NSW WESTERN REGIONAL ASSESSMENTS

Nandewar

Biodiversity surrogates

Vertebrate fauna

Final Report
September 2004

Nand05

RESOURCE AND CONSERVATION ASSESSMENT COUNCIL

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Vertebrate fauna

Mick Andren

Conservation Assessment &
Data Unit

Department of Environment &
Conservation

Project Number NAND05

RESOURCE AND CONSERVATION ASSESSMENT COUNCIL

INFORMATION

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For more information and for information on access to data, contact:

Resource and Conservation Division, Department of Infrastructure, Planning and Natural Resources
P.O. Box 39
SYDNEY NSW 2001
Phone: 02 9228 6586
Fax: 02 9228 6411
Email: info.racd@dipnr.nsw.gov.au

Author: Mick Andren

Cover photo: Border thick-tailed gecko *Underwoodisaurus sphyrurus*
Phil Spark

Contents

List of figures

List of tables

Preface & Acknowledgements

The Nandewar *Vertebrate fauna* project is part of the Nandewar Western Regional Assessment (WRA) initiated by the New South Wales Government and overseen by the Resource and Conservation Assessment Division. It was funded jointly by the Resource and Conservation Assessment Council and the Department of Environment and Conservation.

The project was has been undertaken by the Conservation Assessment and Data unit of the Department of Environment and Conservation (DEC) based in Coffs Harbour. The project was overseen by a Technical Working Group which included representatives from the Department of Environment and Conservation, Forests New South Wales and the Resource and Conservation Assessment Division of the Department of Infrastructure, Planning and Natural Resources.

Many people have been involved in the project in numerous ways. Some of the key people who deserve special acknowledgement are:

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- **Bat survey specialist:** Harry Parnaby
- **Bat call analysis:** Harry Parnaby, Glenn Hoye
- **Voucher specimen identification:** Sandy Ingleby, Michael Mahoney, Harry Parnaby, Ross Sadlier
- **Scat analysis:** Michiala Bowen

Project Summary

Nandewar supports a diverse and distinctive vertebrate fauna resulting from the zoogeographic transition between Bassian and Eyrean zones, the habitat variation from the high elevation tablelands to the low elevation western foothills and the distinctive vegetation of the region.

A total of 593 fauna sites were surveyed or collated for the region, with 323 of these being full systematic sites. For the Nandewar Western Regional Assessment (WRA) 98 systematic and 27 opportunistic field surveys sites were completed.

The region is considered to support 450 native terrestrial vertebrate species comprised of frogs (33 species), turtles (4 species), lizards (64 species), snakes (23 species), diurnal birds (262 species), nocturnal birds (11 species), arboreal mammals (9 species), large ground mammals (11 species), small ground mammals (9 species) and bats (24 species).

The WRA identified 124 species as being of conservation significance, or 28% of the terrestrial vertebrate fauna.

The region is characterised by the extinction and ongoing decline of many species of vertebrate fauna. Seventeen species are known or considered to be regionally extinct. The ground mammal fauna has suffered a regional collapse, with 14 of the 34 species known or considered to be regionally extinct and 12 species considered to be of conservation significance. This represents 82% of the original ground mammal fauna.

Many of the species in decline were dependent on the grassy box woodlands that have been substantially cleared in the region. A substantial proportion of these species are also ground-dwelling and ground-foraging species susceptible to alteration of the ground layer and predation by feral predators.

Nandewar is a stronghold for the conservation of many species of threatened declining woodland birds, including the turquoise parrot, brown treecreeper, speckled warbler, diamond firetail, hooded robin, black-chinned honeyeater and regent honeyeater. The remnant box – ironbark woodlands are a key resource for many of these species.

The Nandewar WRA surveys have defined the bat community of the region for the first time, with 24 species identified to occur in the region. Nine of these species are threatened and four are considered to be regionally significant. A number of species were captured in the region for the first time, including the hairy-nosed freetail-bat, which is extremely rare in New South Wales.

Extremely significant populations of the booroolong frog and brush-tailed rock-wallaby were found during the surveys. The booroolong frog was previously known only from one highly

degraded locality in northern New South Wales, while the brush-tailed rock-wallaby appears to be in steep decline in Nandewar and currently known only from a few scattered localities.

Nandewar is a highly significant region for the conservation of the border thick-tailed gecko and squirrel glider. The regional distribution of these species in the region was delineated for the first time in the surveys.

The integrated network of key fauna habitats and corridors is the first regional-scale fauna planning system proposed in Nandewar. The key habitats include the reservoirs for the conservation of fauna populations and for the maintenance of ecological processes and are typically the largest, most intact blocks of habitat – the source areas most likely needed for conservation and restoration of the regional fauna. The corridors mapped in Nandewar represent the first regional strategy to retain and restore the natural connectivity required for fauna conservation.

Acronyms and abbreviations

BBS	Brigalow Belt South bioregion
CRA	Comprehensive Regional Assessment
CWR	Critical Weight Range
DEC	Department of Environment and Conservation (the National Parks and Wildlife Sevice is now part of DEC)
GIS	Geographic Information System
IBRA	Interim Biogeographic Regionalisation of Australia
KHC	Key habitats and corridors
LNE	Lower North East
NBA	Nandewar Bioregional Assessment
NEFBS	North-East Forests Biodiversity Study
NP	National Park
NR	Nature Reserve
NPWS	New South Wales National Parks and Wildlife Service
NWCIS	North-West Cypress / Ironbark Study
NWRA	Nandewar Western Regional Assessment
RACAC	Resource and Conservation Assessment Council
RACD	Resource and Conservation Division, Department of Infrastructure Planning and Natural Resources
RFA	Regional Forest Agreement
SBS	State Biodiversity Strategy
SCA	State Conservation Area
SFNSW	State Forests of NSW

TSR	Travelling Stock Reserve
UNE	Upper North East
VCA	Voluntary Conservation Agreement
WRA	Western Regional Assessment

i Background

The New South Wales Government initiated a Western Regional Assessment (WRA) of western NSW to guide future resource planning and encourage partnerships to protect the environment. The Resource and Conservation Assessment Council (RACAC) coordinated the assessment which involved State agencies including the Department of Conservation and Environment (DEC), State Forests of New South Wales, Department of Mineral Resources, Department of Infrastructure, Planning and Natural Resources, consultants and local and regional stakeholders.

The WRA includes consideration of environmental, economic and social values of forest and non-forest land systems and aims to deliver the following outcomes:

- Adequate and complete core data layers to inform regional land use planning and conservation and resource management.
- Enhanced partnerships between core agencies and interest groups concerned with natural resources and ecological sustainability, to increase sharing of information and to reduce duplication.
- The identification of a comprehensive, adequate and representative network of protected and managed areas for western New South Wales.

The Nandewar WRA was initiated in July 2002, following the Brigalow Belt South (BBS) WRA. The Nandewar WRA area encompasses the New South Wales section of the Nandewar Bioregion and part of the New England Tablelands Bioregion that had not been previously assessed in either the Comprehensive Regional Assessments or the Brigalow Belt South WRA.

Other Nandewar WRA projects undertaken by DEC are Aboriginal culture and consultation, vegetation, landscape conservation and conservation criteria.

1 Introduction

The WRA *Biodiversity surrogates: Vertebrate fauna* project continues the DEC research program to systematically investigate the vertebrate fauna of Nandewar for the first time.

The five-year program commenced in 1999 and has revealed the Nandewar region to possess a unique and important fauna. A detailed inventory of the species of the region has been compiled for the first time, enabling an assessment of vertebrate species of conservation significance and identification of the key habitats of the region.

1.1 STUDY AREA

The Nandewar WRA study area (**Figure 1-A**) encompasses the New South Wales Nandewar Interim Biogeographic Regionalisation of Australia (IBRA) Bioregion and the western edge of the New England Tablelands IBRA Bioregion. The study area encompasses approximately 2.7 million hectares, extending 350 kilometres north to south from the Queensland border to the Liverpool Range, and 160 km east to west from the North East Comprehensive Regional Assessment (CRA) areas to the BBS WRA area.

The study area includes 240 000 hectares of land previously assessed in coastal CRAs and BBS WRA that lie within the Nandewar IBRA bioregion (see hatched areas **Figure 1-A**). These previously assessed areas are included in the study area for bioregional context.

The Nandewar WRA study area includes all of the major Nandewar provinces of Peel, Inverell Basalts, Northern Complex and Kaputar, as well as part of five New England Tableland provinces: Severn River Volcanics, Glen Innes-Guyra Basalts, Tingha Plateau, Walcha Plateau and Eastern Nandewars. A previously unassessed part of the Upper Hunter is also included.

1.1.1 Climate

Average annual rainfall varies markedly across Nandewar, from 470 millimetres along the western boundary to 1 100 millimetres on Mount Kaputar and along the northern slopes of the Liverpool Range (which forms the south-eastern boundary of the bioregion). The majority of the region receives from 510 to 700 millimetres annually, with rainfall tending to decrease from east to west (although this trend is significantly modified by topography with elevated areas receiving between 100 to 200 millimetres more than the lowlands).

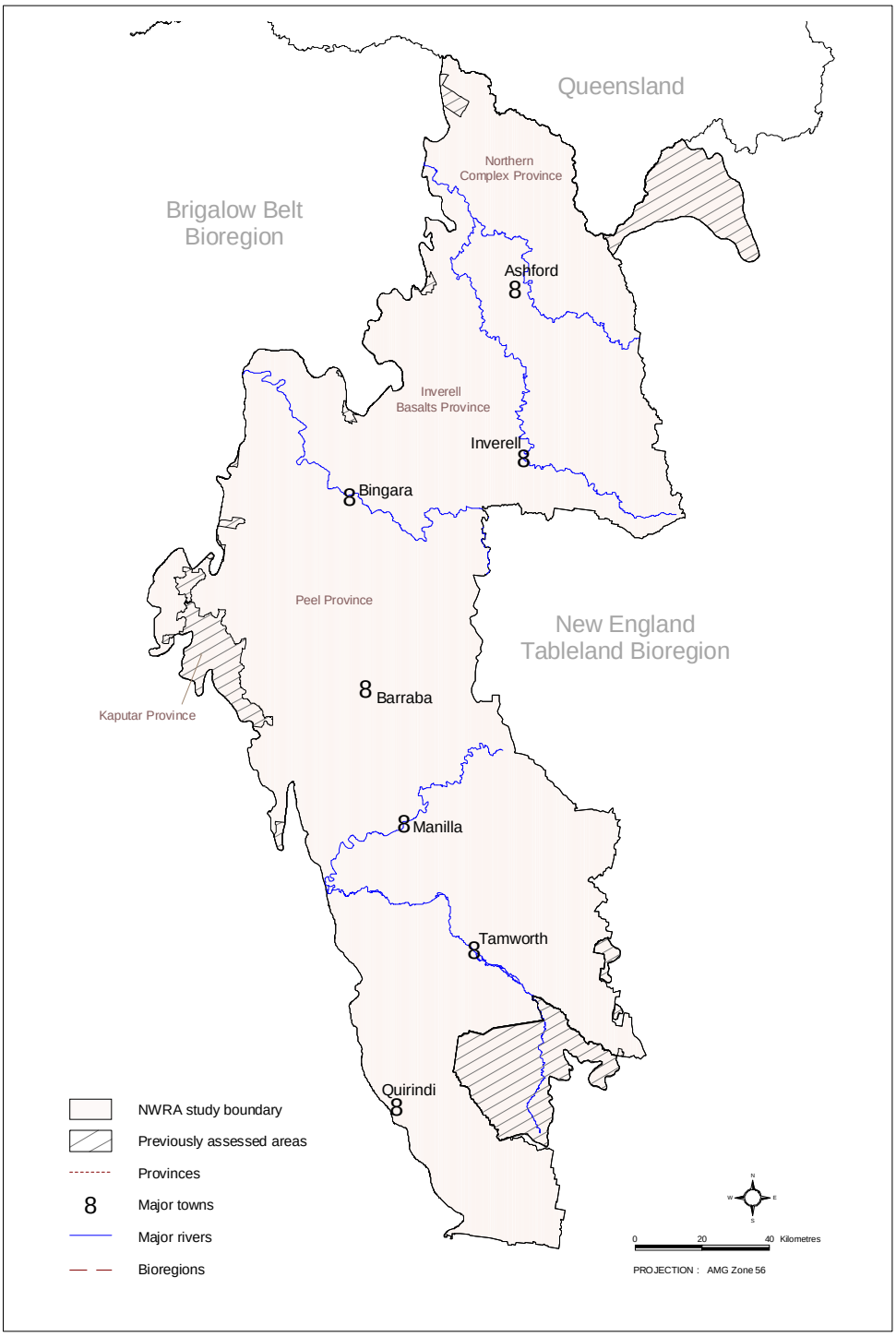


FIGURE-1A

Nandewar WRA study area

Average annual temperature also varies markedly across Nandewar, with values strongly correlated with elevation. Temperatures range from an annual average minimum of 10.3^{o} celcius on Mount Kaputar and Crawney Mountain (south-east of Quirindi, on the Liverpool Range), to an annual average maximum of 18.8^{o} celcius in the far north-west near Glenarbon (on the Queensland side of the Dumaresq River). The cooler areas include the central portion of the region, along the Nandewar Range to Mount Kaputar, and the south-eastern periphery of the Bioregion, including the western edge of the northern tablelands and the northern slopes of the Liverpool Range. The warmer areas correspond to the lowlands of the three major river catchments, the Macintyre, Gwydir and Namoi.

1.1.2 Vegetation

Vegetation of the Nandewar WRA area is influenced primarily by geology in conjunction with topographic, rain shadow and edaphic effects. Temperate climatic conditions prevailing over the transitional zone between semi-arid inland and moist coastal and tablelands forests help shape the distinctive dry open forests and woodlands of the western slopes. Nandewar is characterised by box forests and woodlands (particularly white box), typically at low to mid elevation in agriculturally productive areas. Cypress pine - ironbark - tumbledown red gum woodlands and open forests occupy much of the less-productive parts of Nandewar. The region is of significance for biodiversity due to its location at the distributional overlap of many temperate and semi-arid flora and fauna species. Refer to the WRA *Biodiversity surrogates: Vegetation (NAND06)* project report for detail on the vegetation patterns of the region.

1.1.3 Geology

The Nandewar region is geologically complex. It comprises an underlying basement of ancient metasediments, intruded in the higher elevation eastern margins by granitic uplift, and over-laid in many areas by tertiary basaltic flows. Superheating at the sediment-granite interface produced several grades of vulcanised or metamorphosed sediments, in addition to unique areas of serpentinite and limestone. Refer to the WRA *Geology – Integration and Upgrade (NAND04)* project report for detailed information on the geology of Nandewar. This variability has resulted in a concomitant ecosystem diversity that is strongly patterned in relation to geological and climatic variation in the region.

1.1.4 Tenure

Eighty-five percent of the Nandewar WRA study area is in private ownership with a further 11% leasehold land. State forests comprise 35 678 hectares (1.45 % of the study area) and current formal reserves (national park estate) occupy 61 711 hectareas, or 2.3% of the study area. The area of formal reserves not previously considered by coastal CRAs or BBS WRA is 21 850 hectares, only 0.9% of the study area (see **Figure 1-B**). The majority of the public land estate supports woody vegetation (with travelling stock reserves containing the best

examples of some vegetation communities) whereas only 22.8% of freehold land retains forest or woodland cover.

The residual nature of land set aside for conservation is reflected in the high proportion of reserved land that is rugged in terrain, particularly biased to high elevation granite areas in the east. In contrast a very low proportion of reserved land has moderate or high land use capability with further reservation options being minimal in agriculturally productive areas such as the heavily cleared Inverell Basalts province.

1.2 OBJECTIVES OF THE PROJECT

The objectives of the WRA *Biodiversity surrogates: Vertebrate fauna* project are to:

1. Complete the systematic survey of terrestrial vertebrates across all major tenures and habitats of the Nandewar WRA Region.
2. Develop a list of vertebrate species of conservation significance for the Nandewar WRA Region*.
3. Produce a map of recommended vertebrate key habitats and corridors for Nandewar by refining the *"North-West Slopes Interim Key Habitats & Corridors"*.

* The original objective to model and map distributions of fauna species and assemblages could not be completed in the project timeline, although the extensive data compiled would enable future analyses to be carried out. However, as foreshadowed in the project specifications, it was possible to develop a list of vertebrates of conservation significance and complete the key habitats and corridors without undertaking the modelling analysis.

The fauna survey completed for the project is described in Chapter 2, including the collation of pre-existing data, the sites surveyed and methods used. Results of the compilation of data are presented including species diversity (total numbers of species known and likely to occur in Nandewar by broad taxonomic group and relative abundance of the most common species).

The species identified as being of conservation significance in Nandewar are identified in Chapter 3. This chapter includes a listing of those species considered regionally extinct, those likely to be extinct, and those approaching extinction. The rationale behind the decision to include species in the conservation significance list is presented.

Chapter 4 explains the refinements undertaken to the key habitats and corridors map for Nandewar. The background to this approach is explained, the Nandewar process outlined and the final key habitats and corridors map presented.

2 Fauna survey

2.1 INTRODUCTION

The Nandewar WRA *Biodiversity surrogates: Vertebrate fauna* project began in July 2002 and continued the vertebrate fauna survey program initiated by DEC in Nandewar in 1999. The overall objective was to survey the terrestrial vertebrate fauna groups throughout the 2.67 million hectare study area. The survey program consisted of the:

- *Nandewar Bioregional Assessment Scoping Study* (December 1999 – June 2001);
- *Nandewar Bioregional Assessment Stage 1* (July 2001 – June 2002); and
- *Biodiversity surrogates: Vertebrate fauna* (July 2002 – June 2004).

The two earlier surveys were funded by the NSW *State Biodiversity Strategy*. When the data from these, and other collated studies, were compiled for the WRA, the resultant dataset represented one of the largest datasets compiled for a region in western NSW; a total of 323 systematic sites and 272 opportunistic sites. This level of data is considered to give a reliable regional picture of the vertebrate fauna.

The vertebrate groups covered by systematic survey were reptiles, nocturnal birds, diurnal birds, arboreal mammals, bats and small ground mammals. Other groups, notably frogs and large ground mammals, were targeted on all surveys (particularly when conditions were most suitable). Some groups (such as turtles) and individual species (particularly highly cryptic species) were not well targeted by the generalist methods used. However, due to the five years spanned by the combined program, some information was gathered on the majority of species, including data on 360 vertebrate species.

In this report, scientific names of frogs are taken from Cogger (2000), reptiles from Swan *et al.* (2004), birds from Christidis and Boles (1994) and mammals from Menkhorst and Knight (2001).

2.2 PRE-EXISTING INFORMATION

Prior to the *Nandewar Bioregional Assessment Scoping Study* commencing in 1999, no systematic surveys had been carried out across the Nandewar region. The major sources of

pre-existing data are listed below. All these datasets have been collated and entered into databases.

A number of institutions maintain databases of species records. The most significant of these are the *Atlas of NSW Wildlife* (DEC), the Australian Museum specimen database and the bird atlas database of Birds Australia. In addition, the CSIRO, Australian Bird and Bat Banding Scheme, Queensland Museum and the University of New England all maintain databases that include information on Nandewar vertebrate species. However, in comparison with more populated and studied areas of New South Wales, the level of information in these databases for Nandewar was extremely poor.

In 1993, State Forests of New South Wales commenced a faunal impact study of the north-west cypress/ironbark State forests (NWCIS) in the Nandewar and Brigalow Belt South bioregions (Date and Paull 1999). Although this study was focussed on the Brigalow Belt South, a number of systematic sites were surveyed in Nandewar State forests.

As part of the North-East Forests Biodiversity Study (NEFBS), a number of sites were surveyed by DEC at Woolomin, south of Tamworth in 1993 (NPWS 1995). DEC also conducted a systematic survey of Kwiambal National Park in 1997.

During the north-east NSW Comprehensive Regional Assessments (CRA), a number of surveys were carried out along the eastern edge of the Nandewar WRA region. These were located in:

- Kings Plains National Park (1997);
- Severn River Nature Reserve (1997);
- Ironbark Nature Reserve (1997)
- Linton Nature Reserve (1997)
- Watson's Creek Nature Reserve (1997);
- Attunga State Forest (1997); and
- Nundle State Forest (1998).

Few scientific fauna studies have been conducted in Nandewar. However, work undertaken by researchers and volunteers on the regent honeyeater population in the Bingara – Barraba region has generated many significant bird records (for example, see Oliver *et al*. 1999). A recent unpublished study of the impact of Coolatai grass infestation has also generated systematic data in Arakoola Nature Reserve and Greenhatch Travelling Stock Reserve near Manilla.

A small number of sites from the Brigalow Belt South (BBS) WRA have been included. These sites are compatible with sites done in Nandewar and occur on public land near the north-western edge of Nandewar in Bebo State Forest, Parkhurst State Forest and Arakoola Nature Reserve.

There have also been a number of surveys conducted for environmental impact statements. The most significant of these were the surveys carried out for the Transgrid powerline which traverses the north east section of the study area.

2.3 SURVEYED AND COLLATED SITES

Approximately 70% of the systematic sites and 90% of the opportunistic sites in this project were collated from previous studies. A systematic site was defined as a site where most of the standard survey techniques applied by DEC in Nandewar (see section 2.4) were carried out, while at opportunistic sites only one, or a small number of these techniques were completed. Almost half (49%) of systematic sites and 53% of the opportunistic sites were surveyed in the *State Biodiversity Strategy* funded projects.

All of the sites collated and surveyed are listed in **Table 2-A**.

TABLE 2-A

Distribution of vertebrate survey sites by tenure

Survey*	Site Type**	SFNSW estate	NPWS estate	Crown land	Crown lease	TSR	Private property	Total
NEFBS (DEC)	S						6	6
	O						8	8
NWCIS (SF)	O	43			1	4		48
CRA (DEC)	S	9	23	1				33
	O	3	3	4		1	8	19
NPWS (DEC)	S		6					6
	O		10	1				11
NBA (DEC)	S	72	40	10	3	11	22	158
	O	82	36	4	4	7	9	142
BBS (DEC)	S	11	2					13
	O	2						2
NWRA (DEC)	S	8	7	23	5	27	28	98
	O	1	1	4	1	5	15	27
Other	S			3		2	4	9
	O		4	8			1	13
Total	S	100	78	37	8	40	60	323
	O	131	54	21	6	17	41	270
								593

* NEFBS = North-east Forests Biodiversity Study NWCIS = North-west Cypress / Ironbark Study (State Forests)
CRA = Comprehensive Regional Assessment NPWS = National Parks and Wildlife Service
NBA = Nandewar Bioregional Assessment BBS = Brigalow Belt South WRA
NWRA = Nandewar WRA (this project)

** S = Systematic site; O = Opportunistic site

The site selection process for the Nandewar WRA surveys was complicated by the large number of pre-existing survey sites which had been selected using different criteria and within different study areas. Even the survey sites completed in the *State Biodiversity Strategy* projects by DEC were selected using different criteria. The Nandewar IBRA bioregional boundary was used (which is significantly different to the WRA boundary) and in order to maximise the efficient coverage of sites, they were preferentially located on public land. The CRA and NEFBS studies were focussed on the north coast, the NWCIS study was concentrated on the BBS and local studies do not take a regional perspective into account.

The WRA sites were selected using a stratification of the WRA study area to determine those strata that had not been sampled, or were most under-sampled by the pre-existing survey sites. There were limited data on which to base a stratification. While there were a number of climatic and terrain variables available, there was no mapped information on the vegetation communities or soils, and only a broad geology map. The variables chosen for stratification were:

- **Elevation.** The most striking gradient in the Nandewar bioregion is the fall from the high-elevation tablelands in the east to the low elevation plains in the west, with the obvious exception of the Mt Kaputar range. Climatic variables of known importance in influencing fauna distributions such as rainfall and temperature correspond well with the elevational gradient. This gradient has a dramatic influence on the fauna distributions.

- **Geology.** Geology is also recognised, particularly through its influence on soil fertility, as a major determinant of fauna distributions. Geology was categorised into "fertility" classes for the purpose of the stratification.

- **Major catchment.** The Nandewar WRA area is elongated in shape, running approximately 360 kilometres from north to south. There is a strong latitudinal influence on the fauna, with marked affinities with Queensland fauna in the north which decrease to the south. To cater for this influence in the stratification, three major catchments were used to split the bioregion latitudinally; the MacIntyre River catchment in the north, Gwydir River in central Nandewar and Peel River in the south.

A number of other factors were taken into account during detailed site selection in the field. Within the designated strata, sites were chosen to sample the range of **broad vegetation types.** Additionally, **topographic position** was also taken into account by typically selecting sites in groups of three (gully, mid-slope and ridge).

The collated and surveyed sites are shown in **Figure 2-A**.

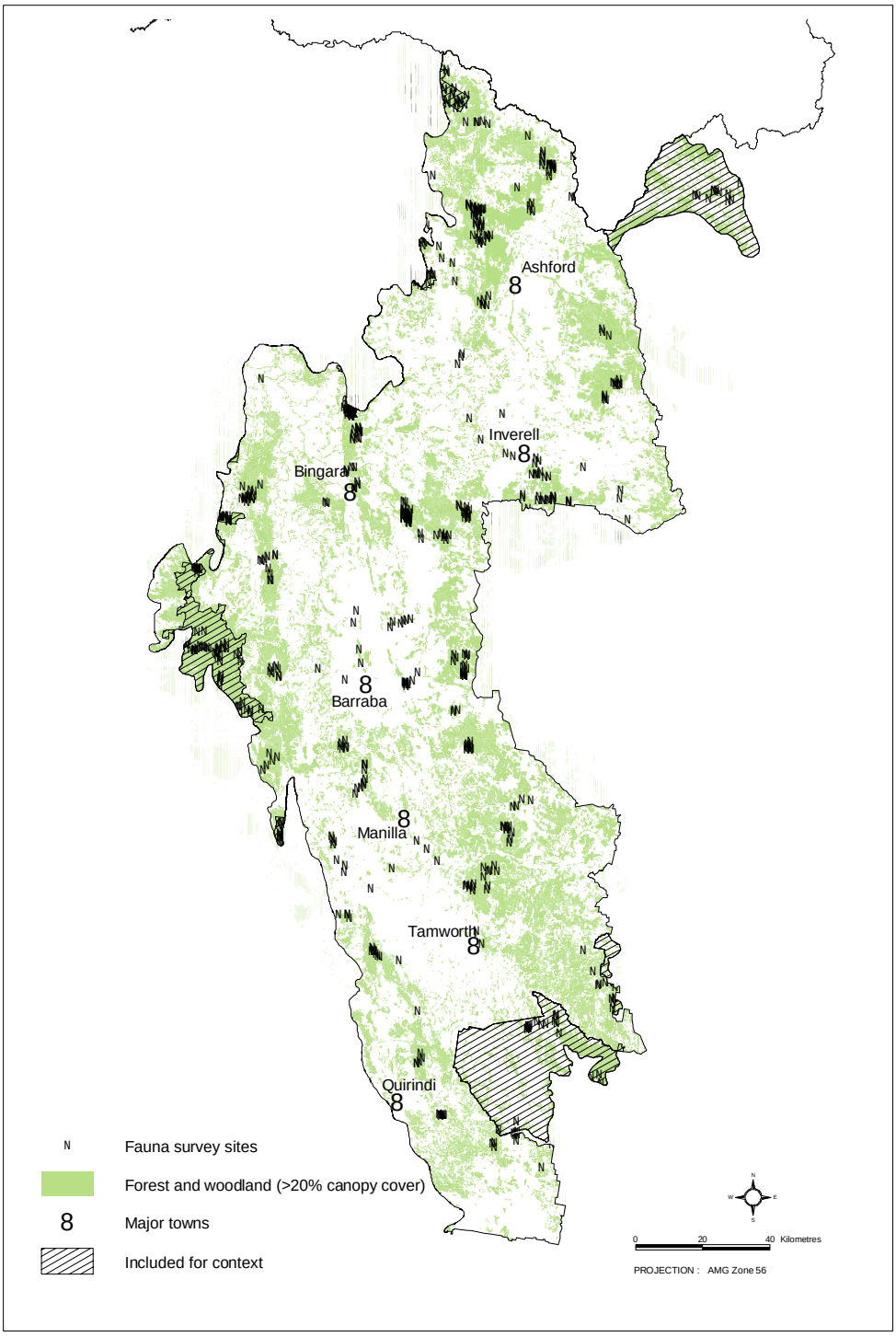


FIGURE-2A

Systematic fauna survey sites

2.4 SURVEY METHODS

The methods used to survey vertebrates in the DEC surveys (including Nandewar WRA surveys) were generally the same as those used in other regional assessments in NSW, particularly the north-east CRAs and the BBS WRA surveys.

Each systematic survey technique was conducted in a two hectare survey site. The two hectare site varied in shape, but was typically two hundred metres by one hundred metres. Sites were chosen to maximise the consistency of the habitat encompassed.

In practice, this was difficult for gully sites, where habitats often changed markedly over short distances perpendicular to the gully. This problem was often offset by selecting a more linear configuration of the two hectares for gully sites.

Targeted surveys for species of conservation significance (see Chapter 3) were also conducted using a wide range of methods.

2.4.1 Systematic reptile census

Reptile microhabitats were actively searched for one person-hour within each site. This is a well-established method for reptile survey and generally worked well in compiling data on the more common reptile species. In earlier surveys in Nandewar (during the *State Biodiversity Strategy* surveys), pitfall trapping was trialled as a method to complement the one hour search, but was found to be inefficient (high resource requirements for few additional species). Pitfall trapping appears to be a more effective method when used to target particular species or is conducted in a more suitable environment, such as the plains west of Nandewar.

In all Nandewar surveys by DEC, this technique detected 78% of the lizard species considered likely to occur in the region and 75% of the snake species.

2.4.2 Systematic bird census

All birds seen or heard in the two hectare site over a twenty minute period were recorded. The census involved surveyors remaining stationary for periods of time as well as slowly searching the site. Numbers of individual birds within the site boundaries were estimated. Censuses were conducted from soon after sunrise to not more than three hours after sunrise. Late afternoon censuses were conducted when necessary, but this only occurred on a few occasions. Each site was surveyed twice, in line with the method used in the BBS (and in contrast to the single bird census conducted in the coastal CRAs).

This method is consistent with many other rapid bird census techniques employed in Australia. Repeating the survey on a subsequent morning was considered to be of mixed success; although additional species were detected, this could well have been outweighed by the value that could have been derived from surveying a different site (and thereby doubling the number of sites surveyed).

In all Nandewar surveys by DEC, this technique detected 86% of the terrestrial diurnal bird species considered likely to occur in the region. Waterbirds were not surveyed systematically. However, water bodies were targeted in all surveys for non-systematic data.

2.4.3 Systematic nocturnal call playback

Pre-recorded calls of nocturnal species (powerful owl, masked owl, barking owl, squirrel glider, koala and bush stone-curlew) were played individually for three minutes, followed by a two minute listening period at each two hectare site. A ten minute listening period was required prior to, and following, call playback. At the end of the final listening period, the immediate area was searched with a spotlight.

In all Nandewar surveys by DEC, the technique was successful in detecting all target species except for the bush stone-curlew. However, overall numbers were very low except for the squirrel glider with 31 records. Of the other species played, there were only four koala records, four powerful owl, three barking owl and two masked owl records obtained. The low responses for most species probably reflect their low density of occurrence in the region.

In all Nandewar surveys by DEC, this technique detected 82% of the nocturnal bird species and 70% of the arboreal mammals considered likely to occur in the region.

The technique was also of some use for detecting frogs (32% of the frog species considered likely to occur) and large audible bats (yellow-bellied sheathtail-bat and white-striped freetail-bat).

2.4.4 Systematic spotlighting

Each two hectare site was thoroughly searched for one person-hour, focussing on arboreal mammal and herpetofauna habitat.

In all Nandewar surveys by DEC, this very effective technique detected 92% of the gecko species, 70% of the arboreal mammal species, 64% of the nocturnal bird species and 56% of the frog species considered likely to occur in the region. It was also effective in detecting large bats (grey-headed flying-fox, little red flying-fox, yellow-bellied sheathtail-bat and white-striped freetail-bat) and macropods.

2.4.5 Systematic Elliott trapping

Forty Elliott traps were set at ten metre intervals for four nights at each two hectare standard site. Traps were placed in protected locations and on stable substrates.

This technique appeared to be effective in detecting most native small mammals remaining in the region, with three species recorded (yellow-footed antechinus, common dunnart and brown antechinus). Habitat of the water-rat was not targeted, while other native small mammals that might occur appear to be very rare. The technique was effective in detecting

the two introduced small mammals in the region (house mouse and black rat). It also detected 22% of lizard species, being particularly effective for capturing *Egernia striolata*, *Egernia modesta* and *Eulamprus quoyii*.

2.4.6 Systematic harp trapping

Three trap-nights were undertaken at each two hectare site, with harp traps placed in the best flyways available (such as roads and creeks).

Over 4,000 bat records were obtained in all Nandewar surveys by DEC, using this very effective technique. The data obtained defined the microchiropteran bat fauna of Nandewar for the first time.

The benefits gained in trapping success by positioning traps in enhanced flyways was considered to outweigh the costs – overall, trapping success was highest in creeklines (approximately seven captures per trap-night) and roads (approximately six captures per trap-night) and lowest in general habitat (approximately two captures per trap-night). The benefit in obtaining a three-fold increase in capture rate was considered to outweigh the cost of capturing bats which were not using the specific habitat surveyed (that is, bats in transit along flyways) for the purposes of this survey.

2.4.7 Systematic anabat

A thirty minute Anabat recording was undertaken at each two hectare site as soon as possible after dusk.

This was one of the least cost-effective techniques, considering the prime survey time (soon after dusk) utilised to record calls and the cost of hiring a specialist to analyse the tapes. A small amount of data on the key bat species (those which were not regularly captured in harp traps) was obtained, but not enough to justify the cost. In all Nandewar surveys by DEC, only about 40% of the species were definitely identifiable, and it appeared that adequate call sequences of these species were relatively infrequently obtained.

2.4.8 Targeted survey methods

Herpetofauna

Habitats of the targeted frog and reptile species of an area were actively searched. A particular focus of these surveys was spotlight searches of streams and waterbodies for frogs, as no systematic frog surveys were conducted. Playback of frog calls was also used.

Birds

Habitats of target species were searched. Call playback for diurnal and nocturnal species was undertaken. Nests were examined (but not disturbed) and mist nets were used on several occasions.

Ground mammals

Additional Elliott trapping and small numbers of cage traps were used opportunistically to target the ground mammal fauna of a particular area or target particular species. Searches by foot or vehicle of target habitats were also carried out.

Bats

Triplines were used regularly on suitable waterbodies and were highly successful in capturing bats, including species not frequently captured in harp traps. Caves, tunnels, bridges, disused mines and buildings were all searched opportunistically. Anabat recording was also used opportunistically at target locations (such as waterbodies and flowering trees) and at different times of the night.

Targeted spotlighting

Spotlighting was undertaken opportunistically by foot and vehicle. This was conducted on all surveys as there was no systematic transect spotlighting due to problems encountered in all previous regional assessments in analysing transect data in a way which is compatible with the other site-based analyses. Spotlighting along long transects was an effective companion technique to site spotlighting, enabling the coverage of large distances and diverse habitats.

Targeted scat collection

Predator scats and scats of target herbivores were collected opportunistically. This technique is relatively easy to implement and confirmed a number of interesting koala occurrences.

However, the results were generally disappointing, with few interesting positive identifications. This may be due to some of the target species (such as the spotted-tailed quoll, brush-tailed rock-wallaby and small terrestrial mammals) being too rare in Nandewar for this technique to detect at the intensity implemented, and the hair analysis not being able to confidently distinguish to species level for a number of groups. The poor results supported the decision to abandon scat collection as a systematic technique.

2.5 SPECIES DIVERSITY

All of the terrestrial vertebrate species known or likely to occur, or historically occur, in Nandewar are listed in **Appendix 1.** The total number is estimated at 467 native species and 22 introduced species.

Any consideration of diversity and abundance must take into account the shortcomings of the available data. The most severe of these shortcomings is that conspicuous species will always appear to be far more abundant than cryptic species, and species which occur in close proximity to human population centres will be recorded incidentally more frequently than those of remote regions. While the second shortcoming can be eliminated by examining systematic data only, the first remains an intractable problem for broad-scale surveys as well as incidental data. However, the trends discussed below have become apparent over five years of survey and data review and can be expected to be reasonably reliable.

The systematic data reflects the diversity and abundance of species in forest and woodland habitats, as all sites were located in these ecosystems. Overall, diversity and abundance in Nandewar may differ substantially to that presented by systematic data because the species which favour cleared environments will be under-represented. In contrast, the non-systematic data held in the *Atlas of NSW Wildlife* often over-represents species found near populated areas compared with species of forest and woodland interior. The two datasets can be used in conjunction to build a picture of the total diversity and abundance.

2.5.1 Frogs

33 native species considered likely to occur in Nandewar

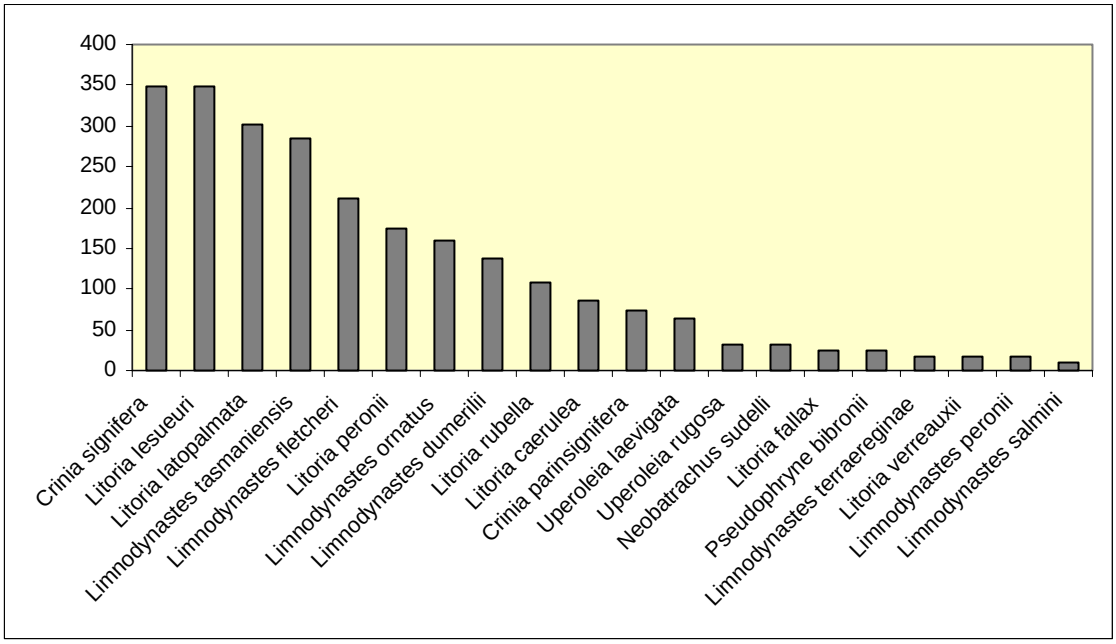
Figure 2-B shows the twenty most frequently recorded frog species from all data sources.

The 12 most commonly recorded species according to data from all sources account for 77% of non-systematic data and over 90% of the systematic records. Many of these species are found in suitable waterbodies in a range of environments from forest and woodland to predominantly cleared areas.

No specific systematic techniques were used to target frogs. However, systematic records were obtained in spotlighting and nocturnal call playback surveys carried out in forest and woodland habitats. The six most commonly recorded species in these systematic surveys were (in order of decreasing frequency) *Crinia signifera, Litoria peronii, Litoria latopalmata, Litoria lesueurii, Limnodynastes dumerilii* and *Limnodynastes tasmaniensis*. These species appear to be abundant and secure in Nandewar and together account for 64% of the systematic frog records and 52% of the non-systematic records.

FIGURE 2-B

All records of most frequently recorded frog species



Most of the more common species, including the six listed above, have an easterly distribution with the majority also found in coastal regions. While this eastern influence appears to dominate frog abundance in Nandewar, a significant number of western species occur in the region. However, most of these species appear to be relatively uncommon.

2.5.2 Turtles

4 native species considered likely to occur in Nandewar

The systematic survey techniques undertaken were not suitable for detecting significant numbers of turtles. Furthermore, much of the extant forest and woodland is located away from permanent watercourses and many of the higher order streams and rivers were therefore relatively poorly surveyed by systematic methods. Most turtle records were therefore obtained from targeted surveys of rivers, creeks and dams and incidental observations. Some data were obtained on three of the four Nandewar species, but overall this group remains particularly under-recorded in both systematic and non-systematic datasets.

Chelodina longicollis was the only species recorded in systematic surveys, and was recorded on only ten occasions. This species appears to occupy a relatively broad range of wet habitats and accounts for over 80% of all turtle records in Nandewar.

There are few records of the other three species. However, *Emydura macquarii* was observed in large numbers at Lake Inverell and is potentially more common, particularly on large permanent watercourses, than is apparent from the small number of records.

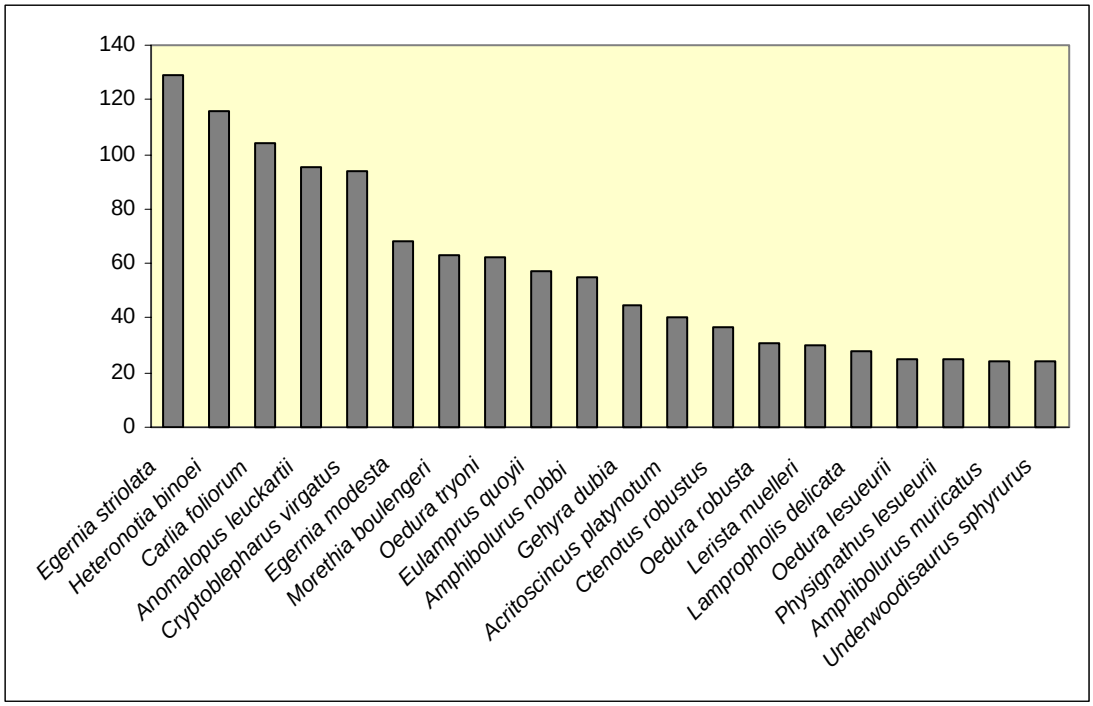
2.5.3 Lizards

64 native species considered likely to occur in Nandewar

Figure 2-C shows the systematic records of the twenty most frequently recorded lizards.

FIGURE 2-C

Systematic records of frequently recorded lizard species



The twenty most frequently recorded lizards in the systematic surveys comprise 87% of the systematic data and 67% of the *Atlas of NSW Wildlife* data. There is relatively good correlation between the systematic and non-systematic data.

2.5.4 Snakes

23 native species considered likely to occur in Nandewar

Only sixty records of snakes were obtained during the systematic surveys in Nandewar and there are only 370 records in the *Atlas of NSW Wildlife*. Additionally, only 43% of the species considered likely to occur were recorded during the DEC survey program. While in

part this reflects the cryptic nature of most species, it is also likely that many snakes are rare in the region.

There is a considerable discrepancy between the snakes most commonly recorded in the systematic surveys and those most common according to the non-systematic dataset. This appears to reflect the predominance in the non-systematic data of the larger snakes, while small burrowing species are more often recorded in the systematic surveys.

The snake most frequently recorded in the systematic surveys, *Demansia psammophis,* was recorded only ten times. The most frequently recorded species in the non-systematic dataset are *Pseudonaja textilis* and *Pseudechis porphyriacus.* Other more frequently recorded species are *Suta dwyeri* and *Furina diadema.* These five species represent 53% of the systematic snake data and 53% of the non-systematic data.

2.5.5 Diurnal birds

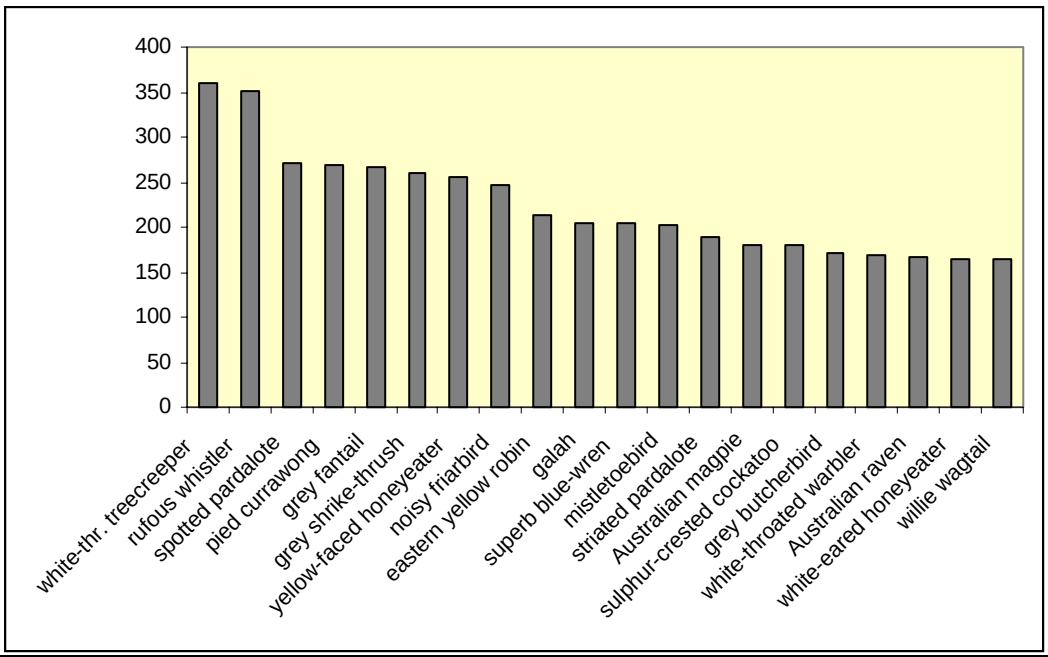
262 native species, 9 introduced species considered likely to occur in Nandewar (plus 2 regionally extinct species)

There are large differences between the birds most commonly recorded in the systematic surveys and those most common according to the non-systematic dataset. This reflects a lower frequency of systematic data on species found in the most disturbed habitats (agricultural and urban areas), with all the systematic sites located in forest and woodland.

Figure 2-D shows the systematic records of the twenty most frequently recorded diurnal birds.

FIGURE 2-D

Systematic records of frequently recorded diurnal birds



The twenty species shown above account for nearly half of the systematic bird data. The majority of the most common species in the non-systematic dataset are typically found in cleared or very open habitats, such as the four most common species. These are, in order of decreasing frequency, the superb blue wren, willie wagtail, Australian magpie and galah. Other species of open habitats to rank very highly in the non-systematic dataset are the magpie-lark, noisy friarbird, eastern rosella and laughing kookaburra.

The nine introduced bird species are, in order of decreasing frequency, the common starling, house sparrow, rock dove, spotted turtle-dove, common myna, European goldfinch, common blackbird, mallard and feral goose. All are species of disturbed environments and most are well established although the European goldfinch, mallard and feral goose are not abundant. Two species are likely to greatly expand their current distribution if left unchecked: the common myna and the common blackbird.

The common myna appears to be invading Nandewar from the south, with the northernmost record at Bingara. It is highly likely that this species will continue to increase both its range and abundance throughout the urban and rural areas of the region. The common blackbird currently appears to be uncommon in Nandewar, having established in a small number of urban areas, notably Inverell. It is also likely to increase in range and abundance in urban and rural areas.

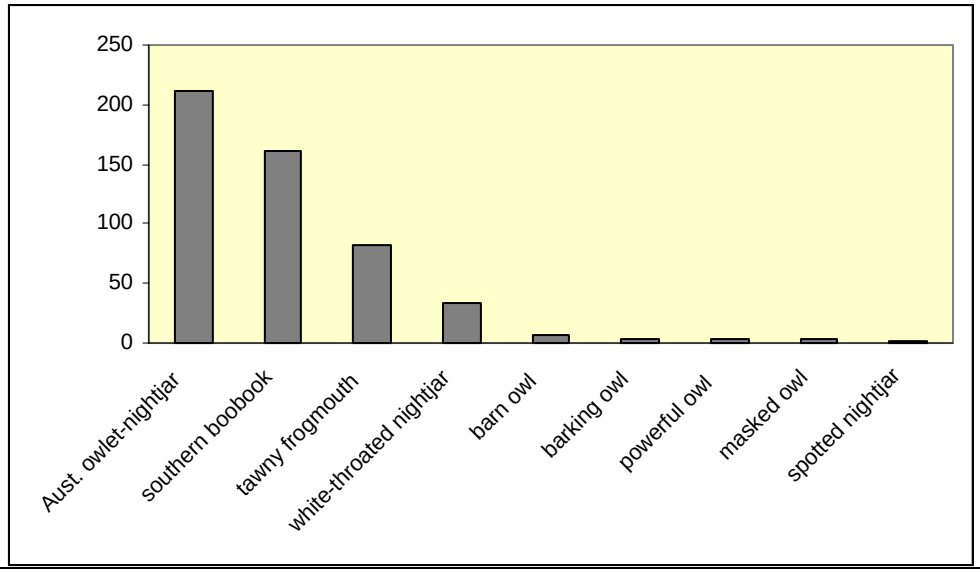
2.5.6 Nocturnal birds

11 native species considered likely to occur in Nandewar

Figure 2-E shows the systematic records of the nocturnal birds recorded.

FIGURE 2-E

Systematic records of nocturnal bird species



Both the systematic and non-systematic nocturnal bird data is dominated by three common and widespread species, the Australian owlet-nightjar, southern boobook and tawny frogmouth. These species account for 90% of the systematic nocturnal bird data and 82% of the non-systematic data.

The two nocturnal bird species not recorded were the bush stone-curlew and eastern grass owl.

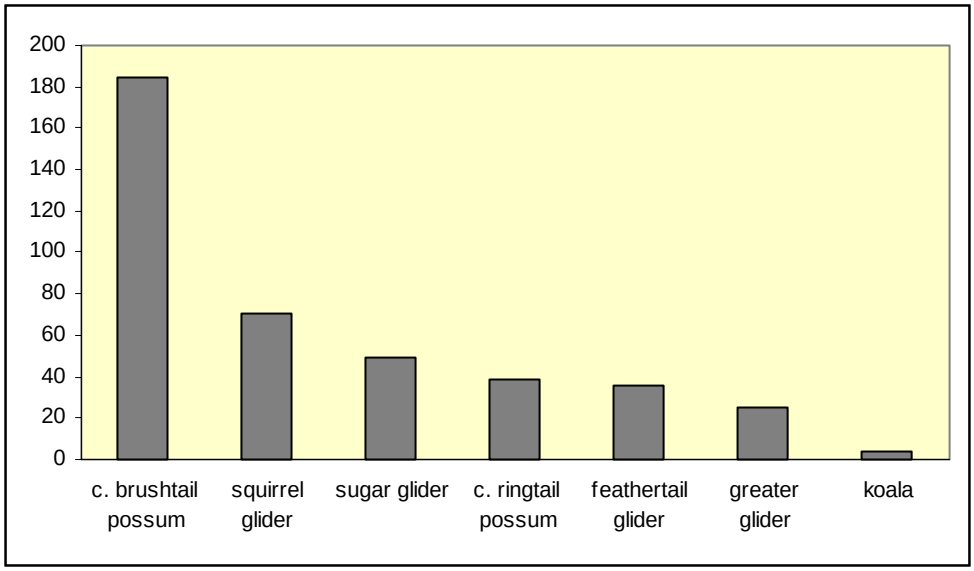
2.5.7 Arboreal mammals

9 native species considered likely to occur in Nandewar (plus 1 regionally extinct species)

Figure 2-F shows the systematic records of the arboreal mammals recorded.

FIGURE 2-F

Systematic records of arboreal mammal species



Most of the arboreal mammal data are derived from systematic surveys. Easily the most frequently recorded species was the common brushtail possum, which alone accounted for 46% of the systematic data.

The non-systematic data follows a similar pattern, with the common brushtail also easily the most frequently recorded, accounting for 33% of total records. One major difference however is that the koala is the second most recorded species in the non-systematic dataset (accounting for 22% of the records), but was only recorded 4 times in all systematic surveys (less than 1% of records). An explanation of this

disparity is that some of the best remaining koala habitat is in small remnants on fertile soils that were less well sampled by systematic sites. These areas are also well settled and there is a higher likelihood of the koala being noticed and recorded in the *Atlas of NSW Wildlife* than other arboreal mammals.

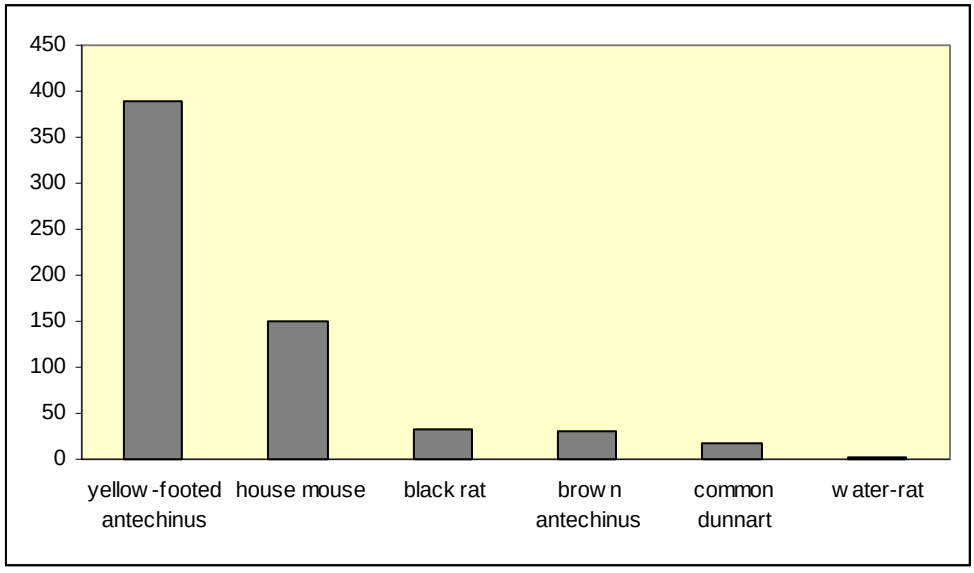
2.5.8 Small ground mammals

9 native species, 2 introduced species considered likely to occur in Nandewar (plus 7 regionally extinct species),

Figure 2-G shows the systematic records of the small ground mammals recorded.

FIGURE 2-G

Systematic records of small ground mammal species



Only 27% of the native small ground mammal species thought to occur, or have once occurred, in Nandewar were recorded in the surveys. The extant native small ground mammal fauna appears to be dominated by the yellow-footed antechinus, which accounts for 62% of the total small mammal systematic data and 88% of the systematic data for native species alone. The habitat of the water-rat was under-sampled, while the common dunnart appeared to be widely distributed although at a low frequency of detection (although this species is thought to be difficult to trap which may lead to under-estimation of its abundance).

Two introduced species, the house mouse and black rat, accounted for 29% of the systematic small mammal data and 28% of the non-systematic data.

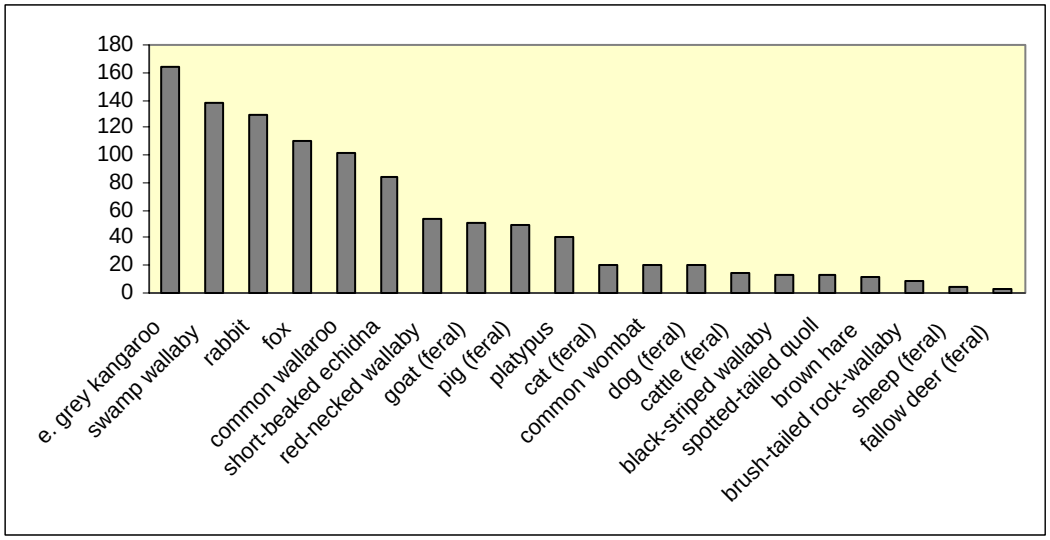
2.5.9 Large ground mammals

11 native species, 10 introduced species considered likely to occur in Nandewar (plus 7 regionally extinct species)

Figure 2-H shows the twenty most frequently recorded large ground mammal species from all data sources.

FIGURE 2-H

All records of most frequently recorded large ground mammal species



No systematic technique was used to specifically target the large ground mammal fauna. However, systematic records were obtained during spotlighting and nocturnal call playback. The swamp wallaby, eastern grey kangaroo and common wallaroo were the most frequently recorded native species, comprising 81% of the systematic records for native species and 57% of the non-systematic records.

Introduced species comprised 32% of all systematic records and 38% of non-systematic records for large ground mammals. Of the introduced predators, the fox was recorded most often and accounted for 17% of the total systematic data for large ground mammals (third most commonly recorded species) and 10% of non-systematic data.

The introduced herbivores in the region are the rabbit, brown hare, pig (feral), goat (feral), cattle (feral), fallow deer (feral), sheep (feral) and horse (feral). The rabbit remains the most common introduced herbivore, accounting for 17% of the total systematic data for large ground mammals (fifth most commonly recorded species) and 11% of the non-systematic data.

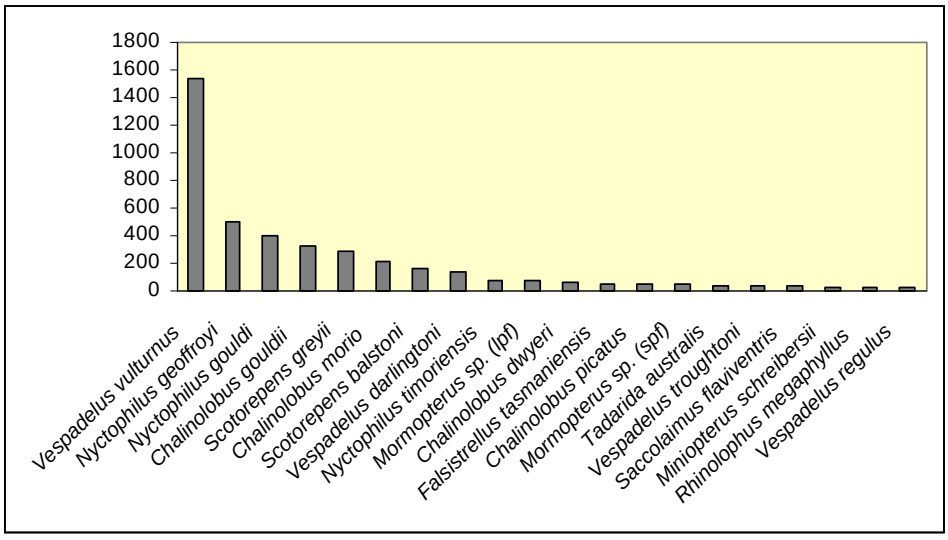
2.5.10 Bats

24 native species considered likely to occur in Nandewar

Figure 2-I displays the systematic records of the twenty most common bats.

FIGURE 2-I

Systematic records of most frequently recorded bat species



The six most frequently recorded bats in systematic surveys listed above comprise 78% of the systematic data and appear to be common in forests and woodland of the region.

Flying-foxes appear to be uncommon in Nandewar. The more frequently recorded species, the little red flying-fox, was recorded on only nine occasions in the systematic surveys and there are only fourteen records of the species in the *Atlas of NSW Wildlife*. Furthermore, during the surveys only two flying-fox camps were observed.

3 Conservation significance of the fauna

The convergence of major zoogeographic zones, primarily the eastern Bassian and western Eyrean zones (Schodde and Calaby 1972), has been implicated by many authors in characterising the faunal assemblages of the New South Wales tablelands, western slopes and plains (for example, Caughley and Gall 1985, Ford and McFarland 1991, Schodde 1994, Heatewole *et al.* 1995, Date and Paull 1998, Oliver *et al.* 1999, Paull and Date 1999, NPWS 2000). The Nandewar fauna is characterised by this convergence, with the strong Eyrean influence distinguishing Nandewar from the coastal fauna of New South Wales.

Apart from the dominant east / west transition, Nandewar also exhibits a less marked north / south transition. There is a significant Torresian (northern) zoogeographic influence that is most pronounced in the north and decreases to the south of the region. Nandewar therefore differs from the New South Wales south-western slopes where Torresian influences are far less marked. There are also minor Tumbunan (old rainforest) and Irian (lowland New Guinea) influences present in Nandewar.

Altitude also exerts a powerful influence over the vertebrate fauna of Nandewar. The lower slopes, generally at 300 – 400 metres in elevation are contiguous with the plains of the BBS. The north-western area joins the Moree plains, while the Tamworth area joins the Liverpool plains. The incursion of western species into these lower slopes is a feature of the Nandewar fauna not found to any significant degree on the adjacent New England tablelands. Conversely, the inclusion of high elevation areas (generally 800 – 1 000 metres) in eastern Nandewar, Mount Kaputar and the Liverpool Range is characterised by eastern species that are far less dominant further west.

As a result of these influences, Nandewar has a high proportion of species at or near the edge of their range. Species at the margins of their distribution are more susceptible to decline as they are usually at the limits of their ecological tolerance. Marginal populations are of conservation significance as their conservation prevents contraction of a species' range. If range contraction does occur, it is very difficult to reverse. These populations are also often removed from the main populations of a species and can be important refugia if catastrophic events affect the main populations. In particular, Nandewar is geographically situated to act as drought refuge for western species, many of which are near their eastern limit in the region. Species at their range limits are also scientifically interesting for demonstrating the limits of a species' ecological tolerance which can be essential for understanding the constraints on a species' distribution. Many of these species near the limits of their range are also rare in the region.

The temperate box – ironbark woodlands, particularly the widespread white box woodlands that characterise Nandewar are of key importance for fauna conservation. They support many species of conservation significance dependent on grassy and shrubby woodlands and

are a major nectar and hollow resource for residents, seasonal migrants and nomadic species.

Nandewar therefore supports a diverse and distinctive vertebrate fauna for a bioregion of relatively small size. There is currently considered to be only one endemic species, the undescribed Mount Kaputar rock-skink *Egernia* sp. However, a number of herpetofauna species have most of their distribution in the WRA study area, including the two nationally-listed species *Underwoodisaurus sphyrurus* and *Elseya bellii*.

Temperate woodland is considered the "most threatened widespread wooded ecosystem in Australia" (Robinson and Traill 1996). This ecosystem has been lost and fragmented in Nandewar at a dramatic rate – about two-thirds is gone – with catastrophic effects on the native fauna. The loss of habitat has not been borne equally, with the fertile regions now more than 90% cleared (fertile regions were estimated using an environmental coverage based on geology). These areas were likely to have been dominated by grassy woodlands that are now extensively fragmented and modified.

In conjunction with the high degree of clearing, Nandewar has been invaded by introduced plants and animals. The impact of the fox on the ground mammal fauna is well documented, but other species such as cats, rabbits, pigs and goats are likely to have had significant impacts and the effects of recent weed invasions are still to be fully realised. The outcome of these, and a host of other serious threats has been the decline of many of the remaining fauna species. Identifying these species as being of high conservation significance is a first step toward addressing their ongoing decline.

Since 1999 there has been considerable input from a wide range of people, particularly those involved in the Nandewar field surveys, into development of the list of species of conservation significance. There was a clear need to develop a list in order to focus the field surveys on those species for which information was most needed. Many criteria were considered relevant including legislative status, rarity, importance of Nandewar populations, susceptibility to threat, edge of range, disjunct population, threats to habitat, migratory requirements, reproductive rate, complex habitat requirements, dispersal ability, susceptibility to predation, size, mobility, indicator species, keystone species, poorly known species and population size.

Recent schemes for determining species of conservation significance have implemented different versions of scoring systems to determine a final list, ostensibly to reduce subjectivity. However, the task of systematically scoring all 470 vertebrates species for the above categories, or even the most relevant subset, was considered beyond the scope of the project. In any case, these schemes retain considerable subjectivity. Recher (1999) for instance, criticises them for placing too much emphasis on a narrow definition of threat of extinction that has resulted, in his opinion, in too few species being identified as being of conservation significance.

An early version of this list was reported in 2000 (NPWS 2000a) following review of other relevant lists (such as lists for the UNE and LNE CRAs, BBS WRA, Birds Australia lists and species of conservation significance in Western Division) and the literature. Threatened

species listed on the NSW *Threatened Species Conservation Act 1995* or the Federal *Environment Protection and Biodiversity Conservation Act 1999* that are known or likely to occur in Nandewar were automatic inclusions on the basis of their known state-wide or national significance. Subsequent field survey and research has resulted in amendments to the version from 2000.

The species of conservation significance resulting from this process are discussed below, including the rationale for their listing.

3.1 SIGNIFICANT SPECIES

A total of 126 species of conservation significance were identified from 450 extant native vertebrate species estimated to occur in the region (or 28% of the vertebrate species). These species are listed in **Appendix 2** and are discussed in detail in following sections.

Table 3-A shows the number of species of conservation significance categorised by broad taxonomic group.

TABLE 3-A

Significant species categorised by taxon

Taxonomic group	No. of extant species	No. of regionally extinct species	No. of significant species	% of taxon significant
Frogs	33		14	42
Turtles	4		2	50
Lizards	64		15	23
Snakes	23		12	52
Diurnal birds	262	2	45	17
Nocturnal birds	11		7	64
Arboreal mammals	9	1	5	56
Small ground mammals	9	7	6	67
Large ground mammals	11	7	6	54
Bats	24		14	58
Total	450	17	126	28

The taxonomic breakdown of significant species shows that diurnal birds have a relatively low proportion of significant species. The comparatively low figure (17%) is consistent with other estimates for diurnal birds, such as Garnett and Crowley (2000) who identify 17% of

the Australian avifauna as threatened. The relatively low figure may be related to the relatively high mobility of the group. However, it is also possible that this group is under-represented. Recher (1999) believes bird conservation to be in a far more critical state than currently understood and predicts that Australia will lose half of its bird fauna this century (although a more optimistic view is presented by Garnett (1999)). Many of the forest and woodland dependent species will have suffered significant declines in Nandewar due to habitat loss and the impact on many species in the longer term remains to be determined.

If diurnal birds are excluded, 44% of the remaining species are considered to be of conservation significance. This figure reflects the crisis facing most vertebrate groups in the region. A further statistic of concern is that more than half (58%) of the extant mammal fauna is of conservation significance.

Almost half (48%) of the species of conservation significance are near, or at the edge of their range. This is also cause for concern given the increased propensity for species to decline and become locally extinct at the margins of their range.

3.2 EXTINCTION

The Nandewar region is characterised by an extraordinary rate of vertebrate extinction. The 17 species in **Table 3-B** are known or likely to have occurred in Nandewar in historical times and are now known or considered to be regionally extinct. According to research carried out by DEC, none of them have been recorded in Nandewar for at least 50 years. (Note that reliable dates are not available for the last record of every species.)

Most of the regionally extinct species are ground mammals (14 species, or 82% of the total number of regionally extinct species). Of the 14 regionally extinct ground mammals, 13 (or 86%) are in the critical weight range (CWR) of 35 – 5 500 grams (Burbridge and McKenzie 1989). Since there was likely to have been 38 species in the original ground mammal fauna, and given 19 (50%) of them were in the CWR group, it is clear that the pattern of extinction in Nandewar supports the pattern in Australia that CWR mammals are most at risk. A majority (63%) of the CWR mammals have become regionally extinct compared with only 11% of the non-CWR species.

Almost all of the regionally extinct species are ground-dwelling and/or ground-foraging species (although the brush-tailed phascogale spends only part of its time foraging on the ground).

TABLE 3-B

Regionally extinct species

Common Name	Scientific Name	TSC Act status*	EPBC Act status*	Last known Nandewar record
paradise parrot	*Psephotus pulcherrimus*	PE	PE	1927
star finch	*Neochmia ruficauda*	PE	E	
western quoll**	*Dasyurus geoffroii*	PE	V	
brush-tailed phascogale**	*Phascogale tapoatafa*	V		
stripe-faced dunnart	*Sminthopsis macroura*	V		1950
long-nosed bandicoot**	*Perameles nasuta*			1907
western barred bandicoot*	*Perameles bougainville*	PE	PE	
bilby**	*Macrotis lagotis*	PE	V	
rufous bettong**	*Aepyprymnus rufescens*	V		1927
brush-tailed bettong**	*Bettongia penicillata*	PE	PE	1840
eastern hare-wallaby**	*Lagorchestes leporides*	PE	PE	
bridled nailtail wallaby	*Onychogalea fraenata*	PE	E	1924
white-footed tree-rat**	*Conilurus albipes*	PE	V	
plains rat**	*Pseudomys australis*	PE	PE	
Gould's mouse**	*Pseudomys gouldii*	PE	PE	
pale field-rat**	*Rattus tunneyi*			
long-haired rat**	*Rattus villosissimus*	V		

*TSC - NSW *Threatened Species Act 1995*
EPBC - Federal *Environment Protection and Biodiversity Conservation Act 1999*
PE - Presumed Extinct in NSW
E - Endangered in NSW
V - Vulnerable in NSW
** - CWR species

Table 3-C shows the species considered likely to be extinct. None of the *Species likely to be extinct* have been recorded in Nandewar in the last 30 years. However, four of the six species have been recorded within 50 years, disqualifying them from the *Regionally extinct* group. While it is unlikely that the other two species (Australian bustard and flock bronzewing) still occur in Nandewar, it was considered that they did not warrant *Regionally extinct* status (particularly as they are mobile bird species).

This group highlights very clearly the contemporary nature of the extinction process in Nandewar. If, as expected the *Likely to be extinct* group is accepted as *Regionally extinct* over the next 20 years, this will increase the number of *Regionally extinct* species by 35%.

TABLE 3-C

Species likely to be extinct

Common Name	Scientific Name	TSC Act status*	EPBC Act status*	Last Nandewar record
tusked frog	*Adelotus brevis*	EP		1972
yellow-spotted bell frog	*Litoria castanea*	E	E	1972
Australian bustard	*Ardeotis australis*	E		
flock bronzewing	*Phaps histrionica*	E		
fat-tailed dunnart	*Sminthopsis crassicaudata*			1972
narrow-nosed planigale	*Planigale tenuirostris*			1967

*TSC - NSW *Threatened Species Act 1995*
EPBC - Federal *Environment Protection and Biodiversity Conservation Act 1999*
EP - Endangered population
E - Endangered
V - Vulnerable

The *Species likely to be extinct* departs from the pattern of extinction of CWR mammals; both mammal species are below the CWR limit and there are equal numbers of bird and frog species. However, it is still comprised of ground-dwelling and/or ground-foraging species.

A final group of species, those approaching extinction, are listed in **Table 3-D**.

TABLE 3-D

Species approaching extinction

Common Name	Scientific Name	TSC Act status*	EPBC Act status*	Nandewar status
crucifix toad	*Notaden bennettii*			Last record 1972
booroolong frog	*Litoria booroolongensis*	E		Only two known populations
pale-headed snake	*Hoplocephalus bitorquatus*	V		Last record 1913
bush stone-curlew	*Burhinus grallarius*	E		No extant populations confirmed
squatter pigeon	*Geophaps scripta*	E	V	Two recent known localities
black-throated finch	*Poephila cincta*	E	V	Last record 1992
brush-tailed rock-wallaby	*Petrogale penicillata*	E	V	Less than 5 known populations remaining

*TSC - NSW *Threatened Species Act 1995*
EPBC - Federal *Environment Protection and Biodiversity Conservation Act 1999*
PE - Presumed Extinct
EP - Endangered population
E - Endangered
V - Vulnerable

The *Species approaching extinction* are still currently found, or could potentially still be found in Nandewar. However, it appears that their populations and total numbers are so low that it would be very difficult to reverse their decline. Although the pale-headed snake has not been recorded since 1913 in Nandewar (and therefore might qualifies as *Regionally extinct*), it was considered that there was still a reasonable chance that small populations of this cryptic species will be found. However, a significant amount of targeted survey effort was expended in DEC fauna surveys for the pale-headed snake without success.

The *Species likely to be extinct* and *Species approaching extinction* point to the future of extinction in Nandewar with a broader range of species now at risk compared with the species already lost; herpetofauna and bird species as well as mammals. Furthermore, during the total DEC survey program, 91 species expected to occur were not recorded in Nandewar. This represents 21% of the vertebrate fauna, and while the status of many species not found is poorly known (many are notoriously cryptic and others occur in specialised habitats not well surveyed), many of them appear to be genuinely rare in the bioregion. Urgent changes are required under current management regimes to halt the loss of vertebrate species in Nandewar.

3.3 RATIONALE FOR INCLUSION ON THE LIST OF SPECIES OF CONSERVATION SIGNIFICANCE

3.3.1 Frogs

Many frogs appear to have been greatly affected by the high levels of disturbance to wet habitats in Nandewar, with 42% of the frog species classified as species of significance.

Declining frogs

The north-west slopes and tablelands are recognised as a major region for declining frogs in Australia. Disturbance to frog habitat through clearing and the loss of water quality from a range of disturbance factors, as well as disease and tadpole predation from introduced fish *(Gambusia holbrooki)* has been implicated in the decline (EA 1999). Four frog species have been particularly affected: *Adelotus brevis*, *Pseudophryne bibronii*, *Litoria booroolongensis* and *Litoria castanea.* Two other species, *Notaden bennettii* and *Litoria tyleri*, may also be in decline in Nandewar.

Adelotus brevis is at its western limit in Nandewar and has declined from both Nandewar and the northern tablelands to the extent that the western population has been listed as an *Endangered Population* under the TSC Act. *A. brevis* has been included, along with ***Litoria castanea*** (listed as *Endangered* under both the TSC and EPBC Acts), as *Likely to be extinct* in Nandewar. Neither has been confirmed in Nandewar since 1972. *L. castanea* was considered common within a small area of the northern tablelands, which extended into the WRA region east of Inverell, but disappeared rapidly during the 1970s for reasons that have not been established (Mahoney 1999).

Notaden bennettii and ***Litoria booroolongensis*** are classified as *Approaching extinction*. *N. bennettii* is near the eastern edge of its range and has not been recorded in Nandewar, or further east, since 1972. It was considered rare in the New England area by Heatewole *et al.* (1995) and is listed as a regionally significant species in the BBS (NPWS 2000b). *L. booroolongensis* appeared to be once widespread in Nandewar and the northern tablelands (Gillespie and Hines 1999). In northern NSW it is now only known from two localities in Nandewar (one discovered during the WRA surveys) and is listed as *Endangered* on the TSC Act.

One of the species considered to have declined most dramatically in the region is ***Pseudophryne bibronii*** (Mahoney 1999). Although older records are widely distributed across Nandewar, this species was encountered only twice during recent surveys. *P. bibronii* was common on the northern tablelands, where it was considered "virtually ubiquitous" (Heatewole *et al.* 1995). While the species was found to be abundant at one locality on the tablelands, further targeted surveys are required to determine the extent of its current distribution. *P. bibronii* is listed as a regionally significant species in the BBS (NPWS 2000b).

Litoria tyleri is at the western edge of its range in Nandewar and has been recorded twice in the Inverell region. There is some evidence that this species is declining in the western part of its range – until it was found at Paradise Creek east of Inverell during DEC surveys in 1997, it had not been recorded in either the tablelands or Nandewar since 1972. Subsequent DEC surveys did not locate *L. tyleri*. Prior to 1972, the Australian Museum registered 14 specimens from sites scattered across the tablelands, indicating a formerly wide distribution in the area. *L. tyleri* was considered rare in the New England region by Heatewole *et al.* (1995).

Burrowing frogs

Seven species of burrowing frog were included as species of conservation significance. Six of these appear to be rare in Nandewar and are at or near the eastern limits of their distribution: ***Limnodynastes salmini, Cyclorana brevipes, Cyclorana novaehollandiae, Cyclorana platycephala, Cyclorana verrucosa*** and ***Litoria alboguttata***. These species are difficult to survey and it is hard to estimate their population size. However, the paucity of records for all six species suggests that they should be classified as being of conservation concern in the region until more information is obtained. All six species are also restricted in their Nandewar distribution and appear to be absent from the higher elevation eastern areas. *C. verrucosa* is listed as a regionally significant species in the BBS (NPWS 2000b).

The seventh species, ***Limnodynastes terraereginae***, also appears restricted in its Nandewar distribution and was infrequently recorded. This species was considered rare in the New England region by Heatewole *et al.* (1995).

Disjunct population

Pseudophryne major has been recorded at Mt Kaputar National Park and confirmed specimens lodged with the Queensland Museum (Heatewole *et al.* 1995). This is a very disjunct population and the only one known from Nandewar; it is of high conservation

significance. While the species has not been subsequently confirmed, there are anecdotal reports to suggest it still occurs in the park.

3.3.2 Turtles

One of the four species of turtle, ***Elseya bellii***, is listed as *Vulnerable* on both the TSC Act and EPBC Act. The main population of *E. bellii* appears to occur in the streams within the upper Namoi and Gwydir River catchments in eastern Nandewar and the western New England tablelands. (According to Cann (1998), there is also one outlying record of the species in Bald Rock creek on the northern New England tablelands.) There are few records of the species and it was not seen on recent surveys.

There are also very few records of ***Chelodina expansa***, the broad-shelled river turtle, which is found in rivers and dams (Cann 1998). Although this turtle is large in size, with the largest carapace of all Australian freshwater chelids, *C. expansa* is rarely observed as it lies concealed in debris on the bottom of muddy waterways (Cann 1998) – its status in the region is very poorly known. Nests of *C. expansa* may be vulnerable as it has a long incubation period, while the degradation of rivers in the region may also affect the species. Only one locality was recorded during the WRA surveys, at Keepit Dam west of Tamworth.

3.3.3 Lizards

The number of lizard species of conservation significance in Nandewar is low (15 of 64 species, or 23%) when compared with all groups except diurnal birds. The number of threatened species is also low, with only two species listed in state and federal legislation (and one state preliminary listing). At face value, this suggests that lizards have coped better than most other groups with the historical disturbance to the habitats of the region, and there are a suite of native species which occur throughout the agricultural and urban areas of Nandewar. However, a significant number of lizards are cryptic and there is very limited information on the response to disturbance of many species. More research needs to be undertaken to accurately determine the status of many species.

Geckoes

Four of the 12 species of gecko are classified as species of conservation significance.

Underwoodisaurus sphyrurus is an icon species for Nandewar, as one of the few vertebrates with the bulk of its range contained within the WRA region. It is listed as *Vulnerable* on the TSC Act and EPBC Act.

The DEC survey program in Nandewar since the NEFBS study in 1993 has largely defined the distribution of *U. sphyrurus*. Approximately three-quarters of the reliable localities for this species in Australia were recorded in these surveys (that is, 41 of the 56 reliable localities known to DEC). Only six reliable localities are known from beyond the Nandewar WRA region, but all are within approximately 30 kilometres of the boundary. The southern limit for *U. sphyrurus* was extended during the Nandewar WRA survey.

In the past, *U. sphyrurus* was considered a granite specialist. However, although it still appears to be most abundant in granite areas, the DEC surveys have established a widespread distribution across a range of geological substrates, predominantly in rugged areas.

In common with *U. sphyrurus,* (but unlike most other vertebrates) a large proportion of the total range of ***Oedura tryoni*** is contained within the Nandewar WRA region. Although not uncommon in some areas, the WRA region is of prime importance for the conservation of the entire species. ***Strophurus intermedius*** is known historically from Nandewar where it reaches its eastern limit at Tamworth. The are no recent records, suggesting that the distribution of the species may have contracted to the west.

Another gecko species found in Nandewar, ***Oedura rhombifer,*** has been given a preliminary listing as *Vulnerable* on the TSC Act. This species is only known from three localities in NSW, including one in Nandewar, and is included as a species of conservation significance.

Legless lizards

There are six species of legless lizard in Nandewar. All are cryptic and little is known of the status of most of them. *Delma inornata, Delma plebeia* and *Pygopus lepidopodus* appear to be uncommon in Nandewar and are included as species of conservation significance. The eastern distribution limit of ***Delma inornata*** was established during the WRA surveys near Inverell. Nandewar appears to be a stronghold of ***Delma plebeia***, with a significant proportion of the known localities occurring in the region.

Dragons

Eight species of dragon occur in Nandewar, with two species included as significant: *Diporiphora australis* and *Tympanocryptis tetraporophora*. Both are extremely rare in the region.

Diporiphora australis is very rare in NSW and is known from northern Nandewar / BBS area and the lower Clarence valley. Only one “probable” record (Australian Museum identification) was obtained for Nandewar, but the species was also found close to the Nandewar boundary in the BBS, so is likely to occur in Nandewar.

Tympanocryptis tetraporophora occurs near its eastern limit in Nandewar. There is an Australian Museum specimen from 1972 near Inverell, which is the only record in Nandewar. However, there are also records close to the western boundary of Nandewar in the BBS, indicating the species may still occur in the region.

Goannas

One of the three species of goanna, ***Varanus tristis orientalis*** is a species of conservation significance. It is also listed as a regionally significant species in the BBS (NPWS 2000b). There are only about 25 localities known for this species in NSW, three in the far north of the Nandewar region where it occurs at its eastern limit. One of the three known Nandewar localities was found during the WRA surveys.

Skinks

Only four of the 35 skink species in Nandewar have been categorised as species of conservation significance. One of these, ***Anomalopus mackayi***, is listed as *Vulnerable* on the EPBC Act and *Endangered* on the TSC Act. This species is at the eastern edge of its range in Nandewar and has a population stronghold in the Wallangra area. This population was confirmed in the WRA surveys with two records obtained in the locality. *A. mackayi* is only found on fertile soils and is highly restricted in its distribution.

Three other species of skink of conservation significance are very restricted in their overall range. Taxonomic uncertainty surrounds ***Ctenotus eurydice.*** For example, it is lumped with *C. taeniolatus* in Swan *et al.* (2004), but is shown as a separate species in Wilson and Swan (2003). Should it be confirmed as a separate species, it is likely to be highly restricted in its distribution in New South Wales. It is tentatively known from three localities in Nandewar, where it would be at its western limit. A recently described species, ***Egernia* sp.** Mount Kaputar rock-skink (Swan *et al.* 2004) is considered a species of conservation significance as it appears to be confined to the Mount Kaputar area and is the only endemic species in Nandewar. The range of the species in the Mount Kaputar area is poorly known. ***Lampropholis caligula*** is known from four localities in Nandewar, all along the Liverpool Range. The Nandewar populations form an important connection from the great divide to Coolah Tops.

Eremiascincus richardsonii is very rare in Nandewar, with only three localities known and close to the eastern edge of its range. This is possibly an isolated population (Swan *et al.* 2004). It was not detected in recent DEC surveys.

3.3.4 Snakes

Snakes were infrequently encountered in Nandewar surveys. Their status is not well known; most species are cryptic and appear to occur in relatively low densities in the region. Over half (52%) of snake species are included as species of conservation significance.

Blind snakes

Four species of blind snake occur in Nandewar and three of them are species of conservation significance: ***Ramphotyphlops bituberculatus, Ramphotyphlops proximus*** and ***Ramphotyphlops wiedii***. With few known localities, all three species appear to be rare in Nandewar, although these are very cryptic species. *R. bituberculatus* is close to its eastern range limit. It was considered that these species should be included as species of conservation significance pending further knowledge of their status in the region.

Pythons and tree snakes

The two species of python (*Antaresia maculosa* and *Morelia spilota metcalfei*) and one species of tree snake (*Dendrelaphis punctulata*) are species of conservation significance.

Antaresia maculosa is rare in NSW, with less than 10 records in the state. It is listed as a regionally significant species in the BBS (NPWS 2000b) and is known from Yetman, adjacent to the north-western boundary of Nandewar. Suitable habitat occurs in the region.

Despite repeated anecdotes during recent DEC surveys of sightings of ***Morelia spilota metcalfei,*** no live animals were observed in the surveys. One record was obtained, from a skin in Arthur's Seat State Forest. Few records have been lodged with the *Atlas of NSW Wildlife*. *M. spilota metcalfei* is listed as a regionally significant species in the BBS (NPWS 2000b) and the anecdotal evidence suggests a decline of this species in Nandewar.

The Nandewar population of ***Dendrelaphis punctulata*** appears to be highly disjunct, with no records between the eastern tablelands and north-western Nandewar. It also appears to be uncommon in this region.

Elapids

Six of the 16 species of elapid are of conservation significance.

Although ***Acanthophis antarcticus*** has not been recorded in Nandewar, it could be expected to occur given its wider distribution in New South Wales. This species is very cryptic, but any location in Nandewar would be highly significant given the paucity of recent records west of the divide in New South Wales. ***Furina dunmalli*** has also not been recorded in Nandewar, but has been found adjacent to the north-west boundary in the BBS. It is listed on the Federal EPBC Act and any additional record in New South Wales would be highly significant. *A. antarcticus* and *F. dunmalli* are listed as a regionally significant species in the BBS (NPWS 2000b).

Hoplocephalus bitorquatus is listed as Vulnerable on the TSC Act and has not been recorded in Nandewar since 1913. It is classified as *Approaching extinction.*

There are a number of historical records of ***Drysdalia coronoides*** in Mount Kaputar National Park. This population is highly disjunct from the bulk of the range of the species. It has not been recorded since 1974 and was not re-located in recent surveys.

Pseudechis guttatus and ***Brachyurophis australis*** are both widely distributed species, but apparently at low densities. They are rarely recorded in Nandewar. *P. guttatus* has been recorded at less than 10 localities, and *B. australis* at approximately 10 localities in the WRA region. Although both species may be significantly more common than suggested by these figures, they are included as species of conservation significance pending further research.

3.3.5 Birds

Many bird species in Nandewar have declined in abundance. Barrett and Silcocks (2002) reported that 99 species (36% of the bird fauna) in the Nandewar bioregion declined in abundance between the two bird atlas surveys (1977/81 to 1998/2001). A growing literature on bird species of decline in temperate woodlands of south-eastern Australia has also identified many species that occur in Nandewar. Recher (1999) suggests that 30% to 90% of Australia's avifauna has declined in abundance.

Along with other regions in Australia, the Nandewar avifauna is also subject to changes in species composition. Many species are increasing in range and abundance in response to changing disturbance regimes. The impact of increased abundance is often under-estimated. It can be as significant as decline and lead to ecologically dysfunctional ecosystems (Recher 1999).

Two bird species considered extinct in NSW (listed as *Presumed Extinct* on the TSC Act) are likely to have occurred in Nandewar. The paradise parrot is the only bird species to have become extinct in Australia (excluding offshore islands). A breeding population occurred near Inverell, with the last confirmed sighting in 1927 (Irby 1927, quoted in Higgins 1999). The only confirmed New South Wales record of the star finch was the type specimen collected by Gould near the Namoi River in 1839 (Morris *et al.* 1981). This location suggests that the species probably once occurred in Nandewar. There is also a report of the star finch from Inverell in 1964 (Baldwin 1975).

The **flock bronzewing** and **squatter pigeon** are listed as *Endangered* on the TSC Act. They are species of grassy woodlands and plains and are both ground-foraging and ground-nesting. They have declined markedly in New South Wales. The flock bronzewing was historically known from the Liverpool Plains near Narrabri (Morris and Holmes 1981) and is likely to have also once occurred in Nandewar. Its current distribution is much further west and the species is classified as *Likely to be extinct* in Nandewar. The squatter pigeon was known historically from as far south as Inverell (Baldwin 1975). It is currently known from only two recent localities in the far north of Nandewar, but previously was not recorded in New South Wales for over a decade. It is classed as *Approaching extinction*.

The **black-throated finch** is also listed as *Endangered* on the TSC Act and classed as *Approaching extinction.* It was known from the Inverell district (Baldwin 1975) and was last reliably recorded near Pindari Dam north of Inverell. It has not been seen for over a decade, despite a number of targeted surveys. This population appears isolated from the Queensland population of the southern subspecies *(Poephila cincta cincta)* and any sightings would be highly significant.

Large ground birds

Most of the large ground species are in decline. Ground species are particularly susceptible to predation, particularly those that nest on the ground, while much of the habitat suitable for ground-foragers has been highly modified. Large species are often relatively wide-ranging and now face significant impediments to movement, such as large distances between suitable habitat patches (including large clearings) and fencing.

The **Australian bustard** and **bush stone-curlew** have decreased in much of their former range in NSW and are both listed as *Endangered* on the TSC Act. The Australian bustard is classed as a species *Likely to be extinct* in Nandewar and the bush stone-curlew *Approaching extinction*. Any occurrences of these species in Nandewar would be highly significant.

The **emu** appears to be in decline over much of its range in Australia (Olsen *et al.* 2003, Barrett and Silcocks 2002). The emu has disappeared from most of its former range on the northern tablelands, such as the Armidale plateau (Barrett *et al.* 1994), and has retreated to

the central and northern regions in Nandewar. The emu has also been found to be declining in Nandewar (Barrett and Silcocks 2002) and the NSW sheep – wheat belt (Reid 1999).

The **Australian brush-turkey** occurs as a highly disjunct population in Nandewar. Recent surveys have established a total known range of the brush-turkey that extends from Mt Hallam (northern and eastern extent) to Mt Kaputar NP (southern extent) and nearby Deriah State Forest (western extent, just inside the BBS region). It is likely that there are at least three discrete populations: Mt Hallam, Warialda-Derra Derra, and Mt Kaputar-Horton Range.

There are only 43 records of the brush-turkey within this distribution. Of these, 15 records are not accurately geo-referenced and require confirmation (many of these records are also relatively old). There is an outlying 1980 record in the south-eastern BBS south of Gunnedah that also requires confirmation. This isolate would extend the population by approximately 100 kilometres south from Kaputar, but through extremely fragmented habitat. There is also a single record from the Nandewar Bioregion in Queensland, approximately 40 kilometres north-east of the northern-most record in NSW (Mt Hallam).

Given the outlying records and the occurrence of patches of suitable habitat, it is likely that the population does extend beyond the currently confirmed distribution in NSW (Mt Hallam to Mt Kaputar). However, the brush-turkey is a moderately conspicuous species given the large size of both the bird and its mounds. Given the moderate amount of survey throughout the Nandewar and BBS bioregions in recent years, it appears unlikely that there would be large numbers of brush-turkeys occurring beyond the currently confirmed distribution.

The brush-turkey is a sedentary species, although movements of young birds are not well known (Marchant and Higgins 1993). The brush-turkey in Nandewar is likely to be disjunct from the main coastal population and further fragmented into several small isolated populations. There are no recent records in the central and western New England tablelands, which appears to form a substantial barrier to the species. The tablelands are highly cleared and even where substantial native vegetation remains (such as along the granite belt) the habitat is apparently unsuitable, with no brush-turkeys recorded.

There are also substantial barriers to the north and south of the confirmed range in Nandewar, and also between brush-turkey populations. Two particularly significant barriers are the highly cleared Inverell basalt plains in the north and the Liverpool Plains – Tamworth agricultural region in the south.

Although the total area of native vegetation within the confirmed range of the brush-turkey in Nandewar is in excess of 300 000 hectares, the species appears to have very specific habitat requirements and thereby occupies only a very small percentage of the area.

There is anecdotal evidence that the population is limited by food availability west of the divide. According to reports summarised in Marchant and Higgins (1993), the range of the brush-turkey apparently expanded west to Moree and Nyngan early last century due to the infestation of prickly pear, which was adopted as a food resource. Following the decrease in prickly pear abundance, the range of the species is thought to have contracted to its normal range.

Although the brush-turkey takes a wide range of food, in Nandewar the species may have specific food requirements. There is a strong association between many of the recorded localities and dry rainforest vegetation elements. For example, the occurrences at Derra Derra (the largest patch of Semi-Evergreen Vine Thicket in NSW), Benbraggie State Forest, Warialda State Forest, Washpool Creek, Kaputar National Park (Waa Gorge) and Deriah State Forest are largely associated with dry rainforest elements including well-developed occurrences of *Ficus rubiginosa.* These habitat elements are very patchily distributed in Nandewar and often associated with better quality soils (such as basalt) and creek lines.

Although the habitat of the brush-turkey in Nandewar is relatively open when compared with the coastal population, there appears to be a preference for areas with at least some significant patches of denser cover. A number of mounds were observed in locations within relatively dense understorey and where there was sufficient litter and loose soil for construction material. These habitat requirements are also patchily distributed.

From the considerations above, the total amount of suitable of habitat is only a tiny fraction of the total native vegetation within the range of the brush-turkey. The broad-scale vegetation mapping project in Nandewar mapped only 2 589 hectares of dry rainforest scattered throughout the area and the subjective impression from the surveys is that the densities of the birds is very low. The amount of mapped dry rainforest as a percentage of the total range of the brush-turkey is less than one percent.

Predation appears to be a major threat throughout the life-cycle of the brush-turkey. Pigs may disturb nest mounds, cats and foxes are predators of chicks and adults may occasionally be taken by dogs, dingoes or foxes (summarised by Marchant and Higgins 1993). All of these feral predators are common throughout the range of the brush-turkey in Nandewar, with foxes noted in recent surveys as abundant throughout the region. At least one mound was observed to be heavily disturbed.

Marchant and Higgins (1993) consider the species susceptible to loss or modification of habitat and that the range of the species has contracted west of the divide. As a result of the clearing in Nandewar, a disproportionate area of brush-turkey habitat (mesic communities on fertile soils) is likely to have been lost. This has almost certainly reduced the total extent of brush-turkey habitat and isolated the remaining populations.

All of the reliable and accurately geo-referenced records are found in five large forest blocks, with the smallest over 9 000 hectares. Despite recent visits and surveys to a number of small remnants with apparently suitable brush-turkey habitat, no animals were observed in small remnants. Therefore, although the evidence is currently anecdotal only, it appears that the Nandewar brush-turkey strongly favours large forest blocks.

A burning regime that is too frequent may have adverse impacts on the brush-turkey. In the short term, opening the understorey and decreasing cover could increase vulnerability to predation, while over a longer time period, the promotion of more xeric vegetation could affect food supply. Although there is no direct evidence, consideration of many of the favoured foods suggest that pigs may compete with the brush-turkey for food.

Many of the ground-dwelling and ground-foraging vertebrates in the Nandewar are of conservation concern. In this context, the Nandewar populations of the brush-turkey are clearly of high conservation significance, with the population likely to decline without targeted conservation attention.

Waterbirds

While Nandewar lacks extensive wetlands, the habitat is significant as part of the broader inland network, with the headwaters of a number of major rivers found in Nandewar (such as the Namoi, Gwydir, MacIntyre and Dumeresq). The habitats are particularly important for nomadic, irruptive, migratory and highly dispersive species which may use them on an occasional basis (such as seasonally, in transit, during wet conditions or as a drought refuge). The wetland habitat in Nandewar is extensively degraded.

The six waterbirds of conservation significance are listed on the TSC Act and are generally highly mobile: **blue-billed duck** (young dispersive), **freckled duck** (nomadic, irruptive), **Australasian bittern** (occasionally irruptive), **black-necked stork** (unknown movements in Nandewar), **brolga** (locally seasonally migratory and dispersive) and **painted snipe** (dispersive or irruptive, possibly part-migratory).

No records were obtained for any of these species from the recent DEC survey program in Nandewar.

The primary focus of the WRA fauna project was on the forest and woodland species. A targeted study would be required in order to more fully understand the waterbird community of the region. It is likely that other waterbird species could be included as species of conservation significance following further research.

Raptors

The two species of raptor of conservation significance are listed as *Vulnerable* on the TSC Act: osprey and square-tailed kite. Both are highly mobile species. The **osprey** has a marginal distribution in the region, having been recorded only once at an artificial water storage (Split Rock Dam). While it is a sedentary species, it can also be highly dispersive. The western occurrences of the osprey such as that in Nandewar are useful for broadening the knowledge of habitat use by the species.

The **square-tailed kite** is rare in Nandewar and was recorded on only four occasions in recent surveys. As a high-order predator, it is susceptible to declines in abundance of its main prey, forest and woodland birds. It is listed by Barrett and Silcocks (2002) as declining in Nandewar.

Owls and nightjars

The four owls listed as *Vulnerable* on the TSC Act are species of conservation significance in Nandewar: powerful owl, barking owl, masked owl and grass owl. While the barn owl has not been listed as being of conservation significance, there is anecdotal evidence that it may be declining in the region and its regional status should be monitored.

The **powerful owl** is only reliably known from the Liverpool Range in southern Nandewar. This is an important corridor from the coastal ranges to Coolah Tops (where the powerful owl is also known to occur). The species was found in two separate localities along the range in the WRA surveys, Crawney Pass and Wallabadah Nature Reserve. These are the only confirmed localities for the species in Nandewar.

There are relatively few records of the **barking owl** in Nandewar (approximately 18 known localities). Most of the barking owl records in Nandewar are associated with large forest blocks, including the two new localities of the barking owl found in the WRA surveys on the Tingha Plateau. The more fertile sections of the plateau appear to be important for the species in the area, with the barking owl recorded at three of four sites surveyed in this habitat. The central granite belt also appears to provide important habitat for the species in Nandewar, with five localities recorded along a forty kilometre section north from Warrabah National Park.

The **grass owl** has not been recorded in Nandewar. However, there are a number of records close to the north-west boundary, indicating the potential for the species to occur within the WRA region. Given the paucity of inland records of the grass owl in New South Wales, any localities in Nandewar would be highly significant.

The **masked owl** generally appears to occur at low densities west of the divide in New South Wales. Its distribution in Nandewar is consistent with this pattern, with only seven localities known for the species. It was only recorded twice in recent DEC surveys, in Attunga State Forest and Kelvin State Forest. All localities for the masked owl in Nandewar are of significance.

The ranges of the white-throated and spotted nightjars overlap in Nandewar. Both are ground-nesting species (increasing the risk of predation by feral predators), partly migratory and uncommon in Nandewar.

The **white-throated nightjar** has a coastal distribution in New South Wales that extends to the western slopes and plains. The Nandewar population is an important one in this context as it is a key component of the inland population. The white-throated nightjar is a partial migrant in south-eastern Australia and there is evidence to suggest that it migrates north during winter (Barrett *et al.* 2003). However, given that it has been recorded in Nandewar in winter, its movement patterns in the region have yet to be fully understood. This is confounded by the highly cryptic nature of the species outside its calling period and its conspicuousness during its calling period.

The **spotted nightjar** occurs near its eastern limits in central Nandewar, where it is very rare, having been recorded on only a few occasions. There is also evidence to suggest that the spotted nightjar migrates north during winter (Barrett *et al.* 2003), although its movements in Nandewar are poorly understood.

Cockatoo and Parrots

The glossy black-cockatoo, superb parrot, swift parrot and turquoise parrot are listed as *Vulnerable* on the TSC Act. They are all hollow-dependent species.

The **glossy black-cockatoo** is uncommon in Nandewar, with substantial sections of the region lacking suitable habitat. However, there are significant populations in Bebo, Severn River – King's Plains and the Liverpool Range (Crawney Pass), and the species was also recorded at a number of other isolated localities in the WRA which are also likely to be significant populations: the Rock of Gibraltar, Tingha Plateau (Clive State Forest) and Watson's Creek Nature Reserve.

Glossy black-cockatoos were utilising *Allocasuarina litoralis* in widespread localities, *A. inophloia* in the north and north-west and *A. torulosa* in the south. In the Severn River – King's Plains area, it utilises shrubby allocasuarinas (probably *A. brachystachya* and potentially *A. rigida* and *A. gymnanthera).*

The **swift parrot** is *Endangered* nationally. There is a single reliable Nandewar record near Barraba from 1996. However, the species is easily overlooked as it is a winter migrant to Nandewar and is highly mobile as it seeks suitable nectar resources.

The **superb parrot** is *Vulnerable* nationally. It has not been recorded on the *Atlas of NSW Wildlife* in Nandewar, but there are reports of it occurring as far to the north-east as Barraba, and there are recent records approximately three kilometres from the south-eastern Nandewar boundary. The superb parrot could also be easily overlooked as it may also be a winter migrant to Nandewar.

Nandewar is a stronghold of national significance for the **turquoise parrot**, with over four hundred localities recorded in the *Atlas of NSW Wildlife.*

Other non-passerines of conservation significance

The **painted button-quail** was considered "common in small parties" in woodland in the Inverell District (Baldwin 1975). This ground-foraging and ground-nesting species is considered to have declined across the New South Wales sheep – wheat belt (Reid 1999) and in Nandewar (Barrett and Silcocks 2002). It is still widespread, but apparently at low densities in the region. The **red-chested button-quail** is an extremely cryptic species that also appears to occur at low densities in Nandewar. It is also a ground-foraging and ground-nesting species found in temperate and tropical grasslands and grassy woodlands and is known to occur on the lower western slopes in Nandewar. This species was found at only one locality in the DEC surveys. The red-chested button-quail may also be susceptible to high stocking rates that reduce its preferred habitat of long grass (Marchant and Higgins 1993). It is listed as a regionally significant species in the BBS (NPWS 200b).

The black-eared cuckoo, forest kingfisher and red-backed kingfisher are rare in Nandewar, with only two records obtained on recent surveys for the black-eared cuckoo and none for the kingfishers. All three species are likely to be summer migrants to Nandewar.

The **black-eared cuckoo** is listed by Barrett and Silcocks (2002) as declining in Nandewar. The **forest kingfisher** is known from Nullamanna (Baldwin 1975) and recent records in adjacent bioregions suggest that the species is still likely to occur in the region. The **red-backed kingfisher** is listed by Barrett and Silcocks (2002) as declining in Nandewar and by Barrett *et al.* (2003) as declining in Australia. It was once a regular migrant, widely scattered

in woodland of the Inverell district (Baldwin 1975) and was still regularly recorded on the *Atlas of NSW Wildlife* until the early 1980s, but has not been recorded since 1981.

Woodland passerines

There are 22 species of declining woodland passerine classified as species of conservation significance. Many (59%) of them are ground-foraging species likely to have been affected by the profound alteration to the ground layer by clearing, grazing of stock, invasion of introduced grasses and changed fire regimes.

Five medium-sized ground-foraging woodland species, the superb lyrebird, grey-crowned babbler, white-browed babbler, spotted quail-thrush and crested bellbird, plus an additional species which spends significant time on the ground (the spotted bowerbird), are classified as species of conservation significance.

In Nandewar, the **superb lyrebird** is known only from the Rock of Gibraltar in the far north-east of the WRA region (a locality documented for the first time in the WRA surveys when a single record was obtained). The occurrence at this location is likely to be the less common "granite" form of the superb lyrebird that has a restricted distribution in the northern New England tablelands. The Rock of Gibraltar population may also be disjunct from other populations.

In New South Wales, the **grey-crowned babbler** is widely recognised as declining and listed as *Vulnerable* on the TSC Act. Its distribution in Nandewar overlaps with the **white-browed babbler** which also appears to have declined in Nandewar (Barrett *et al.* 2003, Barrett and Silcocks 2002), the New South Wales sheep – wheat belt generally (Reid 1999) and is listed as a regionally significant species in the BBS (NPWS 200b). Both species are now absent from much of the adjacent New England tablelands. For example, the white-browed babbler was considered to have once been a common species on the Armidale Plateau, but is now absent (Barrett *et al.* 1994).

The **spotted quail-thrush** is listed by Barrett *et al.* (2003) as declining Australia-wide, by Reid (1999) as declining in the New South Wales sheep – wheat belt and by Barrett and Silcocks (2002) as declining in Nandewar. It is listed as a regionally significant species in the BBS (NPWS 200b) and appears restricted in its Nandewar distribution to large forest blocks.

The **crested bellbird** is now extremely rare in Nandewar, with few confirmed records. It was not recorded in recent surveys. However, Baldwin (1974) describes the species as "once common" in the Inverell district (Baldwin 1975). Reid (1999) lists the crested bellbird as declining in the New South Wales sheep – wheat belt and Barrett and Silcocks (2002) as declining in Nandewar. It also appears to be declining in the adjacent BBS region (Barrett *et al.* 2003).

Another species that spends significant time on the ground, the **spotted bowerbird**, is near its eastern limit in Nandewar and is also very rare in the region. It was recorded on only three occasions in recent surveys. The spotted bowerbird is listed as a regionally significant species in the BBS (NPWS 200b).

Seven small ground-foraging bird species are classified as species of conservation significance: five insectivorous species (southern whiteface, chestnut-rumped thornbill, red-capped robin, flame robin and hooded robin) and two granivores (diamond firetail and plum-headed finch).

The **southern whiteface** and **chestnut-rumped thornbill** are widely distributed in inland NSW, but occur at low density in restricted areas of Nandewar. Both are listed as declining species in the New South Wales sheep – wheat belt by Reid (1999). The southern whiteface is also listed as a regionally significant species in the BBS (NPWS 200b) and as declining in Nandewar by Barrett and Silcocks (2002) and Barrett *et al.* (2003). The chestnut-rumped thornbill also forages in low shrubs and is marginal in Nandewar, with only five records in the west of the region. However, it was observed on the Gwydir near Inverell in 1965 (Baldwin 1975), an area in which it appears to have since declined.

The **red-capped robin** is listed as declining in Nandewar by Barrett and Silcocks (2002) and declining in the New South Wales sheep – wheat belt by Reid (1999). Nandewar appears to be a stronghold for the species in the eastern part of its range. The **flame robin** is considered to be declining throughout its range (Barrett *et al.* 2003), including Nandewar (Barrett and Silcocks 2002). The flame robin is known from eastern and southern Nandewar, although most records are more than twenty years old. It was known historically from the Gwydir River near Inverell (Baldwin 1975). The **hooded robin** is widely recognised as a declining woodland bird and is listed as *Vulnerable* on the TSC Act. Nandewar appears to be a stronghold for the species, with over 250 records on the *Atlas of NSW Wildlife.* The hooded robin was recorded in a number of widespread localities during the WRA surveys.

The **plum-headed finch** and **diamond firetail** are granivorous species likely to have been affected by alteration to native grasslands, grazing and the loss of woodland habitat. The plum-headed finch is not common in Nandewar and appears to be declining in the New England tablelands (Barrett *et al.* 2003), although it may never have been common there (Barrett *et al.* 1994). It is listed as a regionally significant species in the BBS (NPWS 200b). The diamond firetail is widely recognised as a declining woodland bird and is listed as *Vulnerable* on the TSC Act. Nandewar appears to remain a stronghold for the species, with over 400 records on the *Atlas of NSW Wildlife.* The diamond firetail was recorded in a number of widespread localities during the WRA surveys.

An additional two species which also spend significant time foraging on the ground are the **chestnut-rumped heathwren** and **speckled warbler**. The chestnut-rumped heathwren is a species of specialised habitat (heath or heathy woodland, usually associated with rock outcrops), currently known from only six disjunct areas in Nandewar. It was recorded in only three localities during recent surveys and is listed as declining in Nandewar by Barrett and Silcocks (2002). The speckled warbler is widely recognised as a declining woodland bird and is listed as *Vulnerable* on the TSC Act. Nandewar appears to remain a stronghold for the species, with over 330 records on the *Atlas of NSW Wildlife.* The speckled warbler was recorded in a number of widespread localities during the WRA surveys.

Two species of treecreeper are classified as species of conservation significance. They are susceptible to the loss of old trees as they are both hollow-dependent and utilise bark as a

major foraging substrate. The **brown treecreeper** is widely recognised as a declining woodland bird and is listed as *Vulnerable* on the TSC Act. Nandewar appears to remain a stronghold for the species, with over 650 records on the *Atlas of NSW Wildlife.* The brown treecreeper was recorded in a number of widespread localities during the WRA surveys. The **red-browed treecreeper** is declining in Australia according to Barrett *et al.* (2003) and in the New England tablelands (Barrett and Silcocks 2002). In Nandewar it is uncommon and restricted to the eastern edge of the region on the New England tablelands and on the Liverpool Range. It is known in total from approximately eight localities in Nandewar and was recorded in five localities during recent DEC surveys.

The **crested shrike-tit** also utilises bark as a foraging substrate and is listed by Barrett *et al.* (2003) as a nationally declining species, by Reid (1999) as a declining species in the New South Wales sheep – wheat belt, by Barrett *et al.* (1994) as a declining species on the Armidale plateau, by Smith *et al.* (1995) as a species of conservation significance in the Western Division of New South Wales and by NPWS (2000b) as a regionally significant species in the BBS. The crested shrike-tit can be found in moderate numbers (it was recorded in widespread localities during recent DEC surveys) and Nandewar may be a stronghold for the species.

Nandewar is an important region for nectarivorous species, with the widespread winter-flowering white box a key resource for many species. Mugga ironbark is a prolific nectar-producer and although much less common than white box, is an important resource. Much of the most important nectar-producing fertile woodlands have been cleared. Four nectarivorous bird species are classified as species of conservation significance: musk lorikeet, regent honeyeater, black-chinned honeyeater and painted honeyeater.

The **musk lorikeet** has a high level of daily and seasonal mobility and is adapted to feeding on nectar and pollen. It is generally not common in Nandewar, although significant flocks have been observed, particularly in the Bundarra – Barraba area. This is an important area for nectarivores as it is retains a relatively high proportion of native forest and is a core area for mugga ironbark in the Nandewar WRA region. It is key area for the **regent honeyeater** (Oliver *et al.* 1999), listed as *Endangered* on the TSC Act as well as **the black-chinned honeyeater** (listed as *Vulnerable*).

The **painted honeyeater** is a nomadic species usually associated with mistletoe. It is listed as *Vulnerable* on the TSC Act and is rare in Nandewar (only thirteen records in the *Atlas of NSW* wildlife).

3.3.6 Arboreal mammals

Five species of arboreal mammal were included as species of conservation significance. Four of these, the koala, yellow-bellied glider, squirrel glider and eastern pygmy possum are listed as *Vulnerable* on the TSC Act. The **koala** appears to be absent or occur at very low densities in many of the less fertile regions of Nandewar. It was rarely recorded in recent DEC surveys. The main Nandewar strongholds for the species appear to be in the very small

remnants remaining on the highest fertility soils (particularly the Inverell basalts) and areas of the low fertility volcanics in the north of the region.

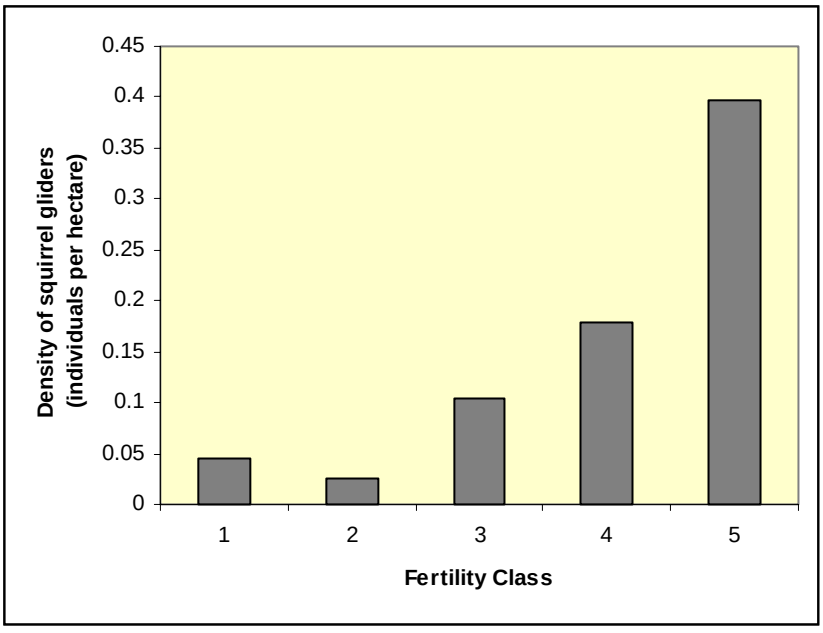
The **yellow-bellied glider** is extremely marginal to the area, but has been recorded close to the study area boundary east of Inverell and the areas of high coastal influence east of Nundle. The **eastern pygmy possum** has not been recorded in Nandewar, but could feasibly occur given recent records of the species in the BBS.

Substantial numbers of **squirrel gliders** occur in Nandewar; the region is important for the conservation of the species as a stronghold of high significance. Squirrel gliders were recorded at 40 of the 263 site spotlights conducted, or 15% of sites. A total of 70 individual animals were recorded, which equates to an overall density in the region of one squirrel glider every 7.5 hectares. Clearly, with a substantial amount of non-habitat surveyed, densities would be considerably higher in preferred habitat. Of the 293 nocturnal call playback surveys conducted, squirrel gliders were recorded at 27 sites (9%). Thirty-eight individual animals were recorded. On a few occasions, the circumstantial evidence suggested that the animals responded to the call playback (although not necessarily to the squirrel glider call).

The distribution of the squirrel glider in the western part of its distribution corresponds with fertile soils (van der Ree 2002), a pattern clearly observed in Nandewar. Widespread remnants of white box woodlands on medium to high fertility soils were very often found to support squirrel gliders. The density of squirrel gliders in zones of different soil fertility is plotted in **Figure 3-B.**

FIGURE 3-B

The relationship between squirrel glider density and soil fertility classes



The fertility classes in **Figure 3-B** are derived by classifying the fertility grid into five fertility classes of equal area, from lowest fertility class one to highest class five. There was roughly a ten-fold increase in the density of squirrel gliders from low to the highest fertility classes. These data support the conclusion that squirrel glider habitat in Nandewar has been preferentially cleared as the highest fertility areas were converted to agricultural landscapes.

In the DEC fauna surveys, white box, mugga ironbark and yellow box communities were found to be important squirrel glider habitat, including an aggregation estimated at 20 individuals in one hectare of flowering mugga in Warialda State Forest. Squirrel gliders were also found in a wide variety of remnants. In fertile areas they were found in small remnants (including remnants of about three hectares in size) and in long thin linear roadside remnants. The decreasing degree of connectivity and degradation of the remnants are likely to be major threat to the viability of the species in many areas in the long term unless it can be reversed.

The **greater glider** is the only arboreal mammal of significance not listed on the TSC Act. There is a highly disjunct population in Mt Kaputar National Park and a marginal distribution in the south-eastern edge of the study area including the Liverpool Range. The greater glider is recognised to be sensitive to disturbance and in some areas in Nandewar with a history of heavy logging, densities appeared to be very low.

3.3.7 Ground mammals

Platypus

There are only eleven records of the **platypus** in the *Atlas of NSW Wildlife.* It is a species of specialised habitat (higher order streams) which is typically highly degraded in Nandewar. The platypus is poorly known in the region, with most records along major rivers, including the Macdonald River, Macintyre River, Mole River, Namoi River and Severn River.

Dasyurids

The loss of dasyurid species has occurred most heavily in south-eastern mainland Australia (Dickman *et al.* 2001). Dasyurids have been severely depleted in Nandewar, with seven of the nine species of dasyurid either regionally extinct or of conservation significance. Two species of antechinus (yellow-footed antechinus and brown antechinus) have not been included. The yellow-footed antechinus remains widespread, with 390 animals trapped during the DEC survey program. The brown antechinus occurs only in the south of the region and is secure in areas adjacent to the eastern boundary. However, given the decline of small mammals (and dasyurids) in Nandewar, the regional status of these two species should be monitored.

Three species of Nandewar dasyurids are considered regionally extinct: western quoll, brush-tailed phascogale and stripe-faced dunnart. All are close to range limits in Nandewar. At a maximum weight of 25 grams, the stripe-faced dunnart is the smallest mammal to

become extinct in Nandewar, and is the only species below the CWR limit to have become extinct. Although the brush-tailed phascogale has been classified as an arboreal mammal, it spends part of its time on the ground and is also within the CWR limits.

The **narrow-nosed planigale** and **fat-tailed dunnart** have been classified as *Likely to be extinct*. Neither species has been recorded for more than 30 years and the narrow-nosed planigale is listed as a regionally significant species in the BBS (NPWS 2000b).

Of the four dasyurids still be found in Nandewar, two are considered to be of conservation priority: spotted-tailed quoll and common dunnart. **The spotted-tailed quoll** is listed as *Endangered* on the EPBC Act and as *Vulnerable* on the TSC Act. There are very few records of the species in Nandewar and it was not recorded on recent DEC surveys. There have been recent records of the spotted-tailed quoll in Mount Kaputar National Park, but it appears likely that the species is now restricted to the remaining large forest blocks.

The **common dunnart** appears to occur at low density throughout Nandewar. As one of only two small ground mammals that remain widespread (the other being the yellow-footed antechinus which is still relatively common in the region), it is important that the common dunnart is retained in Nandewar.

Bettongs

The regionally extinct CWR mammals include the only two species of bettongs to have occurred in Nandewar, the brush-tailed bettong and the rufous bettong. Bettongs appear to have been common in Nandewar, with the brush-tailed bettong reported to be abundant in the 1840s (Short 1998). Almost 1.3 million rat-kangaroo (bettong) bounties were paid in the north-west slopes and tablelands from 1888 to 1920, reaching a peak of almost 100 000 in 1892 in the northern tablelands and greater than 40 000 per annum in 1911 and 1912 in the north-west slopes (Short 1998). This represents about 40% of the total bounties paid for rat-kangaroos during this period in NSW. However, the major decline of the rat-kangaroos appears to correspond with the arrival of the fox in the north-west slopes and Short (1998) directly implicates predation by the fox as the major cause in the loss of these species.

Peramelids

The three species of peramelids (bandicoots and bilby) are considered *Regionally extinct* in Nandewar: western barred bandicoot, long-nosed bandicoot and bilby. All are within the CWR group and close to their range limits. The western barred bandicoot and bilby were near their eastern limit, while the long-nosed bandicoot is near its western limit. While the long-nosed bandicoot is still secure on the coast, the western barred bandicoot is *Presumed Extinct* on the EPBC Act and the bilby *Vulnerable* on the EPBC Act.

Wombat

The **wombat** has a marginal distribution in Nandewar, occurring in the atypical region in the south-east of the study area. The wombat is thought to have declined in northern NSW and it is considered important to retain the connectivity of wombat populations along the Liverpool Range.

Macropods

The two smallest macropods have become extinct in Nandewar, while two of the remaining six species are classified as being of conservation significance.

Only one macropod small enough to be within the CWR group historically occurred in Nandewar. That species, the eastern hare-wallaby, has gone extinct (listed as *Presumed Extinct* on the TSC Act and EPBC Act). The next largest macropod, the bridled nailtail wallaby, is extinct in New South Wales (listed as *Presumed Extinct* on the TSC Act and *Endangered* on the EPBC Act). Reaching up to eight kilograms in weight, this is the largest species to have become extinct in Nandewar and the only extinct species above the CWR limit.

The **black-striped wallaby** and **brush-tailed rock-wallaby** are listed as *Endangered* on the TSC Act and the brush-tailed rock-wallaby is also listed as *Vulnerable* on the EPBC Act. The black-striped wallaby is historically known from Nandewar and is likely to occur in the north-west of the study area in the vicinity of recent records in the BBS near the Nandewar boundary.

The brush-tailed rock-wallaby is classified as *Approaching extinction.* It appears to be a species in major decline in Nandewar, with only a small number of extant populations currently known. This is despite the widespread occurrence of apparently suitable habitat and knowledge of historic populations such as those in the Mt Kaputar and Warrabah areas. Remaining populations appear to be small, isolated and highly threatened. Much of the apparently suitable habitat was heavily infested with goats, with foxes also likely to occur.

During the WRA surveys, there was a single confirmed observation of the brush-tailed rock-wallaby north of Kelvin State Forest. The available habitat at this locality appeared small and was infested with goats. It is about 35 kilometres from this locality north to the only known population remaining in Mount Kaputar National Park. The brush-tailed rock-wallaby is also likely to occur in the Liverpool Range area in the south of the region, and in the far north-east. Old scats were found in Warrabah National Park during the DEC surveys that were assessed as “probable” brush-tailed rock-wallaby. However, the species has not been confirmed in Warrabah for more than a decade. A population at Attunga appears to have become extinct over the duration of the DEC survey program (P. Spark pers. comm.).

Rodents

There are no secure species of native rodents in Nandewar. Of the nine species of native murid rodent considered to have occurred in Nandewar, five are considered *Regionally extinct* and three are of conservation significance. The other species, the bush rat, appears restricted to a small amount of potentially suitable habitat in the far south-east (in an area atypical of Nandewar generally) and is secure in the adjacent region.

Three of the five species of conilurine rodent in Nandewar have become regionally extinct, the **white-footed tree-rat**, **plains rat** and **Gould’s mouse**. All of them were in the CWR

group. The other two species, the **New Holland mouse** and the **delicate mouse** have not been recorded in Nandewar, but are known from close to the northern Nandewar boundary – delicate mouse in the west, New Holland mouse in the east. The southern part of the delicate mouse's distribution extends along the inland warmer areas generally dominated by summer rainfall and grassy understorey, while the New Holland mouse occupies the colder areas of the divide (Ford pers. comm.). Nandewar may therefore be a part of an overlap between the two species, which appear to hybridise (Ford pers. comm.). Any occurrence of these species would be highly significant.

The fox has also been strongly implicated in the decline of this group in Australia by Smith and Quin (1996). Their "hyperpredation" hypothesis intuitively may apply to Nandewar, where high numbers of foxes are evident. This hypothesis suggests that increased predation pressure from elevated fox numbers, resulting from high numbers of rabbits, leads to the decline and extinction of native species. Although rabbit numbers have declined considerably in Nandewar in recent years, they are still frequently recorded and, subjectively, fox numbers appear to have remained high.

Other murid rodents have fared no better than the conilurines, with two of the four species considered *Regionally extinct*, the **pale field-rat** and **long-haired rat**. There are only seven records of the **water-rat** in the *Atlas of NSW Wildlife.* It is a species of specialised habitats (permanent pools) which are typically highly degraded in Nandewar. The water-rat is poorly known in the region, with most records along major rivers, including the Namoi River, Peel River, Manilla River, Gwydir River and MacIntyre River.

Dingo

There is debate about the taxonomy of dingoes and other wild dogs. Both are currently considered to be descendent from grey wolves *Canis lupus* (Fleming *et al.* 2001). The nomenclature recommended by Fleming *et al.* (2001) and adopted in the *Atlas of NSW Wildlife* is to treat dingoes and domestic dogs as sub-species: *C.l. dingo* and *C.l. familiaris*.

The dingo is likely to have once been widespread in Nandewar, however there are very few recent confirmed sightings and only one record was obtained in recent DEC surveys (from Arakoola Nature Reserve). The dingo is listed as regionally significant in the BBS (NPWS 2000b) and Upper and Lower North-East New South Wales and is of high conservation concern in Nandewar.

3.3.8 Bats

While no bat species are known to have become extinct in Nandewar, more than half (54%) of the bat fauna is considered to be of conservation significance. Nine of the 13 species of conservation significance are listed as *Vulnerable* on the TSC Act, and 62% of them are dependent on old trees for roosting hollows.

Flying-foxes

There are very few records of the **grey-headed flying-fox** (listed as *Vulnerable* on the EPBC and TSC Acts) in Nandewar and few sightings in recent DEC surveys. However, the species can be highly mobile and is known to utilise nectar resources when they are available. The **little red flying-fox** is uncommon in the region and highly nomadic. A key nectar resource in Nandewar for these species is white box and significant flowering is thought to occur about once every three years (Eby *et al.* 1999). Flowering events usually occur in colder months of the year which were not generally covered in recent surveys.

The extent to which the grey-headed flying-fox species utilises this now fragmented white box resource is therefore not known. However, during a survey of population numbers in winter 1998, Eby *et al.* (1999) found the species to be concentrated along the coast where the nectar resource is more reliable. At least one camp in the Nandewar WRA region, at Bendemeer, is known to be used by the species. Further work needs to be undertaken to determine the location of other camps and their pattern of use.

Horseshoe-bat

The eastern horseshoe-bat appears to occur at low densities in Nandewar, was recorded at only 25 localities and never trapped in large numbers at any location. This species is listed as a regionally significant species in the BBS (NPWS 2000b) and is considered to be of conservation significance in Nandewar pending further work to determine its population size and the extent to which suitable cave roosts occur in the region.

Freetail-bats

Three of the four species of freetail-bat to occur in Nandewar are included as species of conservation significance. These are the inland, southern and hairy-nosed freetail-bats.

The inland, southern and hairy-nosed freetail-bats are all near their eastern range limit in Nandewar. The **inland freetail-bat** and **southern freetail-bat** generally appeared to occur at low densities; both species are known from only approximately 20 localities in Nandewar. The **hairy-nosed freetail-bat** was recorded in Nandewar for the first time in the WRA survey and is only known in NSW from a small number of localities. It is a species of very high conservation priority.

Threatened micro-bats

Eight other bats considered to be of conservation significance in Nandewar are listed as *Vulnerable* on the TSC Act: **yellow-bellied sheathtail-bat, large-eared pied bat, little pied bat, eastern false pipistrelle, large bentwing-bat, greater long-eared bat, greater broad-nosed bat** and **eastern cave bat**. The large-eared pied bat and greater long-eared bat are also listed as *Vulnerable* on the EPBC Act.

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4 Nandewar key habitats and corridors

4.1 INTRODUCTION

The alarming loss of fauna species and habitat in Nandewar presents a great challenge to fauna conservation in the region. Habitat loss, degradation and fragmentation have been heavily implicated in the decline and extinction of fauna through the gradual loss of ecological functioning caused by a wide range of factors. These include regional reductions in critical resources (such as loss of seasonal resources, refuge areas, high productivity areas, dispersal areas), localised reductions in critical resources (such as foraging, sheltering, and nesting resources), degradation of resources (such as by weed invasion, erosion and salinisation), increased competition from aggressive species and predation by feral predators.

The provision of habitat of sufficient size, quality and spatial configuration is therefore a basic requirement of fauna conservation. Over the last decade, fauna conservation has progressed to the adoption of programs that support habitat retention, enhancement, restoration and connectivity at a regional scale. In addition to a comprehensive, adequate and representative reserve system and recovery actions for threatened species, fauna conservation requires consideration of multiple tenures and must make a practical contribution to regional planning.

The objective in developing key habitats and corridors (KHC) for Nandewar is to integrate disparate fauna information (point localities of species and habitats, field knowledge and environmental information such as vegetation mapping and soil fertility) into a unified output that can be used as a regional planning tool for fauna conservation. The mapped output provides the only spatially complete fauna conservation planning framework for the region. It forms an explicit basis for regional protected habitat networks and provides a landscape framework for conservation planning.

The KHC approach to regional fauna conservation planning was developed only recently in north-east New South Wales by Scotts and Drielsma. Their publications (Scotts 2003, Scotts and Drielsma 2003) describe the approach in detail. The KHC model developed in north-east NSW adopted species and ecological processes as planning tools to identify a regional conservation framework. Habitat gain and connectivity were promoted by delineating and mapping regional key habitats for forest fauna and habitat-specific corridors as a priority subset of overall landscape connectivity (Scotts 2003).

The main impetus for undertaking the mapping of KHC in Nandewar was the success of the north-east NSW project in establishing the utility of the approach for regional fauna conservation planning. KHC maps have been considered in programs in north-east NSW such as catchment management boards, regional vegetation management committees and regional and local government environmental planning. The seamless extension of the north-east KHC further west was a logical step for fauna conservation planning in Nandewar.

A second important reason to undertake the project was the existence of a draft version of KHC for Nandewar. The *North-West Slopes Interim Key Habitats and Corridors* was developed by DEC in 2002 for regional vegetation committees in the north-west slopes and tablelands. Since 2002, there have been considerable improvements in data and knowledge of the region that enabled substantial improvements to be made to the interim version.

The original aim of the project for Nandewar was to implement the same methods developed for north-east NSW by Scotts and Drielsma (2003). However, the lack of fauna modelling data for Nandewar did not allow the full implementation of the methods as originally conceived. Nonetheless, with the quantum increase in knowledge of the region since 2002, it was possible to make substantial improvements to the *North-West Slopes Interim Key Habitats and Corridors* without implementing the complete methods. In addition to the major increases in fauna data and knowledge of fauna habitats in the region, for the first time an API-derived vegetation map was available which dramatically improved the basis for the mapping of the KHC.

A regional project of this type is inevitably subject to limitations and assumptions of many kinds. However, there is an urgent need to consolidate accumulated fauna knowledge and data into a product suitable to inform current and on-going conservation and management programs. Detailed species research on questions regarding corridor use by species, dispersal, breeding requirements, population viability, responses to habitat fragmentation and edges and landscape configuration scenarios, is still required to refine and modify the conservation priorities determined more broadly at this regional scale (Scotts 2003). KHC mapping as a framework for regional habitat conservation programs should be perceived as a basis on which future programs can build.

4.2 KEY HABITATS

Fauna habitat in fragmented landscapes is typically distributed as a mosaic of optimal habitats, sub-optimal habitats and non-habitats (Scotts 2003). Within such a mosaic, animal populations occur as metapopulations – a series of sub-populations embedded within a matrix of unfavourable habitat. Increasing numbers of species exhibit a metapopulation structure with increasing fragmentation of natural systems. To conserve species and ecological functioning, it is critical to facilitate their capacity to live within these mosaics of fragmented habitat (Scotts 2003).

Conservation values vary across the landscape and it is vital to identify the important areas as key habitats as they are the foundation for designing networks for fauna conservation. Key habitats include the reservoirs for the conservation of animal populations and for the maintenance of ecological processes within the overall system. Key habitats are typically the largest, most intact blocks of habitat – the source areas most likely to support diverse habitats and intact and functioning fauna communities, and to maintain natural disturbance regimes (Scotts 2003).

While the most ecologically intact areas must form the basis for key habitats, they need not be free from the effects of significant disturbance. In particular, many important areas of high productivity that have been greatly modified still retain their inherent value and support remnants of species assemblages. These areas may be candidates for ecological restoration and need to be included to ensure that regional networks of fauna habitat are representative (Scotts 2003).

Delineation of key habitats is contingent upon the types of data available. The integrated, probabilistic nature of the predicted fauna assemblage distributions and centres of endemism, derived previously for the UNE and LNE RFAs, were ideal for the purpose of identifying key habitats (Scotts 2003). In their absence, alternative data was used to identify key habitats in Nandewar.

4.2.1 The development of Nandewar key habitats

Six main considerations drove the development of the Nandewar key habitats: size, shape, fertility, vegetation type, habitat significance and condition.

The importance in Nandewar of the remaining large, intact habitat remnants to the ongoing persistence of vertebrate fauna was identified during the development of the *North-West Slopes Interim Key Habitats* in 2002. Patches of forest or woodland greater than 1,000 hectares in size were considered to support core habitat of species with the largest home ranges. For example, the barking owl is considered to require a “core” habitat in the Pilliga of 800-1 000 hectares (D. Milledge pers. comm.).

Not all large remnants satisfying these criteria were included in the *North-West Slopes Interim Key Habitats* and areas were excluded by experts on the basis of knowledge of the habitat values of particular remnants.

It was clear that in refining the *North-West Slopes Interim Key Habitats* for the Nandewar WRA that there were limited options for identifying intact key habitats of large size in a region which was so heavily cleared. In addition to being at least 1 000 hectares in size, these large remnants also needed to be relatively intact and shaped in a consolidated pattern, not in linear strips or too highly fragmented. To ensure that they were intact, they were restricted predominantly to native forest and woodland greater than 20% canopy cover. This was based on the assumption that where open woodland had less than 20% canopy cover, it was primarily the result of disturbance. Grassy rangelands which had been artificially thinned were therefore not included in the large key habitats.

The availability of the WRA vegetation mapping enabled some major refinements to be undertaken to the large key habitats, including:

- Improved resolution. The *North-West Slopes Interim Key Habitats* were mapped from the landsat-derived vegetation coverage "Woody - Non-woody" at a resolution of 50 x 50 metre grid cells. This was replaced with API linework mapped from 1:25 000 and 1:50 000 aerial photographs resulting in a major improvement in the delineation of remnants.
- More reliable condition mapping. Attributes relating to condition (such as canopy cover and disturbance tags) were taken directly from the API mapping and also resulted in major improvements.
- Greatly increased fauna knowledge of the region. This enabled more reliable expert decisions to be made regarding those remnants that should be included or excluded on the basis of the significance of the habitats encompassed.
- More detailed checking. A thorough verification of the key habitat mapping was undertaken using Landsat images, topographic maps and aerial photographs to check the reliability of the linework and limit the extent to which highly disturbed areas were encompassed in key habitats.

Another principle adopted from the *North-West Slopes Interim Key Habitats* was that the key habitats which are not represented in the large forest blocks also needed to be identified. These include habitats found on fertile soils where remaining native forest and woodland cover is extremely sparse and highly fragmented. Most of these remnants are comprised of grassy box woodlands that are widely recognised as highly important ecosystems requiring targeted conservation. They were very poorly represented in the large 1 000 hectare blocks of key habitat. Remnants of these woodlands are the last fragments of an ecosystem that would once have covered a large proportion of the Nandewar region. They remain critical ecosystem elements in supplying seasonal resources (such as nectar) for wide-ranging species and residential habitat for species with small spatial requirements. In recognition of their important ecological function and the urgent need to protect, rehabilitate and re-connect these remnants, they were also included as key habitats.

To identify some of these key habitats, it was necessary to first identify areas of high fertility. In the absence of soil mapping, geology was used as the basis for developing a surrogate for fertility. Within the most fertile areas, remnant patches of suitable shape and condition (generally greater than 20% canopy cover and visually checked using landsat) greater than 50 hectares in size were considered to be key habitat. It was considered that 50 hectares was a sufficient size to potentially support a relatively rich native vertebrate community when compared with smaller remnants, at least in the short term. For example, remnants of this size and larger on the New England tablelands (Barrett *et al.* 1994) and central Lachlan wheat belt (Seddon *et al.* 2003) have been shown to be rich in native woodland bird species.

The new WRA vegetation map was also utilised to identify additional smaller patches of key habitat. The key vegetation types identified to be of particular importance to vertebrate fauna are listed below.

- Patches of grassy white box, yellow box or grey box were included as these box woodlands were likely to have been a major habitat of the historic Nandewar

landscape. Although now largely cleared, the remaining patches are still of considerable value.

- Mugga ironbark is a major nectar-producing and hollow-forming species recognised as important for vertebrate fauna. Although less widespread than the grassy box communities, the remaining patches are still an important resource.
- River red gum, which is also important for nectar and hollows and is a key component of riparian habitat on fertile soils. This habitat is also highly cleared and degraded.
- Dry rainforest and semi-evergreen vine thicket is included as it is a rare habitat and a number of vertebrates appear to be loosely associated with dry rainforest vegetation elements.

Patches greater than 50 hectares in size of the above types were only included as key habitat if they were mapped with canopy cover greater than 20%, or if less than 20% they appeared relatively intact on a landsat image or aerial photograph.

Other areas were identified on the basis of their known special fauna habitat. These included a number of habitats of the booroolong frog, five-clawed worm-skink, glossy black-cockatoo, powerful owl, regent honeyeater, squirrel glider and groups of declining threatened woodland birds and threatened bats. However, further work would of course be needed to fully identify local key habitats, reflecting local species considerations, in order to complete any local conservation plan.

The Nandewar key habitats were divided into fifteen biogeographically distinct fauna sub-regions. Threatened species lists were generated for each sub-region, categorised into "Known", "Likely" and "Potential". Of course, all of the listed species will not occur in every key habitat in the sub-region. However, the list is intended to assist in predicting which species might occur and should be used in conjunction with consideration of the specific habitat types contained in the key habitat.

The Nandewar key habitats in each fauna sub-region are shown in **Figure 4A** and the threatened species of different sub-regions are listed in **Appendix 3**.

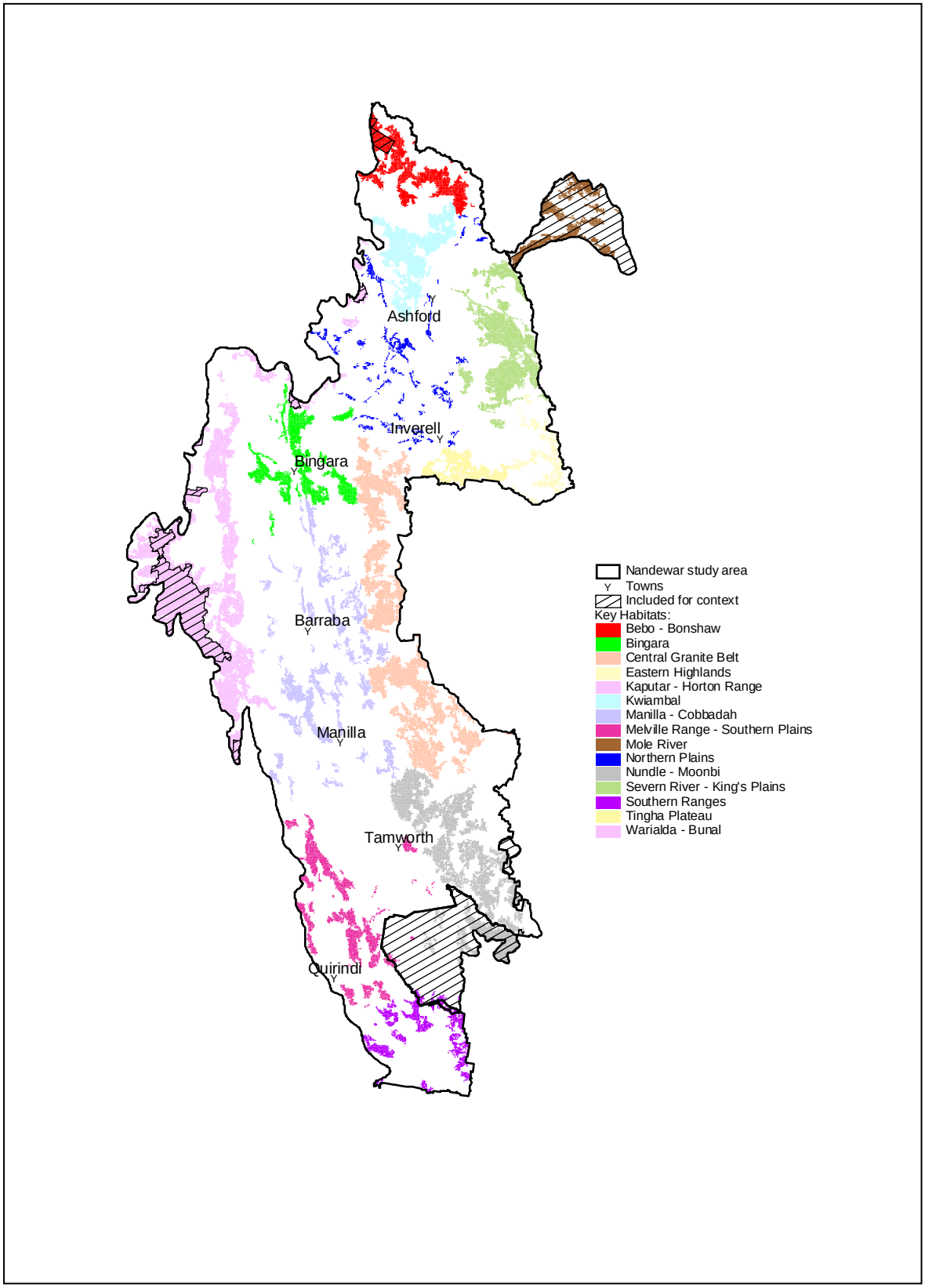

FIGURE-4A

Nandewar key habitats in each fauna sub-region

4.3 CORRIDORS

A landscape presents a continuously variable mosaic of opportunities for habitation and movement (Scotts 2003). Connectivity is the degree to which movement is enabled or impeded and is a fundamental consideration for fauna conservation programs. Habitat configurations promoting occupancy and movement of fauna through the landscape are required for the ecological functioning on which the long-term persistence of fauna species depends.

While all habitat exhibits connectivity at some level, corridors of native vegetation represent a particularly important subset of overall connectivity, assuming that they are of suitable size, shape and habitat type, and that they connect areas of substantial habitat value (Scotts 2003). The benefits of corridors include:

- providing habitat for resident species and supplementary habitat for wide-ranging species;
- assisting species to move through the landscape, including dispersing individuals and nomadic or migratory species;
- increasing immigration rates to habitat isolates; and
- facilitating the continuity of ecological processes, such as flow of energy, nutrients, biota and abiotic matter (Scotts 2003).

The mapping of corridors represents an explicit strategy to retain or restore natural connectivity. The formal characterisation and mapping of corridors in regional conservation planning is a recommended scientific strategy (for a review see Bennett 1990) and facilitates transparency in land-use decision-making.

4.3.1 The development of Nandewar corridors

Following the general approach of the north-east New South Wales KHC project, regional corridors and potential sub-regional corridors were identified in Nandewar.

Regional corridors are primary landscape corridors designed to provide residential and dispersal habitat, and supplementary habitat for wide-ranging species (Scotts 2003). Regional corridors generally link the largest remnants, including the largest public land remnants.

The Nandewar regional corridors were based on those developed for the *North-West Slopes Interim Corridors* by DEC in 2002. The GIS tool CORRIDORS (developed by DEC) was used in 2002 to map potential linkage pathways. The CORRIDORS analysis operates under the assumption that fauna species are most likely to inhabit and move through habitats they perceive to be more favourable (Scotts 2003). These preferred habitats are presumed to exact a lower cost for their use than less preferred, marginal, or non-habitats. Areas of unsuitable native vegetation, and areas that had been cleared of native vegetation and developed for human uses such as agriculture and urban expansion, were considered non-habitats.

Three mapped layers were used in the CORRIDORS analysis for the *North-West Slopes Interim Corridors*: land tenure, interim key habitats and vegetation extent (the woody – non-

woody vegetation mapping derived from landsat). The initial regional corridors produced were then substantially refined during a three-day expert workshop.

The regional corridors developed in the *North-West Slopes Interim Corridors* were further refined in the Nandewar WRA project using a number of principles (adapted from Scotts 2003):

- Animals usually follow the path of least resistance when moving through landscapes, and corridors need to follow the best available routes linking remnants. The vegetation mapping completed for the WRA and landsat imagery were used for detailed corridor refinements.
- Corridors are not necessarily continuous – they may be broken by currently degraded or cleared areas but must contribute to overall landscape connectivity, or have the potential to do so given restoration. Accordingly, stepping-stone patches provide connectivity and can function as corridors for mobile species, particularly those willing to cross expanses of cleared land.
- A high level of regional connectivity was important *within* more highly vegetated landscapes to increase the viability of vertebrate populations in these areas.
- Connectivity *between* more highly vegetated landscapes is important and needs to be addressed despite the scale of the restoration required in many instances in Nandewar.
- Corridors spanning natural gradients (such as altitudinal and latitudinal gradients) are critically important in the context of ecological processes and climate change. While latitudinal gradients were relatively straightforward in Nandewar with a dominant trend of vegetation to run north–south (such as the western tablelands granite belt, Peel fault and Kaputar range), altitudinal gradients tend to run east–west and traverse cleared valley floors. These were seen as important linkages requiring significant restoration.

In the north-east New South Wales project, the residential and dispersal requirements of assemblage reference species (those considered most extinction-prone) were used to determine the most appropriate spatial dimensions of corridors. These dimensions were considered likely to be effective for most other species. Minimum benchmark corridor widths were set at least twice the average home ranges of assemblage reference species (Scotts 2003). The rationale was that the species should be able to live within the corridor and that more than one home-range diameter would be required to allow movement and habitation by more than one territorial individual or pair. A minimum width of regional corridors was set at 500 metres (Scotts 2003).

Most of the regional corridors on the western New England tablelands from the north-east New South Wales project were one kilometre in width. This width was extended throughout Nandewar and mapped as the recommended width for regional corridors, although 500 metres is retained as the recommended absolute minimum. These relatively wide regional corridors are important for many species of conservation significance, including many declining woodland birds. Many of these declining birds are sedentary and have relatively large territories. Wide regional corridors are required to facilitate occupation by these species and provide enough interior habitat to mitigate the impact of aggressive species that tend to occupy edges and disturbed areas.

Sub-regional corridors serve more as routes for dispersal and movement for species, rather than significant residential habitats in themselves. In Nandewar, sub-regional corridors were mapped to a relatively fine scale where it is recognised that in practice, local factors would influence corridor location (such as tenure, alternative landuses and local planning). Therefore, the Nandewar sub-regional corridors are considered "potential" only – as recommendations for increasing connectivity.

The widths of sub-regional corridors in north-east New South Wales were at least as wide as one home-range diameter for assemblage reference species (Scotts 2003). In Nandewar, the threatened squirrel glider was used as an assemblage reference species.

A corridor must provide functional connectivity for the species concerned, reflected in the ability of a species to inhabit or move through a corridor. The squirrel glider is widespread in remnants of all sizes in Nandewar, including linear corridors. However, its preferred habitat of forest on fertile soils is also the most heavily cleared habitat in Nandewar – the squirrel glider is therefore likely to benefit greatly from increased connectivity within these regions. Additionally, the squirrel glider is known to only rarely travel across the ground (van der Ree and Bennett 2003) and is therefore highly restricted by treeless gaps. In a detailed woodland study in Victoria, the squirrel glider was observed to glide a maximum of 80 metres. However, it was considered that a 75 metre gap was in general a physical limit to regular movement (van der Ree *et al.* 2003). The squirrel glider is therefore highly susceptible to gaps in connectivity when compared with more mobile species (such as birds and bats) or species that will cross open ground.

Species acting as vectors for ecological processes (such as propagule dispersers, predators) require special consideration (Scotts 2003). The squirrel glider plays the ecological roles of pollinator and insectivore (in which role it may be significant, like the sugar glider, in the control of tree dieback).

An estimate for the home range size of the squirrel glider in temperate woodland is 1.4 – 2.8 hectares reported from Victoria (van der Ree and Bennett 2003). This estimate is from a fertile region, so the upper limit (2.8 hectares) was used to account for less fertile squirrel glider habitat in Nandewar corridors. This equates to a home range diameter of 189 metres. This figure was rounded up to provide a width of potential subregional corridors in Nandewar of 200 metres.

The expert panel for the *North-West Slopes Interim Corridors* had identified important riparian corridors along major rivers (including the Dumeresq, Gwydir, Horton, Isis, Macintyre, Manilla, Mole, Namoi, Peel and Severn rivers). These were also included as potential sub-regional corridors for Nandewar as they traverse productive landscapes and are well established as important for the protection and reconstruction of fauna habitat.

The detailed mapping of potential sub-regional corridors in Nandewar used Landsat imagery and was driven by practical considerations, such as the location of existing vegetation (from the new vegetation mapping), topography, land tenure and field knowledge of fauna habitats.

Corridors relevant at more localised scales clearly remain to be added to the regional and sub-regional network. The delineation of local corridors falls to local planners and

communities. In order to maximise overall landscape connectivity, local corridors should link into the wider regional and sub-regional network.

The Nandewar KHC map is shown in **Figure 4-B** (only regional corridors are shown as the detailed potential sub-regional corridors cannot be distinguished at this scale).

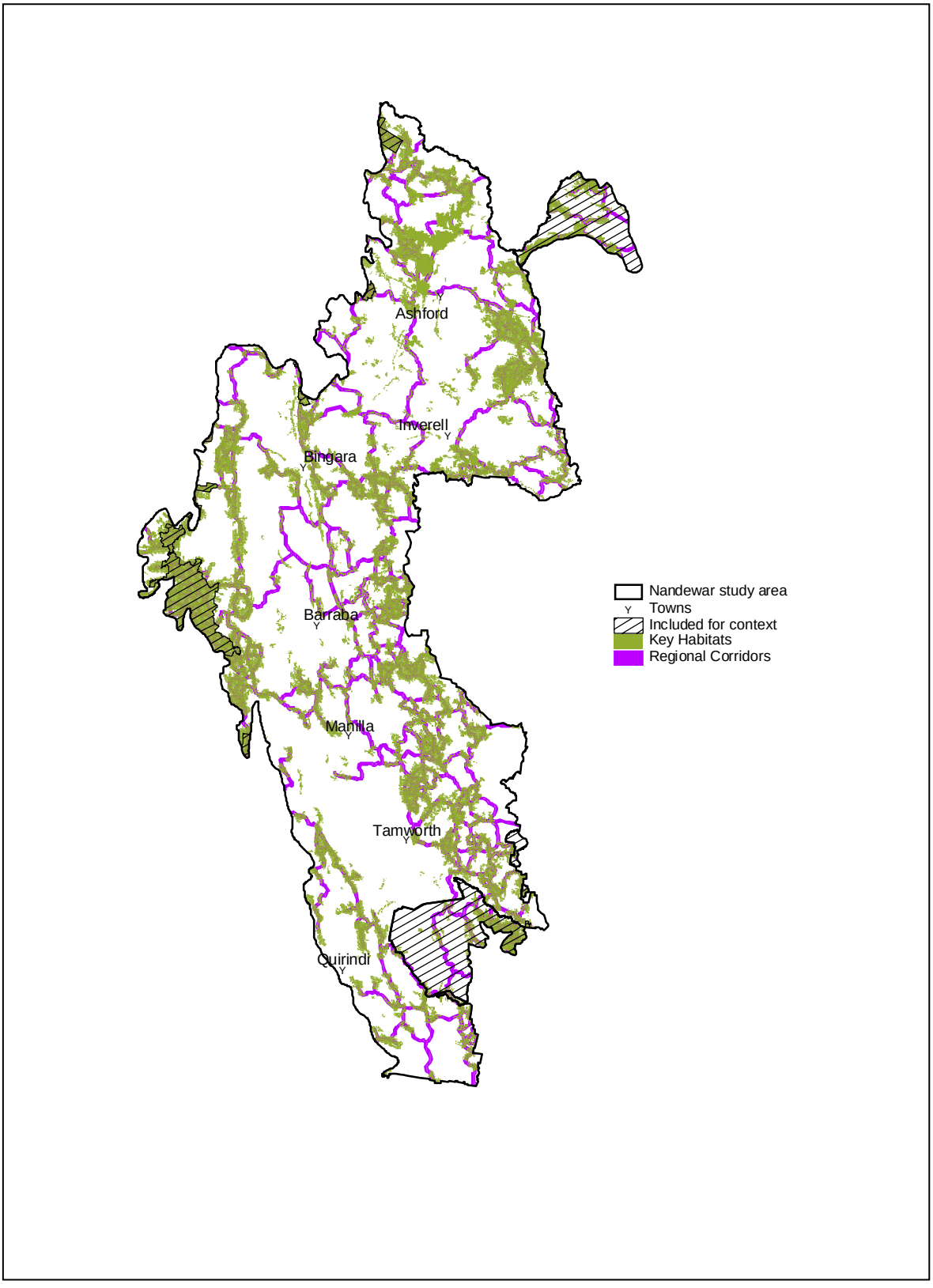

FIGURE-4B

Nandewar key habitats and regional corridors

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Appendix 1: Nandewar vertebrate list

Common Name	Scientific Name
FROGS	
tusked frog	*Adelotus brevis*
plains froglet	*Crinia parinsignifera*
common eastern froglet	*Crinia signifera*
eastern banjo frog	*Limnodynastes dumerilii*
long-thumbed frog	*Limnodynastes fletcheri*
ornate burrowing frog	*Limnodynastes ornatus*
brown-striped frog	*Limnodynastes peronii*
salmon-striped frog	*Limnodynastes salmini*
spotted grass frog	*Limnodynastes tasmaniensis*
northern banjo frog	*Limnodynastes terraereginae*
common spadefoot toad	*Neobatrachus sudelli*
crucifix toad	*Notaden bennettii*
brown toadlet	*Pseudophryne bibronii*
large toadlet	*Pseudophryne major*
smooth toadlet	*Uperoleia laevigata*
wrinkled toadlet	*Uperoleia rugosa*
Tyler's toadlet	*Uperoleia tyleri*
short-footed water-holding frog	*Cyclorana brevipes*
New Holland water-holding frog	*Cyclorana novaehollandiae*
smooth water-holding frog	*Cyclorana platycephala*
rough water-holding frog	*Cyclorana verrucosa*
striped burrowing frog	*Litoria alboguttata*
Booroolong frog	*Litoria booroolongensis*
green tree frog	*Litoria caerulea*
yellow-spotted bell-frog	*Litoria castanea*
bleating tree frog	*Litoria dentata*
eastern dwarf tree frog	*Litoria fallax*
broad-palmed frog	*Litoria latopalmata*
Lesueur's frog	*Litoria lesueuri*
Peron's tree frog	*Litoria peronii*
desert tree frog	*Litoria rubella*
laughing tree frog	*Litoria tyleri*
whistling tree frog	*Litoria verreauxii*
TURTLES	
broad-shelled river turtle	*Chelodina expansa*
eastern long-necked turtle	*Chelodina longicollis*
Bell's turtle	*Elseya bellii*
Macquarie turtle	*Emydura macquarii macquarii*
LIZARDS	
stone gecko	*Diplodactylus vittatus*
dubious dtella	*Gehyra dubia*
tree dtella	*Gehyra variegata*
prickly gecko	*Heteronotia binoei*

Lesueur's velvet gecko	*Oedura lesueurii*
zigzag gecko	*Oedura rhombifer*
robust velvet gecko	*Oedura robusta*
southern spotted velvet gecko	*Oedura tryoni*
southern spiny-tailed gecko	*Strophurus intermedius*
eastern spiny-tailed gecko	*Strophurus williamsi*
thick-tailed gecko	*Underwoodisaurus milii*
border thick-tailed gecko	*Underwoodisaurus sphyrurus*
olive legless lizard	*Delma inornata*
leaden legless lizard	*Delma plebeia*
painted legless lizard	*Delma tincta*
Burton's legless lizard	*Lialis burtonis*
common scaly-foot	*Pygopus lepidopodus*
hooded scaly-foot	*Pygopus schraderi*
Burn's dragon	*Amphibolurus burnsi*
jacky lizard	*Amphibolurus muricatus*
nobbi dragon	*Amphibolurus nobbi*
eastern two-lined dragon	*Diporiphora australis*
eastern water-dragon	*Physignathus lesueurii*
eastern bearded dragon	*Pogona barbata*
long-tailed earless dragon	*Tympanocryptis tetraporophora*
sand monitor	*Varanus gouldii*
freckled monitor	*Varanus tristis orientalis*
lace monitor	*Varanus varius*
red-throated skink	*Acritoscincus platynotum*
two-clawed worm-skink	*Anomalopus leuckartii*
five-clawed worm-skink	*Anomalopus mackayi*
litter skink	*Carlia foliorum*
southern rainbow-skink	*Carlia tetradactyla*
tussock rainbow-skink	*Carlia vivax*
Carnaby's skink	*Cryptoblepharus carnabyi*
wall skink	*Cryptoblepharus virgatus*
brown-backed yellow-lined skink	*Ctenotus eurydice*
striped skink	*Ctenotus robustus*
copper-tailed skink	*Ctenotus taeniolatus*
Cunningham's skink	*Egernia cunninghami*
eastern ranges rock-skink	*Egernia modesta*
black rock-skink	*Egernia saxatilis*
Mount Kaputar rock-skink	*Egernia* sp.
tree skink	*Egernia striolata*
White's skink	*Egernia whitii*
broad-banded sand-swimmer	*Eremiascincus richardsonii*
yellow-bellied water-skink	*Eulamprus heatwolei*
alpine water-skink	*Eulamprus kosciuskoi*
eastern water-skink	*Eulamprus quoyii*
greater bar-sided skink	*Eulamprus tenuis*
three-toed earless skink	*Hemiergis decresiensis*
montane sun-skink	*Lampropholis caligula*
garden sun-skink	*Lampropholis delicata*
grass sun-skink	*Lampropholis guichenoti*
southern slider	*Lerista bougainvillii*
three-toed slider	*Lerista muelleri*
spotted slider	*Lerista punctatovittata*

Grey's skink	*Menetia greyii*
Boulenger's skink	*Morethia boulengeri*
grassland tussock-skink	*Pseudemoia pagenstecheri*
three-toed skink	*Saiphos equalis*
weasel skink	*Saproscincus mustelinus*
shingleback	*Tiliqua rugosa*
eastern blue-tongue lizard	*Tiliqua scincoides*
SNAKES	
prong-snouted blind snake	*Ramphotyphlops bituberculatus*
blackish blind snake	*Ramphotyphlops nigrescens*
proximus blind snake	*Ramphotyphlops proximus*
brown-snouted blind snake	*Ramphotyphlops wiedii*
spotted python	*Antaresia maculosa*
inland carpet python	*Morelia spilota metcalfei*
green tree-snake	*Dendrelaphis punctulata*
common death adder	*Acanthophis antarcticus*
coral snake	*Brachyurophis australis*
yellow-faced whip snake	*Demansia psammophis*
De Vis' banded snake	*Denisonia devisi*
white-lipped snake	*Drysdalia coronoides*
red-naped snake	*Furina diadema*
Dunmall's snake	*Furina dunmalli*
pale-headed snake	*Hoplocephalus bitorquatus*
eastern tiger snake	*Notechis scutatus*
spotted black snake	*Pseudechis guttatus*
red-bellied black snake	*Pseudechis porphyriacus*
eastern brown snake	*Pseudonaja textilis*
eastern small-eyed snake	*Rhinoplocephalus nigrescens*
Dwyer's black-headed snake	*Suta dwyeri*
curl snake	*Suta suta*
bandy bandy	*Vermicella annulata*
DIURNAL BIRDS	
emu	*Dromaius novaehollandiae*
Australian brush-turkey	*Alectura lathami*
stubble quail	*Coturnix pectoralis*
brown quail	*Coturnix ypsilophorus*
king quail	*Coturnix chinensis*
mallard	*Anas platyrhynchos*
plumed whistling-duck	*Dendrocygna eytoni*
wandering whistling-duck	*Dendrocygna arcuata*
blue-billed duck	*Oxyura australis*
musk duck	*Biziura lobata*
freckled duck	*Stictonetta naevosa*
black swan	*Cygnus atratus*
goose (feral)	
Australian shelduck	*Tadorna tadornoides*
wood duck	*Chenonetta jubata*
pacific black duck	*Anas superciliosa*
Australasian shoveler	*Anas rhynchotis*
grey teal	*Anas gracilis*
chestnut teal	*Anas castanea*
pink-eared duck	*Malacorhynchus membranaceus*

hardhead	*Aythya australis*
Australasian grebe	*Tachybaptus novaehollandiae*
hoary-headed grebe	*Poliocephalus poliocephalus*
great crested grebe	*Podiceps cristatus*
darter	*Anhinga melanogaster*
little pied cormorant	*Phalacrocorax melanoleucos*
pied cormorant	*Phalacrocorax varius*
little black cormorant	*Phalacrocorax sulcirostris*
great cormorant	*Phalacrocorax carbo*
Australian pelican	*Pelecanus conspicillatus*
white-faced heron	*Egretta novaehollandiae*
little egret	*Egretta garzetta*
pacific heron	*Ardea pacifica*
great egret	*Ardea alba*
intermediate egret	*Ardea intermedia*
cattle egret	*Ardea ibis*
nankeen night heron	*Nycticorax caledonicus*
little bittern	*Ixobrychus minutus*
Australasian bittern	*Botaurus poiciloptilus*
glossy Ibis	*Plegadis falcinellus*
sacred ibis	*Threskiornis molucca*
straw-necked ibis	*Threskiornis spinicollis*
royal spoonbill	*Platalea regia*
yellow-billed spoonbill	*Platalea flavipes*
black-necked stork	*Ephippiorhynchus asiaticus*
osprey	*Pandion haliaetus*
pacific baza	*Aviceda subcristata*
letter-winged kite	*Elanus scriptus*
black-shouldered kite	*Elanus axillaris*
square-tailed kite	*Lophoictinia isura*
black kite	*Milvus migrans*
whistling kite	*Haliastur sphenurus*
white-bellied sea-eagle	*Haliaeetus leucogaster*
spotted harrier	*Circus assimilis*
swamp harrier	*Circus approximans*
brown goshawk	*Accipiter fasciatus*
grey goshawk	*Accipiter novaehollandiae*
collared sparrowhawk	*Accipiter cirrhocephalus*
wedge-tailed eagle	*Aquila audax*
little eagle	*Hieraaetus morphnoides*
brown falcon	*Falco berigora*
Australian hobby	*Falco longipennis*
black falcon	*Falco subniger*
peregrine falcon	*Falco peregrinus*
nankeen kestrel	*Falco cenchroides*
brolga	*Grus rubicunda*
buff-banded rail	*Gallirallus philippensis*
Baillon's crake	*Porzana pusilla*
Australian crake	*Porzana fluminea*
spotless crake	*Porzana tabuensis*
purple swamphen	*Porphyrio porphyrio*
dusky moorehen	*Gallinula tenebrosa*
black-tailed native-hen	*Gallinula ventralis*

Eurasian coot	*Fulica atra*
Australian bustard	*Ardeotis australis*
little button-quail	*Turnix velox*
red-chested button-quail	*Turnix pyrrhothorax*
painted button-quail	*Turnix varia*
Latham's snipe	*Gallinago hardwickii*
marsh sandpiper	*Tringa stagnatilis*
common greenshank	*Tringa nebularia*
common sandpiper	*Actitis hypoleucos*
sharp-tailed sandpiper	*Calidris acuminata*
red-necked stint	*Calidris ruficollis*
curlew sandpiper	*Calidris ferruginea*
painted snipe	*Rostratula benghalensis*
black-winged stilt	*Himantopus himantopus*
red-necked avocet	*Recurvirostra novaehollandiae*
red-capped plover	*Charadrius ruficapillus*
black-fronted plover	*Elesyornis melanops*
red-kneed dotterel	*Erythogonys cinctus*
banded lapwing	*Vanellus tricolor*
masked lapwing	*Vanellus miles novaehollandiae*
Australian pratincole	*Stiltia isabella*
silver gull	*Larus novaehollandiae*
gull-billed tern	*Sterna nilotica*
caspian tern	*Sterna caspia*
whiskered tern	*Chlidonias hybridus*
rock dove	*Columba livia*
spotted turtle-dove	*Streptopelia chinensis*
common bronzewing	*Phaps chalcoptera*
crested pigeon	*Ocyphaps lophotes*
flock bronzewing	*Phaps histrionica*
squatter pigeon	*Geophaps scripta*
diamond dove	*Geopelia cuneata*
peaceful dove	*Geopelia striata*
bar-shouldered dove	*Geopelia humeralis*
wonga pigeon	*Leucosarcia melanoleuca*
glossy black-cockatoo	*Calyptorhynchus lathami*
yellow-tailed black-cockatoo	*Calyptorhynchus funereus*
galah	*Cacatua roseicapilla*
little corella	*Cacatua sanguinea*
sulphur-crested cockatoo	*Cacatua galerita*
cockatiel	*Nymphicus hollandicus*
rainbow lorikeet	*Trichoglossus haematodus*
scaly-breasted lorikeet	*Trichoglossus chlorolepidotus*
musk lorikeet	*Glossopsitta concinna*
little lorikeet	*Glossopsitta pusilla*
Australian king-parrot	*Alisterus scapularis*
red-winged parrot	*Aprosmictus erythropterus*
superb parrot	*Polytelis swainsonii*
crimson rosella	*Platycercus elegans*
eastern rosella	*Platycercus eximius*
pale-headed rosella	*Platycercus adscitus*
mallee ringneck	*Barnardius zonarius barnardi*
blue bonnet	*Northiella haematogaster*

swift parrot	*Lathamus discolor*
red-rumped parrot	*Psephotus haematonotus*
budgerigar	*Melopsittacus undulatus*
turquoise parrot	*Neophema pulchella*
pallid cuckoo	*Cuculus pallidus*
brush cuckoo	*Cacomantis variolosus*
fan-tailed cuckoo	*Cacomantis flabelliformis*
black-eared cuckoo	*Chrysococcyx osculans*
Horsfield's bronze-cuckoo	*Chrysococcyx basalis*
shining bronze-cuckoo	*Chrysococcyx lucidus*
common koel	*Eudynamys scolopacea*
channel-billed cuckoo	*Scythrops novaehollandiae*
white-throated needletail	*Hirundapus caudacutus*
fork-tailed swift	*Apus pacificus*
azure kingfisher	*Alcedo azurea*
laughing kookaburra	*Dacelo novaeguineae*
forest kingfisher	*Todiramphus macleayii*
red-backed kingfisher	*Todiramphus pyrrhopygia*
sacred kingfisher	*Todiramphus sanctus*
rainbow bee-eater	*Merops ornatus*
dollarbird	*Eurystomus orientalis*
superb lyrebird	*Menura novaehollandiae*
white-throated treecreeper	*Cormobates leucophaes*
red-browed treecreeper	*Climacteris erythrops*
brown treecreeper	*Climacteris picumnus*
superb fairy-wren	*Malurus cyaneus*
variegated fairy-wren	*Malurus lamberti*
white-winged fairy-wren	*Malurus leucopterus*
red-backed fairy-wren	*Malurus melanocephalus*
spotted pardalote	*Pardalotus punctatus*
striated pardalote	*Pardalotus striatus*
white-browed scrubwren	*Sericornis frontalis*
chestnut-rumped heathwren	*Hylacola pyrrhopygia*
speckled warbler	*Chthonicola sagittata*
weebill	*Smicrornis brevirostris*
western warbler	*Gerygone fusca*
white-throated warbler	*Gerygone olivacea*
brown thornbill	*Acanthiza pusilla*
inland thornbill	*Acanthiza apicalis*
chestnut-rumped thornbill	*Acanthiza uropygialis*
buff-rumped thornbill	*Acanthiza reguloides*
yellow-rumped thornbill	*Acanthiza chrysorrhoa*
yellow thornbill	*Acanthiza nana*
striated thornbill	*Acanthiza lineata*
southern whiteface	*Aphelocephala leucopsis*
red wattlebird	*Anthochaera carunculata*
spiny-cheeked honeyeater	*Acanthagenys rufogularis*
striped honeyeater	*Plectorhyncha lanceolata*
noisy friarbird	*Philemon corniculatus*
little friarbird	*Philemon citreogularis*
regent honeyeater	*Xanthomyza phrygia*
blue-faced honeyeater	*Entomyzon cyanotis*
noisy miner	*Manorina melanocephala*

yellow-throated miner	*Manorina flavigula*
Lewin's honeyeater	*Meliphaga lewinii*
yellow-faced honeyeater	*Lichenostomus chrysops*
singing honeyeater	*Lichenostomus virescens*
white-eared honeyeater	*Lichenostomus leucotis*
yellow-tufted honeyeater	*Lichenostomus melanops*
fuscous honeyeater	*Lichenostomus fuscus*
white-plumed honeyeater	*Lichenostomus penicillatus*
black-chinned honeyeater (eastern ssp.)	*Melithreptus gularis gularis*
brown-headed honeyeater	*Melithreptus brevirostris*
white-naped honeyeater	*Melithreptus lunatus*
brown honeyeater	*Lichmera indistincta*
painted honeyeater	*Grantiella picta*
eastern spinebill	*Acanthorhynchus tenuirostris*
black honeyeater	*Certhionyx niger*
scarlet honeyeater	*Myzomela sanguinolenta*
crimson chat	*Ephthianura tricolor*
white-fronted chat	*Ephthianura albifrons*
jacky winter	*Microeca fascinans*
scarlet robin	*Petroica multicolor*
red-capped robin	*Petroica goodenovii*
flame robin	*Petroica phoenicea*
rose robin	*Petroica rosea*
hooded robin	*Melanodryas cucullata*
eastern yellow robin	*Eopsaltria australis*
grey-crowned babbler (eastern ssp.)	*Pomatostomus temporalis temporalis*
white-browed babbler	*Pomatostomus superciliosus*
spotted quail-thrush	*Cinclosoma punctatum*
varied sittella	*Daphoenositta chrysoptera*
crested shrike-tit	*Falcunculus frontatus*
crested bellbird	*Oreoica gutturalis*
golden whistler	*Pachycephala pectoralis*
rufous whistler	*Pachycephala rufiventris*
grey shrike-thrush	*Colluricincla harmonica*
leaden flycatcher	*Myiagra rubecula*
satin flycatcher	*Myiagra cyanoleuca*
restless flycatcher	*Myiagra inquieta*
magpie lark	*Grallina cyanoleuca*
rufous fantail	*Rhipidura rufifrons*
grey fantail	*Rhipidura fuliginosa*
willie wagtail	*Rhipidura leucophrys*
black-faced cuckoo-shrike	*Coracina novaehollandiae*
white-bellied cuckoo-shrike	*Coracina papuensis*
ground cuckoo-shrike	*Coracina maxima*
cicadabird	*Coracina tenuirostris*
white-winged triller	*Lalage sueurii*
olive-backed oriole	*Oriolus sagittatus*
white-breasted woodswallow	*Artamus leucorhynchus*
masked woodswallow	*Artamus personatus*
white-browed woodswallow	*Artamus superciliosus*
black-faced woodswallow	*Artamus cinereus*
dusky woodswallow	*Artamus cyanopterus*
little woodswallow	*Artamus minor*

grey butcherbird	*Cracticus torquatus*
pied butcherbird	*Cracticus nigrogularis*
Australian magpie	*Gymnorhina tibicen*
pied currawong	*Strepera graculina*
Australian raven	*Corvus coronoides*
forest raven	*Corvus tasmanicus*
little raven	*Corvus mellori*
torresian crow	*Corvus orru*
white-winged chough	*Corcorax melanorhamphos*
apostlebird	*Struthidea cinerea*
spotted bowerbird	*Chlamydera maculata*
satin bowerbird	*Ptilonorhynchus violaceus*
singing bushlark	*Mirafra javanica*
Richard's pipit	*Anthus novaeseelandiae*
house sparrow	*Passer domesticus*
zebra finch	*Taeniopygia guttata*
double-barred finch	*Taeniopygia bichenovii*
black-throated finch (southern subsp.)	*Poephila cincta cincta*
plum-headed finch	*Neochmia modesta*
red-browed finch	*Neochmia temporalis*
diamond firetail	*Stagonopleura guttata*
chestnut-breasted mannikin	*Lonchura castaneothorax*
European goldfinch	*Carduelis carduelis*
mistletoebird	*Dicaeum hirundinaceum*
white-backed swallow	*Cheramoeca leucosternus*
welcome swallow	*Hirundo neoxena*
tree martin	*Hirundo nigricans*
fairy martin	*Hirundo ariel*
reed-warbler	*Acrocephalus stentoreus*
little grassbird	*Megalurus gramineus*
tawny grassbird	*Megalurus timoriensis*
rufous songlark	*Cinclorhamphus mathewsi*
brown songlark	*Cinclorhamphus cruralis*
golden-headed cisticola	*Cisticola exilis*
silvereye	*Zosterops lateralis*
common blackbird	*Turdus merula*
bassian thrush	*Zoothera lunulata*
common starling	*Sturnus vulgaris*
common myna	*Acridotheres tristis*
NOCTURNAL BIRDS	
bush stone-curlew	*Burhinus grallarius*
powerful owl	*Ninox strenua*
barking owl	*Ninox connivens*
southern boobook	*Ninox novaeseelandiae*
masked owl	*Tyto novaehollandiae*
barn owl	*Tyto alba*
grass owl	*Tyto capensis*
tawny frogmouth	*Podargus strigoides*
white-throated nightjar	*Eurostopodus mystacalis*
spotted nightjar	*Eurostopodus argus*
Australian owlet-nightjar	*Aegotheles cristatus*

ARBOREAL MAMMALS	
koala	*Phascolarctos cinereus*
yellow-bellied glider	*Petaurus australis*
sugar glider	*Petaurus breviceps*
squirrel glider	*Petaurus norfolcensis*
greater glider	*Petauroides volans*
common ringtail possum	*Pseudocheirus peregrinus*
eastern pygmy-possum	*Cercartetus nanus*
feathertail glider	*Acrobates pygmaeus*
common brushtail possum	*Trichosurus vulpecula*
SMALL GROUND MAMMALS	
yellow-footed antechinus	*Antechinus flavipes*
brown antechinus	*Antechinus stuartii*
narrow-nosed planigale	*Planigale tenuirostris*
fat-tailed dunnart	*Sminthopsis crassicaudata*
common dunnart	*Sminthopsis murina*
house mouse	*Mus musculus*
water-rat	*Hydromys chrysogaster*
delicate mouse	*Pseudomys delicatulus*
New Holland mouse	*Pseudomys novaehollandiae*
bush rat	*Rattus fuscipes*
black rat	*Rattus rattus*
LARGE GROUND MAMMALS	
platypus	*Ornithorhynchus anatinus*
short-beaked echidna	*Tachyglossus aculeatus*
spotted-tailed quoll	*Dasyurus maculatus*
common wombat	*Vombatus ursinus*
black-striped wallaby	*Macropus dorsalis*
eastern grey kangaroo	*Macropus giganteus*
common wallaroo	*Macropus robustus*
red-necked wallaby	*Macropus rufogriseus*
brush-tailed rock-wallaby	*Petrogale penicillata*
swamp wallaby	*Wallabia bicolor*
dingo	*Canis lupus dingo*
dog (feral)	*Canis familiaris*
fox	*Vulpes vulpes*
cat (feral)	*Felis catus*
rabbit	*Oryctolagus cuniculus*
brown hare	*Lepus capensis*
horse (feral)	*Equus caballus*
pig (feral)	*Sus scrofa*
goat (feral)	*Capra hircus*
cattle (feral)	*Bos taurus*
sheep (feral)	*Ovis aries*
fallow deer	*Dama dama*
BATS	
grey-headed flying-fox	*Pteropus poliocephalus*
little red flying-fox	*Pteropus scapulatus*
yellow-bellied sheathtail-bat	*Saccolaimus flaviventris*
eastern horseshoe-bat	*Rhinolophus megaphyllus*
large-eared pied bat	*Chalinolobus dwyeri*
Gould's wattled bat	*Chalinolobus gouldii*

chocolate wattled bat	*Chalinolobus morio*
little pied bat	*Chalinolobus picatus*
eastern false pipistrelle	*Falsistrellus tasmaniensis*
eastern bentwing-bat	*Miniopterus schreibersii oceanensis*
lesser long-eared bat	*Nyctophilus geoffroyi*
Gould's long-eared bat	*Nyctophilus gouldi*
greater long-eared bat	*Nyctophilus timoriensis*
greater broad-nosed bat	*Scoteanax rueppellii*
inland broad-nosed bat	*Scotorepens balstoni*
little broad-nosed bat	*Scotorepens greyii*
large forest bat	*Vespadelus darlingtoni*
southern forest bat	*Vespadelus regulus*
eastern cave bat	*Vespadelus troughtoni*
little forest bat	*Vespadelus vulturnus*
inland freetail-bat	*Mormopterus* sp. (spf)
southern freetail-bat	*Mormopterus* sp. (lpf)
hairy-nosed freetail-bat	*Mormopterus* sp. 6
white-striped freetail-bat	*Tadarida australis*

Appendix 2: Nandewar species of conservation significance

Species of conservation significance are classified into "Significant" and "Highly Significant" based on the importance of, and level of threat to their Nandewar population.

Key to the symbols used:

NE Nationally Endangered (*Environment Protection and Biodiversity Conservation Act 1999)*
NV Nationally Vulnerable (*Environment Protection and Biodiversity Conservation Act 1999)*
E Endangered (NSW *Threatened Species Act 1995)*
EP Endangered Population (NSW *Threatened Species Act 1995)*
V Vulnerable (NSW *Threatened Species Act 1995)*
*V Preliminary Listing as Vulnerable (NSW *Threatened Species Act 1995)*
RS Regionally Significant

Common Name	Scientific Name	Highly Significant	Significant
FROGS			
tusked frog	*Adelotus brevis*	EP	
salmon-striped frog	*Limnodynastes salmini*		RS
northern banjo frog	*Limnodynastes terraereginae*		RS
crucifix toad	*Notaden bennettii*	RS	
brown toadlet	*Pseudophryne bibronii*		RS
large toadlet	*Pseudophryne major*	RS	
short-footed water-holding frog	*Cyclorana brevipes*	RS	
New Holland water-holding frog	*Cyclorana novaehollandiae*	RS	
smooth water-holding frog	*Cyclorana platycephala*	RS	
rough water-holding frog	*Cyclorana verrucosa*	RS	
striped burrowing frog	*Litoria alboguttata*	RS	
Booroolong frog	*Litoria booroolongensis*	E	
yellow-spotted bell-frog	*Litoria castanea*	NE,E	
laughing tree frog	*Litoria tyleri*		RS
TURTLES			
broad-shelled river turtle	*Chelodina expansa*		RS
Bell's turtle	*Elseya bellii*	NV,V	
LIZARDS			
zigzag gecko	*Oedura rhombifer*	V*	
southern spotted velvet gecko	*Oedura tryoni*		RS
southern spiny-tailed gecko	*Strophurus intermedius*		RS
border thick-tailed gecko	*Underwoodisaurus sphyrurus*	NV,V	
olive legless lizard	*Delma inornata*		RS
leaden legless lizard	*Delma plebeia*		RS
common scaly-foot	*Pygopus lepidopodus*		RS
eastern two-lined dragon	*Diporiphora australis*		RS
long-tailed earless dragon	*Tympanocryptis tetraporophora*		RS
freckled monitor	*Varanus tristis orientalis*		RS

five-clawed worm-skink	*Anomalopus mackayi*	NV,E	
brown-backed yellow-lined skink	*Ctenotus eurydice*		RS
Mount Kaputar rock-skink	*Egernia* sp.		RS
broad-banded sand-swimmer	*Eremiascincus richardsonii*		RS
montane sun-skink	*Lampropholis caligula*		RS
SNAKES			
prong-snouted blind snake	*Ramphotyphlops bituberculatus*		RS
proximus blind snake	*Ramphotyphlops proximus*		RS
brown-snouted blind snake	*Ramphotyphlops wiedii*		RS
spotted python	*Antaresia maculosa*		RS
inland carpet python	*Morelia spilota metcalfei*		RS
green tree-snake	*Dendrelaphis punctulata*		RS
common death adder	*Acanthophis antarcticus*	RS	
coral snake	*Brachyurophis australis*		RS
white-lipped snake	*Drysdalia coronoides*		RS
Dunmall's snake	*Furina dunmalli*	NV	
pale-headed snake	*Hoplocephalus bitorquatus*	V	
spotted black snake	*Pseudechis guttatus*		RS
DIURNAL BIRDS			
emu	*Dromaius novaehollandiae*		RS
Australian brush-turkey	*Alectura lathami*	RS	
blue-billed duck	*Oxyura australis*		V
freckled duck	*Stictonetta naevosa*		V
Australasian bittern	*Botaurus poiciloptilus*		V
black-necked stork	*Ephippiorhynchus asiaticus*		E
osprey	*Pandion haliaetus*		V
square-tailed kite	*Lophoictinia isura*		V
brolga	*Grus rubicunda*		V
Australian bustard	*Ardeotis australis*	E	
red-chested button-quail	*Turnix pyrrhothorax*		RS
painted button-quail	*Turnix varia*		RS
painted snipe	*Rostratula benghalensis*	NV,V	
flock bronzewing	*Phaps histrionica*	E	
squatter pigeon	*Geophaps scripta*	NV,E	
glossy black-cockatoo	*Calyptorhynchus lathami*		V
musk lorikeet	*Glossopsitta concinna*		RS
superb parrot	*Polytelis swainsonii*	NV,V	
swift parrot	*Lathamus discolor*	NE,V	
turquoise parrot	*Neophema pulchella*		V
black-eared cuckoo	*Chrysococcyx osculans*		RS
forest kingfisher	*Todiramphus macleayii*		RS
red-backed kingfisher	*Todiramphus pyrrhopygia*		RS
superb lyrebird	*Menura novaehollandiae*		RS
red-browed treecreeper	*Climacteris erythrops*		RS
brown treecreeper	*Climacteris picumnus*		V
chestnut-rumped heathwren	*Hylacola pyrrhopygia*		RS
speckled warbler	*Chthonicola sagittata*		V
chestnut-rumped thornbill	*Acanthiza uropygialis*		RS
southern whiteface	*Aphelocephala leucopsis*		RS
regent honeyeater	*Xanthomyza phrygia*	NE,E	
black-chinned honeyeater (eastern ssp.)	*Melithreptus gularis gularis*		V
painted honeyeater	*Grantiella picta*	V	
red-capped robin	*Petroica goodenovii*		RS

flame robin	*Petroica phoenicea*		RS
hooded robin	*Melanodryas cucullata*		V
grey-crowned babbler (eastern ssp.)	*Pomatostomus temporalis temporalis*		V
white-browed babbler	*Pomatostomus superciliosus*		RS
spotted quail-thrush	*Cinclosoma punctatum*		RS
crested shrike-tit	*Falcunculus frontatus*		RS
crested bellbird	*Oreoica gutturalis*		RS
spotted bowerbird	*Chlamydera maculata*		RS
black-throated finch (southern subsp.)	*Poephila cincta cincta*	NV,E	
plum-headed finch	*Neochmia modesta*		RS
diamond firetail	*Stagonopleura guttata*		V
NOCTURNAL BIRDS			
bush stone-curlew	*Burhinus grallarius*	E	
powerful owl	*Ninox strenua*	V	
barking owl	*Ninox connivens*	V	
masked owl	*Tyto novaehollandiae*	V	
grass owl	*Tyto capensis*	V	
white-throated nightjar	*Eurostopodus mystacalis*		RS
spotted nightjar	*Eurostopodus argus*		RS
ARBOREAL MAMMALS			
koala	*Phascolarctos cinereus*		V
yellow-bellied glider	*Petaurus australis*	V	
squirrel glider	*Petaurus norfolcensis*	V	
greater glider	*Petauroides volans*		RS
eastern pygmy-possum	*Cercartetus nanus*	V	
SMALL GROUND MAMMALS			
narrow-nosed planigale	*Planigale tenuirostris*	RS	
common dunnart	*Sminthopsis murina*		RS
water-rat	*Hydromys chrysogaster*		RS
delicate mouse	*Pseudomys delicatulus*	V*	
New Holland mouse	*Pseudomys novaehollandiae*	RS	
LARGE GROUND MAMMALS			
platypus	*Ornithorhynchus anatinus*		RS
spotted-tailed quoll	*Dasyurus maculatus*	NE,V	
common wombat	*Vombatus ursinus*		RS
black-striped wallaby	*Macropus dorsalis*	E	
brush-tailed rock-wallaby	*Petrogale penicillata*	NV,E	
dingo	*Canis lupus dingo*	RS	
BATS			
grey-headed flying-fox	*Pteropus poliocephalus*	NV,V	
little red flying-fox	*Pteropus scapulatus*		RS
yellow-bellied sheathtail-bat	*Saccolaimus flaviventris*		V
eastern horseshoe-bat	*Rhinolophus megaphyllus*		RS
large-eared pied bat	*Chalinolobus dwyeri*	NV,V	
little pied bat	*Chalinolobus picatus*		V
eastern false pipistrelle	*Falsistrellus tasmaniensis*		V
eastern bentwing-bat	*Miniopterus schreibersii oceanensis*		V
greater long-eared bat	*Nyctophilus timoriensis*		NV,V
greater broad-nosed bat	*Scoteanax rueppellii*	V	
eastern cave bat	*Vespadelus troughtoni*	V	
inland freetail-bat	*Mormopterus* sp. (spf)		RS
southern freetail-bat	*Mormopterus* sp. (lpf)		RS
hairy-nosed freetail-bat	*Mormopterus* sp. 6	RS	

Appendix 3: Indicative threatened species for Nandewar key habitats

For each of the fauna sub-regions below, the threatened species known to occur, likely to occur and potentially occurring have been listed. The species lists are indicative only – clearly, not all of the species will occur in all of the key habitats within each fauna sub-region. The lists are a regional guide only. At local scales, local habitat characteristics also need to be considered.

The fauna sub-regions are shown in **Figure 4-A**.

1. Bebo - Bonshaw

Known:
Oedura rhombifer (preliminary listing), *Furina dunmalli*, square-tailed kite, squatter pigeon, glossy black-cockatoo, turquoise parrot, brown treecreeper, speckled warbler, painted honeyeater, hooded robin, grey-crowned babbler, diamond firetail, koala, squirrel glider, black-striped wallaby, delicate mouse (preliminary listing), *Saccolaimus flaviventris, Chalinolobus picatus, Miniopterus schreibersii, Nyctophilus timoriensis, Vespadelus troughtoni*

Likely:
black-chinned honeyeater

Potential:
Underwoodisaurus sphyrurus, barking owl, masked owl, spotted-tailed quoll, *Pteropus poliocephalus, Chalinolobus dwyeri, Mormopterus beccarii*

2. Bingara

Known:
Underwoodisaurus sphyrurus, turquoise parrot, masked owl, brown treecreeper, speckled warbler, black-chinned honeyeater, hooded robin, grey-crowned babbler, diamond firetail, koala, squirrel glider, *Saccolaimus flaviventris, Chalinolobus picatus, Nyctophilus timoriensis*

Likely:
square-tailed kite, painted honeyeater

Potential:
swift parrot, barking owl, regent honeyeater, spotted-tailed quoll, black-striped wallaby, *Pteropus poliocephalus, Chalinolobus dwyeri, Miniopterus schreibersii, Vespadelus troughtoni*

3. Central Granite Belt

Known:
Underwoodisaurus sphyrurus, Elseya bellii, barking owl, masked owl, turquoise parrot, brown treecreeper, speckled warbler, regent honeyeater, black-chinned honeyeater, hooded robin, grey-crowned babbler, diamond firetail, koala, squirrel glider, *Saccolaimus flaviventris, Falsistrellus tasmaniensis, Miniopterus schreibersii, Nyctophilus timoriensis, Scoteanax rueppellii*

Likely:
painted honeyeater

Potential:
square-tailed kite, swift parrot, spotted-tailed quoll, brush-tailed rock-wallaby, *Pteropus poliocephalus, Chalinolobus dwyeri,Vespadelus troughtoni*

4. Eastern Highlands

Likely:
turquoise parrot, brown treecreeper, speckled warbler, black-chinned honeyeater, hooded robin, diamond firetail, koala, squirrel glider, *Saccolaimus flaviventris, Miniopterus schreibersii*

Potential:
Underwoodisaurus sphyrurus, square-tailed kite, barking owl, masked owl, regent honeyeater, painted honeyeater, grey-crowned babbler, *Pteropus poliocephalus, Falsistrellus tasmaniensis, Nyctophilus timoriensis, Scoteanax rueppellii, Vespadelus troughtoni*

5. Kaputar – Horton Range

Known:
Underwoodisaurus sphyrurus, square-tailed kite, glossy black-cockatoo, barking owl, masked owl, turquoise parrot, brown treecreeper, speckled warbler, regent honeyeater, painted honeyeater, hooded robin, grey-crowned babbler, diamond firetail, spotted-tailed quoll, squirrel glider, koala, brush-tailed rock-wallaby, *Pteropus poliocephalus, Saccolaimus flaviventris, Chalinolobus dwyeri, Chalinolobus picatus, Miniopterus schreibersii, Nyctophilus timoriensis, Scoteanax rueppellii, Vespadelus troughtoni*

Likely:
black-chinned honeyeater

Potential:
swift parrot, black-striped wallaby

6. Kwiambal

Known:
turquoise parrot, brown treecreeper, speckled warbler, hooded robin, grey-crowned babbler, diamond firetail, koala, squirrel glider, *Saccolaimus flaviventris, Chalinolobus picatus, Miniopterus schreibersii, Nyctophilus timoriensis*

Likely:
Underwoodisaurus sphyrurus, black-chinned honeyeater

Potential:
square-tailed kite, barking owl, masked owl, painted honeyeater, spotted-tailed quoll, *Chalinolobus dwyeri, Vespadelus troughtoni*

7. Manilla - Cobbadah

Known:
Underwoodisaurus sphyrurus, square-tailed kite, swift parrot, barking owl, turquoise parrot, grey-crowned babbler, speckled warbler, hooded robin, brown treecreeper, black-chinned honeyeater, regent honeyeater, painted honeyeater, diamond firetail, squirrel glider, *Pteropus poliocephalus, Saccolaimus flaviventris, Chalinolobus dwyeri, Miniopterus schreibersii, Nyctophilus timoriensis*

Likely:
koala

Potential:
painted snipe, masked owl, Chalinolobus picatus, Vespadelus troughtoni

8. Melville Range - Southern Plains

Known:
Underwoodisaurus sphyrurus, turquoise parrot, brown treecreeper, speckled warbler, black-chinned honeyeater, diamond firetail, koala, squirrel glider, *Saccolaimus flaviventris, Chalinolobus dwyeri, Vespadelus troughtoni*

Likely:
painted honeyeater, hooded robin, *Nyctophilus timoriensis*

Potential:
square-tailed kite, swift parrot, barking owl, masked owl, regent honeyeater, grey-crowned babbler, brush-tailed rock-wallaby, *Pteropus poliocephalus, Miniopterus schreibersii*,

9. Mole River

Known:
Underwoodisaurus sphyrurus, glossy black-cockatoo, turquoise parrot, brown treecreeper, speckled warbler, grey-crowned babbler, diamond firetail, koala, *Miniopterus schreibersii, Nyctophilus timoriensis, Scoteanax rueppellii, Vespadelus troughtoni*

Likely:
hooded robin, black-chinned honeyeater

Potential:
square-tailed kite, barking owl, masked owl, swift parrot, regent honeyeater, painted honeyeater, black-throated finch, spotted-tailed quoll, squirrel glider, brush-tailed rock-

wallaby, *Saccolaimus flaviventris, Chalinolobus dwyeri, Falsistrellus tasmaniensis, Mormopterus beccarii*

10. Northern Plains

Known:
Anomalopus mackayi, turquoise parrot, brown treecreeper, speckled warbler, painted honeyeater, hooded robin, grey-crowned babbler, diamond firetail, koala, squirrel glider, *Pteropus poliocephalus, Saccolaimus flaviventris, Miniopterus schreibersii*

Likely:
square-tailed kite, black-chinned honeyeater, *Nyctophilus timoriensis, Chalinolobus picatus*

Potential:
squatter pigeon, swift parrot, barking owl, masked owl, regent honeyeater, *Vespadelus troughtoni*

11. Nundle - Moonbi

Known:
Litoria booroolongensis, Underwoodisaurus sphyrurus, square-tailed kite, barking owl, masked owl, turquoise parrot, brown treecreeper, speckled warbler, black-chinned honeyeater, hooded robin, diamond firetail, koala, squirrel glider, *Saccolaimus flaviventris, Chalinolobus dwyeri, Falsistrellus tasmaniensis, Miniopterus schreibersii, Nyctophilus timoriensis, Scoteanax rueppellii*

Likely:
Pteropus poliocephalus

Potential:
glossy black-cockatoo, swift parrot, grey-crowned babbler, regent honeyeater, painted honeyeater, spotted-tailed quoll, brush-tailed rock-wallaby

12. Severn River – King's Plains

Known:
Underwoodisaurus sphyrurus, square-tailed kite, glossy black-cockatoo, turquoise parrot, brown treecreeper, speckled warbler, black-chinned honeyeater, hooded robin, diamond firetail, spotted-tailed quoll, koala, squirrel glider, *Miniopterus schreibersii*

Likely:
Saccolaimus flaviventris

Potential:
barking owl, masked owl, swift parrot, grey-crowned babbler, regent honeyeater, painted honeyeater, black-throated finch, brush-tailed rock-wallaby, *Chalinolobus dwyeri, Falsistrellus tasmaniensis, Nyctophilus timoriensis, Scoteanax rueppellii, Vespadelus troughtoni*

13. Southern Ranges

Known:
Litoria booroolongensis, glossy black-cockatoo, powerful owl, masked owl, brown treecreeper, diamond firetail, spotted-tailed quoll, *Falsistrellus tasmaniensis, Scoteanax rueppellii*

Likely:
turquoise parrot, black-chinned honeyeater, hooded robin, koala, *Pteropus poliocephalus, Miniopterus schreibersii*

Potential:
square-tailed kite, swift parrot, barking owl, speckled warbler, regent honeyeater, painted honeyeater, squirrel glider, brush-tailed rock-wallaby, *Chalinolobus dwyeri, Vespadelus troughtoni*

14. Tingha Plateau

Known:
Underwoodisaurus sphyrurus, square-tailed kite, glossy black-cockatoo, barking owl, turquoise parrot, brown treecreeper, speckled warbler, regent honeyeater, painted honeyeater, black-chinned honeyeater, hooded robin, grey-crowned babbler, diamond firetail, koala, squirrel glider, *Saccolaimus flaviventris, Falsistrellus tasmaniensis, Miniopterus schreibersii, Nyctophilus timoriensis, Scoteanax rueppellii*

Potential:
swift parrot, masked owl, spotted-tailed quoll, Pteropus poliocephalus, Chalinolobus dwyeri, Chalinolobus picatus, Vespadelus troughtoni

15. Warialda - Bunal

Known:
Oedura rhombifer (preliminary listing), *Underwoodisaurus sphyrurus,* turquoise parrot, brown treecreeper, speckled warbler, black-chinned honeyeater, hooded robin, grey-crowned babbler, diamond firetail, koala, squirrel glider, *Saccolaimus flaviventris, Chalinolobus picatus, Miniopterus schreibersii, Nyctophilus timoriensis, Vespadelus troughtoni*

Likely:
painted honeyeater

Potential:
square-tailed kite, glossy black-cockatoo, painted snipe, barking owl, masked owl, regent honeyeater, black-striped wallaby, delicate mouse (preliminary listing), *Pteropus poliocephalus, Chalinolobus dwyeri*