water-skink (*Eulamprus quoyii*), Eastern Water Dragon (*Physignathus lesueurii*), Jacky Lashtail (*Amphibolurus muricatus*), Red-throated Skink (*Bassiana platynota*) and Weasel Shadeskink (*Saproscincus mustelinus*). Interestingly, the Dark-flecked Sunskink has not been detected during systematic surveys, though a consultant collected a single record in 1995 near the western boundary of the study area. Similarly the Yellow-bellied Three-toed Skink (*Saiphos equalis*) was not detected, though a single historical record exists for somewhere within ten kilometres of Sandy Hollow. The environments within the study area are too dry for this suite of species, and the low rainfall has not allowed their particular microhabitat requirements to develop, such as semi-permanent water, deep leaf litter or dense forest. The gradation from moist coastal to dry central western slopes environments is clearly reflected in the pattern of fauna species occurrence across the Hunter Range reserves. The northern Yengo National Park reptile assemblage is dominated by coastal species, north-eastern Wollemi National Park supports both eastern and western species, while Manobalai Nature Reserve is dominated by western and northern species.

Few snakes have been recorded within the study area and these have only been detected rarely. The Red-bellied Black-snake (*Pseudechis porphyriacus*) has been seen on three occasions, including once in Spotted Gum-Ironbark gully forest, once in Red Gum alluvial woodland and once on a lower slope in Stringy-bark-Grey Gum sheltered forest. This species is usually found in the vicinity of creeks, rivers or swamps, (Swan *et al.* 2004) and hence within the study area is likely to be restricted to the main creek systems. It probably does not reach high densities, due to the dominance of dry woodlands that are not its preferred habitat. The Red-naped Snake (*Furina diadema*) was recorded for the first time in November 2004, when it was located under pieces of sloughed bark that had been left *in situ* after the removal of Ironbark trees for fence posts. These pieces of bark provide significant habitat for a range of reptile species and are likely to be a factor in the high abundance of reptiles in the area. The remaining two snake species, Diamond/Carpet Python and Yellow-faced Whipsnake were not recorded during the systematic surveys, however historical records exist for the Nature Reserve and they are expected to still occur at low abundance. The Diamond/Carpet Python would be restricted to creekline habitats, particularly areas of dry rainforest, while the Yellow-faced Whipsnake may be more widespread and occupy any of the major habitats in the reserve.

A fifth species of snake was recorded on Giants Creek Road, near the junction of Giants Creek and Back Arm in early December 2004. It is thought to be an Eastern Brown Snake (*Pseudonaja*



Plate 15: Eastern Snake-necked Turtle in Manobalai Crown Lands  
© N. Williams/DEC

*textilis*), though it had an unusually dark head. There is a chance that the individual was in fact a Western Brown Snake (*Pseudonaja nuchalis*), however this requires further investigation. Nevertheless, Eastern Brown Snakes are considered highly likely to occur within the study area, though they have yet gone undetected.

The Eastern Snake-necked Turtle (*Chelodina longicollis*) (Plate 15) has mostly been recorded near the boundary of the study area, either in dams or on the roaming after wet weather. One was observed in a pool in Reedy Creek during a nocturnal streamside search. The species would be restricted to the larger, less ephemeral creeks in the Crown Lands and is unlikely to occur in the Nature Reserve proper, except perhaps during overland migrations in summer.

### 3.8 FROGS

The success of frog surveys is largely dependent on the immediate weather, season and recent climatic conditions. In the lead up to the 2004-2005 systematic survey period, the weather was dry and warm, providing poor conditions for conducting frog surveys. However, storms and heavy downpours occurred prior to and during the summer surveys, providing a window of opportunity to sample the frog fauna. As the duration of optimum conditions was limited, however, only a small number of systematic nocturnal streamside searches were undertaken. Frogs were also encountered on an opportunistic basis during these times as they used the wet weather to disperse and were encountered on roads and trails and during other systematic survey techniques such as site spotlighting, diurnal herpetofauna searches and nocturnal call playback.

The 2004-2005 systematic surveys confirmed the presence of ten species of frog within the study area, of which all were recorded in the Crown Lands and only four were recorded in the Nature Reserve. Three of these species were not previously known to occur. In addition, four species of frog have been recorded within the study area previously, bringing the total of frogs known to occur to 14. This includes seven Myobatrachidae (ground frogs), which lack toe discs and rarely climb trees, and seven Hylidae (tree frogs), which have toe discs and frequently climb trees or rocks (Robinson 1993).

The most frequently encountered frog species is the Green Tree Frog (*Litoria caerulea*, Plate 16). Numerous specimens of this large distinctive frog are lodged within the Australian Museum collections and large numbers (over 35 individuals in one night) were observed after heavy rain downpours in December 2004 (Plate 15). The species bred within the area in December. Calling activity and mating frogs were recorded in numerous dams on the edge of the reserve and eggs were observed at several waterholes along Reedy Creek. Three other tree frogs occur at moderate abundance, Peron's Tree Frog (*Litoria peronii*, recorded at 7 locations) Keferstein's Tree Frog (*Litoria dentata*, 5) and Broad-palmed Frog (*Litoria latopalmata*, 4). These frogs are restricted to breeding along the major creeklines, such as Reedy Creek, Melon Creek and Gundebri Arm, where pools of water at least occasionally form, but may range far from water at other times of the year. Three species have been recorded on only a single occasion, Freycinet's Tree Frog (*Litoria freycineti*), Verreaux's Tree Frog (*Litoria verreauxii*) and Lesueur's Frog (*Litoria lesueurii*). The spatial accuracy of the latter two records is very low, however, and indicates only that the species have been recorded somewhere within a ten kilometre radius of Sandy Hollow.



Plate 16: Green Tree Frogs calling at a waterhole on Reedy Creek  
© Narawan Williams/DEC

The most abundant of the ground frogs belong to the genus *Limnodynastes*, a name that translates to 'lord of the marshes'. The Ornate Burrowing Frog (*Limnodynastes ornatus*) has only been recorded along alluvial flats in the Crown Land, where it was detected for the first time after the wet weather in early December. Twenty-two of these frogs, which aestivate underground during dry or cold times, were located in a single night after heavy rain, primarily along the road that runs beside Reedy Creek. The Bullfrog (*Limnodynastes dumerilii*, also known as Banjo Frog) is also abundant and more widespread, detected at fifteen locations, including along alluvial flats in the southern Crown Land, on

exposed ridgelines and slopes, and Spotted Gum forest in the north of the Nature Reserve. There is confusion about the subspecies of Bullfrog that occurs in the park, but it is thought to be *L. d. greyi*.

An interesting discovery was that of the Painted Burrowing Frog (*Neobatrachus sudelli*) recorded for the first time along Melon Creek in late November 2004. This burrowing frog remains underground during dry periods, emerging only after heavy summer rains when it breeds in grassy marshes, flooded claypans and temporary pools (Cogger 1996). The discovery of the species within the area was fortunate, and a case of simply being in the right place at the right time. The species is also likely to occur in other areas with deep alluvial sands, such as Reedy Creek and the swampy areas of Oaky Arm. The Painted Burrowing Frog is essentially a species of western NSW, more common in woodland and shrubland to the west of the Great Dividing Range (Robinson 1993). Also interesting is the scarcity of the Common Eastern Froglet (*Crinia signifera*). This species is fairly ubiquitous throughout the Sydney Basin Bioregion and the eastern third of NSW, with scattered records occurring on the western slopes and ranges (DEC 2005a). It is an easy species to detect as it calls consistently throughout the year. It is the most abundant frog in north-eastern Wollemi and northern Yengo National Parks (DEC 2005b, DEC 2005c) and common in Goulburn River National Park (NPWS 2001a). However, the species has only been detected twice in the Manobalai southern Crown Land, and never in the Nature Reserve. The reason for this is unknown but is likely to be related to the fact that environments in the park are more typical of the central western slopes than the Sydney Basin.

The remaining three ground frogs have been recorded at very low frequency and include the Smooth Toadlet (*Uperoleia laevigata*, 2 locations), Bibron's Toadlet (*Pseudophryne bibronii*, 1) and Spotted Marsh Frog (*Limnodynastes tasmaniensis*, 1).

### 3.9 INTRODUCED SPECIES

#### 3.9.1 Introduced mammals

The 2004-05 DEC surveys confirmed the presence of seven species of introduced mammal in the park, including (followed by the total number of times they have been detected): Rabbit (*Oryctolagus cuniculus*, 17 locations), House Mouse (*Mus musculus*, 11), Fox (*Vulpes vulpes*, 10), Wild Dog/Dingo (*Canis lupus*, 8), European Cattle (*Bos taurus*, faeces detected at six locations), Black Rat (*Rattus rattus*, 2) and Brown Hare (*Lepus capensis*, 1). Historical records exist for two further mammal species, the Cat (*Felis catus*) and Pig (*Sus scrofa*), though they have not been seen since 1978 and the records have very low spatial accuracy. The Cat is an extremely cryptic animal and can easily go undetected; it is very likely to persist within the study area, yet stay out of sight. In contrast, the Pig is usually easy to detect, primarily by the traces it leaves behind in the form of scats, tracks and diggings. This species prefers moist habitats, such as riparian zones, swamps and wet sclerophyll forests and forested gullies (NSW Scientific Committee 2004b), which are very limited within the study area. It is therefore expected that the Pig does not currently occur in large numbers in Manobalai Nature Reserve and Crown Lands, if at all. The location of introduced mammals is presented in Map 3 and 4.

The common introduced predators are of the most concern because of the impact they have on native wildlife. Records are most concentrated near the perimeter of the park and along roads, however Fox scats have been picked up in the very centre of the Nature Reserve and halfway along Reedy Creek in the Crown Lands, suggesting that due to the relatively small size of the park, they are able to penetrate throughout. Predation by the Red Fox is a major threat to the survival of native Australian fauna, with non-flying mammals weighing between 35 and 5500 grams and ground-nesting birds at greatest risk (NSW Scientific Committee 1998a). Predation by the Red Fox is therefore listed as a Key Threatening Process under the NSW TSC Act (1995) (NPWS 1998a) and the EPBC Act (1999) and as a result a Threat Abatement Plan (Fox TAP) has been prepared (NPWS 2001b). The fact that Foxes prey upon native animals within the study area is evident from scat analysis. It is worth noting, however that the feral Rabbit usually also forms a component of a Fox's diet. The impact of Wild Dogs on populations of native animals is not well researched or understood. Within the Hunter Range, however, Dogs have been found to prey upon a number of native species (DEC 2005b), and elsewhere are thought to threaten Spotted-tailed Quolls, Koalas and Brush-tailed Rock-wallabies.

Predation by the Feral Cat is also listed as a Key Threatening Process on state and federal legislation as they threaten native fauna by direct predation, being capable of killing vertebrates up to three kilograms. Preference is shown for mammals weighing less than 220 grams and birds less than 200 grams, but reptiles, and amphibians are also eaten (NSW Scientific Committee 2000a). Current impacts on native fauna are likely to be most severe in modified, fragmented environments and in areas where the abundance of alternative prey (such as Rabbits and Mice) fluctuates widely (NSW

Scientific Committee 2000a). However, as the distribution and abundance of Cats in the study area is not currently known it will be difficult to manage this threat without further targeted survey.

Of the introduced herbivores, the Rabbit is of greatest concern due to its abundance and potential impacts on native fauna. Rabbits are abundant in well grassed habitats associated with farming lands, alluvial woodlands and richer soils where food source is plentiful and soils are deep enough for burrowing. It has been detected most frequently near the perimeter of the park, but also along the length of Reedy and Melon Creeks. Competition and land degradation by Feral Rabbits is also listed as a Key Threatening Process on state and federal legislation. Feral Rabbits impact negatively on indigenous species via competition for resources, alteration of the structure and composition of vegetation, ring-barking of trees and shrubs and digging of burrows, which in turn contribute to soil erosion (NSW Scientific Committee 2002). They compete for food and/or shelter with some native fauna species (NSW Scientific Committee 2002). Also, Feral Rabbits can sustain high densities of feral Cats and Foxes. The Hare occurs at comparatively low abundance and is unlikely to be having a significant impact on native fauna. The records of House Mouse are confined to three regions, the Clayhole Arm Trail, Diamond Ridge Firetrail, and Reedy Creek Trail, while the Black Rat has been located in the latter two of these (Map 4). The House Mouse is likely to be widespread, particularly at the interface between cleared and forested lands, whereas the Black Rat would be restricted to moist environments and probably remains at relatively low density.

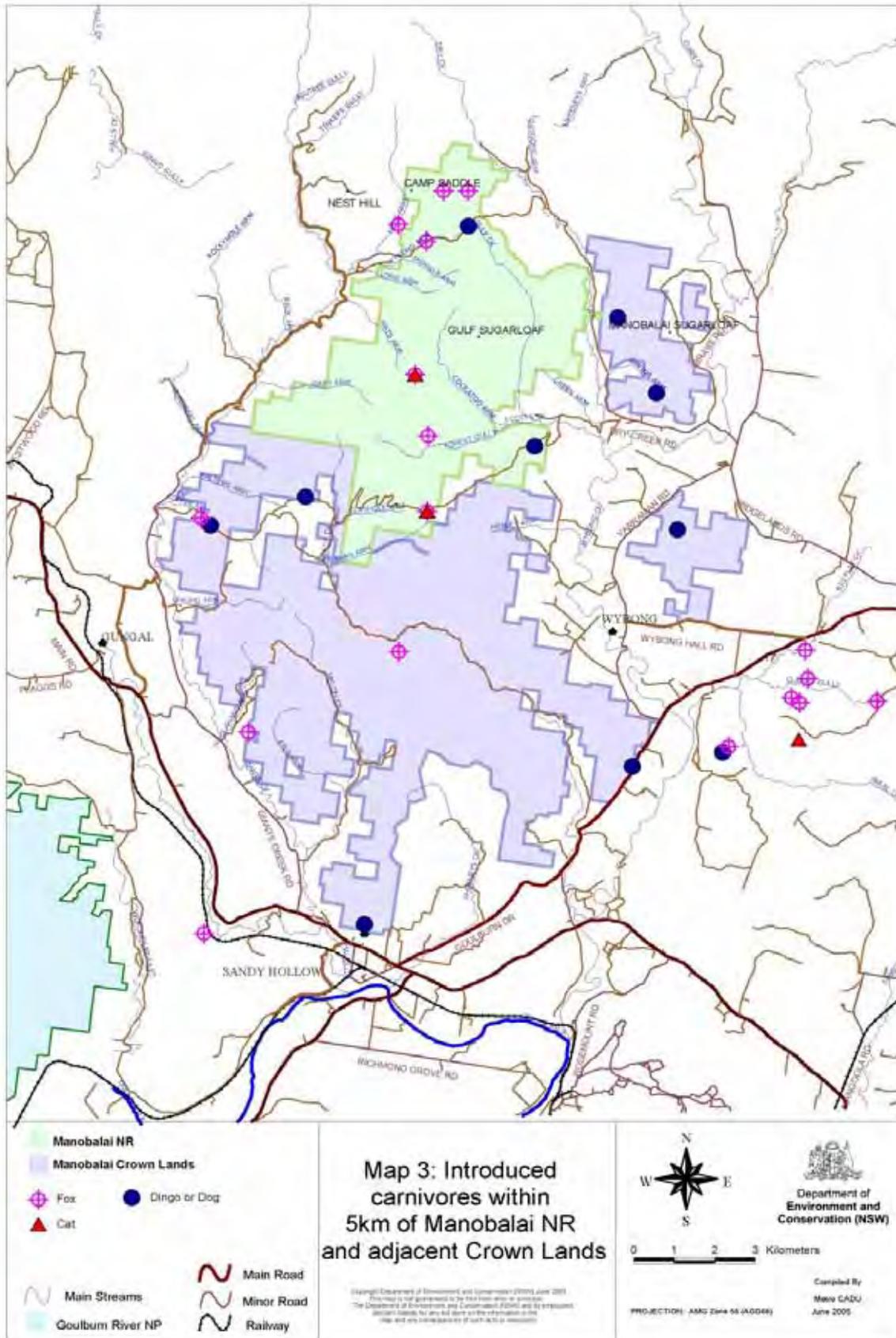
The Cattle detected in the park are likely to be escaped domestic animals, and though the majority have been near the boundary of the park, the species has been recorded up to one kilometre inside the study area boundary, having walked in along major creeklines such as Reedy Creek. The specific impact of Cattle grazing along these creeklines is not known, however depending on its intensity it is likely to be affecting the regeneration of some plants, spreading weeds, and causing harm by trampling and compacting the soil. These impacts may have flow-on effects for the native fauna that rely on these creek-line habitats.

### 3.9.2 Introduced birds

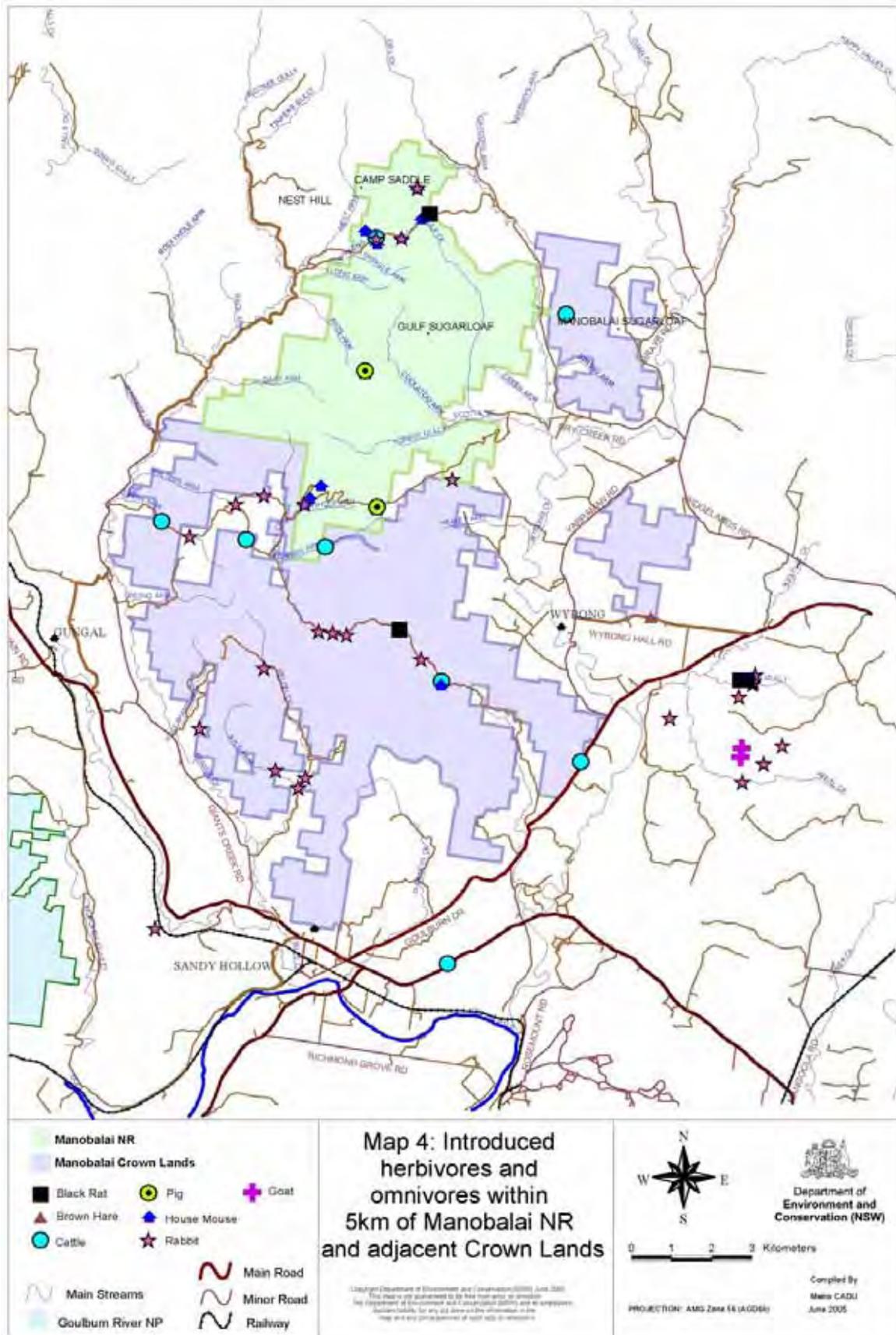
Three introduced bird species have been recorded in Manobalai Nature Reserve and Crown Lands, however all of the records are either spatially inaccurate or are located on or just outside the boundary of the park. The species names of birds discussed in this section are presented in Appendices B and C. The Common Starling is the most pertinent threat, as it was detected in the basalt-influenced cleared private lands that separate the Nature Reserve from the southern Crown Lands (Map 5). Common Starlings are known to compete with native birds for nest sites such as tree hollows. Threatened species that depend on hollows in woodland habitats, such as the Brown Treecreeper, are particularly at threat. As long as the Common Starlings are limited to the cleared lands around the study area, their effects are likely to be minimal. However, if the species is found to move further into the park, or to invade the alluvial woodlands (on which a number of threatened species depend), action should be taken to control the birds. Any such action must be sure to target the introduced species and not impact on native bird species.

The European Goldfinch has not been detected since a spatially inaccurate recording was made in 1978 and is unlikely to occur within the park proper. The House Sparrow was last detected in 1990, however despite the relatively recent date this data is also spatially erroneous and does not indicate that the species inhabits the park. The animals are only likely to occur within highly modified environments and in the vicinity of human habitation, and therefore do not pose a significant threat to native wildlife. A potentially greater threat is posed by the Common Myna, which within the last decade has been detected near Wybong and at Anvil Hill (Map 5). Local residents in the Upper Hunter Area have noticed increasing numbers of this distinctive bird in recent years (J. Barlow pers. comm.). As long as they are restricted to cleared lands they do not pose a problem, but if they invade the study area they would be a significant management issue. Common Mynas are infamous for their aggressive nature, often seen bullying their own and other species for food, nesting sites or territories, particularly in woodland areas. They are known to evict native birds, including Parrots, Kookaburras, Dollarbirds and Australian Magpie-larks from their nests, before dumping out their eggs or chicks (Environment ACT 2004). They are also considered to be a threat to the local survival of mammals that depend on tree hollows, such as Sugar Gliders (Environment ACT 2004). If the species is found to invade the park, targeted action should be taken to control the birds.

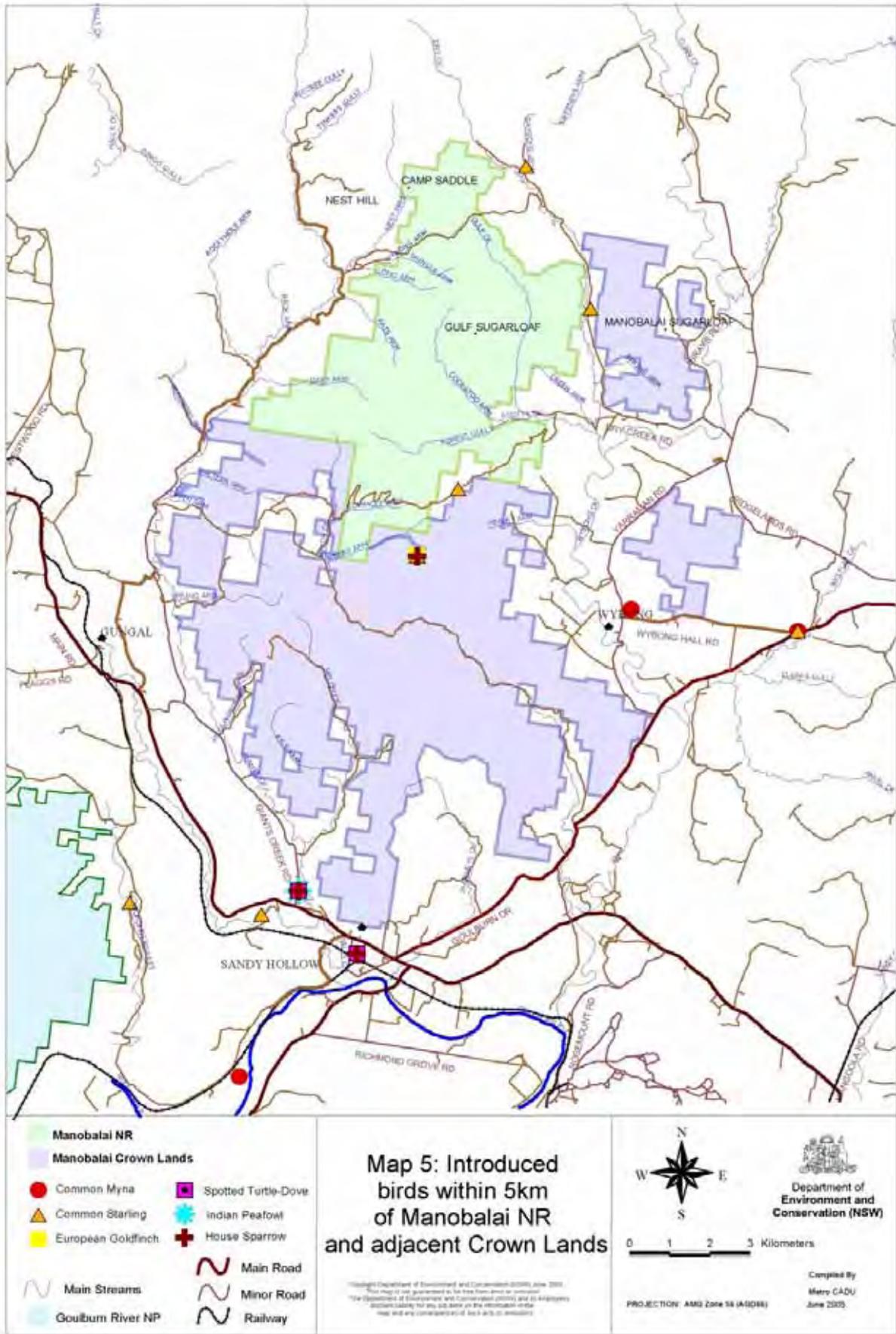
The Spotted Turtle-dove (*Streptopelia chinensis*) and Indian Peafowl (*Pavo cristatus*) have each been recorded in the vicinity of Giants Creek Road, west of the study area (Map 5), but are unlikely to pose a threat to the native fauna as they are usually restricted to human settlements and cleared areas.



**Map 3: Introduced carnivore records within five kilometres of Manobalai Nature Reserve and adjacent Crown Lands**



**Map 4: Introduced herbivore and omnivore records within five kilometres of Manobalai Nature Reserve and adjacent Crown Lands**



**Map 5: Introduced bird records within five kilometres of Manobalai Nature Reserve and adjacent Crown Lands**

# 4 MANAGEMENT RECOMMENDATIONS

## 4.1 AREAS OF HIGH CONSERVATION SIGNIFICANCE

The localities listed below are of high importance for the conservation of vertebrate fauna in the study area, particularly threatened species. Given limited resources, protection and enhancement of these sites and habitats will generate the maximum benefit to threatened species conservation and to vertebrate diversity in the study area.

### 4.1.1 Southern Crown Land

Fauna habitats vary widely in their spatial extent, with some being widespread, some naturally restricted and others heavily depleted due to clearing. They also vary greatly in their level of modification and number of threatened fauna. These disparities occur largely because threatening processes operate unequally across the landscape, with habitats that occur on more fertile soils experiencing greater disruption than habitats on less fertile, rocky and steep areas. The result of this is that some environments provide habitat for a disproportionately large number of threatened species.

Data compiled for this report indicate differences between the habitats present in Manobalai Nature Reserve and those found within the southern Crown Land. These differences are driven by the presence of larger areas of alluvial woodland vegetation in the southern Crown Lands, particularly along Reedy and Melon Creeks. Such habitats have been heavily cleared and remain poorly protected within the reserve system in the Hunter Range area. At least sixteen animal species listed under the TSC Act (1995) occur within the southern Crown Lands, of which eleven species have their primary habitat, the alluvial woodlands, located within this area (Table 5). In addition, the southern Crown Land provides habitat for the Painted Honeyeater, Hooded Robin and Diamond Firetail, though these species have not yet been recorded within its boundaries.

In contrast, data collected during the recent DEC surveys in the smaller portions of Crown Land (north-eastern and south-eastern portions) reveal that, though some threatened species are present, these parcels of land do not have significantly different patterns of fauna assemblages than Manobalai Nature Reserve. The north-eastern and south-eastern portions therefore have comparatively lower conservation significance than the southern portion of Crown Land.

Threatened species	Primary habitat in southern portion of Crown Land (✓ = yes, X = no)
Gang-gang Cockatoo	✓
Glossy Black-cockatoo	X
Turquoise Parrot	✓
Barking Owl	✓
Powerful Owl	X
Masked Owl	X
Brown Treecreeper (eastern subspecies)	✓
Speckled Warbler	✓
Black-chinned Honeyeater	✓
Grey-crowned Babbler	✓
Koala	✓
Squirrel Glider	✓
Large-eared Pied Bat	X
Eastern Bent-wing Bat	X
Greater Long-eared Bat	✓
Eastern Cave Bat	✓

**Table 5: Threatened species known to occur within southern Crown Land (south of Manobalai Nature Reserve)**

At least four Key Threatening Processes operate in the southern Crown Land, which cover the following broad issues: clearing of native vegetation; predation by the Fox; competition and grazing by Feral Rabbits; removal of dead wood and trees. Wild Dogs also pose a threat to native fauna through predation, as does invasion of exotic plant species and removal of hollow-bearing trees.

#### 4.1.2 Maternity roost of the Eastern Cave Bat

The cave used as a maternity roost by the Vulnerable Eastern Cave Bat is a site of considerable conservation and scientific interest. Very few maternity roost sites are known for this species, and it is particularly important being near the southern edge of the species' range. The site is a well-lit sandstone overhang of roughly three metres by ten metres at the entrance with a steeply sloping floor and at least one dome at the rear (Plate 11). It is located on the escarpment east of Melon Creek, and is not easily accessible.

There are no specific management actions required at the site, other than to reduce disturbance to the cave. This includes:

- Avoiding deliberate burning in the vicinity of the cave during spring and summer when the bats are breeding. Research elsewhere has indicated that even low intensity fire can cause bats to abandon cave roosts over the short term (Law *et al.* 2005).
- Minimisation of human visitation, particularly during spring and summer.

#### 4.1.3 Known localities of the Barking Owl

Surveys completed for this project have indicated that the dry woodlands of the Hunter Valley Escarpment are of considerable regional importance for this rare owl. As the majority of preferred habitat for this species is not currently reserved or protected, it is paramount that where territories are known on reserves, caution be exercised to ensure that they are not inadvertently modified in a manner that negatively impacts on the owl. There are at least three Barking Owl territories located within the Manobalai Nature Reserve and Crown Lands (Map 6). The territories of these owls are likely to be complex, probably extending linearly along creeklines (where prey availability is high) or along park boundaries where preferred habitat occurs. Since the exact territories cannot be determined without detailed study, a simplified approach for management purposes may be adopted, consisting of delineating a two kilometre radius around known records. Though this distance is somewhat nominal, it is likely to include the core habitat areas of these individual owls.

- Any park or Crown Land management activities conducted within a two kilometre radius of a known Barking Owl location should critically appraise potential impacts on the species roosting and nesting requirements.
- In the case of hazard reduction burning, creeklines within the designated burn area should be traversed to identify potential nest or roost sites, often indicated by wash on the ground, litter or tree trunks. If nest or roost sites are located, the fire boundaries should be amended accordingly to exclude these sites. Hollow-bearing trees should be carefully protected from hot fires. Alternatively, hazard reduction burns should be excluded from known Barking Owl territories altogether.

#### 4.1.4 Brush-tailed Rock-wallaby colonies

Though there are a number of Brush-tailed Rock-wallaby records for Manobalai Nature Reserve and Crown Lands, none of these exclude a level of doubt in the mind of the observers, and to date there have been no absolutely positive identifications of the species. As noted below, it is recommended that targeted surveys for Brush-tailed Rock-wallaby be undertaken. Any confirmed records, particularly if they constitute a colony, would hold very high conservation significance, and then take priority in park management planning.

## 4.2 RECOVERY PLAN ACTIONS

There are a number of recovery plans for species that occur within the study area that have been approved by the Minister or are in final draft stages. The threats and recovery actions outlined in these plans that are relevant to the study area are discussed below.

#### 4.2.1 Large Forest Owls

None of the recovery actions outlined in the Draft Recovery Plan for Large Forest Owls provide specific management recommendations for immediate on ground implementation in Manobalai Nature Reserve. Of the listed threats to the species, the most fire relevant to Manobalai Nature Reserve and Crown Lands are fire, predation, previous logging activities and in the case of the Crown Lands, cattle grazing. In light of this, it is recommended that:

- Too frequent hazard reduction burning, using low intensity fire with short burn intervals, not be undertaken within known Powerful Owl or Sooty Owl territories.
- A mosaic pattern be used when fuel reduction burns are undertaken. This will ensure that sufficient refugia are left unburnt, particularly along creek lines and gorges for Powerful and Sooty Owls, while a mix of burnt-unburnt patches contributes to the vegetation structural diversity required for Masked Owls.
- Hollow-bearing trees, both living and dead, be retained, even in semi-cleared country at the park and Crown Land boundary. Mature trees should be allowed to develop along creeklines that have previously been logged, in order to provide further nesting and roosting opportunities for the Large Forest Owls in the long term, as well as den sites for prey species.
- Cattle grazing should be discouraged in the southern Crown Land, particularly along major creeklines such as Reedy and Melon Creeks.

#### **4.2.2 Barking Owl**

Of the threats listed to the Barking Owl in the Draft Recovery Plan, the most relevant are likely to be previous logging activities (particularly within the southern Crown Land), predation on fledglings by Cats and Foxes, and potentially occupation of hollows by feral Honey Bees (NPWS 2003a). These threats are poorly understood, however, and further research is required before specific management recommendations can be made. The recommended management of threats posed by fire is outlined in section 4.1.3 above.

#### **4.2.3 Koala**

The Draft Recovery Plan for the Koala (NPWS 2003d) indicates that many remaining Koala populations on the ranges of the Sydney Basin occupy secondary class habitat. Available data indicate that the Koala occurs in low densities in the Manobalai area. The key habitat areas are those where Grey Gum (*E. punctata*) is in abundance or where patches of Grey/White Box (*E. molucanna/albens*) or Red Gums (*E. tereticornis*, *E. blakelyii*) occur, particularly along Reedy and Melon Creeks in the southern Crown Land. Of the threats listed to the Koala in the Draft Recovery Plan, the most relevant to Manobalai Nature Reserve and Crown Lands are likely to be previous logging activities, fire and possibly predation by Dogs. Koalas are known to survive extensive and intense wildfires (K. Madden pers. obs. in DEC 2004b), but are threatened in areas where no refugia persist.

The Draft Recovery Plan highlights a number of generic recommendations to managing threats to the Koala on reserved lands. In summary these are:

- That fire be excluded, where possible, from areas known to contain Koalas.
- That mosaic patterns be used in fuel reduction burns to ensure refuges of unburnt habitat are always available. Such burns should be carried out outside the spring-summer period when Koalas are breeding and most likely to be on the ground and therefore vulnerable to fire. Burns should avoid crown scorch and crown burns.
- Preferred feed trees not be felled during mop-up operations in areas known to be used by Koalas, or during the construction of fire breaks and fire trails.
- In addition it is recommended that mature trees should be allowed to develop along creeklines that have previously been logged.

#### **4.2.4 Brush-tailed Rock-wallaby**

Of the threats listed to the Brush-tailed Rock-wallaby in the Draft Recovery Plan, the most relevant to the Manobalai area are likely to be predation by the Red Fox and aspects relating to fire regimes (DEC 2005j). The plan acknowledges, however that the threatening processes affecting Brush-tailed Rock-wallabies are poorly understood, multi-level, usually inter-related and the inter-relationships are often complex. Until a better understanding of the threatening processes of the Brush-tailed Rock-wallaby is gained, the control of threatening processes will continue to be problematic.

Specific on-ground management recommendations for the Brush-tailed Rock-wallaby cannot be provided at this stage. Instead, attention should be focussed on confirming whether or not the species is extant within the study area, and if so whether a viable colony persists.

## **4.3 FIRE AND BIODIVERSITY**

### **4.3.1 Lessons so far from the Woronora Plateau post-fire fauna surveys**

The impact of controlled burning and wildfire on fauna is poorly understood. Research currently being undertaken by DEC (2004c) is one of very few studies to offer a comparison of fauna composition between long unburnt vegetation and vegetation that has undergone an extensive and severe wildfire. Even fewer studies have examined the impacts of frequent burning on the suite of fauna in an ecosystem; more often fire impact studies have been species specific.

The study (DEC 2004c) on the Woronora Plateau in the south of Sydney is the most relevant guide to the potential impact of an extensive and severe wildfire on fauna in Manobalai Nature Reserve and Crown Lands. Both the Woronora and Manobalai areas are characterised by dry sandstone woodlands and forests and while rainfall levels differ substantially, there is considerable species overlap for many of the fauna groups. It is not unreasonable to hypothesise that the fauna of Manobalai would respond to fire in similar as that on the Woronora Plateau. The following discussion summarises current findings of the Woronora Plateau study.

The Woronora Plateau study has found that the impacts of wildfire depend on the intensity of the fire. High intensity fire has had a much more dramatic impact on species abundance than has low or moderate intensity fire. Arboreal mammal abundance was found to be greatly reduced in areas of high intensity fire. In Manobalai Nature Reserve and Crown Lands, the Squirrel Glider and Koala are threatened species at risk from high intensity fires. Results are unambiguous for arboreal mammals with small home ranges such as the Greater Glider. Unburnt forests were shown to have ten times the number of Greater Gliders than forests burnt by high intensity fire. Squirrel Gliders and Eastern Pygmy-possums have similarly small home ranges and are therefore vulnerable to extirpation during such fire events. Koalas are more mobile and while high intensity fire is recognised as a major threat they are known to have survived such conflagrations. Such is the case in Avon Catchment (DEC 2004c), Nattai National Park (DEC 2004b), Campbelltown and Yengo (NPWS 2003e).

The richness and diversity of bird assemblages are significantly reduced in sandstone woodlands following high intensity fire. Honeyeaters are one group of birds that were shown to suffer greatly reduced numbers in the Woronora study. The consumption of the shrub layer during fire removes the primary source of food and cover. Composition of post fire environments was shown to preference canopy-using bird species.

Loss of key habitat resulted in similar downturns in the richness and diversity of reptile species in sandstone woodlands. Most affected were litter-dwelling skinks while those associated with rocky habitats were less affected though still suffered reduced numbers.

The study is also showing that the recovery of fauna populations to pre-fire levels takes considerable time. There is evidence of only slow increases in abundance of some species even at three years after fire. Such a trend reinforces that subsequent fires within this time are likely to suppress an already reduced fauna population.

The study reveals that while the impacts of the high intensity of fire have been catastrophic in the short term and at a small scale, there has been no recorded loss of species from the Woronora Plateau as a result. This is because there is a mosaic of burn intensities within the study area, with some areas remaining lightly burnt or unburnt. These areas are most likely to act as refugia in which species will survive and from which species will in time recolonise the intensely burnt environments. Subsequent fires that burn unburnt areas after only short fire intervals are likely to severely affect local population numbers.

Research into the impacts of fire on fauna on the Woronora Plateau will continue until five years after the wildfire event (summer 2006-7). A final report detailing findings will then be produced. This report is likely to include key findings that are directly relevant to Manobalai Nature Reserve and Crown Lands and may assist in the formation of fire management strategies that maximise fauna diversity in the study area.

### **4.3.2 Recommendations for fire management**

Landholders who have lived in the area since the 1930s do not recall a wildfire ever burning through Manobalai Nature Reserve, while records indicate that the most recent wildfire in the Crown Lands occurred in 1979/80. Unlike some other reserves in the Hunter Range area, the majority of the park is not currently threatened by too frequent burning. Therefore the threat of fire is restricted to the

potential impacts of a single large wildfire, or by too frequent hazard reduction burning in the future. If a wildfire breaks out, where possible it should be managed to ensure unburnt refugia are retained within the study area. Felling of preferred habitat trees for threatened species, particularly in the Box-Ironbark-Red Gum woodlands, should be avoided where possible during mop-up operations or during the construction of fire breaks and fire trails.

Hazard reduction burns should be separated by an appropriate interval, and a burnt area should not be burnt again for a minimum of four years. A number of threatened species warrant particular consideration when planning hazard reduction burns. These species include the Brush-tailed Rock-wallaby, Barking Owl and Koala, as well as Eastern Cave Bat roost sites. The following generic recommendations for fire management in relation to fauna are also made:

- Fire management should aim for a mosaic of fire regimes.
- Mosaic burning should retain examples of all fauna habitats in a long unburnt state.
- Fire planning should recognise the role of unburnt refugia in the recolonisation of burnt landscapes, particularly after extensive and intense wildfire.

#### **4.4 PEST SPECIES AND BIODIVERSITY**

Three of the introduced species known to occur within the study area are listed as a Key Threatening Process as follows: predation by the Red Fox; competition and grazing by Feral Rabbits; and predation by the Feral Cat. Of these, predation by the Red Fox is likely to be having the most significant impact on threatened species in the study area. The impact of Feral Cats is largely unknown, as though it has not recently been observed its elusive nature may simply mean that it goes largely undetected. The preferred habitat of Rabbits within the study area is restricted to alluvial woodlands where food supply is plentiful and the soil is deep enough for burrowing, particularly along Reedy and Melon Creeks, in the south of the Nature Reserve along the Clayhole Arm, as well as adjacent to farmlands. There is little potential for expansion of the species current range, and thus control of Rabbits is currently of lower priority than that of Foxes. Though not listed as a Key Threatening Process, Wild Dogs pose a significant threat to native fauna through predation and are listed as a pest under the Rural Lands Protection Act (1998). Control of Wild Dogs is currently considered second in priority to Fox control in the study area.

In order to help guide feral animal control programs, the following is noted:

- The threatened species considered most sensitive to Fox predation are the Brush-tailed Rock-wallaby and Spotted-tailed Quoll and to a lesser extent the Squirrel Glider, Koala, Speckled Warbler and Diamond Firetail. Impacts of Foxes on other threatened species are considered to be low (NPWS 2001a).
- It is unlikely that Foxes can be removed from the study area entirely, so control programs should be centred around priority sites or habitats that will achieve the maximum benefit for biodiversity. Control of Foxes, with regards to their impacts on biodiversity, should be focussed on the alluvial woodlands in the south of the Nature Reserve and the southern Crown Lands, as well as known locations of the above threatened species.
- Control of Foxes is most important in the first few years following fire when the ground layer is open providing little refuge for ground-dwelling mammals and birds.
- The foraging efficiency of Foxes seems to be maximal in open habitats where they are able to range widely and freely (Environment Australia 1999). They readily use roads, tracks and other cleared access ways through denser vegetation or complex topography. One option to minimise Fox impacts on threatened species is to reduce such access points to a minimum and to maintain bait stations along those access paths which are retained (Environment Australia 1999).
- Priorities for Wild Dog control, with regards to their impacts on biodiversity, are known locations of Koala and Brush-tailed Rock-wallaby, as well as alluvial habitats within the southern Crown Lands.
- Control of Cats is very difficult and at present there are no particular sites that require attention. Further survey into the abundance and distribution of Cats in the area is recommended. Following this, if deemed necessary, control should be considered in the vicinity of records and habitat of Hooded Robin, Grey-crowned Babbler, Diamond Firetail, Speckled Warbler, Spotted-tailed Quoll and Squirrel Glider.

- Any control programs must consider the impacts that baiting or removal of feral animals from the system are likely to have, and take this into account before going ahead with broad-scale control measures. For example, Dog baiting can have an adverse impact by serving to increase Fox populations and endangering Dingo populations, while evidence collected elsewhere suggests that both Fox and Dog baiting can have an adverse impact on Quoll populations (Belcher 2004).
- The use of 1080 baiting in areas where Quolls are known should be very carefully considered. Burying baits deeper than seven centimetres below the ground surface (rather than burying them in raised mounds) will decrease the number of baits removed by Quolls (Glen and Dickman 2003).

## 4.5 TREE HOLLOW MANAGEMENT

A large proportion of the fauna species known to occur within Manobalai Nature Reserve and Crown Lands utilise tree hollows for shelter, roosting, nesting and/or breeding. As the study area comprises a large area of multi-aged forests and woodlands, suitable tree hollows are widespread and abundant throughout the large majority of the area. A complex mosaic of tree ages occurs across the sandstone landscape, due to the activity of numerous processes, such as fire and erosion, over hundreds of years. Due to the nature of the landscape, much of the study area has avoided the impacts of modern human disturbance, and where human disturbance has occurred, it is highly localised and usually restricted to particular communities. In addition, the geomorphology of the sandstone plateaus and gullies provides a complex array of caves, rock fissures and outcrops, which provide an alternative sheltering resource for numerous fauna species. Consequently, sheltering resources are not limited throughout most of the area, and hence do not require any specific management actions, provided that a mosaic approach to forest management is retained, as described in previous sections of this report.

The majority of human disturbance to the study area has occurred within the vegetation communities closely associated with past or present agricultural activities or timber extraction. Evidence of logging is present in the most accessible gully systems, most notably within the alluvial forests and woodlands along Walters, Webbs and Clayhole Arms, Melon Creek, Reedy Creek and to some extent Oaky Arm. This logging has reduced the diversity of tree ages and the number of large trees in these alluvial systems, and hence limited the number of tree hollows available to fauna. Furthermore, alternative rocky shelter sites are limited within these habitats. These habitats are of high conservation priority to numerous threatened fauna species. Hollow-dependent species occurring within them include the Squirrel Glider, Powerful Owl, Barking Owl, Masked Owl, Turquoise Parrot, Hooded Robin and Brown Treecreeper.

The restricted availability of sheltering resources within alluvial forests and woodlands in the southern Crown Land and southern section of the Nature Reserve necessitates the implementation of management actions that will ensure the re-development of tree-hollow resources over the long term. In light of this it should be recognised that:

- Large remnant hollow bearing trees are vitally important in the disturbed alluvial forests and woodlands, as they often provide the only shelter resource available to hollow-dependent threatened species in these habitats. Hence these large remnant trees should be retained at all costs, whether they occur alone or in a remnant patch, and whether on or off reserve.
- Fire is an important contributor to hollow formation. While the perpetuity of hollows is dependent on a disturbance regime that promotes mortality and regeneration, too frequent fires can cause an area to be depleted of hollows, particularly when the area has previously been logged (Gibbons and Lindenmeyer 2002). The fire regime that exists across the majority of the study area enables a balance between hollow destruction, preservation and formation. In the event of a wild fire across the park, as long as unburnt refugia are retained this balance will be preserved. However the situation in the disturbed alluvial woodlands is more fragile, as these areas are more prone to hollow reduction by fire. Measures that reduce the frequency of high intensity fires over short time intervals within the alluvial woodlands are therefore warranted.

## 4.6 OFF-RESERVE CONSERVATION AND LAND ACQUISITIONS

### 4.6.1 Additions to Manobalai Nature Reserve

The southern, north-eastern and south-eastern Crown Lands are being considered as additions to Manobalai Nature Reserve. Data collected during the recent DEC surveys indicate that the southern Crown Land has high conservation value and should be given priority for reservation above the more

easterly portions. Habitats that are of highest value within the southern Crown Lands include the alluvial woodlands where Ironbark, Box, Rough-barked Apple, Red Gum and Grey Gum occur. Such habitats have been heavily cleared and remain poorly protected within the reserve system in the Hunter Range area. It is highly recommended that the Crown Land south of Manobalai Nature Reserve be added to the reserve system.

#### **4.6.2 Conservation on private lands adjacent to the study area**

Portions of land that are adjacent to the study area and support Box-Red Gum-Ironbark vegetation, or creek flats and riparian systems with intact vegetation, play a role in the ongoing conservation of threatened species in the area. They are of particular importance to species that favour grassy open woodland habitats, such as Hooded Robin and Diamond Firetail. For this reason, landholders should be encouraged to actively participate in conservation programs and/or minimise the undertaking of activities that would decrease the value of these habitats to native fauna. It is recommended that a program be launched across the Hunter Range area to educate neighbours of the importance of these habitats and encourage them to undertake the following.

- Prevent the progress of relevant Key Threatening Processes. This entails in situ retention of fallen wood, dead trees and bushrock, as well as the avoidance of any clearance of native vegetation. In particular, all large trees, whether living or dead, isolated or connected to other vegetation, should be retained as they are likely to provide vital hollow resources.
- Avoid activities that alter the structure of the vegetation, such as frequent burning and over-grazing. Landowners should be strongly encouraged to retain the integrity of the key Box-Red Gum-Ironbark habitats, as well as creekline and riparian vegetation.
- Retain key tree species. For the Painted Honeyeater this includes tree that support mistletoes of the genus *Amyema*. For the Regent Honeyeater this includes Mugga Ironbark and Yellow Box. For Hooded Robin this includes paddock trees (even if they are dead) and other perch sites.
- Avoid the plantation of invasive exotic plant species, particularly exotic grasses. These have the potential to invade key habitats and reduce their value to numerous threatened species, particularly the Diamond Firetail and the Speckled Warbler.
- Avoid the over-use of pesticides near the woodland-agriculture interface, as it has the potential to negatively affect a number of threatened species, including owls, Regent Honeyeater and some bats (such as Yellow-bellied Sheath-tail-bat and Greater Long-eared Bat).

#### **4.6.3 Co-operative pest management**

Control of pests in the study area will not be successful without the adoption of a cooperative landscape-based approach. Baiting on individual tenures will only provide short-term success due to the high mobility of Foxes and the potential of rapid re-invasion. It is strongly recommended that a cooperative targeted pest management program be developed for the catchments that feed into the study area, across all land tenures including private lands, Crown Lands and National Parks.

### **4.7 FURTHER SURVEY AND MONITORING**

#### **4.7.1 Specific threatened species projects**

Land managers are faced with an ominous list of threatened fauna species. However, not all threatened species warrant equivalent management efforts. There are a number of threatened species within the study area that at this stage do not require specific targeted management actions to be undertaken. However, other threatened species require specific management actions, further survey and/or monitoring to be undertaken in order to increase their chances of long term survival within the study area. In terms of further survey, research and monitoring, the following programs are suggested. All of the research programs listed should be undertaken in close consultation with appropriately experienced scientific personnel, experts on the species, as well as with any teams undertaking related work elsewhere in the Department of Environment and Conservation or the federal Department of Environment and Heritage, such as recovery planning or threat abatement planning.

##### *Brush-tailed Rock-wallaby*

A number of unconfirmed sightings of Brush-tailed Rock-wallaby have been made within the study area over the years, but unfortunately none of these resulted in positive identification of the species,

and no scats, hair or remains have ever been collected. Suitable habitat does occur, in the form of rocky north and north-west facing escarpment slopes. The persistence of a colony of Brush-tailed Rock-wallabies within the study area would have high conservation significance, as it could represent the northerly extent of the Hunter Range populations of the species. If a colony does persist, it would require targeted and specific management actions to ensure its survival. Thus it is important that a study be undertaken to ascertain with a strong degree of certainty whether Brush-tailed Rock-wallabies currently occur within Manobalai Nature Reserve and/or Crown Lands. It is recommended that a survey program should be undertaken that includes the following aspects:

- Targeted surveys within areas of suitable habitat, commencing with locations where unconfirmed sightings have been made. Surveys should be designed in consultation with a recognised expert, but are likely to involve observational transects of potential habitat areas.
- Searches within potential habitat areas for scats of the Rock-wallaby should be a priority, with any possible scats collected and sent to a recognised expert for verification. If scats are located, a large number should be collected in order to increase the chance of obtaining a grooming hair, which would enable more positive identification of the species.
- The Brush-tailed Rock-wallaby Recovery Team should be notified immediately of any positive identification.
- If individuals or colonies are located, this should trigger a more detailed research program to determine if the species is breeding in the area and if the colony is viable. Such research would guide further management actions.

#### *Regent Honeyeater and Swift Parrot*

Manobalai Nature Reserve contains extensive areas of Spotted Gum Forest. Spotted Gum is one of only a few winter flowering eucalypt species, and hence is used by a large number of nomadic bird species as a winter food resource. Two bird species listed as endangered under the EPBC Act (1999), the Regent Honeyeater and the Swift Parrot, are known to feed on the flowers of this tree species during winter. Such has been the case in Werakata National Park in the lower Hunter Valley, where Swift Parrots revisit the same locations over consecutive years (Saunders 2002). It is possible that the Regent Honeyeater and/or Swift Parrot have gone unnoticed within the study area because very few surveys have been undertaken in the winter months. It is recommended that targeted surveys be undertaken when the Spotted Gum is in heavy flower, or when other food sources in the region are limited. Such surveys need to be undertaken by experienced observers familiar with the species' call.

#### *Hooded Robin*

It is recommended that targeted surveys be undertaken within remnants of Box-Red Gum Woodland on creek flats and lower escarpment slopes of southern part of the Nature Reserve and the southern Crown Land to ascertain whether Hooded Robins survive there and if so to identify current key areas. Such surveys should be undertaken by a recognised bird survey expert at intervals throughout the year, with a particular focus on the autumn and winter months.

#### *Spotted-tailed Quoll*

Further survey work is required to determine the status of Spotted-tailed Quolls in Manobalai Nature Reserve and Crown Lands the role that the area plays in the regional conservation of the species. Surveys should involve extensive cage trapping and hair tubing over an extended time period, in areas of potential habitat including moister environments, major gully lines and sheltered lower slopes in the north, east and south of the study area. A program should also be implemented to encourage neighbours and park visitors to report any sightings, together with accurate location information.

### **4.7.2 Other future work**

There is now comprehensive documentation of the general fauna characteristics of Manobalai Nature Reserve and Crown Lands. Further study is warranted for the species listed above. In addition, any feral animal control programs should be accompanied by monitoring of impacts on both the predator species and their prey. In particular, Fox management planning could consider the inclusion of a program to monitor impacts of Fox control on the number and distribution of Spotted-tailed Quoll, Squirrel Glider, Koala and Speckled Warbler.

## 5 THREATENED SPECIES PROFILES

This section provides a profile of each of the threatened fauna species that are known to occur within Manobalai Nature Reserve and/or adjacent Crown Lands, together with two additional threatened species that are considered likely to occur. The aim of these profiles is to provide: a background on the species biology; a summary of threats to the species; an assessment of how well the species is protected in the region; a map of known records of the species in the study area and the surrounding five kilometres; and an appraisal of the distribution and status of the species Manobalai Nature Reserve and the surrounding area.

The list of threatened vertebrate fauna for the study area contains records of various levels of reliability. For this reason, a species profile has not been generated for all of the threatened species listed on the DEC Atlas of NSW Wildlife as occurring within the area. Only species that have been directly and reliably observed within the study area, or have been recorded on the Atlas of NSW Wildlife within two kilometres and considered likely to occur within the area, have been afforded a species profile. Table 6 presents all of the threatened species recorded on the Atlas of NSW Wildlife within five kilometres of the study area, together with annotation for each species regarding the latest record, reliability of identification and a rationale for the generation of a species profile.

Scientific name	Common name	Status in NSW (TSC Act 1995)	Status in Australia (EPBC Act 1999)	No. of locations within study area <sup>1</sup>		No. of locations within a five kilometre radius of study area <sup>1</sup>	Notes on reliability and date of last record	Species profile generated?
				NR	CL			
<i>Burhinus grallarius</i>	Bush Stone-curlew	E		0	1	0	Observed once in Crown Land in 1978, but low spatial accuracy. Not likely to currently persist within the study area	N
<i>Callocephalon fimbriatum</i>	Gang-gang Cockatoo	V	-	0	4	0	Recorded at three locations in Crown Lands during DEC surveys	Y
<i>Calyptorhynchus lathami</i>	Glossy Black-cockatoo	V	-	7	23	5	Regularly observed within and surrounding the study area	Y
<i>Neophema pulchella</i>	Turquoise Parrot	V	-	0	2	1	Recorded at two locations in or on the boundary of the Crown Lands, most recently in December 2002	Y
<i>Ninox connivens</i>	Barking Owl	V	-	1	3	1	Recorded four times within the study area, most recently in June 2005	Y
<i>Ninox strenua</i>	Powerful Owl	V	-	3	4	0	Recorded seven times within the study area, most recently in May 2005	Y
<i>Tyto novaehollandiae</i>	Masked Owl	V	-	1	1	1	Recorded twice in the study area by call only, most recently in March 2000. Heard at Anvil Hill in June 2004.	Y
<i>Climacteris picumnus victoriae</i>	Brown Treecreeper (eastern subspecies)	V	-	15	32	10	Regularly observed within and around the study area, most recently in December 2004	Y
<i>Pyrrholaemus sagittatus</i>	Speckled Warbler	V	-	9	17	17	Regularly observed within and surrounding the study area, most recently in December 2004	Y
<i>Grantiella picta</i>	Painted Honeyeater	V	-	0	2	0	Recorded once by Birds Australia in 1979 in the vicinity of the study area (low spatial accuracy) and once by a resident near Wybong Hall in 2002. Likely to be an infrequent visitor to the study area.	Y
<i>Melithreptus gularis gularis</i>	Black-chinned Honeyeater (eastern subspecies)	V	-	0	1	0	Recorded once within the study area in December 2004	Y
<i>Xanthomyza phrygia</i>	Regent Honeyeater	E	E	0	0	1	Not recorded in study area. Recorded once within 5km of the area in July 1996. May be a rare to occasional visitor to the study area.	Y

Scientific name	Common name	Status in NSW (TSC Act 1995)	Status in Australia (EPBC Act 1999)	No. of locations within study area <sup>1</sup>		No. of locations within a five kilometre radius of study area <sup>1</sup>	Notes on reliability and date of last record	Species profile generated?
				NR	CL			
<i>Melanodryas cucullata cucullata</i>	Hooded Robin (south-eastern subsp.)	V	-	0	2	3	Recorded by Birds Australia on two occasions in the late 1970s, however spatial accuracy is low. Recorded at three locations within 5 km, most recently by DEC in November 2004.	Y
<i>Pomatostomus temporalis temporalis</i>	Grey-crowned Babbler (eastern subspecies)	V	-	0	8	10	Reliably recorded within and around the Crown Lands, most recently in December 2004	Y
<i>Stagonopleura guttata</i>	Diamond Firetail	V	-	0	1	3	Recorded once by Birds Australia in 1978, though spatial accuracy is low. Recorded at three locations within five kilometres, most recently in May 2004	Y
<i>Dasyurus maculatus</i>	Spotted-tailed Quoll	V	E	0	0	1	Not recorded on Atlas in the study area, but known by landholders to have occurred in the past. One is thought to have been seen, and a hair collected, in the Crown Lands in January 1997 (identification uncertain).	Y
<i>Phascolarctos cinereus</i>	Koala	V	-	2	2	0	Heard calling twice in Nature Reserve in March 2000 and detected by hair and tracks twice in Crown Lands in 1997	Y
<i>Petaurus norfolcensis</i>	Squirrel Glider	V	-	2	0	0	Recorded twice by DEC within study area in May and June 2005	Y
<i>Petaurus australis</i>	Yellow-bellied Glider	V	-	1	0	0	Two individuals heard calling once in Nature Reserve in March 2000, but occurrence is uncertain. Study area does not constitute high quality habitat.	N
<i>Petrogale penicillata</i>	Brush-tailed Rock-wallaby	E	V	2	1	2	Possibly recorded on three occasions. Recorded on two occasions within 5 km in 1996.	Y
<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheath-tail-bat	V		2	0	0	Recorded once definitely and once probably in the Nature Reserve, most recently in December 2004	Y
<i>Mormopterus norfolkensis</i>	East-coast Freetail-bat	V	-	1	0	0	Recorded only once by anabat within the study area in 1998. Not detected within 5 km, though unidentified bats of the <i>Mormopterus</i> genus have been recorded.	Y
<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	V	V	4	6	0	Regularly recorded in the study area, most recently in December 2004	Y

Scientific name	Common name	Status in NSW (TSC Act 1995)	Status in Australia (EPBC Act 1999)	No. of locations within study area <sup>1</sup>		No. of locations within a five kilometre radius of study area <sup>1</sup>	Notes on reliability and date of last record	Species profile generated?
				NR	CL			
<i>Falsistrellus tasmaniensis</i>	Eastern False Pipistrelle	V	-	0	0	1	Not recorded in study area. Detected once by anabat at Anvil Hill. Study area does not constitute high quality habitat.	N
<i>Miniopterus schreibersii oceanensis</i>	Eastern Bent-wing Bat	V	-	1	4	0	Detected by ultrasonic call at four locations in 2004. Two specimens held by the Australian Museum from the Sandy Hollow area.	Y
<i>Nyctophilus timoriensis</i>	Greater Long-eared Bat	V	V	1	5	0	Captured in harp trap at five locations in Crown Land in 2004 and once in Nature Reserve in 1997	Y
<i>Vespadelus troughtoni</i>	Eastern Cave Bat	V	-	1	1	0	First identified from anabat in Nature Reserve in 1997. Roost site discovered in cave in Crown Lands in 2004.	Y

**Table 6: Threatened fauna species recorded within and around Manobalai Nature Reserve and Crown Lands**

E Endangered

V Vulnerable

<sup>1</sup> Numbers indicate the number of locations at which the species has been recorded on the Atlas of NSW Wildlife, rather than the number of individuals

## GANG-GANG COCKATOO

### *Species Profile*

The Gang-gang Cockatoo (*Callocephalon fimbriatum*) is a small, stocky cockatoo with dark grey feathers on its body, narrowly margined with pale grey, orange and red (Pizzey and Knight 1997). Both sexes have a wispy crest that is curved forward and twisted, but the males crest and head is a bright fiery red. The species is endemic to south eastern Australia, ranging from the mid north coast and central tablelands of NSW to far south west Victoria and occasionally into South Australia (Higgins 1999). Gang-gangs are seasonally nomadic, inhabiting tall mountain forests and woodlands in the summer then moving to lower altitudes to drier, open eucalypt forests and woodlands in the winter (Higgins 1999) when they may also be found in urban areas and farmlands. It is gregarious in nature and primarily arboreal, roosting in tall trees and foraging in pairs or family groups for seeds, berries, fruits, nuts and insects in the canopy or occasionally in the upper understorey (Higgins 1999). The Gang-gang Cockatoo requires hollows in large trees for breeding, which occurs between October and January (Pizzey and Knight 1997).



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### *Threats*

Threats to the Gang-gang Cockatoo are poorly known but are thought to include habitat destruction and degradation; in particular the loss of food trees and large old trees required for roosting and breeding (NSW Scientific Committee 2001e, 2005). Potentially important is that a large amount of winter habitat has been cleared for agricultural and urban development. Competition for nest hollows with other species may also be problematic (NSW Scientific Committee 2001e), while Psittacine Circoviral (Beak and Feather) Disease may threaten small populations that are already stressed (DEH 2004a). Climate change may alter the extent and nature of the cool temperate vegetation that the species utilises (Olsen *et al.* 2003, NSW Scientific Committee 2005).

### *Local and Regional Conservation Status*

The Gang-gang Cockatoo has recently been listed as a Vulnerable Species under the NSW TSC Act (1995). The listing was made on the basis of a decline in the reporting of this species across its distribution between 1984 and 2002, though the reliability of this trend was low (Barrett *et al.* 2003). In the Sydney Basin Bioregion it is abundant south of the Hunter River, though there are fewer records in the Sydney and Wollongong urban areas. Numerous records of the species occur within many reserves, including Wollemi, Kanangra-Boyd, Blue Mountains, Nattai and Yengo National Parks.

The species has been recorded at four locations within the southern Crown Lands, including once by Birds Australia in March 2001 (within the vicinity of Sandy Hollow) and three times during the DEC surveys in December 2004 (Map 7). It has not been seen in Manobalai Nature Reserve itself. The density of Gang-gang Cockatoos in the Crown Lands may increase in winter, as individuals move away from taller mature higher elevation forests into the lower altitude drier forests and woodlands (NSW Scientific Committee 2004a). The sightings made in December 2004 were each located on alluvial flats in the Red Gum-Ironbark or Rough-barked Apple woodlands. Such habitats have been extensively cleared for agricultural and urban development, while much remaining habitat outside reserves is under ongoing pressure. Importantly, the sightings made during the 2004-05 surveys are amongst the most northerly records for this species; it has been recorded in only one reserve further north, Barrington Tops National Park (DEC 2005a). Conservation of the species within the study area is therefore important to the continued conservation of species at the northern edge of its range.

## GLOSSY BLACK-COCKATOO

### Species Profile

The Glossy Black-cockatoo (*Calyptorhynchus lathamii*) is a medium-sized black cockatoo, which has a diagnostic black-brown head, with yellow patches in the female, and red tail panels. It is usually seen in pairs or trios (with dependant young) in eucalypt woodland or forest, where it nests in hollows. This species feeds almost exclusively on Sheoaks (*Allocasuarina* species including *A. verticillata*, *A. torulosa* and *A. littoralis*) (Higgins 1999). Two subspecies are restricted to eastern Australia between Queensland (Eungella) and eastern Victoria, with the nominate *lathamii* found in NSW, and a third, isolated, endangered subspecies on Kangaroo Island (South Australia) (Higgins 1999).

### Threats

Habitat destruction for agriculture or residential development appears to be one of the main threats, due to both removal of nesting and feeding sites, and also from competition from more open habitat species such as Galahs (*Eolophus roseicapillus*). Because many *Allocasuarina* species are fire sensitive, inappropriate burning regimes may affect food supplies and this species has been listed by the NSW Scientific Committee (2000b) as being affected by inappropriate fire regimes. Illegal trapping for aviculture may be a localised, minor threat (Garnett and Crowley 2000). DEH (2004a) lists the Glossy Black-cockatoo as a species that has exhibited symptoms of Psittacine Circoviral (beak and feather) Disease.

### Local and Regional Conservation Status

The Glossy Black-cockatoo is listed as Vulnerable under the NSW TSC Act (1995). Being a large, conspicuous species there are numerous records in the coastal third of the state, though it is also found on the western slopes and an apparently isolated population occurs in the Narrandera-Lake Cargelligo area of the Riverina (NSW Scientific Committee 1999). Relatively large areas of the Sydney Basin provide suitable habitat for the species and there are a large number of records throughout the Bioregion (DEC 2005a). Feeding habitat is well protected, occurring in numerous DEC reserves, including Morton, Nattai, Blue Mountains, Ku-ring-gai Chase, Yengo and Wollemi National Parks.

The Glossy Black-cockatoo was regularly observed across Manobalai Nature Reserve and Crown Lands during recent DEC surveys, and has previously been recorded by other surveyors (Map 7). Within the study area, there are a number of *Allocasuarina* species known to occur including *A. verticillata*, *A. gymnanthera*, and *A. torulosa*. The latter species, commonly known as Forest Oak, appears to be preferentially targeted by the Glossy Black-cockatoo for feeding. In the Manobalai area this tree is restricted to sheltered slopes and gully sites, where it forms a component of the small tree layer. *Allocasuarina* cones that had been chewed by Glossy Black-cockatoos were found on the forest floor at many sites, and form the basis of many records. It is important to note that the birds have only been directly observed once in the Nature Reserve but fifteen times in the Crown Lands.

Manobalai Nature Reserve and Crown Lands are part of an extensive network of reserves that provide quality feeding habitat for the Glossy Black-cockatoo in the Sydney Basin Bioregion. The abundance of a number of different feed tree species, particularly in the southern portion of Crown Lands, underpins the value the area holds for the species.



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## TURQUOISE PARROT

### *Species Profile*

The Turquoise Parrot (*Neophema pulchella*) is a small, brightly coloured parrot, distinguished by its bright green upper parts, yellow under parts and blue face and shoulder patch. The male is considerably brighter than the female, and also has a red shoulder band. The bird usually occurs in pairs or small family parties in eucalypt woodlands and open forests that have a ground cover of grasses. It nests in tree hollows, and has a usual clutch size of two to five eggs (Higgins 1999). It is restricted to eastern Australia, where its range has contracted by over 50 percent since the 1890s (Garnett & Crowley 2000).

### *Threats*

Garnett and Crowley (2000) summarise the main threats as: past clearing for agriculture, which has greatly reduced the overall distribution of the species; predation by cats and foxes; loss of hollows that are used for nesting in managed forests; and inappropriate burning regimes that may favour a shrubby rather than a grassy understorey. Beak and Feather (Psittacine Circoviral Disease (PCD)) is not known from this species, but has been recorded in the congeneric Orange-bellied Parrot (*N. chrysogaster*) (DEH 2004a). The species may also be threatened by competition for nesting sites with introduced birds, such as the Common Myna (*Acridotheres tristis*) as well as feral Honeybees (*Apis mellifera*).



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### *Local and Regional Conservation Status*

The Turquoise Parrot is listed as Vulnerable under the NSW TSC Act (1995). The number of records is highest in the Sydney Basin Bioregion and along the western slopes (Nandewar, Brigalow Belt South and NSW South West Slopes Bioregions) (DEC 2005a). In the Sydney Basin Bioregion, the species is most commonly found within dry grassy woodland environments that are prominent in the Hunter and Capertee Valleys and to a lesser extent the Cumberland Plain. Important conservation reserves for this species in this Bioregion include Wollemi, Yengo and Goulburn River National Parks, Munghorn Gap Nature Reserve and Yerranderie State Conservation Area.

The Turquoise Parrot has not been recorded within vegetation on the sandstone plateau found across much of Manobalai Nature Reserve and adjoining Crown Lands. This species is most prevalent in open dry grassy woodlands and areas of fragmented and scattered tree cover, where it is commonly observed on the ground feeding on grass seed. Alluvial flats and small basalt caps offer the only areas of primary habitat in the study area. There are four records of the Turquoise Parrot in the Manobalai area, two of which occur at Webbs Creek in the southern portion of Crown Land (Map 8). Other records occur near Wybong in open country and in similar habitat near Myambat Defence Lands, as well as in north-eastern Wollemi National Park (DEC 2005b). Recent DEC surveys in the Manobalai area did not record the Turquoise Parrot.

Large amounts of Turquoise Parrot habitat within the Hunter Valley have been cleared in the past for agriculture or are still under threat from urban development and expansion of mining activities. Vegetation communities within Manobalai Nature Reserve are likely to provide secondary resources for the species. Larger alluvial flats associated with the Crown Land to the south are likely to offer more suitable habitat and may make an important contribution to the local and regional conservation of the species.

## BARKING OWL

### Species Profile

The Barking Owl (*Ninox connivens*) is an owl of intermediate size between the larger Powerful Owl (*N. strenua*) and the Southern Boobook (*N. boobook*). It has dark brown upper-parts and a white underbody with coarse brown streaking (Higgins 1999). It is often identified by its call, which is a distinctive, dog-like barking that can be confused with Fox (*Vulpes vulpes*) or Dog (*Canis lupus*) barks. It usually inhabits dry open eucalypt forests and woodlands, where it is associated with hydrological features such as rivers and swamps (Taylor *et al.* 2002a). It nests in hollows, usually of large eucalypts, where it lays one to three eggs. It is an opportunistic feeder, eating more insects than other large forest owls, but consumes small terrestrial and arboreal mammals and birds during the breeding season. The race *connivens* occurs east of a line connecting Cooktown (Queensland) and the Flinders Ranges (South Australia) with an isolated population in the south west of Western Australia. Other races occur across northern Australia, in New Guinea and the Moluccas (Indonesia) (Higgins 1999).



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### Threats

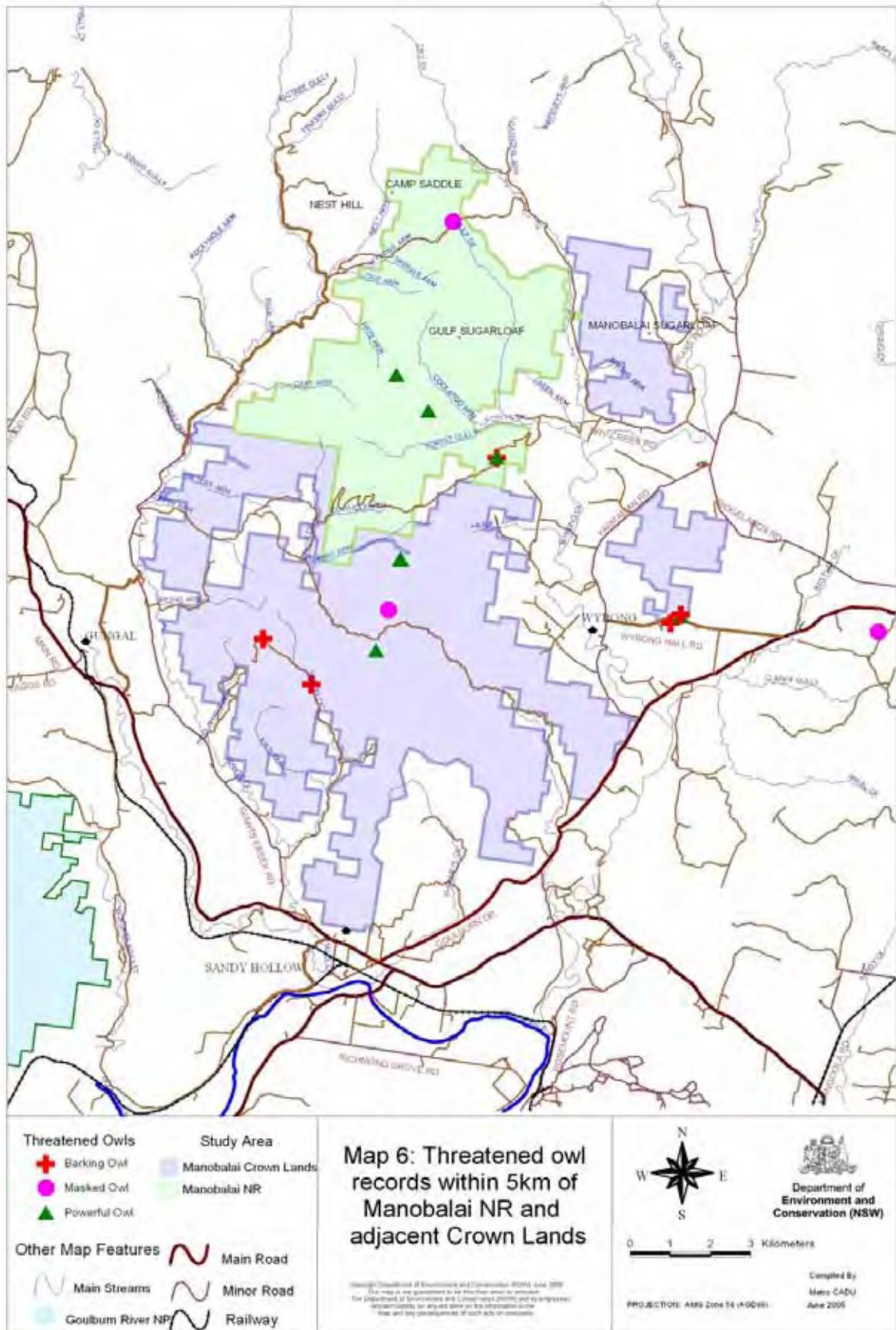
The main identified threat to the species is habitat destruction, particularly the removal of woodlands and forests from more low-lying fertile areas for agriculture (Taylor *et al.* 2002b). Remaining habitat is also subject to further degradation through forestry and collection of firewood, which often involves the removal of large hollows. However, the owl is frequently located at the edge of forest blocks adjacent to cleared land, possibly due to increased prey availability at such locations (Taylor *et al.* 2002b). The owl may also suffer some competition for nest sites from feral Honeybees (*Apis mellifera*) (Garnett and Crowley 2000). The long generation time (ten years) means that the species may take a long time to recover after suffering a decline (NSW Scientific Committee 1998b). NPWS (2003d) also lists predation, particularly of fledglings, mortality from collisions with fences and vehicles, and secondary poisoning from rodenticides as threats.

### Local and Regional Conservation Status

The Barking Owl is listed as Vulnerable under the NSW TSC Act (1995). Records occur throughout NSW, though it is rarer in the far west and at higher altitudes in the south-east (DEC 2005a). Records are scattered throughout the Sydney Basin Bioregion, though important locations appear to be the Capertee Valley, Hunter Valley and to a lesser extent the Cumberland Plain. Very few records occur within the Sydney sandstone reserves (DEC 2005a).

Barking Owls have been recorded at four locations, one within Manobalai Nature Reserve and three in adjoining Crown Lands (Map 6). The 2004-05 DEC surveys achieved positive responses at two call playback sites, one on Melon Creek and the other on Clayhole Arm track. Each of these locations is within dry woodland vegetation, either on creek flats or lower slopes, which is typical of the species habitat preferences. Similar patterns in habitat use were noted in the northern sections of Wollemi National Park (DEC 2005b). These recent surveys in dry alluvial forests in reserves are revealing that the western Hunter Valley supports reasonable habitat for the Barking Owl, although it clearly persists in low abundance.

The Barking Owl may never have been common at the southern end of its range, though it was once more widespread in dry open eucalypt forests and woodlands in the Hunter Valley, however its preferred habitat has been widely depleted by clearing for agriculture, industry and settlements. This species is now genuinely rare in the Sydney Basin Bioregion and any localities have high conservation significance. Management of the owl in the region should be undertaken in accordance with the state-wide recovery plan (currently in draft form, NPWS 2003d). Existence of this species highlights the conservation importance of the Manobalai Crown Lands.



**Map 6: Threatened owl records within five kilometres of Manobalai Nature Reserve and adjacent Crown Lands**

## POWERFUL OWL

### *Species Profile*

The Powerful Owl (*Ninox strenua*) is the largest owl in Australia and is distinguished by its relatively small, round head and long tail. It is dark brown above with prominent off-white barring, and paler underneath with diagnostic dark chevrons. It inhabits various forest habitats, though it usually breeds and roosts in dense forest types, including rainforest and wet sclerophyll forest. It hunts in more open forests, where it feeds mainly on arboreal mammals, particularly Common Ringtail Possums (*Pseudocheirus peregrinus*) and Greater Gliders (*Petauroides volans*) (Kavanagh 2002). This owl usually nests in a hollow in eucalypts within or below the canopy, and normally lays two eggs. They usually maintain a territory of between 300 and 1500 hectares, with size dependent on habitat quality and prey density. The species is endemic to eastern Australia, being recorded between Eungella (Queensland) to near the South Australia-Victoria border (Higgins 1999).



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### *Threats*

Past land clearance for agriculture has reduced the area of habitat available for the Powerful Owl (Garnett and Crowley 2000), particularly the availability of nest sites. The owl can, however, survive in areas with some levels of disturbance, such as in selectively logged forests (Kavanagh 1997) and suburban areas of Brisbane, Sydney and Melbourne (Garnett and Crowley 2000, DEC 2004a). Two of the determining factors for the species persistence in disturbed areas is the presence and suitable abundance of prey species (Chafer 1992) and nesting/roosting sites (Debus and Chafer 1994).

### *Local and Regional Conservation Status*

The Powerful Owl is listed as Vulnerable under the NSW TSC Act (1995). The majority of records occur within the three coastal Bioregions, but occasional sightings have also been made further west, particularly in the South Eastern Highlands Bioregion. It occurs throughout the Sydney Basin Bioregion across extensive areas from the rural-urban fringes of the Sydney Metropolitan area to west of the Dividing Range into the Central Tablelands. Most reserves within this latter Bioregion support known territories of this species. Recent work within the Sydney Catchment Authority Special Areas (Metropolitan and Warragamba) has found Powerful Owls to be at higher densities and more widespread within the sandstone country of the Sydney Basin than previously thought (DEC 2005e).

The Powerful Owl has been recorded three times within Manobalai Nature Reserve and three times in the adjoining Crown Lands (Map 6). Evidence of the species has been collected through the identification of roost sites, direct observation and response to call playback. Playback surveys have achieved only a single positive response from the 21 sites surveyed. Powerful Owls are likely to occur only in low abundance in the area, with the highest chance of detection likely in taller forests along gully lines and alluvial flats. Gully lines or tall forests are essential components of a Powerful Owl's home range for both foraging and roosting.

These results indicate that while the species is a wide ranging habitat generalist, relative to other localities in the Sydney Basin, the habitat within the Manobalai area is not of particularly high quality for the Powerful Owl. Management of the owl in the region should be undertaken in accordance with the state-wide recovery plan (currently in draft form, DEC 2005f).

## MASKED OWL

### *Species Profile*

The Masked Owl (*Tyto novaehollandiae*) is a large 'barn' owl, which has three colour morphs (with intermediates), but is distinguished from the similar Barn Owl (*T. alba*) by its larger size, more thickset and hunchbacked appearance, fully feathered legs and larger feet (Higgins 1999). It inhabits a wide range of woodland habitats with large hollows for roosting and open areas for hunting. It feeds mostly on ground-dwelling mammals, such as rats (*Rattus* sp.) and Antechinus (*Antechinus* sp.), and occasionally on diurnal birds, Sugar Gliders (*Petaurus breviceps*) and insects. The owl has a home range of 800 to 1200 hectares (Kavanagh 2002). It nests in hollow trees, usually eucalypts, where two to three eggs are the normal clutch size (Higgins 1999). The nominate subspecies *novaehollandiae* was formerly found around the southern coast of Australia between Fraser Island (Queensland) and Carnarvon (Western Australia), though its range has contracted, particularly in Western Australia (Garnett and Crowley 2000). Other subspecies occur in Tasmania, northern Australia and in New Guinea and adjoining islands, some of which are sometimes considered separate species (Higgins 1999).

### *Threats*

Clearance of native forest for agriculture and urban development, and the resulting fragmentation of habitat, has negatively affected the abundance of Masked Owls (Kavanagh 2002, Garnett and Crowley 2000). The species does not persist within fragments of forest less than 200 hectares (Kavanagh 2002). The owl may be affected by logging, through removal of hollows or reduction in foraging habitat due to vigorous regrowth (Garnett and Crowley 2000), though it has been suggested that modern mosaic logging operations do not cause major changes to the abundance of the species (Kavanagh 2002).

### *Local and Regional Conservation Status*

The Masked Owl is listed as Vulnerable under the NSW TSC Act (1995). Most records for the species in NSW are located in the NSW North Coast, Sydney Basin and South East Corner Bioregions, with a few scattered records west of the Divide (DEC 2005a). Within the Sydney Basin Bioregion, records are concentrated in the south, the central coast and to a lesser extent across the southern Blue Mountains. Records are scattered within a number of DEC reserves, including Royal, Blue Mountains, Nattai, Kanangra-Boyd, Brisbane Water and Dharug National Parks and Berowra Valley Regional Park (DEC 2005a).

Masked Owls have been heard calling at two sites, one within Manobalai Nature Reserve and the other within the Crown Land to the south (Map 6). However, the recent DEC surveys did not achieve a single positive response from the 21 systematic call playback sites undertaken across the Manobalai area. While the species is occasionally recorded in similar habitats (dry open forests and woodlands) in Wollemi National Park to the south (DEC 2005b) it is certainly uncommon. Our survey results suggest that some of the records for this species in the area may be misidentifications of the similar sounding Barn Owl, a species commonly encountered during recent surveys.

The Central Coast and Hunter Valley support the most significant Masked Owl population remaining in the Sydney Basin Bioregion. The area is under heavy pressure from urban and industrial development, which threatens much of the remaining primary habitat for the species. Localities within reserves will become increasingly important to the survival of the species, and though Manobalai Nature Reserve and Crown Lands may only support low densities and relatively marginal habitat quality, it is important to the long term conservation of the species in the region. Management of the owl in the region should be undertaken in accordance with the state-wide recovery plan (currently in draft form, DEC 2005f).

## BROWN TREECREEPER (EASTERN SUBSPECIES)

### Species Profile

The Brown Treecreeper (*Climacteris picumnus*) is a medium-sized brown bird that is superficially similar in appearance to the Red-browed (*C. erythroptus*) and White-throated (*Cormobates leucophaeus*) Treecreepers. It is distinguished from both by its slightly larger size, distinctive pale supercilium (eyebrow stripe) and by call. It is typically a bird of eucalypt woodlands with a grassy or open shrub understorey and abundant fallen timber and/or dead trees. Unlike most treecreepers, the species spends approximately half of the time on the ground feeding on insects, particularly ants and beetles, taken from live and dead trees, fallen branches and off the ground. It occurs in pairs or small groups in permanent territories where tree hollows are utilised for breeding (Higgins *et al.* 2001). The eastern subspecies (*victoriae*) occurs along the coast and ranges in Victoria, New South Wales and south-east Queensland, with the other two subspecies occurring either further west (*picumnus*) or further north (*melanotus*) (Schodde and Mason 1999).



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### Threats

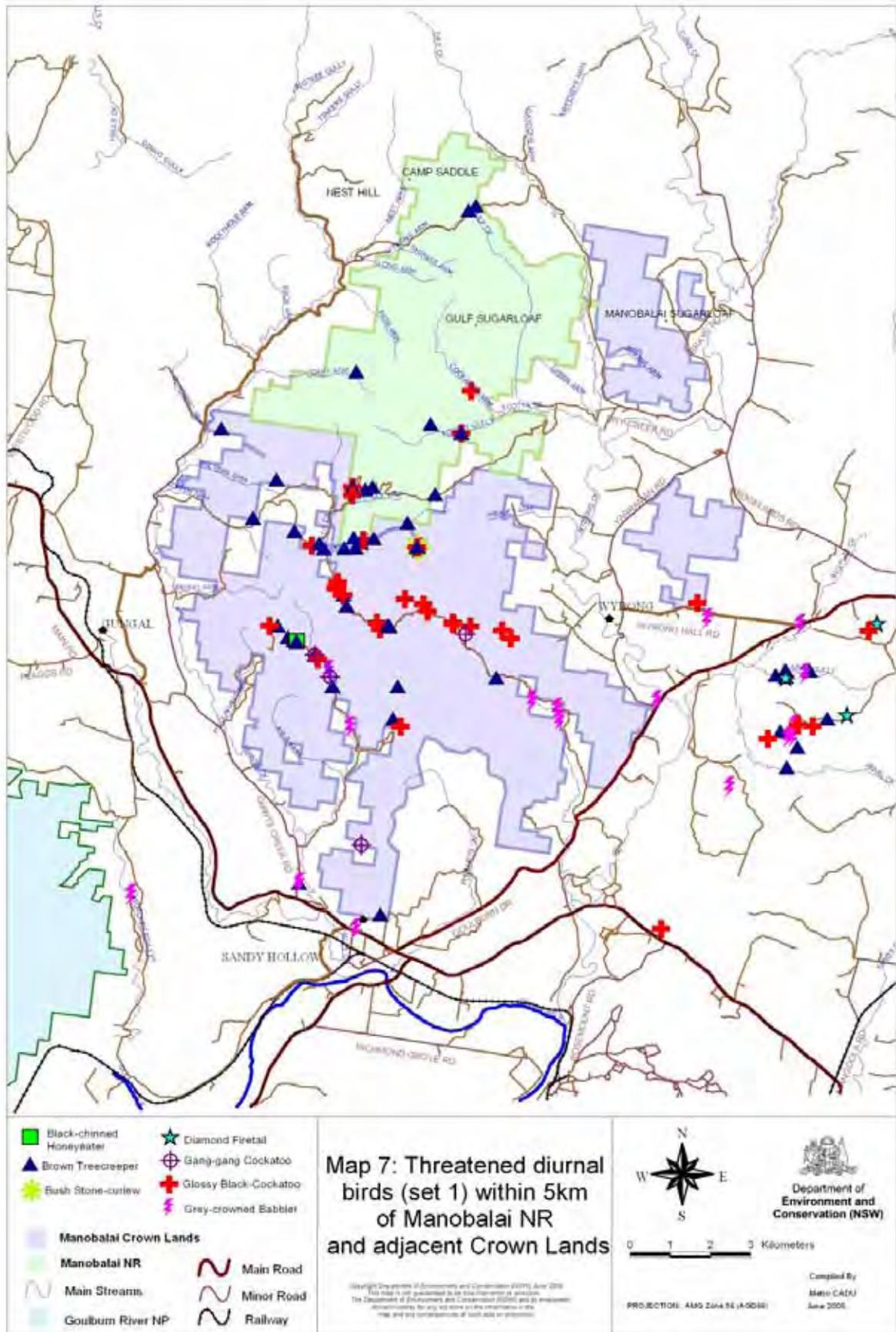
The eastern subspecies of the Brown Treecreeper is one of a suite of woodland birds that have declined throughout their range due to habitat clearance (Reid 1999). Traill and Duncan (2000) stated that the population was estimated to have declined by at least twenty percent in the last fifteen years. Studies have shown that populations can not persist in habitat fragments smaller than 300 hectares, mostly because females either disperse or suffer from preferential mortality. As with most treecreepers, once extinction occurs in a vegetation remnant, natural recolonisation is unlikely (Garnett and Crowley 2000). The lack of hollows may also be the limiting factor as the species is known to compete with introduced species like the Common Starling (*Sturnus vulgaris*) (Higgins *et al.* 2001) Common Myna (*Acridotheres tristis*) and European Honeybee (*Apis mellifera*) (NSW Scientific Committee 2001a). Grazing also has impacts by decreasing the diversity of ground-dwelling invertebrates, which reduces the levels of food availability (NSW Scientific Committee 2001a).

### Local and Regional Conservation Status

The eastern subspecies of the Brown Treecreeper is listed as Vulnerable under the NSW TSC Act (1995). Though it is found through all the eastern Bioregions in New South Wales, it is least common in the South East Coast and Australian Alps, and has declined significantly within the Sydney Basin and NSW North Coast. Within the Sydney Basin Bioregion, the species is restricted to open woodlands of the central tablelands and open coastal plains and valleys such as the Capertee and Hunter Valleys and the Cumberland Plain (DEC 2005a). These environments are all characterised by agricultural and urban clearing with small isolated fragments of native vegetation common. The species has virtually disappeared from the Cumberland Plain in the last 30 years (NSW Scientific Committee 2001a, DEC 2005a). Habitat for the species is contained within a limited number of reserves within the Sydney Basin Bioregion, including Yerranderie State Conservation Area, Nattai National Park (Burrangorang and Nattai Valleys), Blue Mountains, Wollemi and Goulburn River National Parks.

DEC surveys recorded Brown Treecreepers at a total of 36 locations (13 in the Nature Reserve and 23 in the Crown Lands), while they have been recorded five times by other surveyors. The species is most regularly observed within the dry woodlands that occupy creek flats and lower escarpment slopes in the southern half of the study area, though it has twice been seen in the Spotted Gum – Ironbark Forests along the Diamond Ridge Firetrail (Map 7). The species has also frequently been recorded at Anvil Hill (DEC 2005a).

Little of the Brown Treecreeper habitat remaining within the Hunter Valley area is located within public lands or reserves, so the extent of habitat included within the study area has high conservation significance and is important to the continued regional conservation of the subspecies.



**Map 7: Part 1 of threatened diurnal bird records within five kilometres of Manobalai Nature Reserve and adjacent Crown Lands**

## SPECKLED WARBLER

### *Species Profile*

The Speckled Warbler (*Pyrrholaemus sagittata*) is a small, primarily ground-dwelling bird. It is similar in size and shape to the Buff-rumped Thornbill (*Acanthiza reguloides*) but can be identified by its boldly streaked underbody, distinctive facial pattern, noticeably longer tail and distinctive call. The female differs from the male by having a chestnut, rather than black, streak in the eyebrow. It usually occurs in the grassy understorey or low shrubs of dry sclerophyll forests and woodlands dominated by eucalypts. It feeds on insects and seeds with most foraging occurring on the ground. Pairs, and occasionally trios, live permanently in large (up to twelve hectares) territories where a well-concealed domed nest is built on the ground in grass tussocks. Two to four (usually three) eggs are laid, though breeding success can be low.



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The Speckled Warbler is endemic to south-eastern Australia, being found between Maryborough (Queensland) and the Grampians (Victoria) (Higgins and Peter 2002).

### *Threats*

The Speckled Warbler is one of a number of woodland birds that has declined in density throughout its range due mainly to agricultural land clearing (Reid 1999). Speckled Warbler populations are estimated to have declined by at least twenty percent in the last fifteen years (Traill & Duncan 2000). Small isolated patches may result in local extinction due to natural fluctuations (Garnett & Crowley 2000) with extinction occurring in areas with no patches over 100 hectares (NSW Scientific Committee 2001b). The species nests and forages on the ground and hence is susceptible to predation by exotic mammalian predators, loss of ground cover by stock and rabbit grazing, weed invasion (NSW Scientific Committee 2001b, Garnett & Crowley 2000) and inappropriate fire regimes.

### *Local and Regional Conservation Status*

The Speckled Warbler is listed as Vulnerable under the NSW TSC Act (1995). It is widespread in the eastern Bioregions of the state, extending as far west as the Cobar Peneplain, but is scarce or absent from the South East Coast and Australian Alps. Within the Sydney Basin Bioregion most records are in areas supporting dry woodlands, including the Burratorang Valley, lower Hunter Valley and Goulburn River Valley. Habitat is present within a limited number of reserves in the Sydney Basin Bioregion including, in addition to Manobalal, northern Wollemi National Park, Nattai and Goulburn River National Parks and Munghorn Gap Nature Reserve (DEC 2005a).

The Speckled Warbler has been commonly recorded across the Manobalal area in a wide range of vegetation types (Map 8). The 2004-05 DEC surveys identified this species at 20 localities, including seven in the Nature Reserve and thirteen in the Crown Lands. The species demonstrates a preference for the open Box-Red Gum-Ironbark Woodland on creek flats and lower escarpment slopes, particularly where these areas retain a shrubby understorey. Habitat for the Speckled Warbler would once have spread across the valleys that border the park, but is now restricted to patches of remnant woodland. The species has been recorded in such remnants to the south and east of the study area (Map 8).

The Manobalal Nature Reserve and adjoining Crown Land offers high quality habitat for the species. Habitat within the Manobalal area is of local and regional conservation significance as the majority of habitat elsewhere in the Hunter Valley remains threatened by agricultural, industrial and urban development.

## PAINTED HONEYEATER

### *Species Profile*

The Painted Honeyeater (*Grantiella picta*) is a small to medium sized bird (16cm length) with yellow edging to the flight feathers and a distinctive pink bill. Males exhibit black and white plumage and dark streaks on the flanks, while females are smaller, browner birds with no flank streaks (ACT Government 1999, DEC 2005f, Simpson & Day 1996). It is a specialist feeder, foraging almost exclusively on mistletoes of the genus *Amyema*, although it will also take some nectar and insects (ACT Government 1999, Garnett & Crowley 2000). It inhabits dry forests and woodlands, and prefers Boree, Brigalow and Box-Gum Woodlands and Box-Ironbark forests (ACT Government 1999, DEC 2005g, Oliver *et al.* 2003). It exhibits a sparse distribution from south-eastern Australia to north-western Queensland and eastern Northern Territory. The greatest concentrations and almost all breeding records occur on the inland slopes of the Great Dividing Range in Victoria, NSW and southern Queensland (ACT Government 1999, DEC 2005, Garnett and Crowley 2000, Oliver *et al.* 2003). Nomadic movements throughout both breeding and non-breeding seasons have been attributed to the fruiting of mistletoes and abundance of rainfall (Keast 1968, Pizzey and Knight 1999). However, extent of vegetation is also important, with birds more likely to be found in wider blocks of Box-Ironbark woodland than in remnant strips, such as occur in windbreaks and along roadsides (Robinson 1994).

### *Threats*

The main identified threats to the Painted Honeyeater are associated with habitat removal, modification and isolation, particularly the Box-Ironbark and Boree woodlands (Garnett and Crowley 2000). Much of the habitat used during the breeding season has been disturbed, through the clearing of woodlands and open forests, the removal of large trees with heavy mistletoe infestations and inappropriate fire regimes. Non-breeding habitat also continues to be cleared for purposes of agriculture and urban development. Heavy grazing and other agricultural practices such as pesticide and fertiliser application have also been noted as likely to impact on honeyeater habitat and populations (ACT Government 1999, DEC 2005f, Garnett and Crowley 2000).

### *Local and Regional Conservation Status*

The Painted Honeyeater is listed as Vulnerable under the NSW TSC Act (1995). Records for the species are sparsely scattered through the centre of NSW, with concentrations in the Cobar Penneplain, Darling Riverine Plain and NSW South West Slopes Bioregions (DEC 2005a). Within the Sydney Basin Bioregion, records are concentrated between Sydney, Newcastle and Mudgee, particularly around the Hunter Valley (DEC 2005a). The species is very poorly represented in reserves in the Bioregion, having been recorded in Munghorn Gap Nature Reserve, southern Wollemi NP and at the boundary of Goulburn River National Park (DEC 2005a).

The Painted Honeyeater has not definitely been recorded within Manobalai Nature Reserve or adjoining Crown Lands but a spatially inaccurate record was collected by Birds Australia in 1979 and it was seen in 2002 near Wybong, less than 200 metres to the south of the south-eastern portion of Crown Land (Map 8). Painted Honeyeaters are one of a large group of birds that make use of dry open grassy woodlands along creeks and valley flats that support River Oak (*Casuarina cunninghamiana*) with mistletoe. These birds are very rarely recorded in the Hunter Valley and appear when mistletoe or eucalypt species are in heavy flower. As a nomadic species it is likely to be an irregular visitor to the study area, making use of open creek valleys such as Reedy and Melon Creek within the southern portion of Manobalai Crown Lands.

Vegetation clearance has destroyed a large amount of Painted Honeyeater habitat and much of the remaining habitat is fragmented and continues to be degraded or under pressure from development. Thus even though the species may only visit the park on occasion, the area could be important to the survival of the species east of the Great Dividing Range in NSW. Conservation strategies are difficult for a highly mobile species such as this, but measures taken to protect suitable habitat for the suite of declining woodland birds that do occur in the study area are likely to be beneficial to the Painted Honeyeater as well.

## BLACK-CHINNED HONEYEATER (EASTERN SUBSPECIES)

### *Species Profile*

The Black-chinned Honeyeater (*Melithreptus gularis*) is a small, rather stocky and short-tailed honeyeater. It is distinguished from other *Melithreptus* honeyeaters by its relatively larger size, bright blue or jade green eye-wattle and distinctive call. It occupies dry eucalypt woodlands that feature Ironbark and/or Box species with low to moderate rainfall levels, where they are usually found in pairs or small groups of up to twelve. They feed on insects, nectar and lerp usually in the upper canopy and outermost flowers and leaves. There are two subspecies which have in the past been named as two separate species. The eastern, nominate subspecies (*gularis*) is found along the inland slopes of the Great Dividing Range, extending to the coast in the Sydney Basin and Clarence River Valley of NSW, and again between Brisbane and Rockhampton, Qld, as well as westward into south-eastern South Australia. The 'Golden-backed Honeyeater' (*laetior*) is widespread across northern Australia (Higgins *et al.* 2001).

### *Threats*

The eastern subspecies of the Black-chinned Honeyeater is one of a suite of woodland birds that have declined throughout their range due to habitat clearance (Reid 1999). They are threatened by clearance and the fragmentation of woodland habitat and don't appear to survive in remnants less than 200 hectares (NSW Scientific Committee 2001c). The species appears to occur naturally at low densities (NSW Scientific Committee 2001c) and is relatively mobile, so the reason for this absence in small fragments is unknown (Garnett & Crowley 2000). They are also likely to experience high levels of competition from aggressive honeyeater species associated with smaller fragments and may suffer increased nest predation from such species as Pied Currawongs (*Strepera graculina*) (NSW Scientific Committee 2001c).

### *Local and Regional Conservation Status*

The eastern subspecies of the Black-chinned Honeyeater is listed as Vulnerable under the NSW TSC Act (1995). Scattered records for this species occur in the eastern half of the state, though the highest number of records are in the Nandewar, Sydney Basin and NSW South West Slopes Bioregions. In the Sydney Basin region most records come from drier areas such as the Capertee and Hunter Valleys and western Sydney. All of these areas have been heavily cleared in the past and remain subject to ongoing threatening processes. Most of the records for the species are outside of DEC reserves. However, it has been recorded in a small number of reserves, notably Goulburn River and Werakata National Parks and Munghorn Gap Nature Reserve (DEC 2005a), as well as northern Yengo and northern Wollemi National Parks (DEC 2005b, DEC 2005c).

The Black-chinned Honeyeater was recorded in the Manobalai area for the first time during recent DEC surveys, heard calling at the headwaters of Melon Creek (Map 7). This highly nomadic honeyeater is rare, with no records obtained from any of the 66 systematic bird censuses conducted across the study area. Suitable habitat for the Black-chinned Honeyeater is restricted to major creeklines of the southern Crown Land and the headwaters of minor creeks that indent the perimeter of the sandstone plateau.

Habitat for this species would once have been widespread within the valleys of the Hunter and Goulburn Rivers. These areas have been extensively cleared for agriculture, industry and settlements and as a result habitat is now largely restricted to remnant vegetation along creeklines and lower escarpment slopes. Many fragments in the Hunter and Goulburn River Valleys are still under threat from development. The protection of Black-chinned Honeyeater habitat within Manobalai Nature Reserve and adjoining Crown Land has high local and regional conservation significance and, together within neighbouring National Parks (particularly Goulburn River, Yengo and Wollemi National Parks) is vital to the ongoing survival of the species east of the Great Dividing Range.

## REGENT HONEYEATER

### *Species Profile*

The Regent Honeyeater (*Xanthomyza phrygia*) is a medium-sized honeyeater with a striking black and yellow plumage. It typically favours box-ironbark woodland, though it also utilises River Oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*) Forests and coastal habitats such as Swamp Mahogany (*Eucalyptus robusta*) or Spotted Gum (*Corymbia maculata*). The species is semi-nomadic and seems to undertake complex movements, generally dependent on where flowering food trees are available. It feeds mainly on nectar, and nests in the crown of eucalypts where it usually lays two or three eggs. It is endemic to south-eastern Australia, formerly between Rockhampton (Queensland) and Adelaide, though it is now rare in Queensland and probably extinct in South Australia, with a general contraction of range in the other two states (Higgins *et al.* 2001). There is thought to be only a single population of approximately 1,500 individuals of this species remaining, with numbers considered to be still decreasing (Garnett and Crowley 2000).



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### *Threats*

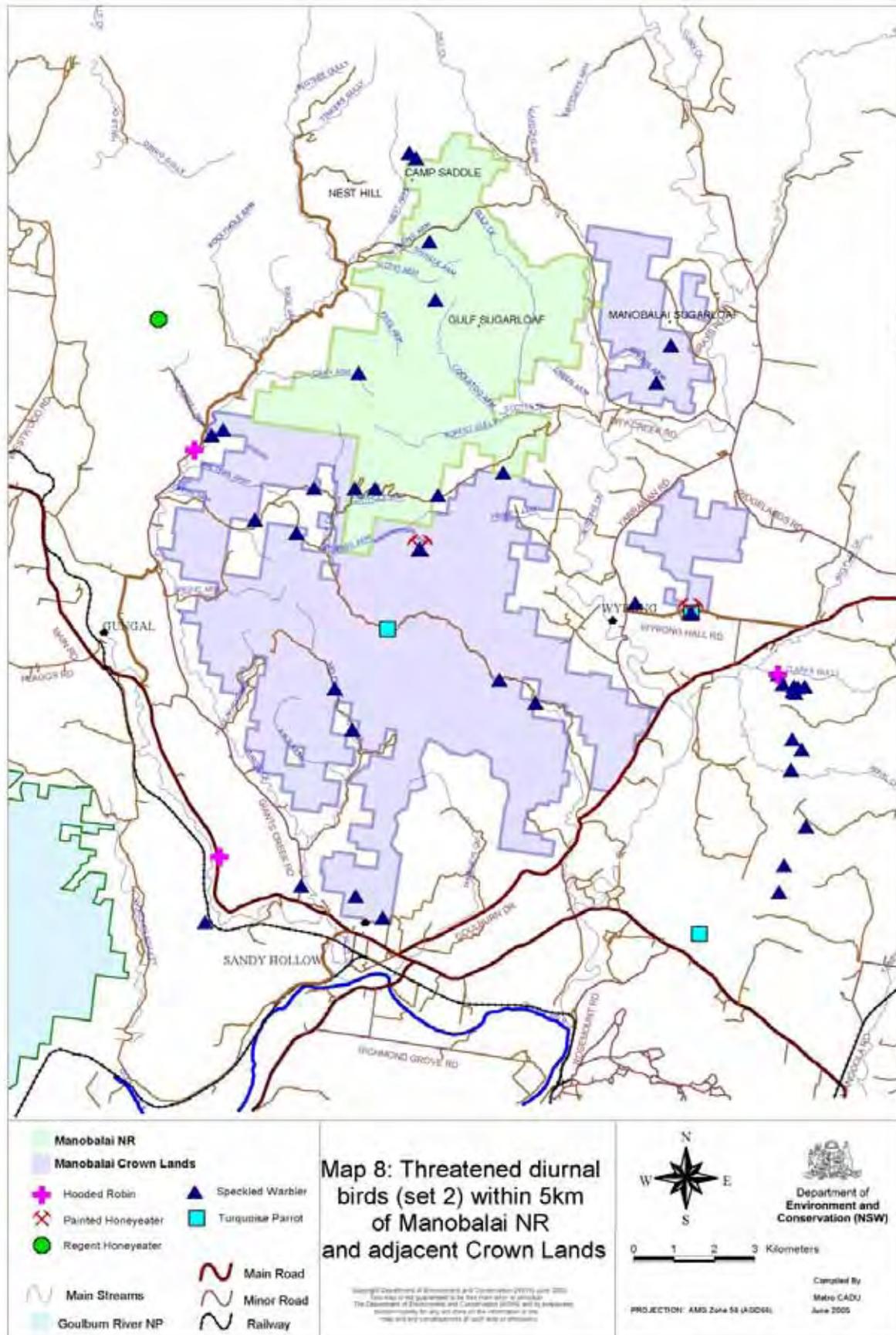
Land clearance for agriculture has removed about three-quarters of the suitable habitat of the Regent Honeyeater. The remaining vegetation is fragmented, and is still being affected by the removal of larger trees. Grazing by domestic stock and rabbits prevents habitat regeneration (NPWS 1999b). Habitat alteration may also advantage more aggressive honeyeaters, such as miners (*Manorina* spp.) and friarbirds (*Philemon* spp.) with resulting competition.

### *Local and Regional Conservation Status*

The Regent Honeyeater is listed as Endangered under the NSW TSC Act (1995) and as Endangered under the Commonwealth EPBC Act (1999). Compiling reliable accounts of the species occurrence was one of the priorities of the Draft Regent Honeyeater Recovery Plan (Menkhorst *et al.* 1999) and so a number of records are included in the Atlas of NSW Wildlife. Records are concentrated in the eastern third of the state, with the greatest number in the Sydney Basin, Nandewar and New England Tableland Bioregions. Important areas in the Sydney Basin appear to be the Capertee and lower Hunter Valleys, the northern Cumberland Plain and the Central Coast. The species is primarily observed outside of reserves, although a small number of parks are regularly used, including Goulburn River and Nattai National Parks and Cockle Bay and Munghorn Gap Nature Reserves (DEC 2005a).

Regent Honeyeaters have never been recorded within Manobalai Nature Reserve or adjoining Crown Lands, however a single record exists at Ravens Nest about four kilometres to the west of the Nature Reserve (Map 8). Habitats present across the study area conform to those known to be used by this rare honeyeater in Goulburn River and Wollemi National Parks. A number of preferred feeding trees including Mugga Ironbark (*E. sideroxylon*), Spotted Gum (*Corymbia maculata*) and Blakely's Red Gum (*E. blakelyii*) feature within a number of widespread vegetation communities. The absence of records may result from the fact that survey effort has not been undertaken in this difficult to access area at times when these tree species are flowering. A targeted survey within the Spotted Gum community of the Nature Reserve and Crown Lands is warranted during periods of winter flowering. This tree species is known to provide an over-wintering resource further east in the lower Hunter Valley.

As vegetation clearance has destroyed about 75 per cent of the Regent Honeyeater's habitat across its former range (Garnett & Crowley 2000) and large amounts of the remaining habitat are fragmented and continue to be degraded, the preservation of potential habitat within the Reserve and Crown Lands is important to the national conservation effort for the species. If positive identifications of the Regent Honeyeater are recorded they should be reported to the Recovery Plan Coordinator.



**Map 8: Part 2 of threatened diurnal bird records within five kilometres of Manobalai Nature Reserve and adjacent Crown Lands**

## HOODED ROBIN (SOUTH-EASTERN SUBSPECIES)

### *Species Profile*

The Hooded Robin (*Melanodryas cucullata*) is a medium-sized bird that typically occurs in eucalypt woodland or *Acacia* shrubland. The adult male is distinctive, having a black hood and upper body combined with a white shoulder stripe. The adult female is mostly grey with a dark-brown wing. Both sexes have a white wing stripe and underparts and a prominent white side-panel on the tail, which along with their larger size and call, distinguish this species from the Jacky Winter (*Microeca fascinans*) and female *Petroica* Robins. They utilise dead or fallen timber as perches, from which they pounce to feed mainly on insects and small lizards from the ground (Garnett and Crowley 2000). The species usually occurs as pairs, though cooperative breeding is also common, with normally two or three eggs laid in a cup-shaped nest placed in a horizontal fork (Higgins and Peter 2002). There are four subspecies covering most of Australia, with the two subspecies in New South Wales being *picata*, which extends from north-western NSW through to the Kimberleys in Western Australia, and the nominate (*cucullata*) which is south and east of this subspecies (between Queensland and South Australia) (Schodde and Mason 1999).

### *Threats*

The south-eastern subspecies of the Hooded Robin has been identified as one of a number of birds that have declined significantly in range and population in the sheep-wheat belt of central west NSW due to the degradation and fragmentation of woodland habitats (Reid 1999). Populations do not appear to persist even in large fragments of remaining habitat although the precise reason for this is as yet unknown (Garnett & Crowley 2000). Habitat modification and reduction of food availability through grazing by stock and weed invasion may also be a threat (NSW Scientific Committee 2001d). Eggs and young have been known to be predated on by native avian predators and possibly by Foxes (*Vulpes vulpes*) (Higgins & Peter 2002) and feral Cats (*Felis catus*).

### *Local and Regional Conservation Status*

The south-eastern subspecies of the Hooded Robin is listed as Vulnerable under the NSW TSC Act (1995). It has been recorded in most Bioregions in New South Wales, though is rare in the Australian Alps, South Eastern Highlands and Riverina Bioregions, and is restricted in the NSW North Coast Bioregion. Within the Sydney Basin Bioregion it is virtually restricted to the Hunter, Capertee and Burratorang Valleys where it is closely associated with the drier woodland habitats. It once occurred on the Cumberland Plain (DEC 2005a, Keast 1995) but has since disappeared. Within the Sydney Basin it has been recorded from a limited number of reserves including Wollemi, Nattai and Goulburn River National Parks and Munghorn Gap Nature Reserve, though most records are on the boundary of the reserves.

The Hooded Robin has not been positively recorded in Manobalai Nature Reserve or adjoining Crown Lands, although a spatially inaccurate Birds Australia record exists. Recent DEC surveys recorded this species on private tenure along Giants Creek, less than one kilometre west of the Crown Lands (Map 8). It is also known from Halls Creek and Clarks Gully to the south-west and east (Map 8). Suitable habitat is not present within the Nature Reserve, however larger alluvial flats in the Crown Land to the south offer potential habitat, particularly at the interface between cleared (or previously logged) and wooded lands. Hooded Robins have a tendency of perching on fences and dead trees, making them quite visible and easy to detect if present, thereby suggesting that they only occur in low numbers on these alluvial flats. However, the species has been described as a winter visitor to some areas of central eastern NSW (Higgins and Peter 2002), a time of year when few bird surveys are conducted and hence the species may go undetected. This could explain the lack of DEC records, as all DEC diurnal bird surveys were undertaken in the spring and summer. It is recommended that targeted surveys be undertaken within alluvial habitats in the study area to ascertain whether Hooded Robins survive here and if so to identify current key areas. Such surveys should be undertaken at intervals throughout the year, with a particular focus on the autumn and winter months.

It is important to note that the Hooded Robin has suffered declines in other parts of the Hunter Valley in recent years. Clearing for agriculture has reduced the once extensive habitat associated with major floodplains and valleys to isolated paddock trees and remnants of Box-Red Gum Woodland, with these areas largely on private tenure and poorly protected. Landholders should be encouraged to retain paddock trees (even if they are dead) and other perch sites for the species. The protection of dry woodlands on creek flats both on the reserve and on adjoining private lands will be important to the survival of the species within the region.

## GREY-CROWNED BABBLER (EASTERN SUBSPECIES)

### *Species Profile*

The Grey-crowned Babbler (*Pomatostomus temporalis*) is the largest of the four Australian babbler species, and the only one with a light-coloured crown. Other distinctive features are a long, decurved bill and a dark band that passes from the bill through the eye, giving it a “masked” appearance (DEC 2005g; Higgins and Peter 2002; Simpson and Day 1996). There are two subspecies in Australia, the nominate being *temporalis*, which occurs in eastern Australia from Cape York to north-east NSW then south and west through central NSW and Victoria to south-eastern South Australia (Higgins and Peter 2002). It is widespread on the inland slopes of the Great Dividing Range in NSW and on the western plains. Grey-crowned Babblers live in open forest and woodland, *Acacia* shrubland and adjoining farmland, preferring Box-Gum woodlands on slopes and Box-Cypress and open Box woodlands on alluvial plains (DEC 2005g, Garnett and Crowley 2000). They feed on invertebrates gleaned from vegetation or the ground (DEC 2005g, Garnett and Crowley 2000). The birds form family parties, consisting of a breeding pair and offspring from prior breeding years, which are thought to be vital for predator avoidance and cooperative feeding of the young (King 1980).

### *Threats*

The Grey-crowned Babbler has been identified as one of a number of birds that have declined significantly in range and population in the sheep-wheat belt of central west NSW due to the degradation and fragmentation of woodland habitats. (Reid 1999). Remaining Babbler habitat occurs in isolated fragments throughout its range, from which they gradually disappear (Garnett and Crowley 2000). This disappearance has been attributed to the consequences of habitat fragmentation on family-group sizes and the resulting reduction in breeding success and higher rates of nest predation (DEC 2005g, Garnett and Crowley 2000, NSW Scientific Committee 2004c). Once lost from a habitat fragment, natural recolonisation is unlikely (Robinson and Traill 1996). Agricultural practices, such as grazing and associated weed invasion also pose a threat, as does increased competitor abundance in disturbed habitats, removal of important feeding sites such as logs and fallen timber from habitat remnants, as well as Cat predation.

### *Local and Regional Conservation Status*

The eastern subspecies of the Grey-crowned Babbler is listed as Vulnerable under the NSW TSC Act (1995). It is most common in the central western Bioregions of NSW, particularly the NSW South Western Slopes and Brigalow Belt South, but also occurs in the NSW North Coast Bioregion such as in the Clarence River Valley (DEC 2005a). Within the Sydney Basin Bioregion the species is largely restricted to the Hunter Valley, with a few records also in the Capertee Valley, where it is closely tied to the drier woodland habitats. Within the Bioregion it is poorly represented in reserves, having been recorded, in addition to Manobalai, in Goulburn River, Yengo, Wollemi and Werakata National Parks and Munghorn Gap Nature Reserve (DEC 2005a).

The Grey-crowned Babbler was recorded on six occasions during recent DEC surveys (Map 7). These locations are restricted to alluvial forests and remnant vegetation of the southern Manobalai Crown Land along Reedy and Melon Creek. The species has not been recorded within the Nature Reserve itself, as the vegetation present on the sandstone plateau does not provide suitable habitat. This bird is dependent to the drier open woodland habitats and are now most commonly observed in the mosaic of forested and cleared country. The small alluvial valleys that descend from the plateau along the edge of the Nature Reserve and Crown Land provide the best habitat, and the Grey-crowned Babbler would be expected to occur in many of them. The species has also been in recorded in remnant woodland east and south of the study area (Map 7).

Habitat for this species would once have been widespread within the valleys of the Hunter and Goulburn Rivers. These areas have been extensively cleared for agriculture, industry and settlements and as a result habitat is now largely restricted to remnant vegetation along creeklines and lower escarpment slopes. Many fragments in the Hunter and Goulburn River Valleys are still under threat from further development. The protection of Grey-crowned Babbler habitat within Manobalai Crown Lands therefore has high local and regional conservation significance and, together within neighbouring National Parks is important to the ongoing survival of the species east of the Great Dividing Range in central NSW.

## DIAMOND FIRETAIL

### *Species Profile*

The Diamond Firetail (*Stagonopleura guttata*) is an attractive finch, which is distinguished by its bold black breast band and white-spotted black flanks. The eye, beak and rump are red, with the latter contrasting strongly with the black tail in flight (Pizzey and Knight 1999). It is most frequently encountered in Eucalypt dominated communities that have a grassy understorey, where it feeds mainly on grass seeds (Garnett and Crowley 2000). They are usually encountered in pairs, though are known to form small flocks in autumn, winter and early spring. They build bottle-shaped nests in trees or sometimes mistletoe and usually produce four to six eggs (Pizzey and Knight 1999). The species is endemic to south-eastern Australia, with records extending from Rockhampton (Queensland) to the Eyre Peninsula and Kangaroo Island (South Australia) (Pizzey and Knight 1999). Most populations occur on the inland slopes of the Great Dividing Range with only small pockets near the coast (Blakers *et al.* 1984).

### *Threats*

Much of the Diamond Firetail's habitat has been cleared and it is therefore included in the suite of woodland birds that have declined in south-eastern Australia (Reid 1999). It appears unable to survive in areas that lack remnants larger than 200 hectares (NSW Scientific Committee 2001e). Clearing and habitat degradation by over-grazing and the spread of exotic grasses may also result in the loss of key food plants and possibly competition from flock-foraging Red-browed Finches (*Neochmia temporalis*) (Garnett and Crowley 2000). Predation by Foxes and feral Cats may be another threat as the species forages on the ground (Smith *et al.* 1995).

### *Local and Regional Conservation Status*

The Diamond Firetail is listed as Vulnerable under the NSW TSC Act (1995) and as Near Threatened nationally by Garnett and Crowley (2000). It is widely recorded in the eastern two thirds of the state, with scattered records in the far west, although it is less widely recorded in the three coastal Bioregions and in the high country of the Australian Alps. Within the Sydney Basin Bioregion the species is closely associated with grassy box woodlands found on the more fertile soils on the inland valleys and plains, including the Capertee, upper Hunter and Burragorang, and occasionally on the Cumberland Plain. These environments are generally poorly represented in reserves, though records are known from the Burragorang Valley in Nattai NP, Wollemi and Goulburn River National Parks and Munghorn Gap Nature Reserve (DEC 2005a).

The Diamond Firetail has not definitely been recorded in Manobalai Nature Reserve or adjoining Crown Lands, although a spatially inaccurate Birds Australia record exists. The species is known from a number of sites east of Wybong (Map 7). Potential habitat for this species does occur in the study area, on creek flats and lower escarpment slopes that support Box-Red Gum woodland with a grassy understorey. Given the presence of other declining woodland birds within these habitats in the southern Crown Land it is unusual that this species was not recorded during recent DEC surveys. Habitat for the Diamond Firetail would once have been widespread across the Hunter Valley and its major tributaries, however clearing for agriculture has reduced the amount of available habitat to remnant patches of grassy Box-Red Gum. Protection of the species remaining habitat requires close cooperation between reserve managers and private landholders.

## SPOTTED-TAILED QUOLL

### Species Profile

The Spotted-tailed or Tiger Quoll (*Dasyurus maculatus*) is a medium-sized marsupial carnivore that is identifiable by its rufous to dark brown fur and white spots which are present on the body and tail. It is essentially terrestrial, but is also an agile climber. It feeds on a wide variety of birds, reptiles, mammals and invertebrates and will also take carrion and domestic poultry (NPWS 1999b). It uses several 'latrines' within its territory for defecation (NPWS 1999b). Two subspecies of Spotted-tailed Quolls have been recognised: *D. maculatus gracilis* from north Queensland and *D. m. maculatus* from south-eastern Queensland, New South Wales, Victoria and Tasmania (Edgar and Belcher 1995). However, genetic work has shown that the true genetic split occurs between Tasmania and the rest of the mainland (Firestone *et al.* 1999). Within NSW the species utilises a variety of habitats on both sides of the Great Dividing Range, including sclerophyll forest and woodlands, coastal heath and rainforest (NPWS 1999b). Habitat requirements include suitable den sites, an abundance of food and large areas of in tact vegetation (NPWS 1999b).



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### Threats

The main problems confronting the Spotted-tailed Quoll are believed to be habitat loss, degradation and fragmentation (Belcher 2004). Other threats include: predation and competition by introduced predators such as Cat (*Felis catus*), Fox (*Vulpes vulpes*) and Dog (*Canis lupus*); disease such as toxoplasmosis; road mortality; and direct mortality at the hands of humans (Mansergh 1984). Quolls were heavily persecuted as killers of domestic fowl, and have been hunted and trapped to extinction in many parts of the country. In more recent years evidence has been collected to suggest that aerial, ground and mound baiting using 1080 (sodium monoflouroacetate) has significant negative impacts on Quoll populations (Belcher 2004), while Dingo control has the potential to impact on Quolls through the competitive release of Foxes and Cats (Glen & Dickman 2005). Inappropriate fire regimes and the removal of dead wood and dead trees may also impact on the species (NSW Scientific Committee 2003b).

### Local and Regional Conservation Status

The Spotted-tailed Quoll is listed as Vulnerable under the NSW TSC Act (1995) and as Endangered under the Commonwealth EPBC Act (1999). The southern populations are believed to have contracted in range by up to 50 percent in recent years (Maxwell *et al.* 1996). Within NSW the species has been most frequently recorded in the NSW North Coast, Sydney Basin and South East Corner Bioregions (DEC 2005a). The distribution of potential habitat within the Sydney Basin Bioregion is extensive although the occupancy rate of this habitat is likely to be very low. Since 1990, the greatest density of records within the Sydney Basin Bioregion occur on the central coast between Hornsby and Newcastle, in the upper Blue Mountains and to a lesser extent in the Kangaroo Valley (DEC 2005a). The species may have recently become extinct in other areas. The species has been recorded in a number of conservation reserves in the Sydney Basin Bioregion, most recently within Blue Mountains, Brisbane Water, Popran and Wollemi National Parks (DEC 2005a).

The Spotted-tailed Quoll is amongst the most cryptic of ground mammals. Where sparse, it is notoriously difficult to trap and requires immense effort to detect in the wild using standard survey techniques (Lunney and Matthews 2001). There are a number of pieces of evidence to suggest that the Spotted-tailed Quoll is present within the Manobalai area. There is historical evidence of quolls being caught in rabbit traps at Oaky Arm in the west of the Reserve many years ago (C. Daniels pers. comm.). A possible sighting of the species was also made by a ranger along Giants Creek in 1997 and a hair sample taken from hair tube transects in Manobalai Crown Land indicated a "probable" Quoll. Habitat is difficult to define other than recognising that gully-lines and alluvial flats are likely to be preferred, as prey density is higher and shelter in ground logs is more available. Equally however, sandstone caves and outcrops may provide habitat for den sites, shelter and latrines. Manobalai area presents habitat that is likely to be occupied by only a handful of individuals that are linked into a small

population of Wollemi, Goulburn River NP and the ranges of the Upper Hunter. Further survey work, including extensive cage trapping and hair tubing over an extended time period, is required to determine the species distribution and abundance within the Manobalai area and adjoining Crown Land. Priority should be given to increasing public awareness of this species and its identification and to encouraging neighbours and park visitors to report any sightings, together with accurate location information. The use of 1080 baiting in areas where Quolls are known should be very carefully considered. Burying baits deeper than seven centimetres below the ground surface (rather than burying them in raised mounds) will decrease the number of baits removed by Quolls (Glen and Dickman 2003).

# KOALA

## Species Profile

The Koala (*Phascolarctos cinereus*) is a distinctive arboreal mammal of eucalypt forest and woodland. It feeds on a wide range of eucalypt and other tree species, though in a local area a few species will be preferred almost exclusively. Individuals spend most of the day resting in the forks of trees, and are most active following sunset (NPWS 1999c). They generally move about a home range, the size of which varies on the density of food trees and population size, though individuals, particularly dispersing juveniles, are known to travel up to 50 kilometres (Martin and Handasyde 1995; NPWS 1999c). Three subspecies occur between north Queensland and the Eyre Peninsula in South Australia. However, the distribution is now fragmented and introductions, such as to Phillip Island, have possibly altered the genetic diversity of many of the populations (Martin and Handasyde 1995).

## Threats

NPWS (1999c) summarises the threats to the Koala as follows: destruction of habitat by clearing for urban development, agriculture and mining; degradation of habitat through fragmentation and disturbance such as fire or weed invasion; direct mortality from dogs and motor vehicles; and infection by *Chlamydia* which causes keratoconjunctivitis (an infection of the eyes) and infertility. The latter appears to occur naturally in Koalas in NSW, and symptoms are displayed when animals are stressed (NPWS 2003d). Throughout its entire range loss, fragmentation and degradation of habitat is its greatest threat (NPWS 2003d). Reed *et al.* (1990) reported that a survey in 1986-87 found the Koala had disappeared from 50 to 75 percent of its known range in NSW and populations had been lost from many localities, particularly on the southern and western edges of its distribution. Within the Hunter Range region all of the listed threatening processes are likely to be important, including road mortalities as the species attempts to move between habitat areas (such as across the Putty Road).

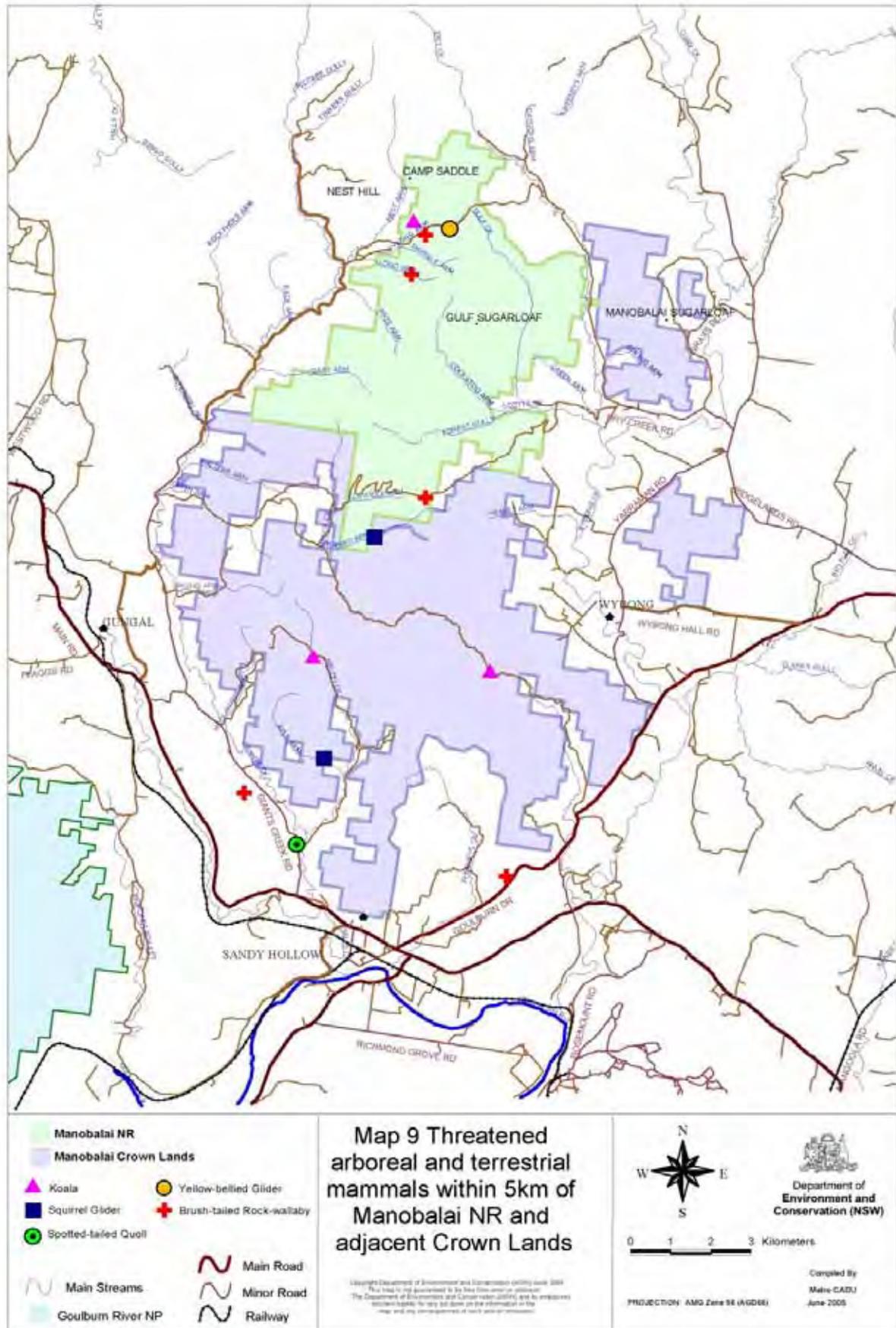
## Local and Regional Conservation Status

The Koala is listed as Vulnerable under the NSW TSC Act (1995). The species is widespread across the eastern third of the state and, being an easily recognisable species, there are a number of records throughout the Sydney Basin Bioregion. Concentrations appear to be located around the Central Coast, Blue Mountains, the fringes of the Cumberland Plain and the Woronora Plateau (DEC 2005a). Records from reserves within this bioregion are less common, though sightings have been made in many including Morton, Dharug, Nattai, Blue Mountains, Brisbane Water, Wollemi, Yengo and Morton National Parks (DEC 2005a).

Historic records suggest that Koalas have a preference for higher fertility soils that support a distinctive suite of eucalypt species on which they feed. The species would once have been more abundant and widespread in the upper Hunter Valley, particularly in the fertile valley floors and plains that have now been cleared for agriculture. Landowners adjoining the study area have reported Koalas over 50 years ago, but few have been seen since (DEC 2005b). It is hypothesised that due to extensive clearing the species has retreated to marginal habitats, commonly found on creek flats and escarpment slopes on the perimeter of agricultural country. Such a pattern appears to exist within Manobalai Nature Reserve and adjoining Crown Lands. Alluvial flats and sheltered slopes comprise stands of Forest Red Gum (*E. tereticornis*) and Grey Gum (*E. punctata*), both of which are recognised as preferred Koala feed tree species (NPWS 2003e). Evidence of Koalas in the Manobalai area was found in 1997 on both Melon Creek (hair sample) and Reedy Creek (tree scratchings). More recently individuals were heard calling in the north west of the Nature Reserve (Map 9). No evidence was found during recent DEC surveys. Koalas, particularly males, can be wide ranging and it is likely that they roam across the sandstone plateaus of the western Hunter and Goulburn River Valleys.



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**Map 9: Threatened arboreal and terrestrial mammal records within five kilometres of Manobalai Nature Reserve and adjacent Crown Lands**

## SQUIRREL GLIDER

### *Species Profile*

The Squirrel Glider (*Petaurus norfolcensis*) is a small to medium-sized nocturnal mammal that inhabits dry sclerophyll forests and woodlands where it shelters in leaf-lined nests in tree hollows. It is similar in appearance to the smaller and more common Sugar Glider (*Petaurus breviceps*). However, the Squirrel Glider is larger, has a longer more pointed face, longer and narrower ears and a bushier tail and also lacks the persistent yapping call of the smaller species. It has a varied diet, including insects, nectar, pollen, seeds, *Acacia* gum and sap from eucalypts (Suckling 1995b). It usually occurs in family groups of up to ten, consisting of one male, one or more females and their dependant young. Home ranges vary between 0.65 and 8.55 hectares, depending on vegetation type and habitat quality, and individuals have been known to move up to 500 metres in one night. It is patchily distributed along the east coast and inland slopes between north Queensland and northern Victoria (NPWS 1999e) in habitats that comprise sufficient numbers of hollow-bearing trees for shelter and winter flowering plant species for food (Quin 1995).



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### *Threats*

The greatest threat to the Squirrel Glider is loss of habitat by broadscale clearing for agriculture (Kavanagh 2004). Most clearing has fallen on open forests and woodlands growing on relatively fertile soils on gentle topography, especially in river valleys (Lunney and Leary 1988), which in many areas comprises prime habitat for the Squirrel Glider. Clearing of land for mining has also resulted in habitat loss in the Hunter Valley (N. Williams pers. comm.). NPWS (1999e) lists the following threats to the Squirrel Glider: loss of nesting resources when the availability of hollow bearing trees are lost through fragmentation or timber extraction; predation by Cats and Foxes; and the entanglement of individuals on barbed-wire fences. Impacts of fire regimes are poorly understood although the availability of food resources and shelter sites may be reduced or lost after fire. The simplification of forest structure resulting from frequent low-intensity prescribed burns, especially where domestic stock also graze, may also threaten the species (Catling 1991).

### *Local and Regional Conservation Status*

The Squirrel Glider is listed as Vulnerable under the NSW TSC Act (1995). Across its range, habitat for the Squirrel Glider appears to occur primarily outside of public forest lands (Kavanagh 2004). Within the Sydney Basin Bioregion the dry woodlands of the Central Coast provide very high quality habitat for the species and the area has been well documented as a stronghold for the species (Smith and Murray 2003). Elsewhere in the Bioregion the species has only been patchily recorded at very low densities, including on a few reserves such as Yengo, Wollemi, Blue Mountains and Werakata National Parks and Dharug Nature Reserve (DEC 2005a).

The Squirrel Glider was recorded for the first time in Manobalai Crown Land during 2004-05 DEC surveys (Map 9). These two observations were made on or adjoining alluvial flats in Webbs Creek and Alys Arm. A number of additional records are known outside the study area in similar habitats, in Myambat Defence Lands at Sandy Hollow and in northern Wollemi National Park. The woodlands and open forests that contain Box, Red Gum, Rough-barked Apple or Ironbark eucalypt species in the canopy form quality habitat for the glider. These dry low elevation woodlands are restricted to small ribbons within the Nature Reserve and Crown Lands to the south. Mostly the habitat occurs as remnant forest on alluvial flats at the head of gullies, just below sandstone slopes.

The species would once have been more abundant and widespread throughout the valleys of the Hunter and Goulburn Rivers, however large amounts of primary habitat have been lost through clearing for agriculture, urban and industrial development. The contribution of the Hunter Range reserves to the viability of the species as a whole should not be underestimated. Squirrel Glider populations in and adjoining the study area will increase in importance as coastal strongholds become decimated by urban and industrial expansion. Manobalai Nature Reserve and particularly the adjoining Crown Land, contributes to the viability of the species across the region and should be managed accordingly.

## BRUSH-TAILED ROCK-WALLABY

### *Species Profile*

The Brush-tailed Rock-wallaby (*Petrogale penicillata*) is a medium-sized macropod, characterised by its distinctive facial markings, black paws and high level of agility (NSW Scientific Committee 2003a). The tail is often used to aid identification, being long and thickly furred with a distinctive brush-like appearance near its tip (NPWS 2002b). Habitats occupied by this species tend to take one of three forms: loose piles of large boulders containing a maze of subterranean holes and passageways; cliffs (usually over fifteen metres high) with many mid level ledges covered by overhangs; or isolated rock stacks, usually sheer sided and often girdled with fallen boulders (NPWS 2002b). Vegetation forms a vital component of the habitat, especially as refugia near major rock outcrops. The species typically exhibits low migration rates between colonies, impeding persistence and recovery of populations affected by threatening processes. The Brush-tailed Rock-wallaby was once abundant and ubiquitous throughout the mountainous country of south-eastern Australia from the Grampians in western Victoria to Nanango in south-east Queensland (Short and Milkovits 1990). The Rock-wallaby has declined significantly in the west and south of its former range, and populations have become more fragmented throughout (NSW Scientific Committee 2003a). It was thought to be extinct in Victoria until small populations were rediscovered in the Grampians and near the Snowy River (Eldridge and Close 1995).



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### *Threats*

Historical decline of the Brush-tailed Rock-wallaby is attributed to three factors: hunting for bounty and fur; predation by introduced predators; and competition with introduced herbivores (especially Feral Goat (*Capra hircus*), Rabbit (*Oryctolagus cuniculus*) and domestic stock) (NSW Scientific Committee 2003a). The major threats continuing to impact on the species include ongoing predation and competition with feral species such as Goats, Foxes (*Vulpes vulpes*) and wild Dogs (*Canis lupus familiaris*), habitat modification by fire, vegetation clearing, disease transmission (toxoplasmosis and hydatosis) by feral carnivores (NSW Scientific Committee 2003a) and inbreeding (Environment ACT 1999).

### *Local and Regional Conservation Status*

The Brush-tailed Rock-wallaby is listed as Endangered under the NSW TSC Act (1995) and as Vulnerable under the Commonwealth EPBC Act (1999). In the Sydney Basin Bioregion the species forms part of one of the three Evolutionary Significant Units (ESU) that summarise genetically distinctive groups on the basis of DNA. The nominate ESU encompasses closely related populations in central NSW including Kangaroo Valley, Jenolan Caves, Broke in the Hunter Valley and the Warrambungles. This central ESU is one of the most fragile in NSW and all sites within it are of very high conservation significance (NSW Scientific Committee 2003a). Recent records from reserves within the Sydney Basin are mostly confined to Yengo, Wollemi and Morton National Parks (DEC 2005a) as well as a recently discovered colony in Nattai NP (DEC 2004c).

There are a number of records of the Brush-tailed Rock-wallaby from Manobalai Nature Reserve and adjoining Crown Land (Map 9). Unfortunately, none of these records exclude a level of doubt in the mind of the observers, and to date there has been no absolutely positive identification of the species through observation, scat or hair analysis. Recent DEC surveys failed to find evidence of the species. Suitable habitats are present, though the high escarpments and habitat complexity of northern Wollemi and Yengo National Parks are not as prevalent in the Manobalai area. Records west of Giants Creek are located on rocky boulders on steep slopes, however positive identification of these wallabies was not possible (S. Bell pers. comm.). Records near Sandy Hollow raise a level of doubt as they occur on sheltered aspects, while observations in the adjoining Wollemi NP, where records are definitive, are invariably made on exposed locations such as north or north-westerly aspects. Records near Clayhole Arm track and in the north west of the reserve are also unconfirmed.

Given the number of unconfirmed records and the absence of evidence during recent surveys it is recommended that targeted habitat searches be carried out. Revisiting sites of unconfirmed observations to search for secondary evidence of scats and habitat suitability is recommended. Discussions with land owners adjoining north-western escarpments would also be a productive starting point. Searched habitat should be mapped and photographed. Any positive evidence of the species should be reported to the Brush-tail Rock Wallaby Recovery Plan coordinator.

## YELLOW-BELLIED SHEATHTAIL-BAT

### *Species Profile*

The Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*) is quite easily distinguished from other species in south-eastern Australia by its characteristic tail, which protrudes from the dorsal surface of the tail membrane (Churchill 1998). A large species, it displays quite distinct coloration, with bright white or yellow fur on the belly and contrasting rich, black, shiny fur on the back (Churchill 1998). Males possess a prominent throat pouch, which is represented by an undeveloped skin fold in the female (Richards 1995). Endemic to Australia, it is the only species of Sheathtail-bat to extend so far into temperate, cool areas (Churchill 1998). Exhibiting a widespread distribution across northern and eastern Australia, its seeming rarity has been attributed to its rapid, high-flying nature and although difficult to capture it is fairly easily identified by its ultrasonic call, which is audible to humans (Pennay *et al.* 2004). It forages for airborne insects (mainly beetles and moths) above the tree canopy, although in more open habitats also feeds closer to the ground (Churchill, 1998, Shelley 2004). Roosting in tree hollows most of the time, it has also been found to utilise abandoned nests of Sugar Gliders and animal burrows, as well as cracks in dry clay and occasionally hanging from the outside of buildings in broad daylight (Churchill 1998, Richards 1995). It is thought to undertake a winter migration from the south to warmer areas, with reports from southern Australia existing only between January and June (Churchill 1998, Richards 1995, Shelley 2004). Habitat preferences of this species are fairly broad, with records in almost all habitats (Churchill 1998), and roost sites can be in cleared grazing areas in open woodland, as well as unmodified forests along the coast (Shelley 2004). There is speculation that in coastal forests, this species may be restricted to roosting in emergent trees, as it needs a clear space below the roost to gain flight speed (Richards 2000, cited in Shelley 2004).

### *Threats*

Unfortunately there is a lack of relevant information on the ecology of this species. The most pertinent threat is likely to be the clearing of forest and woodland for residential and agricultural development, resulting in the loss of hollow-bearing trees for roost sites and reduction of foraging habitat (Australian Museum 1999a, DEC 2005i, Shelley 2004). Foraging activities are also likely to be impacted by the use of pesticides that cause a reduction in the availability of food and possibly a build up of toxins within the bats' tissues (DEC 2005i).

### *Local and Regional Conservation Status*

The Yellow-bellied Sheathtail-bat is listed as Vulnerable under the NSW TSC Act (1995). Most records for the species in NSW come from the Brigalow Belt South, Nandewar and Darling Riverine Plains as well as the NSW North Coast and Sydney Basin Bioregions (DEC 2005a). Within the Sydney Basin, most records are outside of reserves, however it has been detected in the southern Blue Mountains and Ku-ring-gai Chase National Parks (DEC 2005a). There are a number of records in the coastal plain between Wollongong and Cessnock, however the density probably reflects the concentration of report ratings in this highly populated zone.

The Yellow-bellied Sheathtail-bat was confidently detected for the first time in Manobalai Nature Reserve during the recent DEC surveys, when it was detected at two locations by its ultrasonic call (Map 10). The identification of the species was verified by two bat call analysis experts. During surveys undertaken by Stauber and Thumm in 2000, the species was possibly detected on the Diamond Ridge Firetrail, though identification could not be confirmed. In hindsight, the call was likely to be of the species and so the record has been included in Map 10. The Yellow-bellied Sheathtail-bat is a high-flying species and hence is difficult to sample by either harp trapping or anabat detection. It is probably widespread in the study area, ranging widely above the tree canopy or through more open habitats such as the Spotted Gum – Ironbark Forests and the alluvial woodlands. Though it has not been detected within the Crown Lands, it is likely to occur.

Records of the Yellow-bellied Sheathtail-bat within the region hold significance as definite records of the species have not been collected within approximately an 80 kilometre radius of the study area (DEC 2005a). The records thus contribute important information about the species distribution, habitat preferences and status. Additionally, as few confirmed records for the species have been collected on reserves in the Sydney Basin, their protection Manobalai Nature Reserve holds conservation importance.

## EAST-COAST FREETAIL-BAT

### *Species Profile*

The East-coast Freetail-bat (*Mormopterus norfolkensis*) is a member of a complex group of bats that remain in a state of considerable taxonomic uncertainty (Churchill 1998). The species can be distinguished from other members of the group by its long forearm, upright ears and robust build (Allison and Hoye 1995, Parnaby 1992a). Reinhold *et al.* (2001) describes the ultrasonic call as “a pattern of alternating pulses”, making it unique among *Mormopterus*, though it can also call without this pattern. There are very few confirmed specimens of this species on record, but it appears to be restricted to the



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east of the Great Dividing Range between approximately Brisbane (Queensland) and southern New South Wales (Duncan *et al.* 1999; Parnaby 1992a). Habitat preferences are poorly understood, but the species appears to favour dry eucalypt forest and woodland, though it has also been captured in rainforest and wet sclerophyll forest (Churchill 1998). It usually roosts in tree hollows (Gilmore and Parnaby 1994), though it has been recorded in the roof of a hut and under the metal caps of telegraph poles (Churchill 1998).

### *Threats*

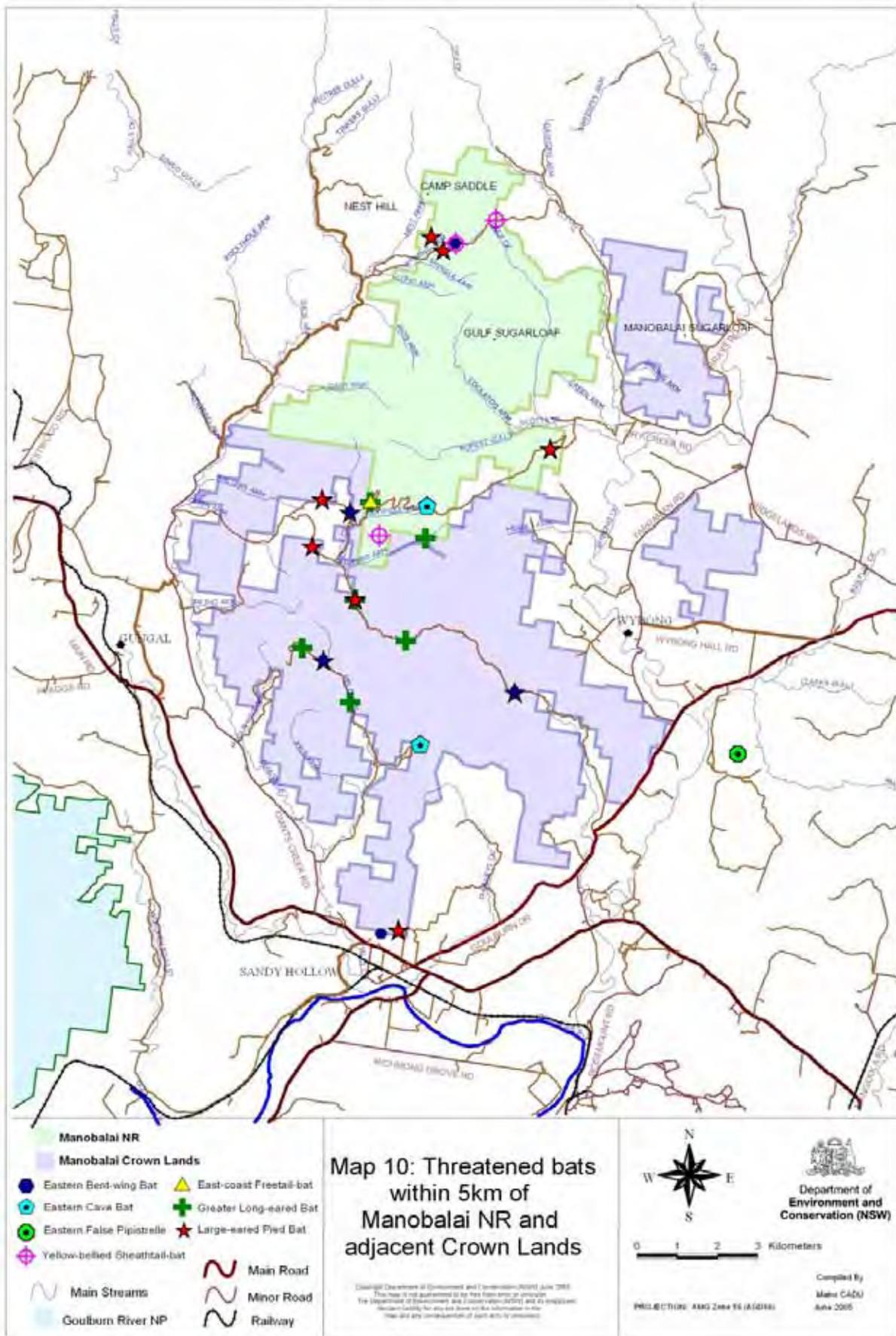
The threats to this species are poorly known, though it is suspected that clearing for agriculture, development and logging have serious impacts (Duncan *et al.* 1999). These threats may be of increased significance since the species' entire known distribution lies within an area of concentrated human population density and increasing urban development.

### *Local and Regional Conservation Status*

The East-coast Freetail-bat is listed as Vulnerable under the NSW TSC Act (1995). Most records for the species in NSW occur within the NSW North Coast, South East Corner and Sydney Basin Bioregions, particularly from the Cumberland Plain and Central Coast areas (DEC 2005a). The majority of records for the species within the Sydney Basin Bioregion occur outside of reserves. However, it has been detected within Nattai, Blue Mountains, Dharug, Yengo, Wollemi and Marramarra National Parks and Western Sydney Regional Park (DEC 2005a).

The East-coast Freetail-bat has been detected just once within Manobalai Nature Reserve, its ultrasonic call recorded along the Clayhole Arm Track during CRA surveys in 1997 (Map 10). It has not been recorded elsewhere within a five kilometre radius of the park, but is known from scattered locations in northern Yengo and north-eastern Wollemi National Parks (DEC 2005b, DEC 2005c). This is a moderately large high-flying species that possibly ranges widely through more open habitats, and could be more widespread than records suggest. Current records are likely to be an underestimate of the status and distribution of the bat, since it would often fly above the range of traps and ultrasonic call detectors. However, as it was not detected during the recent DEC surveys, and generally prefers coastal environments (Churchill 1998) it is expected to only exist at very low density.

Records of East-coast Freetail-bat within the region hold significance as the species approaches the western edge of its known range in this area. Additionally, since few confirmed records for the species have been collected on reserves in the Sydney Basin, protection within Manobalai Nature Reserve holds conservation importance, even if it only provides marginal habitat. The significance of reserved habitats is likely to rise in the future as pressure continues to impede on the species occurrence elsewhere. Little is known of this species so the records collected here contribute to our understanding of its distribution and habitat tolerances.



**Map 10: Threatened bat records within five kilometres of Manobalai Nature Reserve and adjacent Crown Lands**

## LARGE-EARED PIED BAT

### *Species Profile*

The Large-eared Pied Bat (*Chalinolobus dwyeri*) is readily distinguished from other members of its genus by the combination of large ears and overall black colour, with bands of white fur along the undersides of the body, that typically join to form a V-shape (Parnaby 1992a, Churchill 1998). The call (undetected by the human ear) is an alternate pattern made at a low frequency, which is readily distinguishable from all other species (Reinhold *et al.* 2001). Originally described from Copeton in 1966, it has been recorded from a number of scattered locations on either side of the Great Dividing Range between Rockhampton (Queensland) and Bungonia (New South Wales) (Hoye and Dwyer 1995). It has been found in a wide range of habitats, including wet and dry eucalypt forest, rainforest, Cypress (*Callitris*) forest and sub-alpine woodland (Duncan *et al.* 1999). It is a cave-roosting species, though it has also been detected roosting in disused mine shafts and overhangs (Churchill 1998) as well as abandoned Fairy Martin (*Petrochelidon ariel*) nests (Schulz 1998). It seems to prefer the 'twilight' areas of caves, and may be dependent on sandstone outcrops (Duncan *et al.* 1999, Hoye and Dwyer 1995).



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### *Threats*

The only confirmed threat to this species is the destruction or interference of roost sites (Duncan *et al.* 1999). Other potential threats include mining induced subsidence (particularly coal-mining in sandstone areas) which may destroy roost sites, habitat destruction for agriculture and urban development, and predation by feral animals (Duncan *et al.* 1999).

### *Local and Regional Conservation Status*

The Large-eared Pied Bat is listed as Vulnerable under the NSW TSC Act (1995) and also as Vulnerable under the Commonwealth EPBC Act (1999). The Sydney Basin appears to encompass a significant proportion of the known distribution of the Large-eared Pied Bat, with scattered records occurring to the north and west of the Bioregion (DEC 2005a). There is a concentration of records across the Blue Mountains plateau, particularly within Nattai and Blue Mountains National Parks, as well as in the upper Hunter Valley in Yengo, Wollemi and Goulburn River National Park (DEC 2005a). However, these records are likely to reflect the locations of recent DEC survey effort, which has found the species to be more widespread in the Bioregion than previously considered. Records are scattered through the Bioregion, including Wollemi, Kanangra-Boyd, Royal, Gardens of Stone and Morton National Parks (DEC 2005a). However, despite this wide distribution the species is infrequently detected, suggesting that it occurs at low abundance.

The Large-eared Pied Bat was confidently detected for the first time in the study area during the 2004-05 DEC surveys. It is widespread in the southern Crown Lands, but was only recorded once in the Nature Reserve (Map 10). During surveys undertaken by Stauber and Thumm in 2000, the species was possibly detected twice near the Diamond Ridge Firetrail, though identification could not be confirmed. In hindsight the calls were likely to be of the species and so the records have been included in Map 10. The Large-eared Pied Bat has been recorded in a wide range of habitats, but most commonly in the alluvial woodlands. Roost sites have not been discovered, however the numerous overhangs and caves located along the sandstone escarpments provide suitable roost habitats. Recent work on the species in southern Sydney suggests that the Large-eared Pied Bat may require both sandstone overhangs for shelter and proximate to this, more productive landscapes such as rivers or Box woodlands for foraging (DEC 2005e). No maternity roosts have been located within the study area. Maternity roost requirements for the species are poorly understood, but are located within deeper cave systems, which are comparatively rare.

The recent systematic surveys in north-east Wollemi, northern Yengo and Goulburn River National Parks have shown the upper Hunter region to be a stronghold for the species. The records continue to provide evidence that the bat is more common in sandstone reserves in the Sydney Basin Bioregion than previously thought, and is likely to be relatively well protected. The primary threat at this stage is likely to be predation by feral animals and wildfires that scorch roost and maternity caves. These threats should thus be managed appropriately around known habitat areas.

## EASTERN BENT-WING BAT

### Species Profile

The Common Bent-wing Bat (*Miniopterus schreibersii*) is the most widely distributed bat in the world, occurring through Europe, Africa and Australasia (Churchill 1998). However, recent research suggests there to be three taxa in Australia (Duncan *et al.* 1999). The subspecies *oceanensis* occurs in eastern Australia and extends from central Victoria to Cape York Peninsula, Queensland (Duncan *et al.* 1999). This subspecies is commonly called the Eastern Bent-wing Bat. This species is distinguished from most other bats by the long last bone in the third wing digit and from the Little Bent-wing Bat (*M. australis*) by the longer forearm (greater than 44 mm) (Parnaby 1992a). The ultrasonic call can be distinctive, although it is often inseparable from *Vespadelus darlingtoni* and *V. regulus* (Reinhold *et al.* 2001). The species utilises a wide variety of habitats where it usually roosts in caves, though it has been known to use mines and road culverts (Churchill 1998). It is a fast flying bat that usually feeds above the canopy (Churchill 1998) and has been known to travel up to 65 kilometres in a night (Dwyer 1966 in Ayers *et al.* 1996). Though individuals often use numerous roosts, they congregate en masse at a small number of caves and abandoned mines to breed and hibernate (Churchill 1998).



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### Threats

Damage and disturbance to hibernating and maternity roosting sites is the greatest known threat to this species. Because only relatively few nursery caves are used, significant population changes can occur if these sites are damaged (Dwyer 1995). Disturbance of hibernating colonies can lead to starvation due to loss of energy reserves (Gilmore and Parnaby 1994). Disturbance of smaller diurnal roosts by recreational caving and tourism may also be significant. Other potential threats include modification to feeding habitat by agriculture and urban development (Gilmore and Parnaby 1994) and predation by Feral Cats (*Felis catus*) and, less often, Foxes (*Vulpes vulpes*) (Dwyer 1995).

### Local and Regional Conservation Status

The Eastern Bent-wing Bat is listed as Vulnerable under the NSW TSC Act (1995). The species is widely distributed in the eastern third of NSW, with the number of records decreasing with distance from the coast (DEC 2005a). Records are widespread within the Sydney Basin Bioregion and appear to be commonly encountered wherever ultrasound bat surveys are undertaken. Strong clusters of records are present in the Lower Hunter and Central Coast, Cumberland Plain, Woronora Plateau and across the southern Blue Mountains. Individuals have been recorded flying through a diverse range of reserves including Royal, Nattai, Kanangra-Boyd, Blue Mountains and Wollemi National Parks (DEC 2005a). However, roost sites for the species, particularly maternity roosts, are much less frequently recorded and poorly reserved.

The 2004 DEC surveys recorded the Eastern Bent-wing Bat at four widely spaced locations, including three times in the Crown Lands and once in the Nature Reserve (Map 10). This medium-sized bat is a high flying species which can travel at 50 kilometres per hour at many times the height of the canopy (Churchill 1998) and so is not commonly caught in harp traps. No individuals were captured in the study area, but were detected by their ultrasonic call. However, two specimens from Sandy Hollow area are located in the Australian Museum collections (Map 10, although records have low spatial accuracy). The species may be more widespread than records indicate, however the low detection rate suggests that they are not as abundant here as in the nearby north-eastern Wollemi National Park (DEC 2005b). This suggests that the species does not have a permanent roost or maternity roost within the study area, though the area may provide important foraging habitat. The closest known roost site is located in the disused oil shale mines in the Baerami Valley in north-eastern Wollemi National Park, which is within the possible travelling distance for the species.

## GREATER LONG-EARED BAT (SOUTH-EASTERN FORM)

### Species Profile

Immediately recognised as a long-eared bat by its prominent ears, the Greater Long-eared Bat (*Nyctophilus timoriensis*) has fairly uniformly dark grey-brown fur and is distinguished by its thickset body, a low ridge above a broad snout and a inter-canine width greater than 5.6 mm (Parnaby 1995, Churchill 1998). This species utilises tree hollows, crevices and loose bark as roost sites. It is known to be an agile yet slow-flying bat, making use of the understorey and ground to capture non-flying prey (Churchill 1998, DEC 2005h). Ultrasound recordings are of little use in identifying this species, as its call characteristics and frequencies overlap almost completely with other *Nyctophilus* species using Anabat call analysis (Pennay *et al.* 2004). Recent taxonomic revision has shown the mainland form of the Greater Long-eared Bat to be comprised of three distinct species with allopatric (non-overlapping) distributions, in addition to a Tasmanian subspecies (Parnaby 1995, Duncan *et al.* 1999). The nominate south-eastern form occurs across much of inland southern Australia, from south central Queensland, central western NSW, north-western Victoria to south eastern South Australia. It is generally associated with dry woodlands, and semi-arid mallee and savannah (Churchill 1998).



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### Threats

The main threat facing this species is extensive loss of habitat. In NSW, 75% of the eastern part of the species range has been cleared (Duncan *et al.* 1999). Encompassed within this change in habitat is the loss of hollow-bearing trees, which is due to large scale clearing for agriculture, or timber harvesting and grazing in otherwise uncleared areas (Australian Museum 1999, Duncan *et al.* 1999). An altered fire regime is also likely to impact on the species, with a long absence of fire causing a lack of hollow regeneration, while fires of too high intensity can destroy hollow-bearing trees altogether and remove the shrub layer which is commonly used for foraging. Application of pesticides near foraging areas are also likely to cause impact, through reduction of invertebrate populations and accumulation of toxins within the bats' tissues (DEC 2005h).

### Local and Regional Conservation Status

The Greater Long-eared Bat (south-eastern form) is listed as Vulnerable under the NSW TSC Act (1995) and Vulnerable under the Commonwealth EPBC Act (1999). Records for the species are sparsely distributed across the western three quarters of the state, with concentrations in the Brigalow Belt South and Murray Darling Depression Bioregions (DEC 2005a). The species only occurs in the far north-west of the Sydney Basin Bioregion, where western influenced environments occur in the Goulburn and Hunter River Valleys (DEC 2005a). Representation in reserves in the Bioregion is poor, with key areas being Goulburn River National Park, Manobalai Nature Reserve and north-eastern Wollemi National Park.

The Greater Long-eared Bat was first recorded in Manobalai Nature Reserve during CRA surveys in 1997. During the recent systematic surveys a further 12 individuals have been captured at five harp trap locations in both the Nature Reserve and Crown Lands (Map 10). Like all Long-eared Bats, the Greater Long-eared Bat can orientate and forage without using echolocation (Churchill 1998), such that very short quiet calls are often all that is recorded by ultrasonic recording devices. Furthermore, call characteristics and frequencies almost completely overlap with other *Nyctophilus* species, such that they cannot be distinguished using standard parameters (Pennay *et al.* 2004). The abundance and distribution of the Greater Long-eared Bat may therefore be underestimated in relation to bats that can be detected by both methods. The species has been detected here more frequently than in neighbouring North-east Wollemi NP, because of the predominance of dry western-influenced environments. It is likely to be widespread and moderately abundant along the creek flats and lower escarpment slopes in the southern half of the Nature Reserve and the southern Crown Lands.

The presence of Greater Long-eared Bat within Manobalai Nature Reserve and Crown Lands has high conservation significance as the species reaches the eastern limit of its range in this area and is very scarce and poorly conserved within the Sydney Basin Bioregion. The dry alluvial woodland habitats are key to the survival of numerous threatened species within the region, including the Greater Long-eared Bat, and hence should take high priority in park management planning. Land holders should be encouraged to maintain the structural integrity of woodland habitats near the boundary of the park, retain hollow-bearing trees and avoid over-use of pesticides near the woodland-agriculture interface.

## EASTERN CAVE BAT

### *Species Profile*

The Eastern Cave Bat (*Vespadelus troughtoni*) is a small mustard yellow-brown bat with dark wings. It has a patchy distribution throughout eastern Australia and remains one of the least known and understood members of its genus. It is very similar in size to the Large Forest Bat (*V. darlingtoni*), the most reliable distinguishing feature between the two species being the shape and size of the male's genitalia, with *V. troughtoni* possessing a larger more pendulous penis (Parnaby 1992a). The species is very difficult to distinguish from ultrasonic call recordings, as the frequency and call pattern overlaps with that of the Little Forest Bat (*Vespadelus vulturinus*) (Pennay *et al.* 2004). The Eastern Cave Bat displays a predominantly tropical distribution that ranges down the east coast from Cape York in Queensland to Kempsey in NSW, with smaller numbers recorded south to at least the Sydney Basin (Law *et al.* 2005). The western limit appears to be the Warrumbungle Range, with a single record from southern NSW, east of the ACT (DEC 2005i). Although little is known about the biology and ecology of this species, the general preferences of habitat seem to range from dry open forest and woodland in the west and inland through to moister wet eucalypt forest and rainforest along the coast (Churchill 1998; DEC 2005i). A cave-dwelling species, it roosts in small groups in reasonably well lit areas near the entrances of sandstone overhangs, mine tunnels, boulder piles and occasionally buildings (Churchill 1998). It has also been discovered roosting in disused Fairy Martin (*Hirundo ariel*) mud nests (Schulz 1998).



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### *Threats*

Threats to the species are poorly known as little is known about its habitat preferences, diet and breeding requirements. As for other cave-dwelling bats destruction or damage of roosting sites is likely to be the main threat (DEC 2005i). This type of disturbance is likely to result from clearing and isolation of habitat as a result of increasing development, both residential and agricultural, as well as altered fire regimes and consequential habitat species modification and from practices such as timber harvesting and grazing (DEC 2005i). Disturbance of roost sites by cave visitors may also have localised impacts on this bat.

### *Local and Regional Conservation Status*

The Eastern Cave Bat is listed as Vulnerable under the NSW TSC Act (1995). This poorly understood species has only been recorded 34 times on the Atlas of NSW Wildlife between 1980 and the current surveys. The majority of records occur in the North Coast and Sydney Basin Bioregions, with a few records in the Brigalow Belt South Bioregion and one record south of Ulladulla on the NSW South Coast (DEC 2005a). The species is reported in low numbers from DEC reserves including, in addition to Wollemi, Yengo, Goulbourn River and Warrumbungle National Parks and Arakoola and Manobalai Nature Reserves (DEC 2005a). Extensive DEC surveys in various reserves and Sydney Catchment Authority Special Areas in the central area of the Sydney Basin Bioregion have failed to locate this species in that area (DEC 2005e).

The Eastern Cave Bat was first detected in Manobalai Nature Reserve during CRA surveys in 1997, when it was identified from an ultrasonic call on the Clayhole Arm Trail. Then during the 2004-05 DEC surveys a maternity roost, housing at least fifty adults and their juveniles, was found in a cave on the escarpment east of Melon Creek (Map 10). The site is a well-lit sandstone overhang of roughly three metres by ten metres at the entrance with a steeply sloping floor and at least one dome at the rear (Plate 11). This is a highly significant discovery as very few maternity roosts are known for the species, and it is particularly important being near the southern edge of its range. Due to the difficulty in identifying the Eastern Cave Bat using anabat call analysis, its abundance and distribution in the study area may be underestimated in relation to bats that can be detected by this methods. The Eastern Cave Bat is also thought to occur at Anvil Hill (D. Andrew pers. comm.) and Myambat Defence Lands as well as in Goulburn River NP, while recent DEC surveys have discovered roost sites in sandstone caves in Yengo and Wollemi National Parks.

The Hunter Range area appears to be a stronghold for the Eastern Cave Bat in the Sydney area and is likely to play a pivotal role in its conservation within the Sydney Basin. The maternity roost is a site of high conservation significance. As with many of the bats, further research into the ecology of the species in the southern part of its range is required to obtain a better understanding of distribution and habitat requirements, in order to accurately assess conservation status in the study area and the surrounding region. It is possible that the Eastern Cave Bat is more widespread than previously thought, but due to difficulties in identification has been overlooked or mis-identified in other locations. Given the paucity of information on the Eastern Cave Bat, these records make an exciting contribution to the overall understanding of the species ecology and distribution.



Plate 17: Eastern Cave Bat maternity roost cave east of Melon Creek © N. Williams/DEC

## 6 REFERENCES

- ACT Government (1999) Painted Honeyeater (*Grantiella picta*): A vulnerable species. *Action Plan No. 19*. Environment ACT, Canberra.
- Adams, M., Reardon, T.R., Baverstock, P.R. and Watts, C.H.S. (1998) Electrophoretic resolution of species boundaries in Australian Microchiroptera. IV. The Molossidae (Chiroptera). *Australian Journal of Biological Science* 41: 315-326.
- Allison, F.R. and Hoyer, G.A. (1995) Eastern Freetail-bat *Mormopterus norfolkensis*. Pp 484 in *The Mammals of Australia* (ed.) R. Strahan. Reed Books, Chatswood.
- Australian Museum (1999a) Bats in Australia – Yellow-bellied Sheathtail Bat. <http://www.amonline.net.au/bats/records/bat28.htm> Accessed 10/06/05.
- Australian Museum (1999b) Bats in Australia – Greater Long-eared Bat. <http://www.amonline.net.au/bats/records/bat42.htm> Accessed 10/6/05
- Ayers, D., Nash, S. and Bagget, K. (1996) *Threatened Species of Western New South Wales*. NSW NPWS, Dubbo.
- Barrett, G., Silcocks, A., Barry S., Cunningham, R. and Poulter, R. (2003) *The New Atlas of Australian Birds*. Royal Australian Ornithologists Union. Hawthorn East, Victoria.
- Belcher, C. (2004) The largest surviving marsupial carnivore on mainland Australia: the Tiger or Spotted-tailed Quoll *Dasyurus maculatus*, a nationally threatened, forest-dependent species. Pp 612-623 in *Conservation of Australia's Forest Fauna (second edition)* (ed.) D. Lunney. Southwood Press, Marrickville.
- Bell, S.A.J. (1997) *Vegetation Survey and Mapping of Crown Land, south of Manobalai Nature Reserve, Upper Hunter Valley*. Report by Eastcoast Flora Survey to the Department of Land and Water Conservation.
- Bilton, G. (1990) *Manobalai Nature Reserve Information*. Internal report to NPWS, Upper Hunter District (unpublished).
- Blakers, M., Davies, S.J.J.F. and Reilly, P.N. (1984) *The Atlas of Australian Birds*. Melbourne University Press, Carlton, Victoria.
- Braithwaite, R.W. (1995) Brown Antechinus *Antechinus stuartii*. Pp 94-97 in *The Mammals of Australia*. (ed.) R. Strahan. Reed Books, Chatswood.
- Brunner, H. and Coman, B. (1974) *Identification of Mammalian Hair*. Inkata Press, Melbourne.
- Catling, P.C (1991) Ecological effects of prescribed burning practices on the mammals of southeastern Australia. Pp 353-63 in *Conservation of Australia's Forest Fauna*. (ed.) D. Lunney. Royal Zoological Society of New South Wales, Sydney.
- Chafer, C.J. (1992) Observations of the Powerful Owl *Ninox strenua* in the Illawarra and Shoalhaven Regions of New South Wales. *Australian Bird Watcher* 14: 289-300.
- Churchill, S. (1998) *Australian Bats*. Reed New Holland, Sydney.
- Cogger, H.G. (1996) *Reptiles and Amphibians of Australia*. Fifth Edition with Amendments. Reed Books Australia, Port Melbourne.
- Corben, C. (1989) Computer-based call analysis for microbat identification. *Macroderma* 5:7.
- Debus, S.J.S. and Chafer, C.J. (1994) The Powerful Owl *Ninox strenua* in New South Wales. *Australian Birds* (Supplement) 28: 40-64.
- DEC (2004a) *Systematic Survey of Vertebrate Fauna in Lane Cove National Park*. Unpublished report to Sydney North Area (Central PWD) by Conservation Assessment and Data Unit, Metropolitan Branch, EPRD.
- DEC (2004b) *The Vertebrate Fauna of the Nattai and Bargo Reserves*. Unpublished report funded by the Central Directorate Parks and Wildlife Division Biodiversity Survey Priorities Program by NSW Department of Environment and Conservation, Conservation Assessment and Data Unit, Metropolitan Branch, EPRD.

- DEC (2004c) *Post-Fire Study of the Fauna of the Woronora Plateau. Progress Report – July 2004*. Unpublished report as part of the Special Areas Plan of Management (SASPoM) Research and Data Program by Conservation Assessment and Data Unit, Metropolitan Branch, EPRD.
- DEC (2005a) *Atlas of NSW Wildlife. Database of Fauna and Flora records*. GISG, NSW DEC (formerly NPWS), Hurstville. Data extracted June 2005.
- DEC (2005b) *The Vertebrate Fauna of North-eastern Wollemi National Park*. Unpublished report funded by the Central Branch Parks and Wildlife Division Biodiversity Survey Priorities Program by NSW Department of Environment and Conservation, Conservation Assessment and Data Unit, Metropolitan Branch, EPRD.
- DEC (2005c) *The Vertebrate Fauna of Northern Yengo National Park*. Unpublished report funded by the Central Directorate Parks and Wildlife Division Biodiversity Survey Priorities Program by NSW Department of Environment and Conservation, Conservation Assessment and Data Unit, Metropolitan Branch, EPRD.
- DEC (2005d) *The Vertebrate Fauna of Werakata National Park*. Unpublished report funded by the Central Directorate Parks and Wildlife Division Biodiversity Survey Priorities Program by NSW Department of Environment and Conservation, Conservation Assessment and Data Unit, Metropolitan Branch, EPRD.
- DEC (2005e) *The Terrestrial Vertebrate Fauna of the Southern Sydney Region*. Part of an unpublished report for the Sydney Catchment Authority on the Special Areas (Warragamba, Woronora, Metropolitan and Blue Mountains) by Conservation Assessment and Data Unit, EPRD. Hurstville.
- DEC (2005f) *Draft Recovery Plan for the Large Forest Owls: Powerful Owl *Ninox strenua* Sooty Owl *Tyto tenebricosa* and Masked Owl *Tyto novaehollandiae**. NSW DEC, Sydney.
- DEC (2005g) NSW Threatened Species Website: Painted Honeyeater – species profile. <http://203.202.1.211/tsprofile/profile.aspx?id=10357>. Accessed 14/06/2005.
- DEC (2005h) NSW Threatened Species Website: Grey-crowned Babbler (eastern subspecies) – species profile. <http://203.202.1.211/tsprofile/profile.aspx?id=10660>. Accessed 06/06/2005
- DEC (2005i) NSW Threatened Species Website: Yellow-bellied Sheath-tail bat – species profile. <http://203.202.1.211/tsprofile/profile.aspx?id=10741>. Accessed 10/06/2005
- DEC (2005j) Threatened Species Website: Eastern Long-eared Bat – species profile. <http://203.202.1.211/tsprofile/profile.aspx?id=10568>. Accessed 06/06/2005
- DEC (2005k) Threatened Species Website: Eastern Cave Bat – species profile. <http://203.202.1.211/tsprofile/profile.aspx?id=10829>. Accessed 06/06/2005
- DEH (2004a) Draft Threat Abatement Plan for Psittacine Circoviral (Beak and Feather) Disease Affecting Endangered Psittacine Species. <http://www.deh.gov.au/biodiversity/threatened/publications/tap/p-circoviral/pubs/p-circoviral.pdf> Accessed 23/05/05.
- Duncan, A., Baker, G.B. and Montgomery, N. (eds.) (1999) *The Action Plan for Australian Bats*. Environment Australia, Canberra.
- Dwyer, P.D. (1966) The population pattern of *Miniopterus schreibersii* (Chiroptera) in north-eastern New South Wales. *Australian Journal of Zoology* 14:1073-1137.
- Dwyer, P.D. (1995) Common Bentwing-bat *Miniopterus schreibersii*. Pp 494-5 in *The Mammals of Australia*. (ed.) R. Strahan. Reed Books, Chatswood.
- Edgar, R and Belcher, C. (1995). Spotted-tailed Quoll *Dasyurus maculatus*. Pp 67-9 in *The Mammals of Australia*. (ed.) R. Strahan. Reed Books, Chatswood.
- Eldridge, M.D.B. and Close, R.L. (1995) Brush-tailed Rock-wallaby *Petrogale penicillata*. Pp 383-5 in *The Mammals of Australia*. (ed.) R. Strahan. Reed Books, Chatswood.
- Environment ACT (2004) Information on Indian Myna Birds in the Australian Capital Territory. <http://www.environment.act.gov.au/yourenvironmenthwp/indianmynabirds.html> Accessed 15/06/05
- Environment Australia (1999) Threat Abatement Plan for Predation by the European Red Fox. <http://www.deh.gov.au/biodiversity/threatened/publications/tap/foxes/4.html> Accessed 17/02/06.

- Firestone, K.B., Elphinstone, M.S., Sherwin, W.B. and Houlden, B.A. (1999) Phylogeographical population structure of Tiger Quolls *Dasyurus maculatus* (Dasyuridae:Marsupialia), an endangered carnivorous marsupial. *Molecular Ecology* 8: 1613-1625.
- Garnett, S.T. and Crowley, G.M. (2000) *The Action Plan for Australian Birds 2000*. Environment Australia, Canberra.
- Gibbons, P. and Lindenmeyer, D. (2002) *Tree Hollows and Wildlife Conservation in Australia*. CSIRO Publishing, Collingwood, Australia.
- Gilmore, A. and Parnaby, H. (1994) *Vertebrate Fauna of Conservation Concern in North east NSW Forests. North East Forests Biodiversity Study Report No. 3e*. Unpublished report, NSW NPWS, Coffs Harbour.
- Glen, A.S. and Dickman, C.R. (2003) Effects of bait station design on the uptake of baits by non-target animals during control programmes for foxes and wild dogs. *Wildlife Research* 30: 147-9
- Harden, G.J. (ed.) (1999) *Flora of New South Wales Volume 2*. Revised edition. UNSW Press, Kensington.
- Higgins, P.J. (ed.) (1999) *Handbook of Australian, New Zealand and Antarctic Birds, Volume 4, Parrots to Dollarbird*. Oxford University Press, Melbourne.
- Higgins, P.J., Peter, J.M. and Steele, W.K. (eds.) (2001) *Handbook of Australian, New Zealand & Antarctic Birds, Volume 5 Tyrant-flycatchers to Chats*. Oxford University Press Australia, Melbourne.
- Higgins, P.J. and Peter, J.M. (eds.) (2002) *Handbook of Australian, New Zealand and Antarctic Birds, Volume 6: Pardalotes to Shrike-thrushes*. Oxford University Press, Melbourne.
- Hoye, G.A. and Dwyer, P.D. (1995) Large-eared Pied Bat *Chalinolobus dwyeri*. Pp 510-1 in *The Mammals of Australia*. (ed.) R. Strahan. Reed Books, Chatswood.
- Kavanagh, R. P. (1997). *Ecology and Management of Large Forest owls in South-eastern Australia*. Thesis submitted for the degree of Doctor of Philosophy at the School of Biological Sciences, University of Sydney
- Kavanagh, R. P. (2002) Conservation and management of large forest owls in south-eastern Australia. Pp 201-219 in *Ecology and Conservation of Owls*. (eds.) I. Newton, R. Kavanagh, J. Olsen and I. Taylor. CSIRO, Victoria.
- Kavanagh, R. P. (2004) Distribution and conservation status of the possums and gliders of New South Wales. Pp 130-148 in *The Biology of Australian Possums and Gliders*. (eds.) R.L. Goldingay and S.M. Jackson. Surrey Beatty & Sons, Chipping Norton.
- Keast, J.A. (1968) Seasonal movements in the Australian honeyeaters (Meliphagidae) and their ecological significance. *Emu* 67: 159-210.
- Keast, A. (1995) Habitat loss and species loss: the birds of Sydney 50 years ago and now. *Australian Zoologist* 30: 3-25.
- Kerle, A (2004) A cautionary tale: decline of the common brushtail possum *Trichosurus vulpecula* and common ringtail possum *Pseudocheirus peregrinus* in the woodlands of the western slopes and plains of New South Wales. Pp 71-84 in *The Biology of Australian Possums and Gliders*. (eds.) R.L. Goldingay and S.M. Jackson. Surrey Beatty & Sons, Chipping Norton.
- King, B.R. (1980) Social organisation and behaviour of the Grey-Crowned Babbler *Pomatostomus temporalis*. *Emu* 80: 59-76.
- Kovac, M. & Lawrie, J.W. (1991) *Soil Landscapes of the Singleton 1:250 000 sheet*. Soil Conservation Service of NSW, Sydney.
- Law, B., Chidel, M. and Mong, A. (2005) Life under a sandstone overhang: the ecology of the Eastern Cave Bat *Vespadelus troughtoni* in northern NSW. *Australian Mammalogy* 27: 137-145.
- Lunney, D. and Leary, T. (1988) The impact on native mammals of land-use changes and exotic species in the Bega district NSW, since settlement. *Australian Journal of Ecology* 13: 67-92.
- Lunney, D. and Matthews, A. (2001) The contribution of the community in defining the distribution of a vulnerable species, the Spotted-tailed Quoll, *Dasyurus maculatus*. *Wildlife Research* 28: 537-45.

- Lunney, D., Matthews, A. and Triggs, B (2002) Long-term changes in the mammal fauna of logged, coastal forests near Bega, New South Wales, detected by analysis of Dog and Fox scats. *Australian Mammalogy* 23: 101-114.
- Mansergh, I. (1984) The status, distribution and abundance of *Dasyurus maculatus* (Tiger Quoll) in Australia, with particular reference to Victoria. *Australian Zoologist* 21: 109-122
- Martin, R.W. and Handasyde, K.A. (1995) Koala *Phascolarctos cinereus*. Pp 196-8 in *The Mammals of Australia*. (ed.) R. Strahan. Reed Books, Chatswood.
- Maxwell, S., Burbidge, A.A. and Morris, K. eds (1996) *The 1996 Action Plan for Australian Marsupials and Monotremes*. Wildlife Australia, Canberra
- McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. and Hopkins, M.S. (eds.) (1990) *Australian Soil and Land Survey Field Handbook* (second edition). Inkata Press, Melbourne.
- Menkhorst, P.W. and Knight, F. (2001) *A Field Guide to the Mammals of Australia*. Oxford University Press, Melbourne.
- Menkhorst, P., Schedvin, N. and Geering, D. (1999) *Regent Honeyeater Recovery Plan 1999-2003*. Report prepared for the Regent Honeyeater Recovery Team. DNRE, East Melbourne.
- NPWS (1997) *NSW Comprehensive Regional Assessments: Vertebrate fauna surveys, 1997-1998 summer survey season: Field survey methods*. NSW National Parks and Wildlife Service. Unpublished.
- NPWS (1999a) Threatened Species Information – Yellow-bellied Glider.  
[http://www.nationalparks.nsw.gov.au/PDFs/tsprofile\\_yellowbellied\\_glider.pdf](http://www.nationalparks.nsw.gov.au/PDFs/tsprofile_yellowbellied_glider.pdf) Accessed 15/6/04
- NPWS (1999b) Threatened Species Information – Regent Honeyeater.  
[http://www.nationalparks.nsw.gov.au/PDFs/tsprofile\\_regent\\_honeyeater.pdf](http://www.nationalparks.nsw.gov.au/PDFs/tsprofile_regent_honeyeater.pdf) Accessed 15/6/05
- NPWS (1999b) Threatened Species Information – Spotted-tailed Quoll.  
[http://www.nationalparks.nsw.gov.au/PDFs/tsprofile\\_spottedtailed\\_quoll.pdf](http://www.nationalparks.nsw.gov.au/PDFs/tsprofile_spottedtailed_quoll.pdf) Accessed 15/6/04
- NPWS (1999c) Threatened Species Information – Koala.  
[http://www.nationalparks.nsw.gov.au/PDFs/tsprofile\\_koala.pdf](http://www.nationalparks.nsw.gov.au/PDFs/tsprofile_koala.pdf) Accessed 15/6/04
- NPWS (1999d) Threatened Species Information – Squirrel Glider.  
[http://www.nationalparks.nsw.gov.au/PDFs/tsprofile\\_squirrel\\_glider.pdf](http://www.nationalparks.nsw.gov.au/PDFs/tsprofile_squirrel_glider.pdf) Accessed 15/6/05
- NPWS (2001a) *The Fauna of Goulburn River National Park*. Unpublished report by the Central Directorate Conservation Assessment and Data Unit, Central Conservation Programs and Planning Division, Hurstville.
- NPWS (2001b) *Threat abatement plan for Predation by the Red Fox (*Vulpes vulpes*)*. NSW National Parks and Wildlife Service, Hurstville.
- NPWS (2002a). *Brush-tailed Rock-wallaby (*Petrogale penicillata*) Recovery Plan*. Draft for public comment. Hurstville.
- NPWS (2003a) *Priorities for the Collection of Flora and Fauna Data in the Central Directorate*. NSW National Parks and Wildlife Service.
- NPWS (2003b) *The Bioregions of New South Wales: their biodiversity, conservation and history*. NSW National Parks and Wildlife Service, Hurstville.
- NPWS (2003c) *Draft Recovery Plan for the Bush Stone-curlew *Burhinus grallarius**. NSW NPWS, Hurstville.
- NPWS (2003d) *Draft Recovery Plan for the Barking Owl *Ninox connivens**. NSW NPWS, Hurstville.
- NPWS (2003e) *Draft Recovery Plan for the Koala (*Phascolarctos cinereus*)*. NSW National Parks and Wildlife Service. Hurstville.
- NSW Scientific Committee (1998a) Final Determination to list predation by European Red Fox as a key threatening process.  
<http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Predation+by+the+European+red+fox+key+threatening+process+declaration> Accessed 15/6/04

- NSW Scientific Committee (1998b) Final Determination to list the Barking Owl *Ninox connivens* as a vulnerable species. <http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Barking+Owl+-+vulnerable+species+listing> Accessed 15/6/05
- NSW Scientific Committee (1999) Final Determination to list the Glossy Black-cockatoo population, Riverina as an endangered population. <http://www.nationalparks.nsw.gov.au/npws.nsf/content/glossy+black+cockatoo+population+riverina+endangered+population+listing> Accessed 26/05/05
- NSW Scientific Committee (2000a) Final Determination to list predation by Feral Cats as a key threatening process. <http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Predation+by+feral+cats+-+key+threatening+process+declaration> Accessed 15/6/04
- NSW Scientific Committee (2000b) Final Determination to list Ecological consequences of high frequency fires as a Key Threatening Process. <http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Ecological+consequences+of+high+frequency+fires+key+threatening+process+declaration> Accessed 15/06/05
- NSW Scientific Committee (2001a) Final Determination to list Brown Treecreeper (eastern subspecies) as a Vulnerable Species. <http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Brown+treecreeper+eastern+subspecies+-+vulnerable+species+listing> Accessed 27/05/05
- NSW Scientific Committee (2001b) Final Determination to list Speckled Warbler as a Vulnerable Species. <http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Speckled+warbler+-+vulnerable+species+listing> Accessed 07/02/05
- NSW Scientific Committee (2001c) Final Determination to list Black-chinned Honeyeater (eastern subspecies) as a Vulnerable Species. <http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Black-chinned+honeyeater+eastern+subspecies+-+vulnerable+species+listing> Accessed 01/02/05
- NSW Scientific Committee (2001d) Final Determination to list Diamond Firetail as a Vulnerable Species. <http://www.nationalparks.nsw.gov.au/npws.nsf/content/diamond+firetail+-+vulnerable+species+listing> Accessed 14/06/05
- NSW Scientific Committee (2001e) Final Determination to list Gang-gang Cockatoo population, Hornsby and Ku-ring-gai Local Government Areas as an Endangered Population. <http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Gang+gang+cockatoo+population+Hornsby+and+Ku+ring+gai+Local+Government+Areas+endangered+population+listing>. Accessed 27/05/05
- NSW Scientific Committee (2002) Final determination to list competition and grazing by the feral European Rabbit as a key threatening process. <http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Competition+and+grazing+by+the+feral+European+rabbit+key+threatening+process+declaration> Accessed 15/6/04
- NSW Scientific Committee (2003). Final Determination to list Brush-tailed Rock-wallaby (*Petrogale penicillata*) as an Endangered species. <http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Brush-tailed+rock+wallaby+-+endangered+species+listing>. Accessed 15/6/04
- NSW Scientific Committee (2004a). Gang-gang Cockatoo – proposed Vulnerable species listing. [http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Gang-gang\\_cockatoo\\_vulnerable\\_preliminary](http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Gang-gang_cockatoo_vulnerable_preliminary). Accessed 15/6/05
- NSW Scientific Committee (2004b). Final Determination to list Competition and habitat degradation by Feral Pigs. [http://www.nationalparks.nsw.gov.au/npws.nsf/content/feral\\_pigs\\_ktp](http://www.nationalparks.nsw.gov.au/npws.nsf/content/feral_pigs_ktp) Accessed 15/6/05
- NSW Scientific Committee (2004c). Final determination: Grey-crowned Babbler (eastern subspecies) – vulnerable species listing. <http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Grey-crowned+babbler+eastern+subspecies+-+vulnerable+species+listing>. Accessed 14/06/05.
- NSW Scientific Committee (2005) Final determination to list Gang-gang Cockatoo as a Vulnerable species. [http://www.nationalparks.nsw.gov.au/npws.nsf/Content/gang-gang\\_cockatoo\\_vulnerable](http://www.nationalparks.nsw.gov.au/npws.nsf/Content/gang-gang_cockatoo_vulnerable). Accessed 03/02/06.
- Oliver, D.L., Chambers, M.A. & Parker, D.G. (2003) Habitat and resource selection of the Painted Honeyeater (*Grantiella picta*) on the northern floodplains regions of New South Wales. *Emu* 103: 171-176.

- Olsen, P., Weston, M., Cunningham, R. and Silcocks, A. (2003) *The State of Australia's Birds 2003*. *Wingspan* 13(4) Supplement.
- Parnaby, H. (1992a) An interim guide to identification of insectivorous bats of south-eastern Australia. *Technical Reports of the Australian Museum Number 8*. Australian Museum, Sydney.
- Parnaby, H. (1992b) *An ultrasonic survey of microchiropteran bats of north-east NSW forests*. *North East Forests Biodiversity Study Report No. 3b*. NSW National Parks and Wildlife Service, Hurstville.
- Parnaby, H. (1995) Greater Long-eared Bat *Nyctophilus timoriensis*. Pp 507-508 in *The Mammals of Australia*. (ed.) R. Strahan. Reed Books, Chatswood.
- Peake, T. (1999) *The Vegetation of Manobalai Nature Reserve*. A report by Natural Assets Environmental Survey and Assessment, Muswellbrook.
- Pennay, M., Law, B. and Reinhold, L. (2004) *Bat calls of New South Wales: region based guide to the echolocation of microchiropteran bats*. NSW Department of Environment and Conservation, Hurstville.
- Pizzey, G. and Knight, F. (1999) *The Field Guide to the Birds of Australia*. Reprinted with corrections. Harper Collins, Sydney.
- Quin, D.G. (1995) Population ecology of the Squirrel Glider (*Petaurus norfolcensis*) and the Sugar Glider (*P. breviceps*) at Limeburners Creek, on the central-north coast of New South Wales. *Wildlife Research* 22: 471-505.
- Reed, P.C., Lunney, D. and Walker, P. (1990). A 1986-1987 survey of the koala *Phascolarctos cinereus* (Goldfuss) in New South Wales and an ecological interpretation of its distribution. In *Biology of the Koala*. (eds.) A. K. Lee, K.A. Handasyde and G.D. Sanson. Surrey Beatty & Sons, Sydney.
- Reid, J. (1999) *Threatened and Declining Birds in the New South Wales Sheep-wheatbelt: Diagnosis, Characteristics and Management*. Report to NSW National Parks and Wildlife Service, Sydney.
- Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001) *Key to the Bat Calls of South east Queensland and North east New South Wales*. Queensland Department of Natural Resources and Mines, Brisbane.
- Richards, G.C. (2000) *A Report on the Preparation of Threatened Species Profiles and Environmental Impact Assessment Guidelines for the Bat Fauna of NSW*. National Parks and Wildlife Service of NSW, Hurstville. Cited in Shelley (2004).
- Richards, G.C. (1995) Yellow-bellied Sheath-tail-bat *Saccolaimus flaviventris*. Pp 467 – 468 in *Mammals of Australia* (ed.) R. Strahan. Reed Books, Chatswood.
- Richards, G.C. (1992) *Fauna Survey: Wingham Management Area, Port Macquarie Region. Part 4: Bats*. Forestry Commission of New South Wales, Forest Resources Services Report No. 22.
- Robinson, M. (1993) *A Field Guide to Frogs of Australia*. Reed Books, Port Melbourne.
- Robinson D. & Traill, B.J. (1996) Conserving woodland birds in the wheat and sheep belts of southern Australia. *RAOU Conservation Statement* 10.
- Saunders, D (2002) *Assessment of Swift Parrot Sites near Cessnock, Lower Hunter Valley Region, NSW – including the Hunter Employment Zone*. Swift Parrot Recovery Team.
- Schodde, R. and Mason, I.J. (1999) *The Directory of Australian Birds – Passerines*. CSIRO Publishing, Collingwood, Victoria.
- Schulz, M. (1998) Bats and other Fauna in Disused Fairy Martin *Hirundo ariel* Nests. *Emu* 98: 184-191.
- Scotts, D.J. and Craig, S.A. (1988) Improved hair sampling tube for the detection of small mammals. *Australian Wildlife Research* 15: 469-472.
- Shelley, D. (2004) *Macquarie Marshes – Threatened species profiles*. Department of Infrastructure, Planning and Natural Resources, Dubbo.
- Short, J. and Milkovits, G. (1990) Distribution and status of the Brush-tailed Rock-wallaby in south-eastern Australia. *Australian Wildlife Research* 17: 169 –179.
- Simpson, K. and Day, N. (1996) *Field Guide to the Birds of Australia*. 5<sup>th</sup> Edition. Penguin Books, Ringwood.

- Smith, A.P. and Murray, M. (2003) Habitat requirements of the squirrel glider (*Petaurus norfolcensis*) and associated possums and gliders on the New South Wales central coast. *Wildlife Research* 30: 291-301.
- Smith, P.J., Smith, J.E., Pressey, R.L. and Whish, G.L. (1995) *Birds of Particular Conservation Concern in the Western Division of New South Wales: Distribution, Habitats and Threats*. NSW NPWS, Hurstville.
- Stauber, A. and Thumm, K. (2000) *Fauna Survey of Manobalai Nature Reserve – Implications for Fire Management Planning*. NSW National Parks and Wildlife Service.
- Story, R., Galloway, R.W., van-de Graaff, R.H.M. and Tweedie, A.D. (1963) *General Report on the Lands of the Hunter Valley*. Land Research Series No. 8. CSIRO, Melbourne.
- Suckling, G.C. (1995a) Sugar glider *Petaurus breviceps*. Pp 229-231 in *The Mammals of Australia* (ed.) R. Strahan. Reed Books, Chatswood.
- Suckling, G.C. (1995b) Squirrel glider *Petaurus norfolcensis*. Pp 234-235 in *The Mammals of Australia* (ed.) R. Strahan. Reed Books, Chatswood.
- Swan, G., Shea, G. and Sadler, R. (2004) *A Field Guide to Reptiles of New South Wales*. Second Edition. Reed New Holland, Sydney.
- Taylor, I.R., Kirsten, I. and Peake, P. (2002a) *Distribution and habitat of Barking Owls (Ninox connivens) in Central Victoria*. Pp 107-15 in *Ecology and Conservation of Owls* (eds.) I. Newton, R. Kavanagh, J. Olsen and I. Taylor. CSIRO Publishing, Collingwood, Victoria.
- Taylor, I.R., Kirsten, I. and Peake, P. (2002b) *Habitat, Breeding and Conservation of the Barking Owl (Ninox connivens) in Northeastern Victoria, Australia*. Pp 116-124 in *Ecology and Conservation of Owls* (eds.) I. Newton, R. Kavanagh, J. Olsen and I. Taylor. CSIRO Publishing, Collingwood, Victoria.
- Thackway, R. and Cresswell, I.D. (eds.) (1995) *An interim biogeographic regionalisation for Australia: a framework for establishing the national system of reserves, version 4.0*. Australian Nature Conservation Agency, Canberra.
- Tidemann, C.R. and Woodside, D.P. (1978) A collapsible bat trap compared with mist-nets. *Australian Wildlife Research* 5: 363-384.
- Traill, B.J. and Duncan, S. (2000) *Status of birds in the New South Wales temperate woodlands region*. Unpublished consultancy report to the NSW National Parks and Wildlife Service.
- Visser, J. (1997) *Fauna Survey of Manobalai Vacant Crown Land – February 1997*. Report by the Upper Hunter District of the NSW National Parks and Wildlife Service for the Department of Land and Water Conservation.
- Walker, J. and Hopkins, M.S. (1990) Vegetation. Pages 58-86 in *Australian Soil and Land Survey Field Handbook*. Second edition. (eds.) R.C. McDonald, R.F. Isbell, J.G. Speight, J. Walker, and M.S. Hopkins. Inkata Press, Melbourne.
- Wilson, S. and Swan, G. (2003) *A complete Guide to the Reptiles of Australia*. Reed New Holland, Sydney.

# APPENDIX A - LOCATION OF SURVEY SITES

Location and techniques undertaken at systematic fauna survey sites in Manobalai Nature Reserve and Crown Lands. The prefix MNB denotes the site was on the Manobalai 1:25000 map sheet, while SHL denotes the Sandy Hollow 1:25000 map sheet.

Site number	Easting	Northing	Vegetation type	Diurnal bird census	Diurnal reptile census	Site spotlight census	Harp trap	Bat ultrasound detection	Nocturnal call playback	Nocturnal streamside search	Elliott traps	Hair tubes
MNB01W	268370	6431601	Ironbark Woodland on Alluvium	1	1	1			1			
MNB02W	269695	6430809	Ironbark Woodland on Alluvium	1	1	1						
MNB03W	267446	6432262	Narrabeen Exposed Woodland	1	1	1						
MNB04O	269258	6429687	Ironbark Woodland on Alluvium	1	1	1	1		1			
MNB05O	270906	6429410	Rough-barked Apple Woodland on Alluvium	1	1	1	1					
MNB06W	271662	6429810	Narrabeen Sheltered Dry Forest	1	1	1						
MNB07W	269504	6430860	Ironbark Woodland on Alluvium				1					
MNB08W	268815	6431244	Ironbark Woodland on Alluvium				1					
MNB09O	272531	6432596	Dry Rainforest on Alluvium	1	1							
MNB10O	273397	6432151	Red Gum Swamp Open Forest on Alluvium	1	1							
MNB11O	275147	6432120	Narrabeen Exposed Woodland	1	1	1		1				
MNB12W	274362	6431197	Box Woodland on Basalt	1	1	1						
MNB13W	269482	6433400	Red Gum Swamp Open Forest on Alluvium	1	1	1						
MNB14O	270406	6433739	Red Gum Swamp Open Forest on Alluvium	1	1	1			1			1
MNB15W	271464	6433683	Narrabeen Exposed Woodland	1	1							
MNB16O	272202	6436865	Spotted Gum Open Forest Complex on Sandstone	1	1							
MNB17W	272804	6437263	Spotted Gum Open Forest Complex on Sandstone	1	1	1		1				1
MNB18O	273756	6437852	Spotted Gum Open Forest Complex on Sandstone	1	1	1						
MNB19O	273796	6436810	Spotted Gum Open Forest Complex on Sandstone	1	1	1						
MNB20W	272209	6439048	Box Woodland on Basalt	1	1	1		1				
MNB21W	272904	6438496	Narrabeen Sheltered Dry Forest	1	1							
MNB22O	272468	6437220	Cleared				1					
MNB23W	266935	6430341	Narrabeen Exposed Woodland	1	1	1						
MNB24W	268231	6430023	Narrabeen Sheltered Dry Forest	1	1	1						

Site number	Easting	Northing	Vegetation type	Diurnal bird census	Diurnal reptile census	Site spotlight census	Harp trap	Bat ultrasound detection	Nocturnal call playback	Nocturnal streamside search	Elliott traps	Hair tubes
MNB25W	271982	6437456	Spotted Gum Open Forest Complex on Sandstone	1	1	1						
MNB26W	273501	6439281	Spotted Gum Open Forest Complex on Sandstone	1	1							
MNB27O	272302	6431507	Narrabeen Exposed Woodland	1	1	1						
MNB28O	273643	6433206	Spotted Gum Open Forest Complex on Sandstone	1	1							
MNB29W	277118	6433580	Spotted Gum Open Forest Complex on Sandstone	1								
MNB30W	278142	6433436	Spotted Gum Open Forest Complex on Sandstone	1	1							
MNB31W	278505	6434368	Spotted Gum Open Forest Complex on Sandstone	1	1							
MNB32W	277983	6434783	Spotted Gum Open Forest Complex on Sandstone	1	1							
MNB33W	278447	6430543	Spotted Gum Open Forest Complex on Sandstone		1							
MNB34O	273579	6437741	Spotted Gum Open Forest Complex on Sandstone				1					
MNB35O	270192	6430538	Cleared					1				
MNB36O	272994	6436424	Narrabeen Sheltered Dry Forest	1								
MNB37O	272690	6435504	Spotted Gum Open Forest Complex on Sandstone	1	1							
MNB38O	272049	6434484	Narrabeen Exposed Woodland	1	1							
MNB39O	272069	6429898	Rough-barked Apple Woodland on Alluvium				1					
MNB40O	275439	6432392	Narrabeen Exposed Woodland				1					
MNB41O	274667	6431794	Narrabeen Exposed Woodland				1				1	
MNB42W	272031	6430660	Box Woodland on Basalt				1					
MNB44O	273512	6437620	Spotted Gum Open Forest Complex on Sandstone						1			
MNB45O	272593	6430523	Narrabeen Exposed Woodland						1			
MNB46G	267166	6430145	Cleared						1			
MNB47O	274692	6431838	Narrabeen Exposed Woodland						1			
MNB48O	271224	6429504	Rough-barked Apple Woodland on Alluvium						1			
MNB49W	277185	6435319	Spotted Gum Open Forest Complex on Sandstone						1			
S-F-LNE-41-157-G	270700	6430800	Narrabeen Sheltered Dry Forest	1	1		1	1	1	1		
S-F-LNE-41-158-M	271200	6430800	Narrabeen Sheltered Dry Forest	1	1		1	1	1			
S-F-LNE-41-159-R	272100	6430700	Narrabeen Exposed Woodland	1	1	1	1	1	1			
SHL01W	270476	6428101	Narrabeen Sheltered Dry Forest	1		1						

Site number	Easting	Northing	Vegetation type	Diurnal bird census	Diurnal reptile census	Site spotlight census	Harp trap	Bat ultrasound detection	Nocturnal call playback	Nocturnal streamside search	Elliott traps	Hair tubes
SHL02O	274266	6426034	Alluvium Angophora Woodland	1		1		1				
SHL03O	271390	6420096	Narrabeen Acacia Woodland	1		1		1				
SHL04O	270719	6420642	Narrabeen Exposed Woodland	1								
SHL05M	271894	6424810	Narrabeen Rocky Heath	1					1			
SHL06W	271385	6427258	Narrabeen Sheltered Dry Forest	1	1							
SHL07W	272456	6427870	Narrabeen Sheltered Dry Forest	1	1							
SHL08W	273385	6426553	Narrabeen Sheltered Dry Forest		1							
SHL09O	268843	6427329	Ironbark Woodland on Alluvium	1		1						
SHL10O	269766	6426598	Ironbark Woodland on Alluvium	1	1	1						
SHL11W	268402	6427935	Narrabeen Exposed Woodland	1	1							
SHL12W	268484	6426918	Narrabeen Exposed Woodland		1							
SHL13O	269532	6426830	Ironbark Woodland on Alluvium					1				
SHL14W	270678	6423545	Narrabeen Exposed Woodland									
SHL15O	275153	6425462	Ironbark Woodland on Alluvium	1	1							
SHL16W	275831	6424967	Ironbark Woodland on Alluvium	1	1							
SHL17W	271953	6425786	Narrabeen Exposed Woodland	1								
SHL18W	270780	6427639	Rough-barked Apple Woodland on Alluvium							1		
SHL19O	270204	6425804	Ironbark Woodland on Alluvium	1			1					
SHL20O	269019	6427156	Ironbark Woodland on Alluvium				1				1	
SHL21M	273622	6427310	Narrabeen Acacia Woodland	1	1							
SHL22M	274023	6428225	Narrabeen Acacia Woodland		1							
SHL23M	274623	6427015	Narrabeen Acacia Woodland	1								
SHL24W	278792	6429421	Spotted Gum Open Forest Complex on Sandstone		1							
SHL25W	279253	6427933	Spotted Gum Open Forest Complex on Sandstone	1	1							
SHL26O	274084	6426077	Rough-barked Apple Woodland on Alluvium				1					
SHL27O	273335	6427130	Rough-barked Apple Woodland on Alluvium				1					
SHL28O	271578	6427340	Rough-barked Apple Woodland on Alluvium				1					
SHL29W	270318	6428367	Rough-barked Apple Woodland on Alluvium				1	1		1	1	
SHL30W	270948	6420213	Narrabeen Acacia Woodland						1			

Site number	Easting	Northing	Vegetation type	Diurnal bird census	Diurnal reptile census	Site spotlight census	Harp trap	Bat ultrasound detection	Nocturnal call playback	Nocturnal streamside search	Elliott traps	Hair tubes
SHL31W	269982	6423952	Narrabeen Sheltered Dry Forest						1			
SHL32O	268902	6427294	Ironbark Woodland on Alluvium						1			
SHL33W	277548	6424142	Ironbark Woodland on Alluvium						1			
T-F-SYD-50-077	270550	6427850	Alluvium Angophora Woodland						1			
T-F-SYD-50-078	272900	6427600	Narrabeen Sheltered Dry Forest						1			
T-F-SYD-50-079	274100	6426150	Narrabeen Sheltered Dry Forest						1			
T-F-SYD-50-081	270100	6426150	Narrabeen Exposed Woodland						1			

# APPENDIX B – FAUNA SPECIES RECORDED IN MANOBALAI NATURE RESERVE

List of the fauna species recorded within Manobalai Nature Reserve on the DEC Atlas of NSW Wildlife. Records have been included from Biodiversity Survey Priorities (BSP) systematic surveys, Comprehensive Regional Assessment (CRA) surveys, licensed data sets (Birds Australia and the Australian Museum) and observations submitted by individuals, including park rangers and field officers; catchment officers; bushwalkers and naturalists; scientific researchers working in the area; and other visitors to the park. This final category ('other') includes records collected by Stauber & Thumm (2000). The list contains records of various levels of reliability and spatial accuracy. Species where there is doubt about their occurrence within the study area due to possible identification inaccuracy have been marked with an asterisk \* and due to spatial inaccuracy have been marked with an ^. Introduced species are indicated with the addition of an ^.

Family	Scientific name	Common name	TSC	EPBC	BSP	CRA	AM & BA	Other
<b>Frogs</b>								
Myobatrachidae	<i>Limnodynastes dumerilii</i>	Bullfrog	P		✓			✓
Myobatrachidae	<i>Pseudophryne bibronii</i>	Bibron's Toadlet	P		✓			✓
Hylidae	<i>Litoria caerulea</i>	Green Tree Frog	P		✓	✓		✓
Hylidae	<i>Litoria dentata</i>	Keferstein's Tree Frog	P		✓			
Hylidae	<i>Litoria freycineti</i>	Freycinet's Frog	P					✓
Hylidae	<i>Litoria latopalmata</i>	Broad-palmed Frog	P					✓
<b>Reptiles</b>								
Chelidae	<i>Chelodina longicollis</i>	Eastern Snake-necked Turtle	P		✓			✓
Gekkonidae	<i>Diplodactylus vittatus</i>	Eastern Stone Gecko	P		✓			
Gekkonidae	<i>Oedura lesueurii</i>	Lesueur's Velvet Gecko	P		✓	✓		✓
Gekkonidae	<i>Phyllurus platurus</i>	Broad-tailed Gecko	P		✓			✓
Gekkonidae	<i>Saltuarius swaini</i>	Southern Leaf-tailed Gecko *	P					✓
Gekkonidae	<i>Underwoodisaurus milii</i>	Thick-tailed Gecko	P		✓	✓		✓
Agamidae	<i>Amphibolurus nobbi</i>	Nobbi Lashtail	P		✓			✓
Agamidae	<i>Pogona barbata</i>	Eastern Bearded Dragon	P		✓			✓
Varanidae	<i>Varanus gouldii</i>	Sand Monitor	P		✓			
Varanidae	<i>Varanus varius</i>	Lace Monitor	P		✓			✓
Scincidae	<i>Anomalopus swansonii</i>	Punctate Worm-skink	P		✓			
Scincidae	<i>Carlia tetradactyla</i>	Southern Rainbow-skink	P		✓			
Scincidae	<i>Cryptoblepharus virgatus</i>	Cream-striped Shinning-skink	P		✓			✓
Scincidae	<i>Ctenotus robustus</i>	Robust Ctenotus	P		✓			
Scincidae	<i>Ctenotus taeniolatus</i>	Copper-tailed Ctenotus	P		✓	✓		✓
Scincidae	<i>Egernia cunninghami</i>	Cunningham's Spiny-tailed Skink	P		✓			✓
Scincidae	<i>Egernia modesta</i>	Eastern Ranges Rock-skink	P		✓			
Scincidae	<i>Egernia striolata</i>	Tree-crevice Skink	P		✓			
Scincidae	<i>Egernia whitii</i>	White's Rock-skink	P		✓			✓
Scincidae	<i>Eulamprus tenuis</i>	Bar-sided Forest-skink	P		✓			✓
Scincidae	<i>Lerista bougainvillii</i>	South-eastern Slider	P		✓			
Scincidae	<i>Lygisaurus foliorum</i> (recently revised to <i>Carlia foliorum</i> )	Tree-base Litter-skink	P		✓	✓		✓

Family	Scientific name	Common name	TSC	EPBC	BSP	CRA	AM & BA	Other
Scincidae	<i>Morethia boulengeri</i>	South-eastern Morethia Skink	P		✓			✓
Boidae	<i>Morelia spilota</i>	Carpet / Diamond Python	P					✓
Elapidae	<i>Demansia psammophis</i>	Yellow-faced Whipsnake	P					✓
Elapidae	<i>Pseudechis porphyriacus</i>	Red-bellied Black Snake	P		✓			
<b>Birds</b>								
Phasianidae	<i>Coturnix pectoralis</i>	Stubble Quail	P				✓	
Anatidae	<i>Anas superciliosa</i>	Pacific Black Duck	P				✓	
Anatidae	<i>Chenonetta jubata</i>	Australian Wood Duck	P		✓		✓	✓
Ardeidae	<i>Egretta novaehollandiae</i>	White-faced Heron	P				✓	
Accipitridae	<i>Accipiter fasciatus</i>	Brown Goshawk	P		✓			
Accipitridae	<i>Aquila audax</i>	Wedge-tailed Eagle	P		✓		✓	✓
Charadriidae	<i>Vanellus miles</i>	Masked Lapwing	P		✓		✓	✓
Charadriidae	<i>Vanellus tricolor</i>	Banded Lapwing ^	P					✓
Columbidae	<i>Ocyphaps lophotes</i>	Crested Pigeon	P				✓	
Columbidae	<i>Phaps chalcoptera</i>	Common Bronzewing	P		✓			
Cacatuidae	<i>Cacatua galerita</i>	Sulphur-crested Cockatoo	P		✓	✓	✓	✓
Cacatuidae	<i>Calyptorhynchus funereus</i>	Yellow-tailed Black-Cockatoo	P			✓		
Cacatuidae	<i>Calyptorhynchus lathami</i>	Glossy Black-Cockatoo	V		✓	✓		✓
Cacatuidae	<i>Eolophus roseicapillus</i>	Galah	P		✓		✓	
Psittacidae	<i>Alisterus scapularis</i>	Australian King-Parrot	P		✓	✓	✓	✓
Psittacidae	<i>Glossopsitta concinna</i>	Musk Lorikeet	P		✓		✓	
Psittacidae	<i>Glossopsitta pusilla</i>	Little Lorikeet	P		✓	✓		
Psittacidae	<i>Platycercus adscitus eximius</i>	Eastern Rosella	P		✓		✓	
Psittacidae	<i>Platycercus elegans</i>	Crimson Rosella	P		✓			
Psittacidae	<i>Psephotus haematonotus</i>	Red-rumped Parrot	P				✓	
Cuculidae	<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo	P		✓			
Cuculidae	<i>Cacomantis variolosus</i>	Brush Cuckoo	P		✓		✓	
Cuculidae	<i>Chalcites basalis</i>	Horsfield's Bronze-Cuckoo	P				✓	
Cuculidae	<i>Chalcites lucidus</i>	Shining Bronze-Cuckoo	P		✓			
Cuculidae	<i>Cuculus pallidus</i>	Pallid Cuckoo	P					✓
Cuculidae	<i>Eudynamys orientalis</i>	Pacific Koel	P		✓			✓
Cuculidae	<i>Scythrops novaehollandiae</i>	Channel-billed Cuckoo	P		✓			
Strigidae	<i>Ninox boobook</i>	Southern Boobook	P		✓	✓		✓
Strigidae	<i>Ninox connivens</i>	Barking Owl	V		✓			
Strigidae	<i>Ninox strenua</i>	Powerful Owl	V		✓			✓
Tytonidae	<i>Tyto alba</i>	Barn Owl	P		✓			✓
Tytonidae	<i>Tyto novaehollandiae</i>	Masked Owl	V					✓
Podargidae	<i>Podargus strigoides</i>	Tawny Frogmouth	P		✓			✓
Caprimulgidae	<i>Eurostopodus mystacalis</i>	White-throated Nightjar	P					✓
Aegothelidae	<i>Aegotheles cristatus</i>	Australian Owlet-nightjar	P		✓	✓		
Alcedinidae	<i>Alcedo azurea</i>	Azure Kingfisher ^	P					✓
Halcyonidae	<i>Dacelo novaeguineae</i>	Laughing Kookaburra	P		✓	✓	✓	✓
Halcyonidae	<i>Todiramphus sanctus</i>	Sacred Kingfisher	P		✓		✓	

Family	Scientific name	Common name	TSC	EPBC	BSP	CRA	AM & BA	Other
Meropidae	<i>Merops ornatus</i>	Rainbow Bee-eater	P		✓	✓	✓	✓
Coraciidae	<i>Eurystomus orientalis</i>	Dollarbird	P		✓			
Menuridae	<i>Menura novaehollandiae</i>	Superb Lyrebird	P		✓			
Climacteridae	<i>Climacteris picumnus victoriae</i>	Brown Treecreeper (eastern subsp.)	V		✓	✓		
Climacteridae	<i>Cormobates leucophaeus</i>	White-throated Treecreeper	P		✓	✓	✓	✓
Maluridae	<i>Malurus cyaneus</i>	Superb Fairy-wren	P		✓	✓	✓	
Maluridae	<i>Malurus lamberti</i>	Variagated Fairy-wren	P		✓			
Pardalotidae	<i>Pardalotus punctatus</i>	Spotted Pardalote	P		✓	✓	✓	✓
Pardalotidae	<i>Pardalotus striatus</i>	Striated Pardalote	P		✓	✓	✓	
Acanthizidae	<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill	P					✓
Acanthizidae	<i>Acanthiza lineata</i>	Striated Thornbill	P		✓	✓		
Acanthizidae	<i>Acanthiza nana</i>	Yellow Thornbill	P		✓	✓		
Acanthizidae	<i>Acanthiza pusilla</i>	Brown Thornbill	P		✓	✓	✓	✓
Acanthizidae	<i>Acanthiza reguloides</i>	Buff-rumped Thornbill	P		✓	✓		
Acanthizidae	<i>Calamanthus pyrrhopygius</i>	Chestnut-rumped Heathwren	P		✓	✓		
Acanthizidae	<i>Gerygone olivacea</i>	White-throated Gerygone	P		✓	✓	✓	✓
Acanthizidae	<i>Origma solitaria</i>	Rockwarbler	P		✓			
Acanthizidae	<i>Pyrholaemus sagittatus</i>	Speckled Warbler	V		✓	✓		
Acanthizidae	<i>Sericornis frontalis</i>	White-browed Scrubwren	P		✓			✓
Acanthizidae	<i>Smicronis brevirostris</i>	Weebill	P		✓	✓	✓	
Meliphagidae	<i>Acanthorhynchus tenuirostris</i>	Eastern Spinebill	P		✓	✓		✓
Meliphagidae	<i>Anthochaera carunculata</i>	Red Wattlebird	P		✓		✓	
Meliphagidae	<i>Lichenostomus chrysops</i>	Yellow-faced Honeyeater	P		✓	✓	✓	✓
Meliphagidae	<i>Lichenostomus leucotis</i>	White-eared Honeyeater	P		✓	✓		✓
Meliphagidae	<i>Lichenostomus melanops</i>	Yellow-tufted Honeyeater	P		✓	✓		✓
Meliphagidae	<i>Manorina melanocephala</i>	Noisy Miner	P		✓	✓	✓	✓
Meliphagidae	<i>Manorina melanophrys</i>	Bell Miner	P		✓			
Meliphagidae	<i>Melithreptus brevirostris</i>	Brown-headed Honeyeater	P		✓		✓	
Meliphagidae	<i>Melithreptus lunatus</i>	White-naped Honeyeater	P		✓			
Meliphagidae	<i>Myzomela sanguinolenta</i>	Scarlet Honeyeater	P		✓	✓		✓
Meliphagidae	<i>Philemon corniculatus</i>	Noisy Friarbird	P		✓	✓	✓	✓
Meliphagidae	<i>Plectorhyncha lanceolata</i>	Striped Honeyeater	P		✓		✓	
Petroicidae	<i>Eopsaltria australis</i>	Eastern Yellow Robin	P		✓	✓	✓	
Petroicidae	<i>Microeca fascinans</i>	Jacky Winter	P		✓			
Eupetidae	<i>Cinclosoma punctatum</i>	Spotted Quail-thrush	P		✓			
Neosittidae	<i>Daphoenositta chrysoptera</i>	Varied Sittella	P		✓	✓		✓
Pachycephalidae	<i>Colluricincla harmonica</i>	Grey Shrike-thrush	P		✓	✓	✓	
Pachycephalidae	<i>Falcunculus frontatus</i>	Eastern Shrike-tit	P			✓	✓	
Pachycephalidae	<i>Pachycephala pectoralis</i>	Golden Whistler	P		✓			
Pachycephalidae	<i>Pachycephala rufiventris</i>	Rufous Whistler	P		✓	✓	✓	
Dicruridae	<i>Grallina cyanoleuca</i>	Magpie-lark	P				✓	
Dicruridae	<i>Myiagra rubecula</i>	Leaden Flycatcher	P		✓	✓	✓	

Family	Scientific name	Common name	TSC	EPBC	BSP	CRA	AM & BA	Other
Dicruridae	<i>Rhipidura albiscapa</i>	Grey Fantail	P		✓	✓	✓	✓
Dicruridae	<i>Rhipidura leucophrys</i>	Willie Wagtail	P		✓	✓	✓	✓
Campephagidae	<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike	P		✓	✓	✓	
Campephagidae	<i>Coracina tenuirostris</i>	Cicadabird	P		✓	✓		✓
Campephagidae	<i>Lalage tricolor</i>	White-winged Triller	P		✓			
Oriolidae	<i>Oriolus sagittatus</i>	Olive-backed Oriole	P		✓		✓	
Artamidae	<i>Artamus cyanopterus</i>	Dusky Woodswallow	P		✓		✓	
Artamidae	<i>Cracticus nigrogularis</i>	Pied Butcherbird	P		✓		✓	✓
Artamidae	<i>Cracticus torquatus</i>	Grey Butcherbird	P		✓	✓	✓	✓
Artamidae	<i>Gymnorhina tibicen</i>	Australian Magpie	P		✓	✓	✓	✓
Artamidae	<i>Strepera graculina</i>	Pied Currawong	P		✓	✓	✓	✓
Corvidae	<i>Corvus coronoides</i>	Australian Raven	P		✓	✓	✓	✓
Corcoracidae	<i>Corcorax melanorhamphos</i>	White-winged Cough	P		✓		✓	✓
Alaudidae	<i>Mirafra javanica</i>	Horsfield's Bushlark ^	P				✓	
Motacillidae	<i>Anthus australis</i>	Australian Pipit ^	P				✓	
Estrildidae	<i>Neochmia temporalis</i>	Red-browed Finch	P		✓	✓		✓
Estrildidae	<i>Taeniopygia bichenovii</i>	Double-barred Finch	P		✓			
Dicaeidae	<i>Dicaeum hirundinaceum</i>	Mistletoebird	P		✓		✓	
Hirundinidae	<i>Hirundo neoxena</i>	Welcome Swallow	P		✓		✓	✓
Hirundinidae	<i>Petrochelidon nigricans</i>	Tree Martin	P				✓	
Sylviidae	<i>Cincloramphus mathewsi</i>	Rufous Songlark	P				✓	
Sylviidae	<i>Cisticola exilis</i>	Golden-headed Cisticola ^	P				✓	
Zosteropidae	<i>Zosterops lateralis</i>	Silveryeye	P		✓	✓		✓
Sturnidae	<i>Sturnus vulgaris</i>	Common Starling	U				✓	
<b>Mammals</b>								
Tachyglossidae	<i>Tachyglossus aculeatus</i>	Short-beaked Echidna	P		✓			✓
Dasyuridae	<i>Antechinus flavipes</i>	Yellow-footed Antechinus	P		✓			✓
Dasyuridae	<i>Antechinus stuartii</i>	Brown Antechinus	P		✓		✓	✓
Dasyuridae	<i>Dasyurus maculatus</i>	Spotted-tailed Quoll	V	E	Evidence suggests the species exists, though a definite sighting has not been made recently			
Dasyuridae	<i>Sminthopsis murina</i>	Common Dunnart	P					✓
Phascolarctidae	<i>Phascolarctos cinereus</i>	Koala	V					✓
Vombatidae	<i>Vombatus ursinus</i>	Common Wombat	P		✓	✓		✓
Petauridae	<i>Petaurus australis</i>	Yellow-bellied Glider	V					✓
Petauridae	<i>Petaurus breviceps</i>	Sugar Glider	P		✓			✓
Phalangeridae	<i>Trichosurus vulpecula</i>	Common Brushtail Possum	P		✓	✓		✓
Macropodidae	<i>Macropus giganteus</i>	Eastern Grey Kangaroo	P		✓			✓
Macropodidae	<i>Macropus robustus</i>	Common Wallaroo	P		✓			✓
Macropodidae	<i>Macropus rufogriseus</i>	Red-necked Wallaby	P		✓			✓
Macropodidae	<i>Petrogale penicillata</i>	Brush-tailed Rock-wallaby	E1	V				✓
Macropodidae	<i>Wallabia bicolor</i>	Swamp Wallaby	P		✓	✓		✓
Rhinolophidae	<i>Rhinolophus megaphyllus</i>	Eastern Horseshoe-bat	P		✓			

Family	Scientific name	Common name	TSC	EPBC	BSP	CRA	AM & BA	Other
Emballonuridae	<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheath-tail-bat	V		✓			✓
Molossidae	<i>Mormopterus norfolkensis</i>	East-coast Free-tail Bat	V			✓		
Molossidae	<i>Mormopterus planiceps</i>	Little Mastiff-bat	P			✓		✓
Molossidae	<i>Mormopterus species 4 (long penis form)</i> (Adams et al. 1988)	Southern Free-tail Bat	P		✓			
Molossidae	<i>Nyctinomus australis</i>	White-striped Freetail-bat	P		✓			✓
Vespertilionidae	<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	V	V	✓			✓
Vespertilionidae	<i>Chalinolobus gouldii</i>	Gould's Wattled Bat	P		✓	✓	✓	✓
Vespertilionidae	<i>Chalinolobus morio</i>	Chocolate Wattled Bat	P		✓	✓		✓
Vespertilionidae	<i>Miniopterus schreibersii oceanensis</i>	Eastern Bent-wing Bat	V		✓			
Vespertilionidae	<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat	P		✓	✓		
Vespertilionidae	<i>Nyctophilus gouldi</i>	Gould's Long-eared Bat	P		✓	✓		
Vespertilionidae	<i>Nyctophilus timoriensis</i>	Greater Long-eared Bat	V	V		✓		
Vespertilionidae	<i>Scotorepens balstoni</i>	Inland Broad-nosed Bat	P		✓	✓		
Vespertilionidae	<i>Scotorepens greyii</i> *	Little Broad-nosed Bat *	P					✓
Vespertilionidae	<i>Vespadelus pumilus</i> *	Eastern Forest Bat *	P					✓
Vespertilionidae	<i>Vespadelus troughtoni</i>	Eastern Cave Bat	V			✓		
Vespertilionidae	<i>Vespadelus vulturinus</i>	Little Forest Bat	P		✓	✓	✓	✓
Muridae	<i>Mus musculus</i>	House Mouse	U		✓			✓
Muridae	<i>Rattus rattus</i>	Black Rat	U					✓
Leporidae	<i>Oryctolagus cuniculus</i>	Rabbit	U		✓			✓
Canidae	<i>Canis lupus</i>	Dingo, domestic dog	U		✓			
Canidae	<i>Vulpes vulpes</i>	Fox	U		✓			✓
Felidae	<i>Felis catus</i>	Cat	U					✓
Suidae	<i>Sus scrofa</i>	Pig	U					✓

# APPENDIX C – FAUNA SPECIES RECORDED IN CROWN LANDS

List of the fauna species recorded within Manobalai Vacant Crown Lands on the DEC Atlas of NSW Wildlife. Records have been included from Biodiversity Survey Priorities (BSP) systematic surveys, Comprehensive Regional Assessment (CRA) surveys, licensed data sets (Birds Australia and the Australian Museum) and observations submitted by individuals, including park rangers and field officers; catchment officers; bushwalkers and naturalists; scientific researchers working in the area; and other visitors to the park. This final category ('other') includes records collected by NPWS Upper Hunter District (1997). The list contains records of various levels of reliability and spatial accuracy. Species where there is doubt about the occurrence within the study area have been marked with an asterisk \*. Introduced species are indicated with the addition of an †.

Family	Scientific name	Common name	TSC	EPBC	BSP	CRA	AM&BA	Other
<b>Frogs</b>								
Myobatrachidae	<i>Crinia signifera</i>	Common Eastern Froglet	P			✓		
Myobatrachidae	<i>Limnodynastes dumerilii</i>	Bullfrog	P		✓			
Myobatrachidae	<i>Limnodynastes ornatus</i>	Ornate Burrowing Frog	P		✓			
Myobatrachidae	<i>Limnodynastes tasmaniensis</i>	Spotted Marsh Frog	P		✓		✓	
Myobatrachidae	<i>Neobatrachus sudelli</i>	Painted Burrowing Frog	P		✓			
Myobatrachidae	<i>Uperoleia laevigata</i>	Smooth Toadlet	P		✓			
Hylidae	<i>Litoria caerulea</i>	Green Tree Frog	P		✓		✓	
Hylidae	<i>Litoria dentata</i>	Keferstein's Tree Frog	P		✓			
Hylidae	<i>Litoria latopalmata</i>	Broad-palmed Frog	P		✓		✓	
Hylidae	<i>Litoria lesueuri</i>	Lesueur's Frog	P				✓	
Hylidae	<i>Litoria peronii</i>	Peron's Tree Frog	P		✓		✓	
Hylidae	<i>Litoria verreauxii</i>	Verreaux's Tree Frog	P				✓	
<b>Reptiles</b>								
Chelidae	<i>Chelodina longicollis</i>	Eastern Snake-necked Turtle	P		✓		✓	
Gekkonidae	<i>Diplodactylus vittatus</i>	Eastern Stone Gecko	P		✓			
Gekkonidae	<i>Oedura lesueurii</i>	Lesueur's Velvet Gecko	P		✓			
Gekkonidae	<i>Oedura robusta</i>	Robust Velvet Gecko	P		✓			
Gekkonidae	<i>Phyllurus platurus</i>	Broad-tailed Gecko	P		✓			
Gekkonidae	<i>Underwoodisaurus milii</i>	Thick-tailed Gecko	P		✓		✓	✓
Pygopodidae	<i>Lialis burtonis</i>	Burton's Snake-lizard	P		✓			
Agamidae	<i>Amphibolurus nobbi</i>	Nobbi Lashtail	P		✓			
Agamidae	<i>Pogona barbata</i>	Eastern Bearded Dragon	P		✓			
Varanidae	<i>Varanus gouldii</i>	Sand Monitor	P		✓			
Varanidae	<i>Varanus varius</i>	Lace Monitor	P		✓			✓
Scincidae	<i>Anomalopus leuckartii</i>	Two-clawed Worm-skink	P		✓			
Scincidae	<i>Anomalopus swansoni</i>	Punctate Worm-skink	P		✓		✓	
Scincidae	<i>Carlia tetradactyla</i>	Southern Rainbow-skink	P		✓			
Scincidae	<i>Cryptoblepharus virgatus</i>	Cream-striped Shinning-skink	P		✓			
Scincidae	<i>Ctenotus robustus</i>	Robust Ctenotus	P		✓		✓	✓
Scincidae	<i>Ctenotus taeniolatus</i>	Copper-tailed Ctenotus	P		✓			✓
Scincidae	<i>Egernia cunninghami</i>	Cunningham's Spiny-tailed	P		✓			✓

Family	Scientific name	Common name	TSC	EPBC	BSP	CRA	AM&BA	Other
		Skink						
Scincidae	<i>Egernia modesta</i>	Eastern Ranges Rock-skink	P		✓		✓	
Scincidae	<i>Egernia striolata</i>	Tree-crevice Skink	P		✓		✓	✓
Scincidae	<i>Egernia whitii</i>	White's Rock-skink	P		✓			✓
Scincidae	<i>Eulamprus tenuis</i>	Bar-sided Forest-skink	P		✓			
Scincidae	<i>Lampropholis delicata</i> ^	Dark-flecked Garden Sunskink ^	P					✓
Scincidae	<i>Lerista bougainvillii</i>	South-eastern Slider	P		✓		✓	
Scincidae	<i>Lygisaurus foliorum</i> (recently revised to <i>Carlia foliorum</i> )	Tree-base Litter-skink	P		✓			
Scincidae	<i>Morethia boulengeri</i>	South-eastern Morethia Skink	P		✓			
Scincidae	<i>Saiphos equalis</i> ^	Yellow-bellied Three-toed Skink ^	P				✓	
Typhlopidae	<i>Ramphotyphlops wiedii</i>	Brown-snouted Blind Snake	P					✓
Elapidae	<i>Furina diadema</i>	Red-naped Snake	P		✓			
Elapidae	<i>Pseudechis porphyriacus</i>	Red-bellied Black Snake	P		✓			✓
<b>Birds</b>								
Phasianidae	<i>Coturnix pectoralis</i>	Stubble Quail	P				✓	
Anatidae	<i>Anas superciliosa</i>	Pacific Black Duck	P				✓	✓
Anatidae	<i>Chenonetta jubata</i>	Australian Wood Duck	P		✓		✓	✓
Podicipedidae	<i>Tachybaptus novaehollandiae</i>	Australasian Grebe ^	P				✓	
Ardeidae	<i>Ardea pacifica</i>	White-necked Heron ^	P				✓	
Ardeidae	<i>Egretta novaehollandiae</i>	White-faced Heron	P				✓	✓
Threskiornithidae	<i>Threskiornis spinicollis</i>	Straw-necked Ibis ^	P				✓	
Accipitridae	<i>Accipiter fasciatus</i>	Brown Goshawk	P		✓		✓	✓
Accipitridae	<i>Aquila audax</i>	Wedge-tailed Eagle	P		✓		✓	✓
Accipitridae	<i>Circus assimilis</i>	Spotted Harrier ^	P					✓
Accipitridae	<i>Elanus axillaris</i>	Black-shouldered Kite	P				✓	✓
Accipitridae	<i>Hieraaetus morphnoides</i>	Little Eagle	P				✓	
Falconidae	<i>Falco berigora</i>	Brown Falcon	P				✓	✓
Falconidae	<i>Falco cenchroides</i>	Nankeen Kestrel	P		✓		✓	
Falconidae	<i>Falco longipennis</i>	Australian Hobby	P					✓
Falconidae	<i>Falco peregrinus</i>	Peregrine Falcon	P				✓	
Falconidae	<i>Falco subniger</i>	Black Falcon *	P					✓
Turnicidae	<i>Turnix varia</i>	Painted Button-quail	P		✓			
Burhinidae	<i>Burhinus grallarius</i>	Bush Stone-curlew *	E1					✓
Charadriidae	<i>Elseyornis melanops</i>	Black-fronted Dotterel ^	P				✓	
Charadriidae	<i>Vanellus miles</i>	Masked Lapwing	P		✓		✓	✓
Columbidae	<i>Geopelia humeralis</i>	Bar-shouldered Dove	P					✓
Columbidae	<i>Geopelia placida</i>	Peaceful Dove	P		✓		✓	
Columbidae	<i>Ocyphaps lophotes</i>	Crested Pigeon	P		✓		✓	✓
Columbidae	<i>Phaps chalcoptera</i>	Common Bronzewing	P		✓			
Columbidae	<i>Phaps elegans</i>	Brush Bronzewing *	P					✓
Cacatuidae	<i>Cacatua galerita</i>	Sulphur-crested Cockatoo	P		✓		✓	✓
Cacatuidae	<i>Callocephalon fimbriatum</i>	Gang-gang Cockatoo	P		✓		✓	

Family	Scientific name	Common name	TSC	EPBC	BSP	CRA	AM&BA	Other
Cacatuidae	<i>Calyptorhynchus funereus</i>	Yellow-tailed Black-Cockatoo	P					✓
Cacatuidae	<i>Calyptorhynchus lathami</i>	Glossy Black-Cockatoo	V		✓		✓	✓
Cacatuidae	<i>Eolophus roseicapillus</i>	Galah	P		✓		✓	✓
Psittacidae	<i>Alisterus scapularis</i>	Australian King-Parrot	P		✓		✓	✓
Psittacidae	<i>Glossopsitta concinna</i>	Musk Lorikeet	P		✓		✓	
Psittacidae	<i>Glossopsitta pusilla</i>	Little Lorikeet	P		✓			
Psittacidae	<i>Neophema pulchella</i>	Turquoise Parrot	V					✓
Psittacidae	<i>Platycercus adscitus eximius</i>	Eastern Rosella	P		✓		✓	✓
Psittacidae	<i>Platycercus elegans</i>	Crimson Rosella	P				✓	✓
Psittacidae	<i>Psephotus haematonotus</i>	Red-rumped Parrot	P		✓		✓	
Psittacidae	<i>Trichoglossus haematodus</i>	Rainbow Lorikeet	P		✓			
Cuculidae	<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo	P		✓		✓	
Cuculidae	<i>Cacomantis variolosus</i>	Brush Cuckoo	P		✓		✓	
Cuculidae	<i>Chalcites basalis</i>	Horsfield's Bronze-Cuckoo	P				✓	✓
Cuculidae	<i>Cuculus pallidus</i>	Pallid Cuckoo	P		✓		✓	
Cuculidae	<i>Eudynamis orientalis</i>	Pacific Koel	P		✓			
Cuculidae	<i>Scythrops novaehollandiae</i>	Channel-billed Cuckoo	P		✓		✓	✓
Strigidae	<i>Ninox boobook</i>	Southern Boobook	P		✓		✓	✓
Strigidae	<i>Ninox connivens</i>	Barking Owl	V		✓	✓		✓
Strigidae	<i>Ninox strenua</i>	Powerful Owl	V				✓	✓
Tytonidae	<i>Tyto alba</i>	Barn Owl	P		✓			✓
Tytonidae	<i>Tyto novaehollandiae</i>	Masked Owl	V					✓
Podargidae	<i>Podargus strigoides</i>	Tawny Frogmouth	P		✓		✓	✓
Caprimulgidae	<i>Eurostopus mystacalis</i>	White-throated Nightjar	P		✓		✓	✓
Aegothelidae	<i>Aegotheles cristatus</i>	Australian Owlet-nightjar	P		✓	✓	✓	✓
Apodidae	<i>Hirundapus caudacutus</i>	White-throated Needletail	P		✓		✓	✓
Halcyonidae	<i>Dacelo novaeguineae</i>	Laughing Kookaburra	P		✓	✓	✓	✓
Halcyonidae	<i>Todiramphus sanctus</i>	Sacred Kingfisher	P		✓		✓	
Meropidae	<i>Merops ornatus</i>	Rainbow Bee-eater	P		✓		✓	✓
Coraciidae	<i>Eurystomus orientalis</i>	Dollarbird	P		✓			
Menuridae	<i>Menura novaehollandiae</i>	Superb Lyrebird	P		✓		✓	✓
Climacteridae	<i>Climacteris picumnus victoriae</i>	Brown Treecreeper (eastern subsp.)	V		✓		✓	✓
Climacteridae	<i>Cormobates leucophaeus</i>	White-throated Treecreeper	P		✓		✓	✓
Maluridae	<i>Malurus cyaneus</i>	Superb Fairy-wren	P		✓		✓	✓
Maluridae	<i>Malurus lamberti</i>	Variiegated Fairy-wren	P		✓			
Pardalotidae	<i>Pardalotus punctatus</i>	Spotted Pardalote	P		✓		✓	✓
Pardalotidae	<i>Pardalotus striatus</i>	Striated Pardalote	P		✓		✓	✓
Acanthizidae	<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill	P		✓	✓	✓	✓
Acanthizidae	<i>Acanthiza lineata</i>	Striated Thornbill	P		✓		✓	✓
Acanthizidae	<i>Acanthiza nana</i>	Yellow Thornbill	P		✓		✓	✓
Acanthizidae	<i>Acanthiza pusilla</i>	Brown Thornbill	P		✓		✓	
Acanthizidae	<i>Acanthiza reguloides</i>	Buff-rumped Thornbill	P		✓		✓	✓
Acanthizidae	<i>Calamanthus pyrrhopygius</i>	Chestnut-rumped Heathwren	P		✓			

Family	Scientific name	Common name	TSC	EPBC	BSP	CRA	AM&BA	Other
Acanthizidae	<i>Gerygone fusca</i>	Western Gerygone	P					✓
Acanthizidae	<i>Gerygone olivacea</i>	White-throated Gerygone	P		✓		✓	✓
Acanthizidae	<i>Origma solitaria</i>	Rockwarbler	P		✓		✓	✓
Acanthizidae	<i>Pyrrholaemus sagittatus</i>	Speckled Warbler	V		✓		✓	✓
Acanthizidae	<i>Sericornis frontalis</i>	White-browed Scrubwren	P		✓			✓
Acanthizidae	<i>Smicronis brevirostris</i>	Weebill	P		✓		✓	✓
Meliphagidae	<i>Acanthagenys rufogularis</i>	Spiny-cheeked Honeyeater	P					✓
Meliphagidae	<i>Acanthorhynchus tenuirostris</i>	Eastern Spinebill	P		✓			
Meliphagidae	<i>Anthochaera carunculata</i>	Red Wattlebird	P		✓		✓	✓
Meliphagidae	<i>Grantiella picta</i>	Painted Honeyeater	V				✓	✓
Meliphagidae	<i>Lichenostomus chrysops</i>	Yellow-faced Honeyeater	P		✓		✓	✓
Meliphagidae	<i>Lichenostomus leucotis</i>	White-eared Honeyeater	P		✓		✓	✓
Meliphagidae	<i>Lichenostomus melanops</i>	Yellow-tufted Honeyeater	P		✓		✓	✓
Meliphagidae	<i>Lichenostomus penicillatus</i>	White-plumed Honeyeater	P		✓		✓	
Meliphagidae	<i>Manorina melanocephala</i>	Noisy Miner	P		✓		✓	✓
Meliphagidae	<i>Meliphaga lewinii</i>	Lewin's Honeyeater	P					✓
Meliphagidae	<i>Melithreptus brevirostris</i>	Brown-headed Honeyeater	P		✓		✓	
Meliphagidae	<i>Melithreptus gularis gularis</i>	Black-chinned Honeyeater (eastern subspecies)	V		✓			
Meliphagidae	<i>Melithreptus lunatus</i>	White-naped Honeyeater	P		✓			
Meliphagidae	<i>Myzomela sanguinolenta</i>	Scarlet Honeyeater	P		✓		✓	
Meliphagidae	<i>Philemon citreogularis</i>	Little Friarbird	P					✓
Meliphagidae	<i>Philemon corniculatus</i>	Noisy Friarbird	P		✓		✓	✓
Meliphagidae	<i>Plectorhyncha lanceolata</i>	Striped Honeyeater	P		✓		✓	✓
Petroicidae	<i>Eopsaltria australis</i>	Eastern Yellow Robin	P		✓	✓	✓	✓
Petroicidae	<i>Melanodryas cucullata</i>	Hooded Robin	V				✓	
Petroicidae	<i>Microeca fascinans</i>	Jacky Winter	P		✓		✓	✓
Petroicidae	<i>Petroica goodenovii</i>	Red-capped Robin	P				✓	
Petroicidae	<i>Petroica rosea</i>	Rose Robin	P					✓
Pomatostomidae	<i>Pomatostomus superciliosus</i>	White-browed Babbler	P		✓			
Pomatostomidae	<i>Pomatostomus temporalis temporalis</i>	Grey-crowned Babbler (eastern subspecies)	V		✓		✓	✓
Eupetidae	<i>Cinclosoma punctatum</i>	Spotted Quail-thrush	P		✓		✓	✓
Neosittidae	<i>Daphoenositta chrysoptera</i>	Varied Sittella	P		✓		✓	✓
Pachycephalidae	<i>Colluricincla harmonica</i>	Grey Shrike-thrush	P		✓		✓	✓
Pachycephalidae	<i>Falcunculus frontatus</i>	Eastern Shrike-tit	P		✓		✓	
Pachycephalidae	<i>Pachycephala rufiventris</i>	Rufous Whistler	P		✓		✓	✓
Dicruridae	<i>Grallina cyanoleuca</i>	Magpie-lark	P		✓		✓	✓
Dicruridae	<i>Myiagra inquieta</i>	Restless Flycatcher	P		✓		✓	
Dicruridae	<i>Myiagra rubecula</i>	Leaden Flycatcher	P		✓		✓	✓
Dicruridae	<i>Rhipidura albiscapa</i>	Grey Fantail	P		✓		✓	✓
Dicruridae	<i>Rhipidura leucophrys</i>	Willie Wagtail	P		✓		✓	✓
Campephagidae	<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike	P		✓		✓	✓
Campephagidae	<i>Coracina papuensis</i>	White-bellied Cuckoo-shrike	P		✓			

Family	Scientific name	Common name	TSC	EPBC	BSP	CRA	AM&BA	Other
Campephagidae	<i>Coracina tenuirostris</i>	Cicadabird	P		✓			
Campephagidae	<i>Lalage leucomela</i>	Varied Triller *	P				✓	✓
Campephagidae	<i>Lalage tricolor</i>	White-winged Triller	P		✓		✓	
Oriolidae	<i>Oriolus sagittatus</i>	Olive-backed Oriole	P		✓		✓	
Artamidae	<i>Artamus cyanopterus</i>	Dusky Woodswallow	P		✓		✓	✓
Artamidae	<i>Artamus personatus</i>	Masked Woodswallow	P		✓			
Artamidae	<i>Cracticus nigrogularis</i>	Pied Butcherbird	P		✓		✓	✓
Artamidae	<i>Cracticus torquatus</i>	Grey Butcherbird	P		✓		✓	✓
Artamidae	<i>Gymnorhina tibicen</i>	Australian Magpie	P		✓		✓	✓
Artamidae	<i>Strepera graculina</i>	Pied Currawong	P		✓		✓	✓
Corvidae	<i>Corvus coronoides</i>	Australian Raven	P		✓		✓	✓
Corcoracidae	<i>Corcorax melanorhamphos</i>	White-winged Chough	P		✓		✓	✓
Ptilonorhynchidae	<i>Ptilonorhynchus violaceus</i>	Satin Bowerbird	P					✓
Alaudidae	<i>Mirafra javanica</i>	Horsfield's Bushlark ^	P				✓	
Motacillidae	<i>Anthus australis</i>	Australian Pipit ^	P				✓	
Passeridae	<i>Passer domesticus</i>	House Sparrow	U				✓	✓
Fringillidae	<i>Carduelis carduelis</i>	European Goldfinch	U				✓	✓
Estrildidae	<i>Neochmia temporalis</i>	Red-browed Finch	P		✓		✓	✓
Estrildidae	<i>Stagonopleura guttata</i>	Diamond Firetail	V				✓	
Estrildidae	<i>Taeniopygia bichenovii</i>	Double-barred Finch	P		✓	✓	✓	✓
Dicaeidae	<i>Dicaeum hirundinaceum</i>	Mistletoebird	P		✓		✓	✓
Hirundinidae	<i>Cheramoeca leucosternus</i>	White-backed Swallow ^	P				✓	✓
Hirundinidae	<i>Hirundo neoxena</i>	Welcome Swallow	P		✓		✓	✓
Hirundinidae	<i>Petrochelidon ariel</i>	Fairy Martin	P		✓		✓	
Hirundinidae	<i>Petrochelidon nigricans</i>	Tree Martin	P		✓		✓	✓
Sylviidae	<i>Cincloramphus mathewsi</i>	Rufous Songlark	P		✓		✓	✓
Sylviidae	<i>Cisticola exilis</i>	Golden-headed Cisticola ^	P				✓	✓
Zosteropidae	<i>Zosterops lateralis</i>	Silvereye	P		✓		✓	✓
Sturnidae	<i>Sturnus vulgaris</i>	Common Starling	U		✓		✓	✓
<b>Mammals</b>								
Tachyglossidae	<i>Tachyglossus aculeatus</i>	Short-beaked Echidna	P		✓			✓
Dasyuridae	<i>Antechinus flavipes</i>	Yellow-footed Antechinus	P					✓
Dasyuridae	<i>Antechinus sp.</i>	Unidentified Antechinus	P					✓
Dasyuridae	<i>Dasyurus maculatus</i>	Spotted-tailed Quoll	V	E				✓
Dasyuridae	<i>Sminthopsis murina</i>	Common Dunnart	P					✓
Phascolarctidae	<i>Phascolarctos cinereus</i>	Koala	V			✓		✓
Vombatidae	<i>Vombatus ursinus</i>	Common Wombat	P		✓	✓		✓
Petauridae	<i>Petaurus breviceps</i>	Sugar Glider	P		✓			
Petauridae	<i>Petaurus norfolcensis</i>	Squirrel Glider	V		✓			
Pseudocheiridae	<i>Pseudocheirus peregrinus</i>	Common Ringtail Possum	P		✓			
Phalangeridae	<i>Trichosurus vulpecula</i>	Common Brushtail Possum	P		✓	✓		✓
Macropodidae	<i>Macropus giganteus</i>	Eastern Grey Kangaroo	P		✓	✓		✓
Macropodidae	<i>Macropus robustus</i>	Common Wallaroo	P		✓	✓		✓

Family	Scientific name	Common name	TSC	EPBC	BSP	CRA	AM&BA	Other
Macropodidae	<i>Petrogale penicillata</i>	Brush-tailed Rock-wallaby	E1	V				✓
Macropodidae	<i>Macropus rufogriseus</i>	Red-necked Wallaby	P		✓	✓		✓
Macropodidae	<i>Wallabia bicolor</i>	Swamp Wallaby	P		✓	✓		✓
Molossidae	<i>Mormopterus</i> species 2 (Adams <i>et al.</i> 1998)	Eastern Freetail-bat	P		✓			
Molossidae	<i>Mormopterus</i> species 4 (long penis form) (Adams <i>et al.</i> 1998)	Southern Freetail-bat	P		✓			
Molossidae	<i>Nyctinomus australis</i>	White-striped Freetail-bat	P		✓	✓		
Vespertilionidae	<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	V	V	✓			
Vespertilionidae	<i>Chalinolobus gouldii</i>	Gould's Wattled Bat	P		✓			✓
Vespertilionidae	<i>Chalinolobus morio</i>	Chocolate Wattled Bat	P		✓			✓
Vespertilionidae	<i>Miniopterus schreibersii</i> <i>oceanensis</i>	Eastern Bent-wing Bat	V		✓		✓	
Vespertilionidae	<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat	P		✓			
Vespertilionidae	<i>Nyctophilus gouldi</i>	Gould's Long-eared Bat	P		✓			
Vespertilionidae	<i>Nyctophilus timoriensis</i>	Greater Long-eared Bat	V	V	✓			
Vespertilionidae	<i>Scotorepens balstoni</i>	Inland Broad-nosed Bat	P		✓			
Vespertilionidae	<i>Vespadelus troughtoni</i>	Eastern Cave Bat	V		✓			
Vespertilionidae	<i>Vespadelus vulturinus</i>	Little Forest Bat	P		✓			✓
Muridae	<i>Mus musculus</i>	House Mouse	U		✓			
Muridae	<i>Rattus rattus</i>	Black Rat	U		✓			
Leporidae	<i>Lepus capensis</i>	Brown Hare	U		✓			
Leporidae	<i>Oryctolagus cuniculus</i>	Rabbit	U		✓			✓
Canidae	<i>Canis lupus</i>	Dingo, domestic dog	U		✓			
Canidae	<i>Vulpes vulpes</i>	Fox	U		✓			✓
Bovidae	<i>Bos taurus</i>	European cattle	U		✓	✓		

# APPENDIX D – FAUNA SPECIES AROUND (BUT NOT WITHIN) THE MANOBALAI STUDY AREA

Fauna species recorded on the DEC Atlas of NSW Wildlife (as at 23/03/05) within a five kilometre radius of the study area boundary, but not recorded from within either Manobalai Nature Reserve or Crown Lands. The majority of records derive from surveys conducted around and to the north of Anvil Hill, near Wybong, in relation to a proposed mine in the area.

Family	Scientific name	Common name	NSW Legal Status	National Legal Status
<b>Frogs</b>				
Hylidae	<i>Litoria fallax</i>	Eastern Dwarf Tree Frog	P	
<b>Reptiles</b>				
Agamidae	<i>Amphibolurus muricatus</i>	Jacky Lashtail	P	
Scincidae	<i>Tiliqua scincoides</i>	Common Bluetongue	P	
<b>Birds</b>				
Phasianidae	<i>Coturnix ypsilophora</i>	Brown Quail	P	
Phasianidae	<i>Pavo cristatus</i>	Indian Peafowl	U	
Anatidae	<i>Anas gracilis</i>	Grey Teal	P	
Ardeidae	<i>Egretta garzetta</i>	Little Egret	P	
Accipitridae	<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle	P	
Rallidae	<i>Gallinula tenebrosa</i>	Dusky Moorhen	P	
Rallidae	<i>Porphyrio porphyrio</i>	Purple Swamphen	P	
Columbidae	<i>Geopelia cuneata</i>	Diamond Dove	P	
Columbidae	<i>Streptopelia chinensis</i>	Spotted Turtle-Dove	U	
Cacatuidae	<i>Cacatua sanguinea</i>	Little Corella	P	
Cacatuidae	<i>Nymphicus hollandicus</i>	Cockatiel	P	
Psittacidae	<i>Melopsittacus undulatus</i>	Budgerigar	P	
Halcyonidae	<i>Todiramphus macleayii</i>	Forest Kingfisher	P	
Climacteridae	<i>Climacteris erythroptis</i>	Red-browed Treecreeper	P	
Meliphagidae	<i>Xanthomyza phrygia</i>	Regent Honeyeater	E	E
Dicruridae	<i>Rhipidura rufifrons</i>	Rufous Fantail	P	
Oriolidae	<i>Sphecotheres vieilloti</i>	Australasian Figbird	P	
Corvidae	<i>Corvus mellori</i>	Little Raven	P	
Estrildidae	<i>Taeniopygia guttata</i>	Zebra Finch	P	
Sylviidae	<i>Acrocephalus australis</i>	Australian Reed-Warbler	P	
Sylviidae	<i>Cincloramphus cruralis</i>	Brown Songlark	P	

Family	Scientific name	Common name	NSW Legal Status	National Legal Status
Sturnidae	<i>Acridotheres tristis</i>	Common Myna	U	
<b>Mammals</b>				
Vespertilionidae	<i>Falsistrellus tasmaniensis</i>	Eastern False Pipistrelle	V	
Muridae	<i>Rattus fuscipes</i>	Bush Rat	P	
Bovidae	<i>Capra hircus</i>	Goat	U	

# APPENDIX E – FREQUENCY RANGE OF INSECTIVOROUS BAT CALLS RECORDED IN THE HUNTER RANGE AREA

This table has been compiled by Narawan Williams, based on the analysis of ultrasonic calls recorded during the 2004-05 DEC surveys of the Hunter Range Area.

**Key:**

The first row for each species shows the frequency range (in kilohertz) of reference calls, recorded during release of bats captured in harp traps.

The second row for each species shows the frequency range (in kilohertz) of calls recorded at anabat various sites. These only includes sequences for which a 'definite' identification was obtained, unless stated otherwise in the notes. The number in brackets next to each frequency range is the total number of call sequences referred to for frequency range sample.

There are notes under each species.

Bat species	Northern Park	Yengo National	Eastern Park (California and Commission Roads)	Wollemi National (Baerami, Martindale & Doyle's Creek areas)	Northern Wollemi (Hungerford, Martindale & Doyle's Creek areas)	Manobalai Nature Reserve and Crown Lands	Werakata National Park	
Reference call samples followed by analysis result samples.	Valley floors to lower slopes (6 sites)	Mid slopes to ridgelines (7 sites)	Valley floors to lower slopes (0 sites)	Mid slopes to ridgelines (5 sites)	Valley floors to lower slopes (9 sites)	Mid slopes to ridgelines (1 site)	Valley floors to lower slopes (5 sites)	Mid slopes to ridgelines (1 site)
<i>Chalinolobus dwyeri</i>				22-25 (1)				
		23-28(2)		21-27 (12)	22-27 (10)		22-27 (5)	22-24 (4)
Stepped call in good sequence usually between 22- 27 kHz – easy to determine with good sequence.								
<i>Chalinolobus gouldii</i>		28-32 (3) 31-34(3)		29-33(2) 31-33(2)			30-34 (2)	
	29-33(1)	28-33(11)		31-34(2) 29-32 (2)	29-32 (10)	31-34 (2)	28-31(5) 26-30 (2)	28-30 (1)

Bat species	Northern Yengo National Park	Eastern Wollemi National Park (California and Commission Roads)	Northern Wollemi (Baerami, Hungerford, Martindale & Doyles Creek areas)	Manobalai Nature Reserve and Crown Lands	Werakata National Park
Stepped call – one of the easier species to determine.					
<b><i>Chalinolobus morio</i></b>		49-51(2) 50-52 (4)	50-53(3)		49-50(2)
	48-55(7)	47-56 (24)	48-53 (14)	47-57 (25)	49-53 (4)
Call frequencies are variable between call sequences and within call sequence.					
<b><i>Falsistrellus tasmaniensis</i></b>		See notes below	35-41(7)	34-38 (1)	
		35-39 (1) 36-39(1)			
Note: All these frequencies are from only probable <i>Falsistrellus tasmaniensis</i> results – no definite. This species' calls are generally hard to define against variation in <i>Scotorepens orion</i> calls and also <i>Scoteanax rueppellii</i> .					
<b><i>Miniopterus schreibersii oceanensis</i></b>					
		43-46 (5)	44-46 (12)	43-47 (30)	44-47 (3)
Fairly consistent in frequency – the higher numbers in Northern Wollemi are due to this species using mine shafts in Baerami Creek.					
<b><i>Mormopterus norfolkensis</i></b>					
		29.5-32 (2)			28-33(1) 30-32(1) 30-34 (1)
Stepped call usually between 31 – 34 kHz. A couple of the calls are below this however there was regular stepping.					
<b><i>Mormopterus</i> sp. 4 (long penis form) (Adams et</b>					27-29 (10)

Bat species	Northern Park	Yengo National	Eastern Park (California Commission Roads)	Wollemi National and	Northern Wollemi (Baerami, Hungerford, Martindale & Doyles Creek areas)	Manobalai Nature Reserve and Crown Lands	Werakata National Park
<i>al.</i> 1988)							
		24-25 (2)			24-26 (2)	25-29 (9)	25-27 (5)
The higher frequency range of this species overlaps with other <i>Mormopterus</i> species.							
<b><i>Mormopterus</i> sp. 3 (short penis form)</b> (Adams <i>et al.</i> 1988)				See notes			
				30-36 (4)			
Notes: This one call was only 'probable'. Other possible calls were not able to be defined as there is known overlap with other <i>Mormopterus</i> species.							
<b><i>Mormopterus</i> sp. 2</b> (Adams <i>et al.</i> 1988)		29-32 (1) 28-29 (1)				32-34 (1)	
		27-32 (6)		29-30 (3)	29-32 (8)	28-31(3)	28-32 (15)
Most pulses flat and at the lower frequency with occasional step (the higher frequency). There is overlap in frequency with other <i>Mormopterus</i> species.							
<b><i>Nyctophilus geoffroyi</i></b>		30-34 (1)				38-43 (1) 43-46 (2)	
Could not define between other <i>Nyctophilus</i> species.							
<b><i>Nyctophilus gouldi</i></b>		38-45 (5)		28-39 (1) 36-43 (5)			
Could not define between other <i>Nyctophilus</i> species.							
<b><i>Nyctophilus timoriensis</i></b>							
No reference calls. Could not define between other <i>Nyctophilus</i> species.							

Bat species	Northern Yengo National Park	Yengo National Park	Eastern Wollemi National Park (California and Commission Roads)	Northern Wollemi National Park (Baerami, Hungerford, Martindale & Doyles Creek areas)	Manobalai Nature Reserve and Crown Lands	Werakata National Park			
<i>Nyctophilus</i> species	40 (1)	40-45 (2)		38-43 (6)	41-48 (11)		39-44 (8)	43-46 (3)	
<i>Rhinolophus megaphyllus</i>									
	65-67.5 (3)	66.5 – 67 (5)		66-68 (2)	64-68 (14)			66 (1)	
A very distinctive call at fairly consistent frequency.									
<i>Saccolaimus flaviventris</i>									
							17.5 (1) 21 (1)		
Call frequency and characteristics within normal range for this species.									
<i>Scoteanax rueppellii</i>				37-40 (2)					
					32-34 (2)				
Call often hard to define against <i>Scotorepens orion</i> and <i>S. balstoni</i> unless a good call sequence is recorded.									
<i>Scotorepens balstoni</i>							32-35 (5)		
	31-32 (1)	32 (1) Probable		32-34 (2)	31-35 (10)		32-35 (11)		
Most often call frequency was around 31- 33 kHz. The higher frequency of this species overlaps with <i>Scotorepens orion</i> .									
<i>Scotorepens orion</i>				35-36 (3)					
		34-39 (12)		34-36 (2) 35 – 38(4)	34-38 (7)				

Bat species	Northern Yengo National Park	Eastern Wollemi National Park (California and Commission Roads)	Northern Wollemi (Baerami, Hungerford, Martindale & Doyles Creek areas)	Manobalai Nature Reserve and Crown Lands	Werakata National Park
Calls can overlap with <i>Scoteanax rueppellii</i> and <i>Falsistrellus tasmaniensis</i> .					
<b><i>Tadarida australis</i></b>					
	11-12 (2)	11 (2)	11-20 (3)	10-15.5 (9)	10-15 (7)
Standard frequency around 10 –12 kHz.					
<b><i>Vespadelus darlingtoni</i></b>			41-45 (6)		
		42-45 (9)	41-44 (9)	42-45 (6)	
Calls were at expected frequency range and characteristics.					
<b><i>Vespadelus trougtoni</i></b>	See notes				
No Reference calls from area. Overlaps with <i>Vespadelus vulturnus</i> .					
<b><i>Vespadelus vulturnus</i></b>		49-52 (12) 52-55 (7)	49-52 (4) 51-54 (8)		45-48 (1) 47-50 (15) 49-52 (7)
	48-50 (2)	51-54(1) 49-53 (11)	48-53 (7)	47-53(23)	46-50 (3) 47-52 (2) 46-51 (4)
It appears that the call frequency is generally lower in the Valley floors and Manobalai NR which fits the general expected trend for this species.					