Bioregional Assessment Study Part II

Fauna of the Illawarra Escarpment, Coastal Plain and Plateau

ject arising from the Commission of Inquiry into the long term planning and
gement of the Illawarra Escarpment, Wollongong Local Government Area

Central Conservation Programs and Planning Division
NSW National Parks and Wildlife Service
August 2002

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Wollongong Local Government Area Bioregional Assessment (Part II)

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CONTENTS

1 EXECUTIVE SUMMARY

This report details the findings of a study into the distribution and conservation status of the native fauna of the Wollongong Escarpment, Coastal Plain and Plateau. It is a part of the Bioregional Assessment Study recommended by the 1999 Commission of Inquiry into Planning and Development of the Illawarra Escarpment. This report is designed to be used in conjunction with Part I of the Assessment, a report on *Native Vegetation of the Wollongong Escarpment and Coastal Plain* (NPWS 2002a).

The Study has highlighted the rich and diverse nature of the vertebrate fauna in the Illawarra. The Wollongong Area was found to contain habitat for at least 40 fauna species listed on the NSW Threatened Species Conservation Act, 1995. Furthermore, almost 70 percent of vertebrate species found in the Sydney Basin Bioregion have been recorded within the Study Area, despite Wollongong LGA covering less than 2% of the total land area of the Bioregion.

Models of predicted habitat were derived for twenty-nine vertebrate species of the Wollongong Area. These models, which are available in digital format, provide accurate information on the distribution of faunal species habitats in Wollongong. This study illustrates that while many species utilise the well-protected Woronora Plateau, some species are found only along the Wollongong Escarpment. For example, the rainforests and moist eucalypt forests of the Escarpment are high quality habitat for the Sooty Owl, Stuttering Frog, Australian Brush-turkey, Logrunner, Grey-headed Flying-fox and Highland's Forest-skink.

Systematic field data has also been used to describe and map the major faunal assemblages of the Study Area. Maps have been produced showing the distribution of the main assemblages of birds, bats, arboreal mammals and reptiles. Assemblages offer an insight into the combinations of the more common species that occur within the major habitat types. Common species are often overlooked in conservation assessments in favour of threatened species. Nevertheless, if diversity is to be maintained then a range of habitats supporting different assemblages should be protected. This study reveals that a number of assemblages remain poorly reserved in the Wollongong Area, particularly those of the coastal plain and foothills, and hence may be exposed to a number of threatening process.

Two corridors, or fauna linkages, have been highlighted within the Wollongong Local Government Area. The first, the Yallah-Calderwood Fauna Linkage, is the only remaining set of closely spaced remnants linking the escarpment to the vegetation on the shores of Lake Illawarra. Despite being isolated and disturbed, these grassy woodland remnants were found to have similar levels of species richness and diversity as undisturbed environments within the Wollongong Area.

Wollongong has one of the largest areas of rainforest in the Sydney Basin Bioregion. These forests currently run in a narrow but largely unbroken band along the escarpment between the Shoalhaven River and Royal National Park. This study identifies this band of forest as the Escarpment Moist Forest Fauna Linkage. If retained, this linkage would theoretically allow the continued intermixing of wildlife populations restricted to rainforest and moist eucalypt forest. It also provides an opportunity for recolonisation by species that have become locally extinct, such as the Greater Glider in Royal National Park.

Bird assemblages of the Wollongong Area were compared to those in other parts of the Sydney Basin Bioregion. Birds of the Rainforests, Moist Eucalypt Forests and Sandstone environments of Wollongong were found to be comparable to similar environments elsewhere in the Bioregion. Likewise, comparisons of the environments of the Illawarra

Lowland Grassy Woodlands to the Cumberland Plain Woodlands from Western Sydney revealed a similar bird assemblage. It is notable that development, disturbance and fragmentation threaten both these areas.

Overall, most faunal species habitats of the sandstone plateau of Wollongong are well reserved in either conservation reserves or water catchment. Threatened species and assemblages of the escarpment moist forests and rainforests are somewhat less well reserved. Nevertheless, it is unequivocally the wildlife of the native vegetation of the coastal plain and foothills that is most in need of protection.

2 INTRODUCTION

2.1 BACKGROUND

2.1.1 Commission of Inquiry

In 1999 the Commission of Inquiry into Planning and Management of the Illawarra Escarpment concluded that, at that time, insufficient information was available to make informed planning decisions along the escarpment and foothills of the region. In December 2000, the NSW State Government responded to the recommendations of the Commissioner and supported several concurrent studies dealing with the following:

- Riparian and floodplain management
- Regional vegetation management
- Land stability
- A review of the Illawarra Regional Environmental Plan No. 1
- Distribution and status of biodiversity - 'the Bioregional Assessment'

Various State Government agencies and Wollongong City Council have been involved in the management and implementation of these projects. The NSW National Parks and Wildlife Service (NPWS) has been responsible for the Bioregional Assessment, of which this study is part. The outcomes of these studies should highlight the conservation values of the area and provide land managers with a resource that allows more informed planning decisions.

2.1.2 Bioregional Assessment

The Bioregional Assessment, undertaken by NPWS, has three parts: Part 1) Vegetation Mapping and Classification, Part 2) Fauna Assessment (this study) and Part 3) Conservation Priorities.

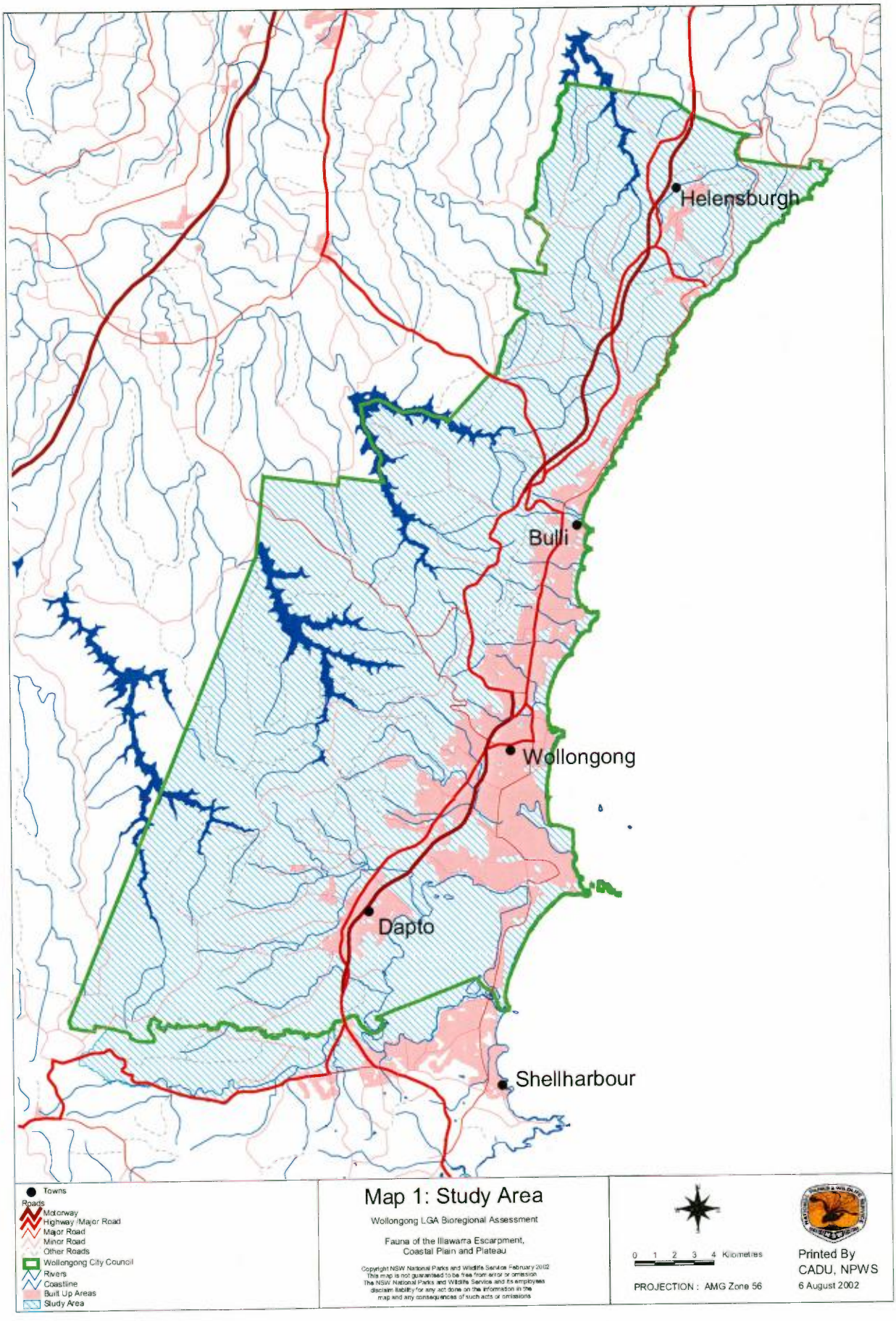
The Vegetation Mapping and Classification Study has resulted in a digitised map of native vegetation and an associated report *The Native Vegetation of the Wollongong Escarpment and Coastal Plain.* These were developed from field data and Aerial Photograph Interpretation (for details see NPWS 2002a).

The Fauna Assessment has used field survey and existing data in combination with the vegetation mapping to provide information on fauna and fauna habitats. The Fauna Assessment will be used in conjunction with the report on vegetation mapping to highlight conservation priorities in the Wollongong Local Government Area (LGA).

2.2 STUDY AREA

Although the focus of the study was on the escarpment and foothills of the Wollongong LGA, fieldwork was undertaken on a broader scale to ensure findings could be put into a landscape context. That is, an attempt was made to assess the uniqueness, both regionally and locally, of the fauna of the Wollongong escarpment and foothills.

The Study Area extends from Garie in Royal National Park (NP) to the Macquarie Rivulet in the south (Map 1). The Woronora River, Cordeaux and Cataract Dams form the western boundary, with Mount Murray at the south west corner. The Pacific Ocean forms the eastern boundary. Macquarie Rivulet was included to


Helensburgh
Bulli
Wollongong
Dapto
Shellharbour
Towns
Roads
Motorway
Highway /Major Road
Major Road
Minor Road
Other Roads
Wollongong City Council
Rivers
Coastline
Built Up Areas
Study Area
Map 1: Study Area
Wollongong LGA Bioregional Assessment
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ensure the Calderwood Valley was included in its entirety, thus encompassing a small amount of Shellharbour LGA in the Study Area.

There exist three major landscape units within the Wollongong LGA. These are 1) the Plateau Area, 2) the Escarpment, and 3) the Foothills and Coastal Plain. The majority of the Coastal Plain and Foothills are covered by urban and rural development. The Plateau, by comparison, has suffered very little habitat degradation, and a significant portion of this area is protected within Sydney Catchment Authority Special Areas and various NPWS managed reserves. The escarpment is partially protected within the Illawarra Escarpment State Conservation Area (SCA), but a substantial portion is privately owned.

The Wollongong LGA is part of the Sydney Basin Bioregion. This is one of 80 Australian Bioregions defined in the Interim Biogeographic Regionalisation of Australia (IBRA) (Thackway & Creswell 1995). Bioregions were mapped on similarity of climate, vegetation, geology and landform. Bioregions were developed to aid in the establishment of a National Reserve System that conserved a representative sample of Australian ecosystems.

The Sydney Basin Bioregion extends from south of Nowra to Newcastle and to the western extent of the Blue Mountains (Map 2). A Bioregion is a useful context in which to examine conservation priorities. In this study the relative importance of the Wollongong Area is assessed in relation to the conservation of a species across the whole Sydney Basin Bioregion.

2.3 OBJECTIVES

The principal aim of this project was to produce a report that provides a detailed review of the fauna values of the Wollongong escarpment and foothills. Objectives related to several main themes. These were to:

1) Identify species that are listed as Vulnerable or Endangered in either the NSW Threatened Species Conservation (TSC) Act (1995) or the Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act (1999). Identify non-listed species that are thought to be declining, isolated or under threat within the Wollongong Area.

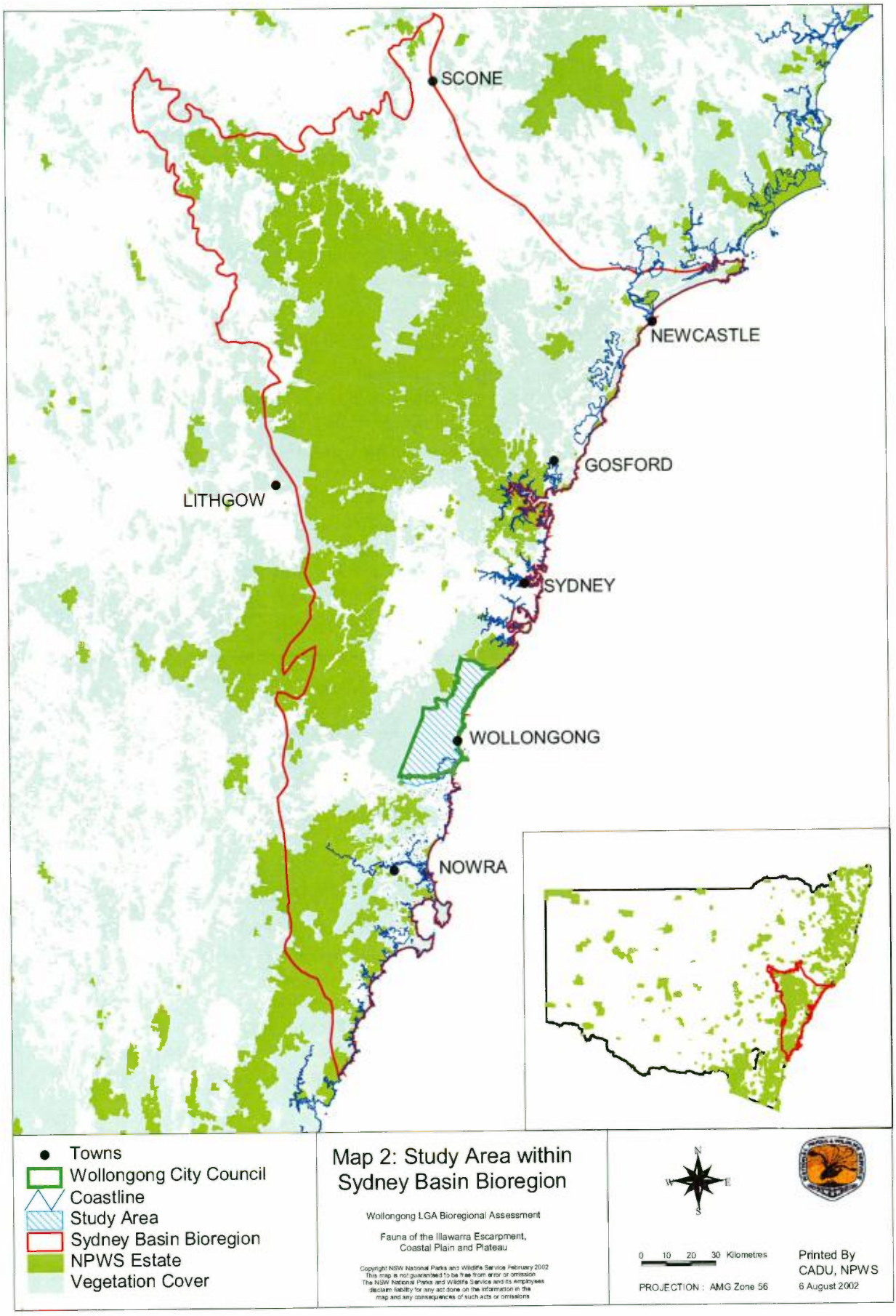
2) Produce maps that illustrate the distribution of habitat for the species identified above. Examine the reservation status of the species at a local and bioregional level.

3) Produce maps that show the distribution of the characteristic assemblages of species found in the major habitat types of the Wollongong area. Examine the reservation status of these assemblages at a local level.

4) Examine the uniqueness of faunal assemblages of the Wollongong Area in relation to assemblages in similar habitats elsewhere in the Sydney Basin Bioregion.

5) Investigate the faunal diversity and species richness of the largest and most intact series of remnants of the Coastal Plain.

6) Highlight areas that may be acting as corridors or linkages for fauna populations in the Wollongong Area.


SCONE
NEWCASTLE
GOSFORD
LITHGOW
SYDNEY
WOLLONGONG
NOWRA
Towns
Wollongong City Council
Coastline
Study Area
Sydney Basin Bioregion
NPWS Estate
Vegetation Cover
Map 2: Study Area within Sydney Basin Bioregion
Wollongong LGA Bioregional Assessment
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3 METHODOLOGY

3.1 EXISTING FIELD SURVEY DATA

All existing fauna data was reviewed for suitability in quantitative analysis. A number of studies have collected systematic field data within the Wollongong Study Area. During 1997-1998 a NPWS fauna survey specifically targeted the escarpment lands of the Illawarra Escarpment SCA (NPWS 1998). Twenty-one sites from that survey were added to the data collected in the current project. Additionally, sites from the Royal NP biodiversity surveys (NPWS 2001d), the Barred River Frogs surveys (Biosphere Environmental Consultants 2000), National Parks Association Dharawal surveys and the Georges River Catchment Biodiversity Study fauna surveys (NPWS 2001e) were used to supplement data collected for the current project.

3.2 SITE SELECTION

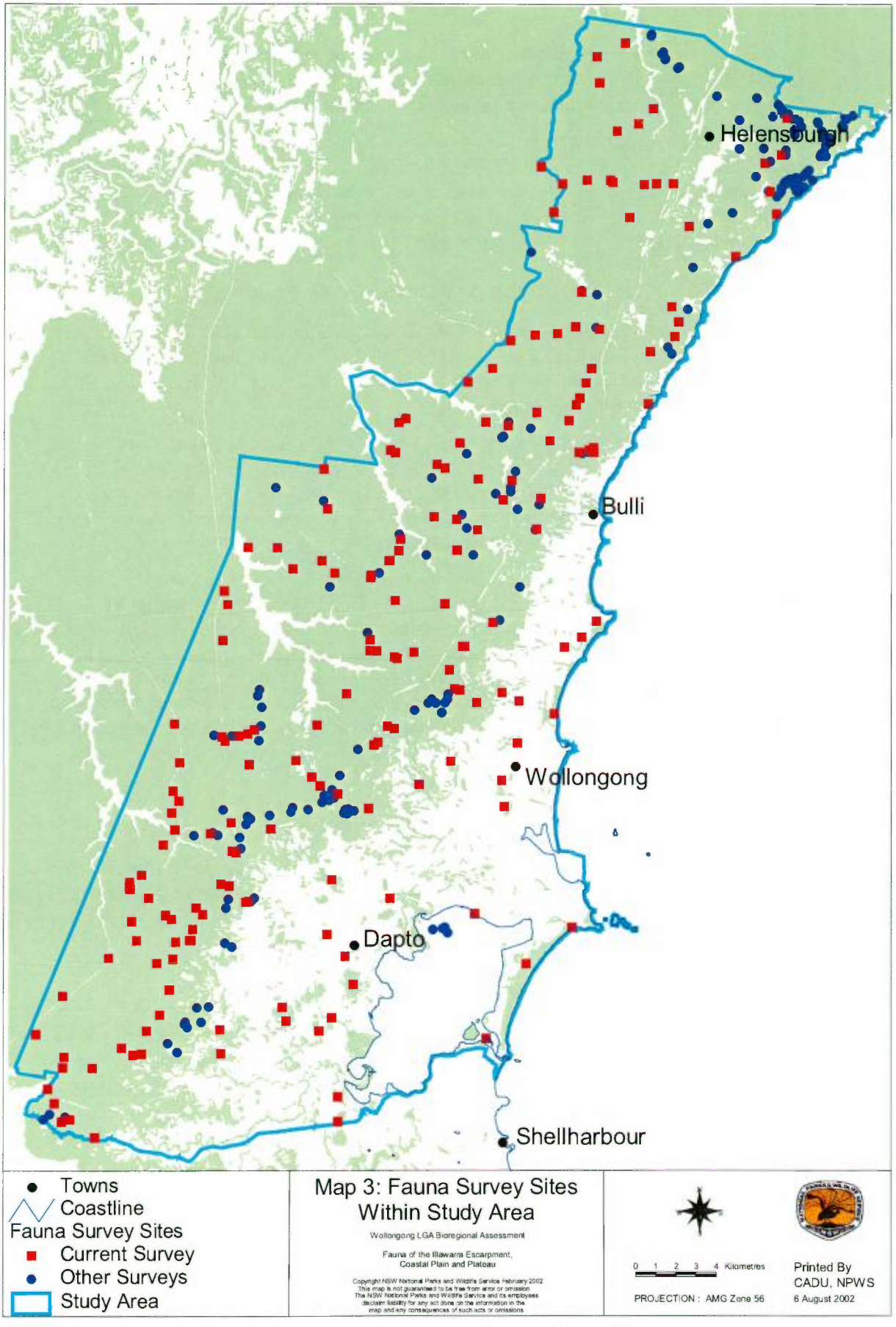
Sites were positioned by vegetation type while aiming to cover the spatial extent of the area (Map 3). To ensure independence, sites were never located within 1km of each another. Generally, it was aimed to separate sites by 2km, although this was not always achievable on the coastal plain. For each fauna survey technique, the aim was to situate a minimum of four sites in the main vegetation communities (Appendix A). Larger vegetation communities often required more than four sites in order to provide adequate coverage. For some of the rarer vegetation communities, particularly those on the highly fragmented coastal plain and foothills, it was impossible to find four sites that were adequately separated from one another. In these instances as many sites as was practicable were selected. In order to sample some of the coastal vegetation communities adequately, a number of sites were undertaken outside the Wollongong Study Area within Shellharbour LGA.

3.3 SURVEY METHODS

Survey methodology generally followed that set out by NPWS for the Comprehensive Regional Assessment (CRA) Fauna Surveys (NPWS 1997). Qualified NPWS staff and consultants carried out each survey. There was a minor deviation from CRA methodology in that spotlighting was only carried out at sites rather than transects, due to the difficulties in analysing the traditional two kilometre spotlight transect. Spotlighting at sites followed CRA protocol, which is detailed below.

3.3.1 Bird Census (diurnal bird search)

This method involves the identification of all birds seen or heard within a two hectare (ha) site over a period of 20 minutes. All censuses were undertaken at times of maximum bird activity, ie. close to dawn or dusk. Censuses were not undertaken on rainy or windy days or during times of extreme heat. The species, number of individuals, if the species was seen or heard and the microhabitat that the birds were using was noted. Birds identified close to the site were recorded as 'off-site' and individuals flying over the site were noted as such. Those recorded before or after the survey period were recorded as 'opportunistic on-site'.


Helensburgh
Bulli
Wollongong
Dapto
Shellharbour
Towns
Coastline
Fauna Survey Sites
Current Survey
Other Surveys
Study Area
Map 3: Fauna Survey Sites Within Study Area
Wollongong LGA Bioregional Assessment
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3.3.2 Reptile Census (diurnal herpetofauna search)

Census for diurnal herpetofauna involves a one person-hour search of a 0.5 ha (50x100m) plot. Surveys were conducted during daylight hours at temperatures between 18 and 30 °C so that conditions were conducive to the highest reptile

activity levels. Searches were not conducted during periods of excessive rain, wind or heat. Sites were sampled by turning rocks and searching fallen logs, leaf litter, decorticating or fallen bark, rock outcrops and other potential reptile microhabitats. Individuals were identified to species level and information taken regarding age, sex and microhabitat usage.

3.3.3 Bat Census (harp trapping and ultrasound recording)

Two techniques were used to survey for microbats (Microchiroptera). These were harp trapping and ultrasound recording. The only megabat, or fruit bat (Macrochiroptera) from the Study Area is the Grey-headed Flying-fox (*Pteropus poliocephalus*). This species was searched for during spotlighting.

Harp traps are an aluminium square frame strung with fishing line suspended over a catch bag that are set across spaces thought to be pathways that bats use regularly (flyways). Bats fly into the 'harp' and fall down into the bag from which they cannot escape. Each site was trapped for two nights with bats removed from the bag at dawn each morning and released at dusk at the same site.

The second technique, bat ultrasound recording, involves the recording and identification of microbat species from their echolocation calls. This technique is generally used as a supplement to harp trapping which is often criticised for missing high-flying bat species that do not typically use flyways. For this study, bat echolocation signals were recorded using the *Anabat* device, which translates the ultrasonic calls into an audible frequency. Ultrasonic bat calls were recorded for 30 minutes per site during the time of peak bat activity, which is usually early in the night and not during periods of cold, wet or windy weather. Calls were then analysed by an expert in this field who categorised records as 'definite', 'probable' or 'possible'.

3.3.4 Frog Census (nocturnal streamside search)

Frog species were surveyed by searching 200 metres of stream or pond edge for one person hour. All frogs seen or heard were recorded. Surveys were only undertaken within two days of rain and when temperatures were above 20°C to ensure frogs were being surveyed during periods of maximum activity.

3.3.5 Arboreal Mammal Census (spotlighting)

Spotlighting surveys covered a standard 2ha site. They were generally centred down a 200 metre stretch of road. Two people with 50-watt spotlights searched this area for 15 minutes or one person searched for 30 minutes. All species seen or heard were recorded, with several minutes dedicated to listening for nocturnal bird and mammal calls.

3.3.6 Owls Search (nocturnal call playback)

Large forest owls were searched for using the call playback technique. This involves playing a recording of each species of owl call through a loud hailer for five minutes, and then listening for ten minutes between each call for any responses elicited by the tape. There is a fifteen minute listening period at the beginning and end of the survey, and a five minute spotlight search at the end to check for owls that may have come in response to the tape, but not called. During the current survey, calls were played of the Powerful

Owl (*Ninox strenua*), Masked Owl (*Tyto novaehollandiae*), Sooty Owl (*T. tenebricosa*) and Barking Owl (*N. connivens*).

3.3.7 Small Mammal Trapping (elliott and cage trapping)

Transects of elliott and cage traps were set to target priority species that are not well sampled using other methods, such as Eastern Pygmy-possum (*Cercartetus nanus*), Long-nosed Potoroo (*Potorous tridactylus*) and Spotted-tailed Quoll (*Dasyurus maculatus*). Transects of cage traps were two kilometre long with traps spaced at 200 metre intervals. Elliott traps were set 10 metres apart for 250 metre transects. This technique was not designed for comparison between areas but rather have the highest probability of detecting priority species. Bait was either peanut butter, rolled oats and honey or peanut butter, rolled oats and sardines. Transects were set with traps alternating between sardine and non-sardine baits.

3.3.8 Hair Analysis (hair tubes and scat analysis)

Experts can often identify hair samples to species level. Two survey methods were employed that took advantage of this; transects of hair tubes and predator scat collection. The hair tubes were a specially designed *Faunatec* model used during the CRA surveys. They were baited with either a peanut butter, rolled oats and honey mix or with cooked chicken necks. Meat and peanut butter hair tubes were laid alternately down the centre line of standard two hectare sites at 20 metre intervals, with a total of ten tubes per site. Tubes were collected after ten days and those that had hair were sent to Barbara Triggs for identification. Additionally, all predator scats, owl boluses and other hair samples that were found, either on-site or off, were collected and were sent to have the contents identified to species level.

3.3.9 Opportunistic Records

All birds, mammals, reptiles and frogs encountered opportunistically during the survey were recorded, along with details about the date and time, location and any other information able to be discerned about habitat usage, sex, age or breeding.

3.3.10 Habitat Characteristics

At every census site, details of the habitat characteristics were taken. Details recorded were a subset of those taken during the CRA surveys. They included, amongst other things, information on the vegetation type, geology, topography, ground cover, percentage of outcropping rock and disturbance. This was then related to the fauna data during the analysis process. A copy of the proforma used to take site details is given in Appendix B.

3.4 IDENTIFICATION OF PRIORITY SPECIES

Priority species were selected from those listed as Endangered or Vulnerable at either a state and/or federal level or via nomination by local fauna experts. The species selected are listed in Table 1. Those for which maps of high quality habitat (HQH) have been developed are highlighted. Species whose habitats have not been mapped have either very few records or have poorly known or poorly defined habitat requirements. These unmapped species are generally those that are locally extinct, rare nomads or vagrants and have no core habitat within the Study Area (assessment taken from Chafer *et al.* 1999, Robinson 1988).

Table 1: List of priority species for the Wollongong Area. All species that are listed under the Threatened Species Conservation Act (1995) and the Environment Protection and Biodiversity Conservation Act (1999) from Wollongong LGA are listed. Protected species that were considered significant are also included. Habitats for species highlighted in red have been modelled. E = Endangered, V = Vulnerable, P = Protected.

Common Name	Scientific Name	Legal Status		Significance of Study Area
		TSC Act NSW	EPBC Act Federal	
Giant Burrowing Frog	*Heleioporus australiacus*	V	V	Core habitat
Stuttering Frog	*Mixophyes balbus*	E	V	Core habitat
Red-crowned Toadlet	*Pseudophryne australis*	V		Core habitat
Green and Golden Bell Frog	*Litoria aurea*	E	V	Core habitat
Littlejohn's Tree Frog	*Litoria littlejohni*	V	V	Core habitat
Rosenberg's Goanna	*Varanus rosenbergi*	V		Core habitat
Highlands Forest-skink	*Nannoscincus maccoyi*	P		Core habitat
Golden-crowned Snake	*Cacophis squamulosus*	P		Core habitat
Broad-headed Snake	*Hoplocephalus bungaroides*	E	V	Core habitat
Mainland Tiger Snake	*Notechis scutatus*	P		Core habitat
Australian Brush-turkey	*Alectura lathami*	P		Core habitat
Australasian Bittern	*Botaurus poiciloptilus*	V		Rare visitor?
Black Bittern	*Ixobrychus flavicollis*	V		Rare resident?
Osprey	*Pandion haliaetus*	V		Vagrant
Square-tailed Kite	*Lophoictinia isura*	V		Vagrant
Wompoo Fruit-dove	*Ptilinopus magnificus*	V		Locally extinct
Rose-crowned Fruit-dove	*Ptilinopus regina*	V		Vagrant
Superb Fruit-dove	*Ptilinopus superbus*	V		Vagrant
Glossy Black-cockatoo	*Calyptorhynchus lathami*	V		Rare visitor
Swift Parrot	*Lathamus discolor*	E	E	Iregular migrant
Turquoise Parrot	*Neophema pulchella*	V		Vagrant
Ground Parrot	*Pezoporus wallicus*	V		Locally extinct?
Pheasant Coucal	*Centropus phasianinus*	P		Rare visitor?
Barking Owl	*Ninox connivens*	V		Rare visitor?
Powerful Owl	*Ninox strenua*	V		Core habitat
Masked Owl	*Tyto novaehollandiae*	V		Rare resident?
Sooty Owl	*Tyto tenebricosa*	V		Core habitat
Red-browed Treecreeper	*Climacteris erythrops*	P		Core habitat
Regent Honeyeater	*Xanthomyza phrygia*	E	E	Rare visitor?
Eastern Bristlebird	*Dasyornis brachypterus*	E	E	Locally extinct?
Logrunner	*Orthonyx temminckii*	P		Core habitat
Pink Robin	*Petroica rodinogaster*	V		Vagrant
Olive Whistler	*Pachycephala olivacea*	V		Rare resident?
Barred Cuckoo-shrike	*Coracina lineata*	V		Vagrant
Green Catbird	*Ailuroedus crassirostris*	P		Core habitat
Grey Currawong	*Strepera versicolor*	P		Core habitat
Platypus	*Ornithorhynchus anatinus*	P		Core habitat
Spotted-tailed Quoll	*Dasyurus maculatus*	V	V	Locally extinct/rare?
Southern Brown Bandicoot	*Isoodon obesulus*	E		?
Koala	*Phascolarctos cinereus*	V		Rare visitor?
Eastern Pygmy-possum	*Cercartetus nanus*	V		Core habitat
Greater Glider	*Petauroides volans*	P		Core habitat
Mountain Brushtail Possum	*Trichosurus caninus*	P		Core habitat
Long-nosed Potoroo	*Potorous tridactylus*	V		Locally extinct?
Grey-headed Flying-fox	*Pteropus poliocephalus*	V	V	Core habitat
Eastern Freetail-bat	*Mormopterus norfolkensis*	V		Rare resident?
Large-eared Pied Bat	*Chalinolobus dwyeri*	V	V	Rare resident
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	V		?
Common Bent-wing Bat	*Miniopterus schreibersii*	V		Core habitat

Common Name	Scientific Name	Legal Status		Significance of Study Area
		TSC Act NSW	EPBC Act Federal	
Large-footed Myotis	*Myotis adversus*	V		Core habitat
Greater Broad-nosed Bat	*Scoteanax rueppellii*	V		?

There were a number of threatened species that have records from within Wollongong City Council but were not considered priority species for this project. Included in this list are the pelagic seabirds, waders and marine mammals and marine reptiles. These species are listed briefly at the end of the priority species profiles (Section 5.53) for completeness. This supplementary list also includes a number of mammal species that are either long extinct or whose existence is only supported by minimal or spurious records.

A number of local species that are not listed as threatened (Protected under the National Parks and Wildlife Act, 1974) were also considered priority species. This list was determined by way of nomination by fauna experts with particular knowledge of the Study Area. The reasons for listing were varied but included significant population in terms of the Sydney Basin Bioregion, limits of geographical range, isolated or declining populations (particularly those with limited scope to recover from catastrophic events such as fire and clearing) and species with a restricted distribution locally. These species, with the level of significance and reason for inclusion as a priority species, are listed in Table 2.

Table 2: List of species that are not listed as threatened but are priority species for the Wollongong Area. Level of significance indicates at a regional (Sydney Basin Bioregion) or local (Wollongong LGA) scale. The reason for the inclusion of this species is also listed. Scientific Names for species are listed in Table 1.

Common Name	Significance Level	Reason
Highlands Forest-skink	Regional	Northern limit of distribution
Golden-crowned Snake	Regional	Southern limit of distribution
Mainland Tiger Snake	Local	Declining (overall and locally) population
Australian Brush-turkey	Local	Isolated, recovering population
Pheasant Coucal	Regional	Southern limit of distribution, isolated
Red-browed Treecreeper	Local	Restricted local distribution
Logrunner	Regional	Southern limit of distribution, isolated
Green Catbird	Regional	Southern limit of distribution, isolated
Grey Currawong	Local	Restricted local distribution
Platypus	Regional	Isolated, declining population
Greater Glider	Local	Restricted, declining local population
Mountain Brushtail Possum	Local	Restricted distribution

3.5 FAUNA HABITAT MODELLING

One of key objectives of the fauna assessment was to produce maps describing the distribution of habitat used by priority species across the Study Area. A computer based modelling package was used to statistically examine relationships between the location of species and environmental attributes such as climate, terrain, vegetation type and geology. These relationships can then be used to identify identical features in the landscape using Geographical Information Systems (GIS), thereby predicting potential habitat.

Not all species had sufficient records within the Study Area from which to develop statistical models. For some of these species, GIS layers were manipulated by fauna-specialists familiar with the habitat requirements of each species to produce expert habitat models.

3.5.1 Preparation of Environmental GIS Layers

The habitat modelling relied on the development of environmental layers that describe the variation of natural environments present within the Study Area. These include data

layers that describe variations in soils, climate, terrain, and vegetation communities. The vegetation layers were derived from data generated from NPWS (2002a) and NPWS (2003).

The following data were used;

- Digital Elevation Model (DEM)
- Mean Annual Rainfall (mm)
- Mean Annual Radiation
- Mean Annual Temperature (degrees Celsius)
- Ruggedness 300m (Degree of change in slope)
- Ruggedness 600m
- Ruggedness 900m
- Topographic Position 300m (height in relation to the average height of the surrounding area)
- Topographic Position 600m
- Topographic Position 900m
- Wetness Index (amount of moisture likely to be collected based on terrain features)
- Slope (degrees)
- Dry Forest Index 500m (amount of dry forest within 500m)
- Eucalyptus Index 500m
- Moist Forest Index 500m
- Rainforest Index 500m
- Rainforest Index 1000m
- Upland Swamp Index 500m
- Wet Vegetation Index 500m (amount of moist forest and rainforest within 500m)
- Wet Vegetation Index 100m
- Number of Vegetation Layers (number of structural layers within the vegetation community)
- Smooth Gum Index (proportion of smooth gum eucalypts within the vegetation community)
- Patch Size Index
- Nectar Index (proportion of nectar producing species within the vegetation community)
- Hollow Index (hollow potential of the vegetation community)
- Fruit Index (proportion of fruiting species present within the vegetation community)
- Fruit Index 100m (mean of Fruit Index over 100 metre radius)
- Fertility Index (relative soil fertility based on geology)
- Eucalyptus Height Index (height of tallest Eucalyptus species within the vegetation community)
- Disturbance Index
- Complexity (structural complexity of the vegetation community)
- Latitude
- Longitude

3.5.2 *Derivation of Species Models*

The aim of the modelling process was to spatially interpolate known occurrences of fauna species from field surveys throughout the Study Area by finding statistical relationships between the biota and the environmental variables outlined in section 3.5.1. Pre-processing of data identified the underlying environmental values for each record of priority fauna species. Statistical analyses of the presence and absence of the species for each of the environmental variables was completed. A module was used that runs under S-PLUS statistical software (produced by Watson 1996) and is then combined with ArcView Spatial Analyst.

The predictive species modelling package provides the user with a choice between the two most commonly used logistic regression procedures, Generalised Linear Modelling (referred to as GLMs) and Generalised Additive Modelling (referred to as GAMs) (Watson 1996). GLMs are essentially an extension of ordinary linear regression that fits linear (straight-line) functions relating a response (dependent) variable to one or more predictor (independent) variables. Two of the basic assumptions of linear regression is that the relationship between response and predictor variables can be approximated by a straight line and that the variance associated with the response is homogenous throughout the full range of the response variables. GLMs overcome these assumptions by allowing a class of models that provide non-linearity and heterogenous variance in response functions (NPWS 1994).

GAMs are essentially an extension of GLMs, the major difference being GAMs use a nonparametric smooth function relating the response to the predictor. The functions are smooth curves estimated from the data using techniques originally developed for smoothing scatterplots. The GAMs derived by this software use cubic splines to fit smooth functions. Hence, the principal difference between the two modelling techniques is that GAMs allow the survey data to determine the shape of the response curves, whereas GLMs are constrained by parametric forms, that is cubic and quadratic polynomial response curves (NPWS 1994; Watson 1996).

Presence-absence modelling utilises information about where survey effort has been expended. This is important because it allows the development of patterns from data that describes where the species does not occur (an absence site) as much as where it does occur (a presence site). This type of model is derived only from sites where systematic survey to detect the species has been undertaken. Sites with no records are included, as an assumption that the species does not occur at this location. Use of this form produces a model of greater statistical robustness, although it is often less effective for fauna because of the assumption that a recorded absence is a definite absence. Many species of wildlife have only a low probability of detection even when they do use a site.

Presence-only data uses all available records for a species, both systematic and non-systematic. Presences are modelled in relation to 1000 'pseudo absences' which are randomly chosen from all land within the Study Area. Pseudo-absence points are given a weighting of n/1000 where n equals the number of presence records for each species. This manner of weighting facilitated approximation of degrees of freedom, deviance and significant levels appropriate to presence-only modelling. The weightings also enabled predictions to be expressed in terms of a relative index of likelihood of occurrence ranging from 0 to 1 (later converted to a percentage). This method is often the only effective way of modelling rare species. However, it can be sensitive to unequal survey effort throughout the Study Area. Clusters of records that may be multiple sightings of the one individual must therefore be thinned so as to approximate independence.

The statistical analyses provides a combination of variables which best describes the pattern of data for each species. This combination of variables or equation is then run through ArcView GIS to map the intersection of these variables in the landscape. A map describing the likelihood of occurrence across the Study Area is produced.

Many of the species did not have an adequate number of records to model or were poorly predicted using the above-described statistical methods. Many of these species had an expert or habitat model generated. Experts on the species' habitat requirements were consulted, along with references on habitat usage, and from this information a habitat model was derived. This often incorporated habitat from locations where the species had been detected. In most cases the various vegetation communities described in NPWS (2002a) were then selected in ArcView and used as the basis of the model. However, in a number of species, such as the Green and Golden Bell Frog and Platypus, a more detailed model was generated by creating buffers around known and potential locations.

The maps produced illustrate the potential distribution of habitat of each species. For predictive models, habitat quality was either mapped as high only, or a combination of high and moderate quality, based on the values generated during the statistical modelling. The categories are only indicative, and the models overall do not indicate whether the species occupies the mapped habitat at any given point in time. Future field surveys can be used to validate the reliability of the habitat models. The success of the model can be judged through empirical validation. As this was beyond the scope of this project, review of the habitat maps was made against expert knowledge of species habitat requirements. Each model was assigned a rating between adequate and excellent.

3.6 COMPARITIVE STATISTICAL ANALYSIS

A number of quantitative techniques were applied to the systematic site data to determine relationships within the data. Each of these techniques is described separately below.

Species Richness

Species richness was calculated as the number of species found at a site. When averaged across a group sites, this statistic can be used as a measure of relative productivity or condition. Species richness was averaged for each assemblage of diurnal birds, reptiles, bats and arboreal mammals. Average species richness was also calculated for sites conducted in the remnants of the Yallah-Calderwood area.

Species Diversity

Species diversity gives an indication of the number of species at a site, and of their relative abundances. The more equal the abundances, the more diverse a site. For example, a site with four individuals each of species A, B, C and D is more diverse than a site with twenty individuals of species A, and 1 individual each of species B, C and D. Both sites have equal species richness (of four species per site). This is often a better measure of relative productivity and condition than species richness.

For this study, diversity was calculated using Shannon-Wiener Diversity Index (H'):

$$H' = \Sigma P_i \log(P_i)$$

P_i = proportion of the total count arising from the i^{th} species.

Species diversity was averaged across sites for each species assemblage and for sites conducted in the Yallah-Calderwood remnants.

Similarity Matrices

Similarity matrices are useful for identifying groups of sites that contain similar suites of species. Bray-Curtis similarity matrices were created for diurnal birds, reptiles, bats and arboreal mammals to examine differences in species composition between groups of sites. This method creates pairwise comparisons for every site using the Bray-Curtis coefficient. Sites that are perfectly similar will have a coefficient of 1, and perfectly dissimilar will have a coefficient of 0. For the arboreal mammal census Euclidean

Distance was used to determine a dissimilarity coefficient. This is because Euclidean Distance allows the inclusion of sites that recorded no arboreal mammals, a common result in some habitats using the spotlighting method. Matrices were the basis of several other techniques performed, including ANOSIM and Cluster Analysis.

Generally, similarity matrices were calculated on presence-absence data, as this is not sensitive to fluctuations in abundance or differences in count estimation by observers. The only exception to this was the bats where there were not enough species per site to determine differences between assemblages on presence-absence alone, and hence abundance data was used. Sites were only included if they were classed as a high quality bat-trap site. This aimed to avoid trap sites that were located in poor flyways that may have had an undue effect on the data.

For the diurnal birds, all records that were noted as flying 'Above Canopy' were excluded because it is not known if they were actually using the site or not. Additionally, species that were only recorded from a single site were excluded, following convention (Clarke & Warwick 1994) so single occurrences of rare species did not overly influence the data.

ANOSIM (Analysis of Similarities)

Analysis of Similarities (ANOSIM) was used to test for differences between the fauna of the major habitat types of the Study Area. It is an extremely robust procedure that requires few replicates or assumptions. For this reason is ideal for application to data collected by many observers over an extended period of time. This statistical test is similar to Analysis of Variance (ANOVA), however it allows for the use of multivariate rather than univariate data. ANOSIM ascertains if there is a greater degree of similarity between replicates (sites) within a grouping than there is between sites from a different grouping. The output is an R statistic and a significance value for each assemblage pairing.

This test can only be applied to groups that were determined *apriori*. Ten broad habitat groups were tested in this analysis, derived from the vegetation mapping projects (NPWS 2002a, NPWS 2003). These were Heaths and Sedgelands, Sandstone Woodlands, Sandstone Gully Forests, Tall Grassy Forests, Moist Eucalypt Forests, Coastal Grassy Environments, Moist Coastal Vegetation, Rainforests, Creeklines and Modified Environments. Not all of broad habitat types were tested for all faunal groups. ANOSIM was applied to diurnal bird, reptile, bat and arboreal mammal data. This technique, and/or the cluster analysis helped derive the assemblages for each of the fauna groups. ANOSIM was also used to test for differences between the bird communities of the Illawarra with other environments within the Bioregion

Cluster Analysis

Cluster analysis is a graphical presentation of a similarity matrix. Sites are linked to one another based on their similarity coefficient to form a dendrogram. This allows the investigation of the faunal assemblages of sites that group together using a statistical procedure known as SIMPER.

SIMPER

SIMPER is a technique that isolates fauna species that characterise site-groupings identified in the cluster analysis. It is exploratory tool that allows examination of the species that contribute to the similarity or dissimilarity between a group of sites. This technique has been used to derive the principal species of each faunal assemblage. It was also used to identify the species driving the similarities and differences between bird assemblages in the various parts of the Bioregion.

4 RESULTS AND DISCUSSION

4.1 FAUNA SURVEY

4.1.1 Overview

During the spring and summer of 2001-2, more than 405 systematic wildlife censuses were completed at over 200 sites in the Wollongong Area (Map 3, Appendix A). These surveys have added 2776 new fauna records of 222 species to the NPWS Atlas of NSW Wildlife.

A complete species list for the Study Area is given in Appendix C. All species found during the current survey, and those recorded previously from the area from the NPWS Atlas of NSW Wildlife are listed. This has been summarised in Table 3 and compared to the species counts for the entire Sydney Basin Bioregion. For the groups listed in Table 3, between 48 and 74 percent of the species known from the Bioregion have been recorded in the Wollongong Study Area. This indicates that the Wollongong Area retains an extremely diverse assortment of native wildlife, especially given its small size.

Table 3: Summary of the number of species, including marine species, in each faunal group from the Wollongong Area and the Sydney Basin Bioregion. A complete species list is given as Appendix C.

	Wollongong Study Area		Sydney Basin Bioregion	
Species Group	Native	Introduced	Native	Introduced
Frogs	23	0	41	1
Reptiles	45	0	93	0
Birds	309	10	418	13
Bats	10	0	30	0
Other Mammals	44	11	72	13
Total	440	21	654	27

The Wollongong Area is a meeting place for north and south coast mesic forests and this is reflected in the diversity of rainforest fauna species encountered. Typical north coast species, such as the Green Catbird are found alongside species of the southern temperate forests, such as the Highlands Forest-skink. The diversity of the area is further enhanced by the presence of Sydney Sandstone species, including many threatened species, such as the Broad-headed Snake and Red-crowned Toadlet, which are confined to the plateau region above Wollongong. Finally, the alluvial flats and coastal areas of Wollongong supports a variety of coastal forest, shore dwelling, wetland and pelagic species. This diversity of environments is the factor driving the diversity of faunal species that are present in the Wollongong area.

4.1.2 Taxonomic Issues

This study has highlighted several issues with the taxonomy of some species that inhabit the Illawarra. It may be that several new species will be recognised from the area within the next few years. This section aims to pre-empt this and address any inconsistencies and variations in species morphology, call or ecology that were encountered.

Green Stream Frog

The Green Stream Frogs (previously all known as *Litoria phyllochroa*) are small, light green tree frogs common on flowing creeks of the Wollongong Escarpment and Plateau. There are two forms of the Green Stream Frog in Wollongong with slight physical differences and highly distinctive mating calls. In the literature these have previously been known as the northern and southern call-races of *L. phyllochroa* (Barker *et al.* 1995). The northern call-race extends from the Plateau area of Wollongong to northern NSW and the southern call-race extends from Stanwell Park to Victoria. There is now increasing acceptance of these being two species, the northern remaining known as

Litoria phyllochroa and the southern as *L. nudidigitus* (Donnellan *et al.* 1999). Wollongong, as the area of geographical overlap, is of particular significance to the taxonomy of these species.

The current survey found *L. phyllochroa* at most flowing creeks above the escarpment and *L. nudidigitus* along the escarpment and below it. Out of 30 sites where one or the other of these species was found, there was only a single locality where both were heard. This was at a ford behind Mount Kembla near Upper Cordeaux Dam Number One. Both species were calling from different parts of the stream bank. There were no calls that appeared a hybrid of the two, with all calls distinctly *L. phyllochroa* or *L. nudidigitus*. This is one of the lowest points in the escarpment and an area of considerable overlap between northern and southern vegetation communities (D. Connolly pers. comm.). It is the only part of Wollongong where *L. nudidigitus* was found above the escarpment. *L. phyllochroa* was never found below the escarpment. The Atlas of NSW Wildlife currently does not have a separate species code for *L. nudidigitus* meaning the two species have been listed together within the database and at the end of this document.

Eastern Water-skink

The Eastern Water-skink (*Eulamprus quoyii*) is a robust water-loving skink found along the coast and ranges Eastern Australia except for the southern-most corner. Herpetologists have long-suspected that this is a composite species (G. Shea pers. comm.) and preliminary analyses at the Australian National University (ANU) have supported this (S. Keogh pers. comm.). The Water-skink that occurs in Wollongong does not fit the description given in Cogger (1996) due to the spots it has on its head, back and cheeks and lack of an immaculate dorso-lateral stripe. It is a darker-coloured animal in general with a slightly different body shape to those water-skinks found north of Sydney Harbour. Within this report, this species has been called *E. quoyii*, as this is the species it is closest to. However, in the past considerable confusion has arisen and people have variously classified this animal as *E. heatwolei* and *E. tympanum* though neither of these occur within Wollongong LGA.

Genetic samples from the Wollongong animals will be sent to the Keogh lab at ANU and results will hopefully clarify the uncertainty surrounding the taxonomy of this animal.

Pale-flecked Garden Sunskink

The Pale-flecked Garden Sunskink (*Lampropholis guichenoti*) is a common species of Wollongong. It is a small litter-dwelling lizard that is particularly abundant on the coastal plain. Previously there has been a similar but much larger version described from the Wollongong foothills and coastal plain (R. Wells, pers. comm.). However, this classification is yet to be accepted by the broader scientific community.

During this survey the majority of the *L. guichenoti* found were typical of those found elsewhere. However, an unusual individual was found near Marshall Mount in Coastal Grassy Red Gum Forest. The skink was similar in most respects to *L. guichenoti* but approximately twice the size. Future genetic studies will clarify if this is a variant of *L. guichenoti*, or a separate species. If this large *Lampropholis* is a separate species it appears to be extremely rare in the Wollongong area and may be of conservation concern.

Mountain Brushtail Possum

Recent work on the Mountain Brushtail Possum (*Trichosurus caninus*) has found it to be two species (Lindenmayer *et al.* 2002). This paper proposes that the northern of the two species (known from the Central Coast of NSW north) retain the scientific name *T. caninus* but be referred to colloquially as the Short-eared Possum. The longer-eared southern species has been given the scientific name *T. cunninghami* but retains the

common name Mountain Brushtail Possum. This paper does not clearly identify a region of overlap or a boundary between the two species. Since publication of this paper trapping has identified animals in the Kangaroo Valley area as *T. cunninghami* (D. Lindenmayer, pers. comm.). As Kangaroo Valley is part of the Illawarra Escarpment, it is highly likely that the Mountain Brushtail of the Wollongong Area are also this newly described species. Nevertheless, this research is new and was not available at the time the surveys were taking place, therefore animals encountered in this survey have been classified and lodged in the Atlas of NSW Wildlife as *T. caninus* and can be changed to *T. cunninghami*, if necessary, at a later date.

4.2 HABITAT MODELLING

Habitat models were created for 29 priority species known to occur in the Wollongong Area (Table 4). For many species statistical generalised linear models (6 species) or generalised additive models (7 species) were developed. For the remainder expert derived models were developed by mapping known habitat preferences (16 species). The results of the modelling process, including the mathematical species-habitat relationships are given in Appendix D.

The majority of models were based on what is known as 'presence only' data which uses all available records. The only species that was modelled using presence-absence data was the Highlands Forest-skink, which is reliably found in suitable habitat - an essential feature of a species that is to be modelled using this type of data. For this project, presence-only data was found to produce a model that of better fit to the species records.

Priority species habitat models were ranked as to their predictive ability as either adequate, good, very good or excellent. The maps of the models, along with profiles of the priority species of the Wollongong Area, are given in the Priority Species Profiles in section 5 of this report.

Table 4: List of priority species of the Wollongong Area for which models were developed. Includes the model type and an evaluation of the predictive ability of the model.
GAM = Generalised Additive Modelling, GLM = Generalised Linear Modelling,
PO = presence only, PA = presence absence

Common Name	Scientific Name	Model Type	Data Type	Evaluation of Model Quality
Giant Burrowing Frog	*Heleioporus australiacus*	Habitat		Good
Stuttering Frog	*Mixophyes balbus*	Habitat		Good
Red-crowned Toadlet	*Pseudophryne australis*	GAM	PO	Adequate
Green and Golden Bell Frog	*Litoria aurea*	Habitat		Very Good
Rosenberg's Goanna	*Varanus rosenbergi*	Habitat		Very Good
Highlands Forest-skink	*Nannoscincus maccoyi*	GAM	PA	Excellent
Golden-crowned Snake	*Cacophis squamulosus*	GAM	PO	Very Good
Broad-headed Snake	*Hoplocephalus bungaroides*	GLM	PO	Good
Australasian Bittern	*Botaurus poiciloptilus*	Habitat		Adequate
Black Bittern	*Ixobrychus flavicollis*	Habitat		Adequate
Swift Parrot	*Lathamus discolor*	Habitat		Good
Ground Parrot	*Pezoporus wallicus*	Habitat		Adequate
Pheasant Coucal	*Centropus phasianinus*	Habitat		Adequate
Powerful Owl	*Ninox strenua*	GAM	PO	Adequate
Sooty Owl	*Tyto tenebricosa*	GLM	PO	Excellent
Red-browed Treecreeper	*Climacteris erythrops*	Habitat		Good
Regent Honeyeater	*Xanthomyza phrygia*	Habitat		Adequate
Eastern Bristlebird	*Dasyornis brachypterus*	Habitat		Adequate
Logrunner	*Orthonyx temminckii*	GAM	PO	Good

Common Name	Scientific Name	Model Type	Data Type	Evaluation of Model Quality
Olive Whistler	*Pachycephala olivacea*	Habitat		Good
Green Catbird	*Ailuroedus crassirostris*	GLM	PO	Very Good
Grey Currawong	*Strepera versicolor*	GLM	PO	Very Good
Platypus	*Ornithorhynchus anatinus*	Habitat		Adequate
Eastern Pygmy-possum	*Cercartetus nanus*	GLM	PO	Good
Greater Glider	*Petauroides volans*	GLM	PO	Good
Long-nosed Potoroo	*Potorous tridactylus*	Habitat		Adequate
Mountain Brushtail Possum	*Trichosurus caninus*	GAM	PO	Good
Grey-headed Flying-fox	*Pteropus poliocephalus*	GAM	PO	Adequate
Large-footed Myotis	*Myotis adversus*	Habitat		Good

4.3 FAUNAL ASSEMBLAGES

4.3.1 *Introduction to Faunal Assemblages*

Faunal assemblages classify wildlife into groups of species that have similar habitat requirements and are found together in the environment. Faunal assemblages are a similar concept to vegetation communities and can be utilised in the same way. Maps of faunal assemblages are based on vegetation maps once fauna data has been related to broad vegetation groups.

Faunal assemblages are derived primarily from the more common species, as are vegetation communities. For the faunal groups analysed there were up to nine assemblages found in the Wollongong area. This is likely to be a minimum, with many of the subtleties in species composition that occur between habitats not statistically discernible. Nevertheless, assemblages are a useful tool for planning as they allow an assessment to be made of the reservation status of more than just threatened species. In the Wollongong Area, some Assemblages of species are well protected while others are very poorly represented in reserves.

For this project, faunal assemblages were derived by relating fauna species to ten broad habitat types. The broad habitat types that were tested, using the ANOSIM procedure, are listed in Table 5. Also shown are the different vegetation communities within each of the broad habitat types, assigned using the vegetation mapping (NPWS 2002a, NPWS 2003). The number of sites conducted in a vegetation community is also given in Table 5. Where there were no sites in a vegetation community but that vegetation community was clearly one of the broad habitat types tested, that vegetation community was included in the assemblage map. For example, no bird sites were conducted in Low Woronora Heathland, yet this vegetation community is clearly part of the Heaths and Sedgelands broad habitat group. Therefore, the Heaths and Sedgelands Bird Assemblage is surmised to occur there.

Table 5: Listed in bold are the broad habitat types of the Wollongong LGA and the vegetation communities (as listed in NPWS 2002a) that fall under this classification. Example localities are given for each broad habitat type. For the four faunal groups analysed, the number of sites and which vegetation community they were in is also listed

Vegetation Communities	Example Localities of Broad Habitat Type	Spotlight sites	Diurnal Bird Sites	Reptile Sites	Harp Trap Sites
HEATHS AND SEDGELANDS					
Upland Swamps: Banksia Thicket	Maddens Plains	2	2		
Upland Swamps: Mallee-Heath	Stockyard Swamp		2		
Upland Swamps: Sedgeland-Heath Complex		5	10		
Woronora Tall Mallee-Heath		1	2	1	
Dwarf Apple Heath			1		
Rock Pavement Heath			1	1	
Rock Plate Heath-Mallee			1	4	

Vegetation Communities	Example Localities of Broad Habitat Type	Spotlight sites	Diurnal Bird Sites	Reptile Sites	Harp Trap Sites
Budawang Ash Mallee Scrub					
Low Woronora Heathland					
Plateau Mallee-Heath Complex					
Sandstone Heath					
Upland Swamps: Tea-Tree Thicket					
SANDSTONE WOODLANDS					
Exposed Sandstone Scribbly Gum Woodland	Helensburgh West	20	21	19	10
Sandstone Heath-Woodland	Stanwell Tops	3	2	1	2
Silvertop Ash Ironstone Woodland	Summit Tank	1	2		
Upland Swamps: Fringing Eucalypt Woodland		3	3		1
Exposed Hawkesbury Scribbly Gum Woodland					
Highland Sandstone Swamp Woodland					
Nepean Enriched Sandstone Woodland					
SANDSTONE GULLY FORESTS					
Escarpment Edge Silvertop Ash Forest	Flat Rock Creek	1	1	1	
Sandstone Gully Apple-Peppermint Forest	Shores of Lake Woronora	5	3	5	2
Sandstone Gully Peppermint Forest		9	7		4
Western Sandstone Gully Forest		1		1	
Nepean Sandstone Gully Forest			2		1
Sheltered Hawkesbury Apple-Peppermint Forest					
TALL OPEN FORESTS					
O'Hares Creek Shale Forest	Darkes Forest	2	3		2
Tall Dry Forest (Garrawarra)	Upper Cordeaux Dams	2		1	2
Tall Open Blackbutt Forest		4	2		
Tall Open Gully Gum Forest		5	4	2	1
Tall Open Peppermint-Blue Gum Forest		5	5	2	1
Highlands Shale Tall Open Forest			1	1	
Shale Ridge Forest					1
Tall Blackbutt-Apple Shale Forest					
Bulgo Forest					
MOIST EUCALYPT FORESTS					
Escarpment Blackbutt Forest	Stanwell Park	7	8	5	3
Escarpment Moist Blue Gum Forest	Gibson Walking	4	2	1	3
Moist Box-Red Gum Foothills Forest	Track, Thirroul	4	5	4	
Moist Coastal White Box Forest	Woonona Heights	3	4	3	5
Moist Gully Gum Forest	Coniston Woodland	2	2	2	1
Moist Blue Gum-Blackbutt Forest		3	2	1	1
Moist Shale Messmate Forest			2		
Moist Brown Barrel Forest				1	
Robertson Basalt Brown Barrel Forest					
COASTAL GRASSY ENVIRONMENTS					
Coastal Grassy Red Gum Forest	All Yallah remnants	2	2	2	3
Lowland Woollybutt-Melaleuca Forest	Calderwood Valley	2	6	5	2
Coastal Headland Grassland	Marshall Mount			1	
Beach Sands Spinifex	Wiseman's Park			1	
MOIST COASTAL VEGETATION					
Coastal Sand Bangalay-Blackbutt Forest	Puckey's Estate	2	1	2	
Exposed Bangalay-Banksia Woodland	Windang Peninsula	1			
Littoral Windshear Thicket	Berkeley NR	3	1	2	
Coastal Sand Scrub	Bellambi Point		1		
Coastal Swamp Oak Forest			6		
Hind-Dune Littoral Rainforest					
Alluvial Swamp Mahogany Forest					
Coastal Sand Swamp Mahogany Forest					
RAINFORESTS					

Vegetation Communities	Example Localities of Broad Habitat Type	Spotlight sites	Diurnal Bird Sites	Reptile Sites	Harp Trap Sites
Coachwood Warm Temperate Rainforest	Mt. Keira Road	4	9	6	4
Illawarra Escarpment Subtropical Rainforest	Clive Bissel Drive	6	7	6	2
Lowland Dry-Subtropical Rainforest	Lady Wakehurst Dr	1	2	1	1
Robertson Cool-Warm Temperate Rainforest	Mt. Kembla				
Cliffline Coachwood Scrub	Scarborough Rainforest				
Sandstone Riparian Scrub					
MODIFIED ENVIRONMENTS					
Cleared (non urban)	Parkland, Paddocks		5		
Weeds and Exotics	Vegetated Gardens		1		
Coal implacements etc	Weed infestations				
CREEKLINES					
All creeks with permanent water	Bellambi Creek			18	13
	Towradgi Creek				
Total Sites		113	141	100	65

4.3.2 *Diurnal Birds*

There were significant differences in the bird assemblages found within all tested habitat types of the Wollongong Area (creeklines were not analysed for birds). The results of an ANOSIM examining the birds of nine major habitat types are given in Table 6. Species richness, diversity and typical species are listed in Table 7 and displayed graphically as Map 4. Vegetation communities that are mapped as supporting these assemblages, along with sample locations, are given in Table 5.

Modified Vegetation was found to have a unique assemblage of birds that exist within the weedy and often isolated environments of the coastal plain. For example, this bird assemblage might be associated with stands of Coral Tree (*Erythrina x*) or Camphor Laurel (*Cinnamomum camphorum*) near a creekline or in an open environment. Such environments had the highest species richness (average of 18 species per site) but only a moderate level of diversity, which is probably a better indication of its value to wildlife. The high level of species richness was in part due to the large number of introduced species, such as Spotted Turtle-dove (*Streptopelia chinensis*). This assemblage was defined by the presence of up to five introduced species per site and of native birds that are typical of modified environments, such as the Magpie-lark (*Grallina cyanoleuca*) (Table 7).

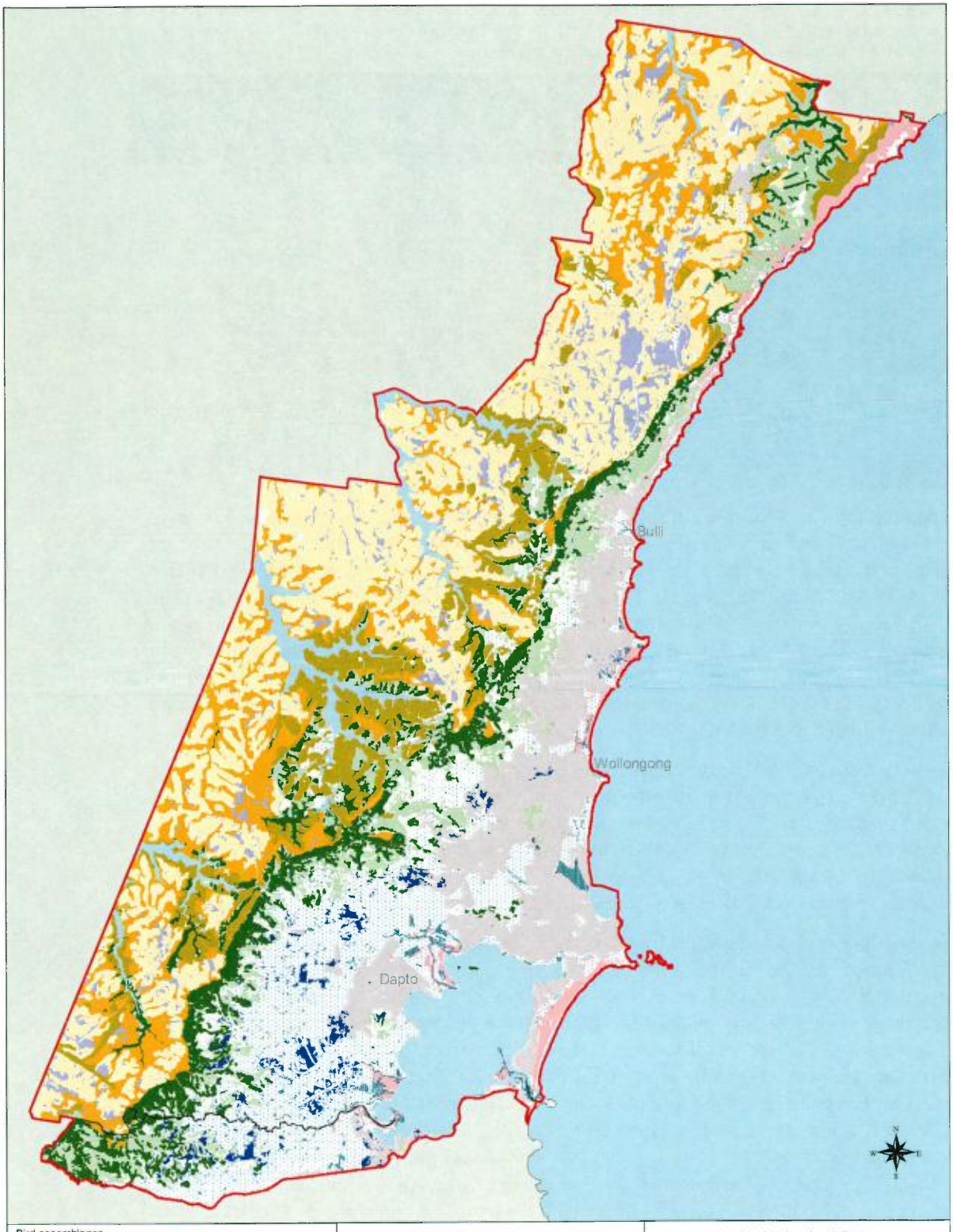
The Coastal Grassy Forests Bird Assemblage was found in the remnant grassy forests of the coastal plain of Wollongong, such as Yallah and the Calderwood Valley floor. It was characterised by bird species that prefer open environments, such as the Black-faced Cuckoo-shrike (*Coracina novaehollandiae*) and Eastern Rosella (*Platycercus eximius*). While many of the species in this assemblage are the large, aggressive birds that are typically associated with disturbed woodlands (such as the Noisy Miner (*Manorina melanocephala*) and Grey Butcherbird (*Cracticus torquatus*)), there was also an abundance of smaller species such as the White-throated Gerygone (*Gerygone olivacea*), Mistletoebird (*Dicaeum hirundinaceum*) and Yellow Thornbill (*Acanthiza nana*). Overall, this assemblage was among the more species-rich and diverse of the entire region and unlike the other coastal assemblages, did not feature either introduced species or waterfowl. Since European settlement this assemblage has suffered more than any other in the Wollongong Area as the majority of its habitat was cleared for farming and over 95 percent of what remains lies outside the formal reserve system (Table 8).

The Moist Coastal Vegetation Bird Assemblage occurs in within the moister native vegetation along the coastline zone, such as at Puckey's Estate or Burning Palms. This is the assemblage with the smallest area, though it is well-protected in reserves, particularly Royal NP (Table 8). The community is dominated by smaller species, such as Silvereye

(*Zosterops lateralis*) and White-browed Scrubwren (*Sericornis frontalis*), and also has the introduced Red-whiskered Bulbul present (Table 7). These birds may be utilising the dense foliage or fruit rainforest plants such as the Lilli Pilli (*Acmena smithii*) or the weeds that are often present in these areas, such as Lantana (*Lantana camara*) and Bitou Bush (*Chrysanthemoides monilifera*).

The Moist Eucalypt Forests Bird Assemblage refers to the suite of bird species that inhabit the more open mesic eucalypt forests of the escarpment such as along Lady Wakehurst Drive in Royal NP, the Blue Gum Forest at Woonona Heights and the Moist Box-Red Gum Foothills Forest of Avondale. This assemblage is characterised by rainforest edge birds, such as Lewin's Honeyeater (*Meliphaga lewinii*). It is one of the most widespread assemblages of the Wollongong Area and the one that people proximate to bushland near the escarpment will have in their backyard.

The Rainforest Bird Assemblage was found in all the rainforests of the Study Area other than the rainforests that are part of the Littoral Windshear Thickett vegetation community (which aligns more closely with the other mesic coastal environments). Examples of where the Rainforest Bird Assemblage can be found at Mount Kembla and at the back of the Calderwood Valley. This assemblage also occurs where there are eucalypt emergents and a well developed, subtropically influenced rainforest understorey. Although the bird assemblages of all these vegetation communities



Bird assemblages

1. Modified Vegetation
2. Coastal Grassy Vegetation
3. Moist Coastal Vegetation
4. Rainforests
5. Moist Eucalypt Forests
6. Tall Open Forests
7. Sandstone Gully Forests
8. Sandstone Woodlands
9. Heaths and Sedgelands

Wetlands

Major waterbody

Study area boundary

Local Government Area boundary

Unsampled Vegetation

Built-up area

Creek or river

Motorway or highway

Other major road

Map 4

Diurnal bird assemblages of the Wollongong area

derived from systematic bird survey sites

Wollongong LGA Bioregional Assessment

Fauna of the Illawarra Escarpment, Coastal Plain and Plateau

0 1 2 3 4 5 Kilometres

Scale 1:150000 (on A3 layout)

Map projection consistent with Australian Map Grid Zone 56

Prepared by N. Corfield
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002

Table 6: Similarity matrix of the birds of the main habitat types in the Wollongong Area, based on presence-absence data. Listed is the R statistic from an ANOSIM of diurnal bird census data, and its significance level (* P<0.05, ** P<0.01; *** P<0.001). All habitat types were significantly different from one another. Number of sites for each assemblage shown as n.

	Modified Vegetation (n=6)	Coastal Grassy Forests (n=8)	Moist Coastal Vegetation (n=9)	Rainforests (n=18)	Moist Eucalypt Forests (n=25)	Tall Open Forests (n=15)	Sandstone Gully Forests (n=13)	Sandstone Woodlands (n=28)	Heaths and Sedgelands (n=19)
Modified Vegetation									
Coastal Grassy Forests	0.39**								
Moist Coastal Vegetation	0.73**	0.62***							
Rainforests	0.99***	0.89***	0.68***						
Moist Eucalypt Forests	0.68***	0.61***	0.26**	0.12**					
Tall Open Forests	1.00***	0.71***	0.85***	0.72***	0.15**				
Sandstone Gully Forests	0.98***	0.69***	0.84***	0.77***	0.30***	0.14**			
Sandstone Woodlands	0.91***	0.72***	0.72***	0.82***	0.52***	0.16**	0.11		
Heaths and Sedgelands	0.67***	0.59***	0.45***	0.78***	0.57***	0.40***	0.22**	0.16***	

supported typical rainforest birds such as the Brown Gerygone (*Gerygone mouki*), there was a significant difference between the assemblage of the Illawarra Escarpment Subtropical Rainforest and the Coachwood Warm Temperate Rainforest (ANOSIM R = 0.218; P<0.05). The Subtropical Rainforest has a higher frequency of birds such as the Black-faced Monarch (*Monarcha melanopsis*), Brown Cuckoo-dove (*Macropygia amboinensis*) and Green Catbird. Temperate Rainforest was more likely to have Grey Fantail (*Rhipidura albiscapa*) and White-browed Scrubwren whereas Subtropical Rainforest was more likely to have the closely related Rufous Fantail (*R. rufifrons*) and Yellow-throated Scrubwren (*S. citreogularis*).

Rainforest occurs both above and below the escarpment in the Wollongong LGA. An ANOSIM was conducted to investigate if there were any significant differences in the bird assemblage in the rainforests above or below the escarpment. Although the Logrunner, Green Catbird and Bassian Thrush (*Zoothera lunulata*) are mostly found below the escarpment, when all species were considered there was little difference between the bird assemblage above or below (ANOSIM, R = 0.073; P=not significant).

The last four bird assemblages are wholly confined to the sandstone plateau area (Map 4). These are the Bird Assemblages of the Sandstone Woodlands, Heaths and Sedgelands, Tall Open Forests and Sandstone Gully Forests (Table 7). These assemblages have many similarities, such as a high frequency of Brown Thornbill (*Acanthiza pusilla*), although there are also many differences. Sandstone Woodlands, Sandstone Gully Forests and Heaths and Sedgelands have the lowest species richness and diversity scores (average of 9 species per site), whereas the Tall Open Forests Bird Assemblage has amongst the highest (Table 6). The Heaths and Sedgelands Bird Assemblage also has a variety of species that were found not recorded elsewhere, such as Southern Emu-wren (*Stipiturus malachurus*), Tawny-crowned Honeyeater (*Gliciphila melanops*) and Beautiful Firetail (*Stagonopleura bella*). Within the Study Area, these species are confined to the upland swamps of the Maddens Plains and other ridgetop heathlands. Overall, the Sandstone Woodland and Tall Open Forests assemblages are some of the best conserved within the Wollongong area (Table 8). Much of the Heaths and Sedgelands Bird Assemblage, however, is at Maddens Plains of which a sizeable portion is privately owned. This is especially important given the high number of priority bird species that do not occur elsewhere, and the probable

Table 7: The nine principal assemblages of birds in the Wollongong Area, based on presence-absence data. Species richness and diversity analysis, and an exploratory procedure where SIMPER was used to define the species typical of an assemblage are listed. *Typical Species* are those that, in combination, account for 90 percent of the variability within an assemblage. The proportion of sites at which they occurred is given in parentheses. Introduced species have been indicated in grey. For scientific names refer to Appendix C.

Assemblage	Richness (Mean no. of species per site)	Diversity (Shannon H')	Typical Species (% of sites present)
1. Modified Vegetation	18	3.15	Yellow Thornbill (100%), Spotted Turtle-dove (100%), Silvereye (83%), Magpie-lark (83%), Australian Magpie (83%), Red-whiskered Bulbul (83%), New Holland Honeyeater (67%), Superb Fairy-wren (67%), Willie Wagtail (67%), Common Myna (67%), Little Wattlebird (50%), House Sparrow (50%), Australian Reed-warbler (50%), Eastern Spinebill (50%), Channel-billed Cuckoo (33%), Australian Raven (33%), White-browed Scrubwren (33%), Eastern Yellow Robin (33%), European Goldfinch (33%), Noisy Miner (33%)
2. Coastal Grassy Forests	12	3.23	Yellow Thornbill (75%), Mistletoebird (63%), Grey Butcherbird (63%), Noisy Miner (50%), Eastern Rosella (50%), White-throated Gerygone (50%), Rufous Whistler (50%), Yellow-faced Honeyeater (50%), Grey Fantail (50%), Eastern Yellow Robin (50%), Silvereye(38%), Brown Thornbill (38%), Black-faced Cuckoo-shrike (38%), Spotted Pardalote (38%)
3. Moist Coastal Vegetation	10	2.66	Red-whiskered Bulbul (100%), Silvereye (100%), White-browed Scrubwren (89%), Grey Fantail (67%), Eastern Yellow Robin (56%), Superb Fairy-wren (56%), Yellow Thornbill (44%), Brown Gerygone (33%), Golden Whistler (33%)
4. Rainforests	13	3.17	Brown Gerygone (94%), Golden Whistler (83%), Lewin's Honeyeater (78%), Grey Fantail (67%), Yellow-throated Scrubwren (67%), Brown Thornbill (61%), Eastern Whipbird (67%), Black-faced Monarch (67%), Silvereye (56%), Rufous Fantail (56%), White-browed Scrubwren (56%), Eastern Yellow Robin (44%), Brown Cuckoo-dove (44%), Satin Bowerbird (39%), Crimson Rosella (33%)
5. Moist Eucalypt Forests	13	3.51	Lewin's Honeyeater (76%), White-browed Scrubwren (76%), Grey Fantail (68%), Golden Whistler (60%), Brown Gerygone (52%), Eastern Yellow Robin (52%), White-throated Treecreeper (52%), Eastern Spinebill (52%), Eastern Whipbird (52%), Brown Thornbill (48%), Black-faced Monarch (48%), Crimson Rosella (48%), Silvereye (44%), Spotted Pardalote (44%), Striated Thornbill (40%)
6. Tall Open Forests	13	3.18	Grey Fantail (100%), Brown Thornbill (93%), Eastern Spinebill (87%), White-browed Scrubwren (87%), White-throated Treecreeper (87%), Spotted Pardalote (67%), Yellow-faced Honeyeater (60%), Crimson Rosella (53%), Rufous Whistler (53%), Striated Thornbill (47%), Golden Whistler (47%), Variegated Fairy-wren (40%), Pied Currawong (40%)
7. Sandstone Gully Forests	9	3.05	Brown Thornbill (100%), Grey Fantail (77%), Spotted Pardalote (62%), White-throated Treecreeper (62%), Eastern Spinebill (54%), Grey Shrike-thrush (54%), Golden Whistler (54%), Rufous Whistler (46%), Variegated Fairy-wren (38%), Eastern Yellow Robin (38%), White-browed Scrubwren (38%)
8. Sandstone Woodlands	9	3.11	Brown Thornbill (82%), Eastern Spinebill (82%), Grey Fantail (68%), New Holland Honeyeater (68%), Rufous Whistler (61%), Crimson Rosella (46%), White-throated Treecreeper (43%), Variegated Fairy-wren (39%), Little Wattlebird (39%), White-browed Scrubwren (36%), Eastern Yellow Robin (36%), White-eared Honeyeater (32%)
9. Heath and Sedgelands	8	3.11	New Holland Honeyeater (84%), Grey Fantail (53%), Rufous Whistler (53%), Eastern Spinebill (47%), Brown Thornbill (42%), Variegated Fairy-wren (37%), Eastern Yellow Robin (37%), Superb Fairy-wren (37%), White-browed Scrubwren (32%), Little Wattlebird (32%), Southern Emu-wren (16%)

Table 8: Reservation status of the nine bird assemblages that were identified within the Wollongong Area.

Bird Assemblage Name	Area in Study Area (ha)	Percentage of Study Area (%)	Area in NP (ha)	Area in SCA (ha)	Area in SF (ha)	Area in WCC (ha)	Percentage of Assemblage Reserved (%)
1. Modified Vegetation	12404	16.3	129	779	3	1367	11.3
2. Coastal Grassy Environments	1254	1.7	0	0	0	53	4.3
3. Moist Coastal Vegetation	1108	1.5	365	0	0	314	61.3
4. Rainforests	4152	5.5	1044	1039	28	103	53.3
5. Moist Eucalypt Forests	7352	9.7	1560	1570	49	263	46.8
6. Tall Open Forests	4384	5.8	270	3453	0	1	84.9
7. Sandstone Gully Forests	9040	11.9	711	7383	77	11	90.5
8. Sandstone Woodlands	15323	20.1	1276	12645	9	14	91.0
9. Heath and Sedgelands	5069	6.7	463	4004	7	5	88.4

extinction of the Eastern Bristlebird and Ground Parrot from these habitats in Wollongong already.

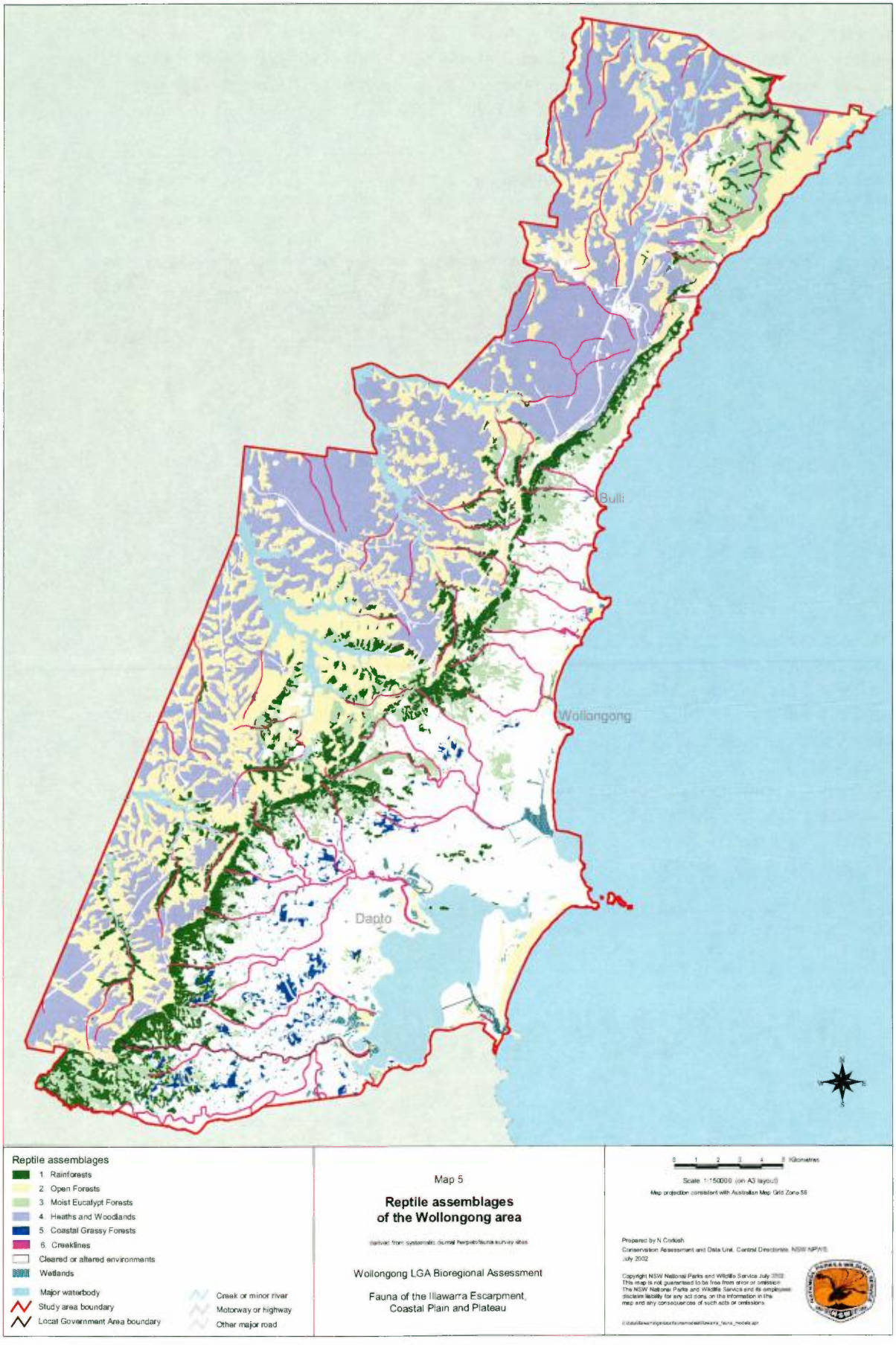
4.3.3 *Reptiles*

There were six distinct assemblages of reptiles within the Wollongong Area (Map 5). These were derived from a dendrogram of sites based on a Bray-Curtis similarity matrix. This was a more effective way of defining reptile assemblages, when there was a cut-off of 30 percent similarity, than the ANOSIM of the apriori defined broad habitat types (Table 9). The species that make up the six reptile assemblages of the Wollongong Area are given in Table 10, along with the average species richness and diversity. Most of the reptile assemblages are fairly well conserved within the Wollongong Area (Table 11). The exception to this is the Coastal Grassy Environments Reptile Assemblage that is not found in either NPWS or SCA estate (Table 11, Map 5).

The Coastal Grassy Environments Reptile Assemblage occurs in the grassed environments, forested and otherwise, of the Wollongong coastal plain and foothills. This Assemblage had a fairly low species diversity and richness and was typified by large numbers of the Pale-flecked Garden Sunskink (*Lampropholis guichenoti*) and a high frequency of the Jacky Lashtail (*Amphibolurus muricatus*), a species that was not a feature of any other assemblage (Table 10). Both these species prefer open environments and are well suited to the remnant vegetation of the Wollongong Coastal Plain. The ubiquitous Dark-flecked Sunskink (*L. delicata*) was also present, although at a far lower frequency and abundance than elsewhere.

The Rainforests Reptile Assemblage was the least diverse and least species-rich (Table 10). This probably relates to the low light conditions of these environments to which only a couple of species are adapted. The darkest, most subtropically influenced forests were populated by a single species, the Highlands Forest-skink. This is a species of the southern temperate rainforests (see species profile 5.8).

The Moist Eucalypt Forest Reptile Assemblage occurs where there is still a rainforest element to the vegetation, but there is an overstorey of Eucalyptus. These forests, while often very dense, usually have more light than rainforests. The Weasel Shadeskink (*Saproscincus mustelinus*) was a feature of this assemblage. This species is found where there is abundant leaf litter and low light conditions.


Bulli
Wollongong
Dapto
Reptile assemblages
1. Rainforests
2. Open Forests
3. Moist Eucalypt Forests
4. Heaths and Woodlands
5. Coastal Grassy Forests
6. Creeklines
Cleared or altered environments
Wetlands
Major waterbody
Study area boundary
Local Government Area boundary
Creek or minor river
Motorway or highway
Other major road
Map 5
Reptile assemblages of the Wollongong area
derived from systematic diurnal herpeto/fauna survey sites
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment, Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corkish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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disclaim liability for any act done, on the information in the
map and any consequences of such acts or omissions.

The next Assemblage was the Open Forests Assemblage, one of the most widespread Reptile Assemblages of the Wollongong Area. This Assemblage was found at the majority of reptile sites from the Sandstone Gully Forests, Tall Open Forests and Moist Coastal Vegetation and they grouped together in the dendrogram. This assemblage was characterised by a high frequency of the Yellow-bellied Three-toed Skink (*Saiphos equalis*) and the Dark-flecked Sunskink (Table 10).

Table 9: Similarity matrix of the nine habitat types for reptiles in the Wollongong Area, based on presence-absence data. Listed is the R statistic from an ANOSIM of diurnal herpetofauna census data, and its significance level (* P<0.05, ** P<0.01; *** P<0.001, NS = not significant). Five types were significantly different from one another. Number of sites for each assemblage shown as n.

	Coastal Grassy Environments (n=9)	Moist Coastal Vegetation (n=4)	Rainforests (n=13)	Moist Eucalypt Forests (n=17)	Tall Open Forests (n=6)	Sandstone Gully Forests (n=7)	Sandstone Woodlands (n=20)	Heaths and Sedgelands (n=6)	Creeklines (n=18)
Coastal Grassy Environments									
Moist Coastal Vegetation	0.60**								
Rainforests	0.68***	0.53**							
Moist Eucalypt Forests	0.31**	NS	0.15*						
Tall Open Forests	0.56**	NS	0.55***	NS					
Sandstone Gully Forests	0.69**	NS	0.60***	NS	NS				
Sandstone Woodlands	0.68***	0.70***	0.84***	0.57***	0.55***	0.44***			
Heaths and Sedgelands	0.85**	0.87**	0.71***	0.46***	0.79**	0.68**	NS		
Creeklines	0.56***	0.42**	0.83***	0.39***	0.57***	0.68***	0.75***	0.95***	

The dendrogram of reptile sites showed there was little difference between species found in heaths and woodlands. At a similarity of 30 percent they were grouped as the Heaths and Woodlands Reptile Assemblage. This was by far the most species rich and diverse of the Reptile Assemblages. This assemblage was found in all the exposed, rocky Hawkesbury Sandstone Woodlands and Heaths of the Plateau. There were many species found here that were not encountered elsewhere (Table 10). In part this has to do with the ease of detection of reptiles in areas with a large proportion of rock, but nevertheless the large amount of shelter afforded by rocky environments leads to an abundant reptile fauna. This assemblage was the best protected in the Wollongong Area with over 90 percent occurring on land with some level of reservation (Table 11).

Table 10: The six principal assemblages of reptiles in the Wollongong Area, based on presence-absence data. Species richness and diversity analysis, and an exploratory procedure where SIMPER was used to define the species typical of an assemblage. *Typical Species* are those that, in combination, account for 90 percent of the variability within an assemblage. The proportion of sites at which they occurred is given in parentheses. For scientific names refer to Appendix C.

Assemblages	Richness (av. No. species per site)	Diversity (Shannon H')	Typical Species (% of sites present)
1.Coastal Grassy Environments	2	0.91	Pale-flecked Garden Skink (91%), Jacky Lashtail (55%), Dark-flecked Garden Skink (45%)
2.Rainforests	1	0.35	Highlands Forest-skink (100%)
3.Moist Eucalypt Forests	2	1.25	Weasel Shadeskink (100%), Dark-flecked Garden Skink (36%)
4.Open Forests	2	1.12	Yellow-bellied Three-toed Skink (84%), Dark-flecked Garden Skink (68%)
5.Heaths and Woodlands	4	2.15	Copper-tailed Ctenotus (73%), Dark-flecked Garden Skink (77%), Lesueur's Velvet Gecko (50%), Red-throated Cool-skink (46%), Mountain Heath Dragon (35%)
6.Creeklines	3	1.39	Eastern Water-skink (100%), Dark-flecked Garden Skink (55%), Pale-flecked Garden Skink (45%), Eastern Water Dragon (41%)

Table 11: Reservation status of the six reptile assemblages that were identified within the Wollongong Area.

Reptile Assemblage Name	Area in Study Area (ha)	Percentage of Study Area (%)	Area in NP (ha)	Area in SCA (ha)	Area in SF (ha)	Area in WCC (ha)	Percentage of Assemblage Reserved (%)
1.Coastal Grassy Environments	1254	1.7	0	0	0	53	4.3
2.Moist Eucalypt Forests	7352	9.5	1540	1537	48	258	46.9
3.Heaths and Woodlands	20213	26.6	1720	16508	16	19	90.4
4.Open Forests	14243	18.7	1315	10625	76	324	86.6
5.Rainforests	3987	5.2	1008	973	26	102	52.9
6.Creeklines	1590	2.1	117	687	4	58	54.5

The final assemblage identified was that of the creek environments of the Plateau and Coastal Plain. This assemblage has been named the Creeklines Reptile Assemblage. This assemblage was highly distinctive due to the presence of two water-loving reptiles, the Eastern Water-skink and the Eastern Water Dragon (*Physignathus lesueurii*). The Eastern Water-skink was often in very high numbers, even in creeks and remnant vegetation surrounded by altered environments.

4.3.4 Arboreal Mammals

There are at least seven species of arboreal mammals found in the Wollongong Area. These are the Eastern Pygmy-possum, Feathertail Glider (*Acrobates pygmaeus*), Sugar Glider (*Petaurus breviceps*), Common Ringtail Possum (*Pseudocheirus peregrinus*), Common Brushtail Possum (*Trichosurus vulpecula*), Mountain Brushtail Possum and Greater Glider. For the assemblage analysis the Grey-headed Flying-fox has been included as they occupy a similar niche and are sampled well by spotlighting when feeding in an area.

An ANOSIM of the broad habitat types (Table 5) was not a particularly effective way of discriminating different assemblages of arboreal mammals in the Wollongong area (Table 12). This is for several reasons. The first is the limited number of species present, ANOSIM being more useful where there is a greater number of variables. The second reason is that some arboreal mammals in the Illawarra are responding to variations in the microhabitat (often the understorey) more than they are responding to broad vegetation communities or canopy species. A dendrogram was also fairly ineffective due to the reasons stated above and the number of sites where there were no observations of arboreal mammals. There were differences between habitats, however, and an ANOSIM of the five most basic habitat types (defined apriori) found there to be significant differences (Table13). It is from this that the five assemblages of arboreal mammals have been defined, though with further systematic survey work several more may be determined.

The first arboreal mammal assemblage was the Rainforests Arboreal Mammal Assemblage. The Common Ringtail Possum and, at a lower frequency Sugar Glider, typified this Assemblage. Sugar Glider tended to be in emergent Eucalyptus rather than in the rainforest tree species themselves. Ringtail Possums were mostly found in dense Lilli Pilli (*Acmena smithii*), *Acacia* spp. and other small rainforest trees.

The Moist Eucalypt Forest Arboreal Mammal Assemblage was the most diverse assemblage and the only one to be typified by the Mountain Brushtail Possum and the Grey-headed Flying Fox. The Grey-headed Flying-fox feeds on Blackbutt (*Eucalyptus pilularis*), where it is regularly found in large numbers during flowering events. They will also use Coast Banksia (*Banksia integrifolia* subsp. *integrifolia*) and fruiting rainforest trees. This Assemblage is the least protected in formal reserves in the Wollongong Area (Table 15).

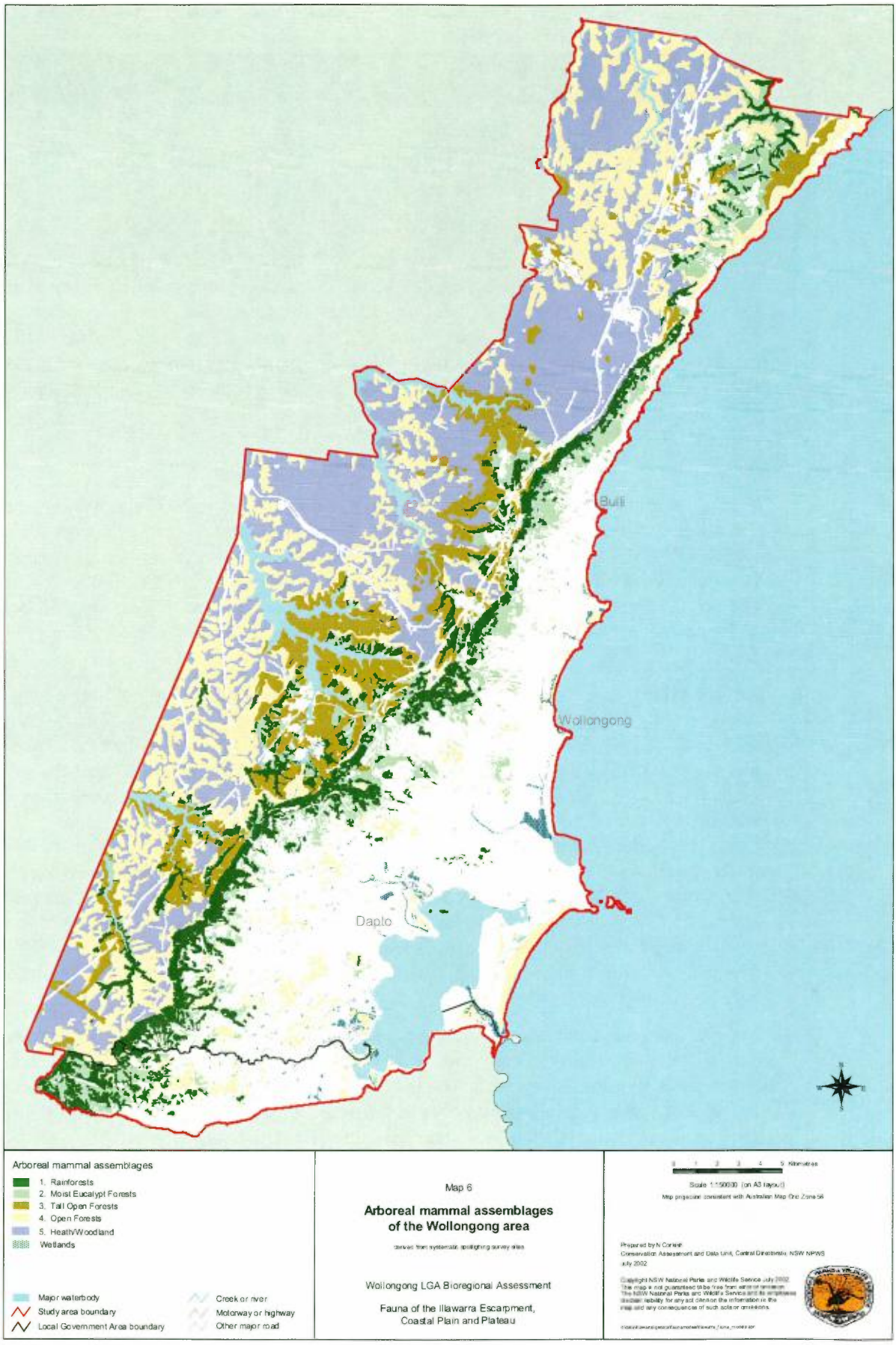

Bulli
Wollongong
Dapto
Arboreal mammal assemblages
1. Rainforests
2. Moist Eucalypt Forests
3. Tall Open Forests
4. Open Forests
5. Heath/Woodland
Wetlands
Major waterbody
Study area boundary
Local Government Area boundary
Creek or river
Motorway or highway
Other major road
Map 6
Arboreal mammal assemblages of the Wollongong area
derived from systematic spotlighting survey sites
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment, Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection: consistent with Australian Map Grid Zone 56
Prepared by N Corkill
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002

Table 12: Similarity matrix from Euclidean Distances of the arboreal mammals of the eight principal habitat types of the Wollongong Area, based on presence-absence data. The R statistic from an ANOSIM of site spotlighting data, and its significance level (* P<0.05, ** P<0.01; *** P<0.001; NS = not significant) is listed. Number of sites for each assemblage shown as n.

	Coastal Grassy Forests (n=4)	Moist Coastal Vegetation (n=6)	Rainforests (n=11)	Moist Eucalypt Forests (n=23)	Tall Open Forests (n=20)	Sandstone Gully Forests (n=14)	Sandstone Woodlands (n=27)	Heaths and Sedgelands (n=8)
Coastal Grassy Forests								
Moist Coastal Vegetation	NS							
Rainforests	NS	NS						
Moist Eucalypt Forests	NS	NS	NS					
Tall Open Forests	NS	NS	0.12*	0.07*				
Sandstone Gully Forests	NS	NS	0.09*	NS	0.09*			
Sandstone Woodlands	NS	NS	0.16*	0.15***	0.23***	NS		
Heaths and Sedgelands	NS	NS	NS	NS	NS	NS	NS	

Table 13: Similarity matrix for Euclidean Distances of the five most basic habitat types of the Wollongong Area, based on presence-absence data. The R statistic from an ANOSIM of site spotlighting data, and its significance level (* P<0.05, ** P<0.01; *** P<0.001; NS = not significant) is listed. Number of sites for each assemblage shown as n.

	Rainforests (n=11)	Moist Eucalypt Forests (n=28)	Tall Open Forests (n=20)	Open Forests (n=24)	Heath/ Woodland (n=35)
1.Rainforests					
2.Moist Eucalypt Forests	NS				
3.Tall Open Forests	0.12*	0.07*			
4.Open Forests	0.10*	0.05*	0.18***		
5.Heath/Woodland	0.11*	0.25***	0.29***	NS	

Table 14: The five principal assemblages of arboreal mammals in the Wollongong Area, based on presence-absence data. Listed are the results of the species richness and diversity analysis, and an exploratory procedure where SIMPER was used to define the species typical of an assemblage. Species that together account for 90 percent of the variability in the assemblage are included. The proportion of sites at which a species was found is given in parentheses. For scientific names refer to Appendix C.

	Richness (Mean No. of species per site)	Diversity (Shannon H')	Typical Species (% of sites present)
1.Rainforest	1	0.98	Common Ringtail Possum (43%), Sugar Glider (21%)
2.Moist Eucalypt Forest	1	1.42	Sugar Glider (35%), Common Ringtail Possum (30%), Mountain Brushtail Possum (26%), Grey-headed Flying-fox (22%)
3.Open Forest	<1	0.63	Sugar Glider (25%), Common Ringtail Possum (15%)
4.Tall Open Forest	1	1.11	Greater Glider (45%), Sugar Glider (20%)
5.Heath/ Woodland	1	0.58	Common Ringtail Possum (36%), Sugar Glider (17%)

The third Arboreal Mammal Assemblage was that of the Open Forests. This assemblage was found in the Sandstone Gully Forests of the Plateau, the Coastal Grassy Forests and the Moist Coastal Environments. It was characterised by a low frequency of any species, with the most commonly encountered species being the Sugar Glider. It is likely that there is a separate assemblage in the Coastal Grassy Forests typified by the Common Brushtail Possum. The Coastal Plain was the only area where Common Brushtail Possum were encountered, however none were detected during systematic survey and hence could not be included in the assemblage analysis. The absence of this species from our systematic dataset is probably because of the limitations to the number of sites that could be conducted on the coastal plain due to the small amount of extant vegetation and restricted access onto private land.

The fourth assemblage occurred where there was tall vegetation on higher fertility soil. These environments are often characterised by an open understorey and a groundcover

dominated by Spiny-headed Mat-rush (*Lomandra longifolia*). This type of habitat is favoured by the Greater Glider and will often support Sugar Gliders as well. The open mid-storey means that the Common Ringtail Possum is absent from these environments. This assemblage is well protected within the Wollongong Area (Table 15).

The last of the five assemblages occurs across the much of vegetated land of the Plateau. This assemblage also had a low rate of detection of any species and is defined by the presence of the Common Ringtail Possum (Table 14). This assemblage is also characterised by low frequencies of the Sugar Glider and the Eastern Pygmy Possum was also found at several sites.

Table 15: Reservation status of the five arboreal mammal assemblages that were identified within the Wollongong Area.

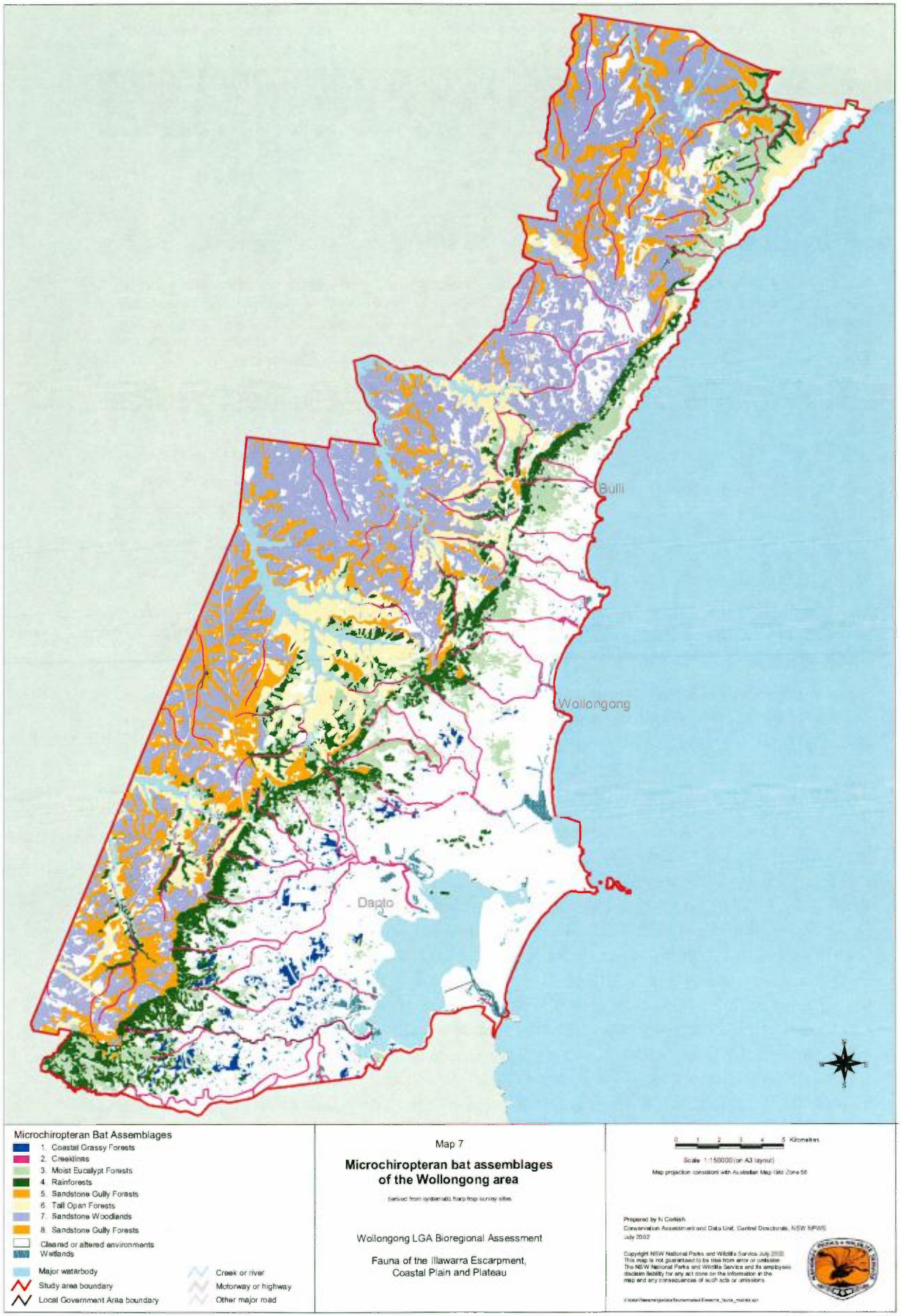
Arboreal Mammal Assemblage Name	Area in Study Area (ha)	Percentage of Study Area (%)	Area in NP (ha)	Area in SCA (ha)	Area in SF (ha)	Area in WCC (ha)	Percentage of Assemblage Reserved (%)
1.Rainforests	4152	5.5	1044	1039	28	103	53.3
2.Moist Eucalypt Forests	7352	9.7	1560	1570	49	263	46.8
3.Open Forests	11419	15.0	1077	7383	77	380	78.1
4.Tall Open Forests	4384	5.8	270	3453	0	1	84.9
5.Heath/Woodland	20392	26.8	1739	16649	16	20	90.3

4.3.5 Microchiropteran Bats

Microchiropteran Bats were unable to be clearly classified into assemblages based on broad vegetation group (Table 16) or a dendrogram of all sites. There are several issues that need to be addressed when using harp-trapping data to define assemblages. The first of these is that harp trapping only samples a proportion of the entire bat community. There are several high-flying species, such as some of the mastiff-bats, that are poorly sampled by this method. This is not a problem for the application of the statistical analyses, so long as harp trapping is equally effective, or ineffective, at sampling a species at every site. It does, however, lead to a smaller number of species on which to base the assemblages. The second problem is that harp trapping does not discriminate between an individual that is using a site, and an individual that is just passing through. This probably leads to a larger amount of noise in the data than is seen with some other methods.

Perhaps as a result of the above-mentioned impediments, it was difficult to discern assemblages of bats that clearly related to the broad vegetation types of Wollongong. The low overall diversity and the large number of sites without captures meant that there was significant amount of noise in the data. Nevertheless, certain species of bats were more likely to be trapped with each another and some vegetation types contained an assemblage of bats that was statistically unique. An increased trapping effort will help to further clarify the situation. Presented here, mostly in the interest of completeness, are the results of an ANOSIM and SIMPER of harp-trapping sites by broad vegetation type (Table 16 and 17). From these results readers may obtain an indication of the species of bats that may be found in a particular vegetation type, and can make their own judgement about the uniqueness, or otherwise, of that assemblage. For example, the Coastal Grassy Forests and Moist Eucalypt Forests appear to have bat assemblages that are quite distinctive (Table 16), while the suites of bat species present at rainforest sites were less unique.

The broad vegetation types that were analysed have been mapped and the species that were most commonly trapped in them listed (Map 7, Table 17). It is important to note that only the assemblages found in the Coastal Grassy Forests and Moist


Bulli
Wollongong
Dapto
Microchiropteran Bat Assemblages
1. Coastal Grassy Forests
2. Creeklines
3. Moist Eucalypt Forests
4. Rainforests
5. Sandstone Gully Forests
6. Tall Open Forests
7. Sandstone Woodlands
8. Sandstone Gully Forests
Cleared or altered environments
Wetlands
Major waterbody
Study area boundary
Local Government Area boundary
Creek or river
Motorway or highway
Other major road
Map 7
Microchiropteran bat assemblages of the Wollongong area
derived from systematic harp trap survey sites
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment, Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection: consistent with Australian Map Grid Zone 56
Prepared by N Corkish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
Copyright NSW National Parks and Wildlife Service July 2002
This map is not guaranteed to be free from error or omission.
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disclaim liability for any act done on the information in the
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Table 16: Results of an ANOSIM of the bats of the principal habitat types in the Wollongong Area, based on abundance data. Listed are the R statistics from an ANOSIM of harp-trapping sites and their significance levels (+ P<0.1; * P<0.05, ** P<0.01; *** P<0.001). Number of sites is shown as n.

	Creeklines (n=13)	Coastal Grassy Forests (n=5)	Rainforests (n=7)	Moist Eucalypt Forests (n=13)	Tall Open Forests (n=7)	Sandstone Gully Forests (n=7)	Sandstone Woodlands (n=13)
Creeklines							
Coastal Grassy Forests	NS						
Rainforests	NS	0.22+					
Moist Eucalypt Forests	0.14*	0.32*	NS				
Tall Open Forests	NS	0.27*	NS	0.40**			
Sandstone Gully Forests	NS	0.30*	0.22+	0.35**	NS		
Sandstone Woodlands	0.11*	0.25*	NS	0.15*	NS	NS	

Table 17: The principal assemblages of bats in the Wollongong Area, based on abundance data. Listed are the results of the species richness and diversity analysis, and an exploratory procedure where SIMPER was used to define the species typical of an assemblage. The species that together account for 90 percent of the variability in the assemblage and the average number of individuals per site for each contributor are included. . For scientific names refer to Appendix C.

Broad Vegetation Type	Richness (av. number of species per site)	Diversity (Shannon H')	Typical Species
1.Creeklines	2	1.8	Large-footed Myotis (2 per site), Little Forest Bat (2 per site), Common Bent-wing Bat (1 per site), Chocolate Wattled Bat (1 per site), Gould's Long-eared Bat (1 per 2 sites)
2.Coastal Grassy Forests	2	1.2	Gould's Long-eared Bat (3 per site), Little Forest Bat (1 per site), Lesser Long-eared Bat (1 per site)
3.Rainforests	1	1.4	Chocolate Wattled Bat (1per 2 sites), Little Forest Bat (1 per 2 sites)
4.Moist Eucalypt Forests	1	1.1	Chocolate Wattled Bat (2 per site), Gould's Wattled Bat (1 per site)
5.Tall Open Forests	2	1.4	Little Forest Bat (3 per site), Large Forest Bat (1 per site), Chocolate Wattled Bat (1 per site)
6.Sandstone Gully Forests	3	1.4	Little Forest Bat (2 per site), Large Forest Bat (2 per site), Chocolate Wattled Bat (2 per site)
7.Sandstone Woodlands	2	1.4	Little Forest Bat (2 per site), Chocolate Wattled Bat (1 per site), Large Forest Bat (1 per site), Gould's Long-eared bat (1 per 3 sites)

Eucalypt Forests could be considered distinctive. The other information has been given for qualitative purposes only as further work needs to be done. For instance, it is quite possible that there is only a single assemblage of bats present in the Sandstone Gully Forests and Sandstone Woodlands. This will require further trapping and analysis to determine.

The Coastal Grassy Forests Bat Assemblage is extremely restricted in distribution within the Wollongong LGA (Table 18). This assemblage occurred in Coastal Grassy Red Gum and Lowland Woollybutt-*Melaleuca* Forests and was characterised by large numbers of the Gould's Long-eared Bat (*Nyctophilus gouldii*), the ubiquitous Little Forest Bat (*Vespadelus vulturnus*) and the Lesser Long-eared Bat (*N. geoffroyi*). The Lesser Long-eared Bat (*N. geoffroyi*) was only found on the coastal plain and foothills during this study. The richness and diversity of bat species found in the Coastal Grassy Forests was quite high (Table 17), despite often being disturbed or isolated. This is an important result as degraded remnants are rarely thought of as potential bat habitat. These results reinforce those of the Georges River Catchment Study (NPWS 2001e) that found fragmented and disturbed Cumberland Plain Woodland maintained a diverse and abundant bat fauna that was likewise dominated by the two species of *Nyctophilus*. The reasons as to why these remnants retain a diverse bat fauna are possibly related to the ability of bats to move between remnants, and because they may not be so dependent on an intact understorey.

Table 18: Reservation status of the seven microchiropteran bat assemblages that were identified within the Wollongong Area.

Bat Assemblage Name	Area in Study Area (ha)	Percentage of Study Area (%)	Area in NP (ha)	Area in SCA (ha)	Area in SF (ha)	Area in WCC (ha)	Percentage of Assemblage Reserved (%)
1.Creeklines	1590	2.1	117	687	4	58	54.5
2.Coastal Grassy Forests	1254	1.6	0	0	0	53	4.3
3.Rainforests	3988	5.2	1008	973	26	102	52.9
4.Moist Eucalypt Forests	7352	9.4	1540	1537	48	258	46.9
5.Tall Open Forests	4331	5.7	270	3406	0	1	84.9
6.Sandstone Gully Forests	8825	11.5	681	7218	76	11	90.5
7.Sandstone Woodlands	15228	19.9	1264	12570	9	14	91.0

4.4 BIOREGIONAL ASSESSMENT

In this section, the bird assemblages in the Wollongong Area are compared to those from similar environments elsewhere in the Sydney Basin Bioregion. This was done by comparing the results of systematic diurnal bird searches to the results of searches conducted during other bioregional surveys, such as the CRA surveys of 1997-8 and the Georges River Catchment surveys of 1999-2000. Areas were chosen for comparison based on similarity of geology, climate and vegetation. The aim of the exercise was to assess the uniqueness of the Wollongong bird assemblages within the Sydney Basin Bioregion.

Sites from Wollongong included in this analysis were a subset that used in the assemblage analysis. Sites from the urban interface were excluded from the analyses, as were post-fire sites from Royal NP and sites conducted outside the Wollongong LGA on the western edge of the Woronora Plateau. This resulted in some minor differences from the assemblage information from section 4.3.2 (mostly with introduced species). This was done in order to get a more accurate picture of natural differences that might occur between Wollongong and other regions. Additionally, it was impossible to acurately gauge if some of the sandstone sites from the Central Coast or the Blue Mountains were conducted in woodland or forest. For this reason all sandstone woodland and forest sites were combined into the one dataset for comparison.

The bird assemblages of Wollongong were compared to bird assemblages of:

1. The Central Coast Area
   - *Rainforests*
   - *Wet Moist Eucalypt Forests*
   - *Coastal sandstone woodland-open forest*
2. The Blue Mountains Area
   - *Moist Eucalypt Forests*
   - *Sandstone woodland-open forest*
3. The Western Sydney Area
   - *Coastal Grassy Woodlands*

4.4.1 The Central Coast Area

Rainforests

The rainforests of the escarpment and foothills are the most distinctive and unique landscape feature of Wollongong. There is only one other place in the Sydney Basin Bioregion that has some similarities in climate, landform and vegetation to the Illawarra - the Watagan Ranges in the Hunter Area. The Watagans are set further back from the coast than the Wollongong Escarpment and the temperatures are correspondingly cooler.

Both areas have large areas of Warm Temperate Rainforests and share a similar vegetation structure. Nevertheless, NPWS (2002a) found there to be significant differences in the plant species composition of the vegetation of these two areas.

There were no significant differences between the rainforest bird assemblages of the Illawarra and Watagan Ranges (ANOSIM, R=0.097, P>0.05). Sites from both areas were typified by Brown Gerygone, Golden Whistler (*Pachycephala pectoralis*), Rufous Fantail and Yellow-throated Scrubwren (Table 19). There were some differences with rarer species, but these did not contribute significantly to the overall assemblage. For example, the Logrunner (present at 11 percent of Wollongong rainforest sites) is only found at two isolated areas within the Watagans (A. Morris, pers. comm.). Conversely, several species that were found to be common north of the Hawkesbury (Scarlet and White-naped Honeyeaters (*Myzomela sanguinolenta* and *Melithreptus lunatus*)) were recorded less often in Wollongong.

Table 19: Results of a SIMPER analysis of the bird sites in rainforest from the Wollongong Area and the Watagan Ranges. There was no significant difference between the rainforest bird assemblages at these two localities.

Areas	Richness (av. no. of species per site)	Diversity (Shannon H')	Rainforest Bird Assemblage
Wollongong (18 sites)	13	3.17	Brown Gerygone (94%), Golden Whistler (83%), Lewin's Honeyeater (78%), Grey Fantail (67%), Yellow-throated Scrubwren (67%), Brown Thornbill (61%), Eastern Whipbird (67%), Black-faced Monarch (67%), Silvereye (56%), Rufous Fantail (56%), White-browed Scrubwren (56%), Eastern Yellow Robin (44%), Brown Cuckoo dove (44%), Satin Bowerbird (39%), Crimson Rosella (33%)
Watagan Ranges (8 sites)	15	3.2	Golden Whistler (100%), Brown Gerygone (100%), Eastern Spinebill (88%), Lewin's Honeyeater (88%), Brown Thornbill (75%), White-browed Scrubwren (63%), Grey Fantail (63%), Yellow throated Scrubwren (63%), Black-faced Monarch (63%), Yellow-faced Honeyeater (50%), Bell Miner (50%), Scarlet Honeyeater (50%), White-naped Honeyeater (50%) Eastern Whipbird (50%), Striated Thornbill (38%), Rufous Fantail (38%), Red-browed Finch (38%), Superb Lyrebird (38%)

Moist Eucalypt Forests

The dissected plateau of the Watagan Ranges is dominated by Moist Eucalypt Forest, as is the escarpment of the Wollongong Area. Both areas are dominated by Blackbutt and Sydney Blue Gum (*Eucalyptus saligna*) and share a similar vegetation structure with a mesic to dense rainforest understorey. This study found no significant differences between the wet sclerophyll bird assemblages of Wollongong and the Watagan Ranges (ANOSIM, R=0.03, P=not significant) (Table 20). Assemblages were both dominated by typical rainforest edge species such as Grey Fantail and Lewin's Honeyeater, however there were also a few differences between them. For example, Crimson Rosella (*Platycercus elegans*) were a feature of the Wollongong wet sclerophyll while being rarer in similar environments of the Watagan Ranges. Conversely, Bell Miner (*Manorina melanophrys*), Red-browed Finch (*Neochmia temporalis*), Scarlet Honeyeater, Varied Sittella (*Daphoenositta chrysoptera*), White-naped Honeyeater and Noisy Friarbird (*Philemon corniculatus*) were a feature of the Watagan Ranges but absent or rare in Wollongong. The Bell Miner is a species that often inhabits stands regenerating from logging and colonised the Watagan Ranges during the mid 1960s (Higgins *et al.* 2001). It is rarely reported on the coastal plain in the Illawarra region, with a colony at Wongawilli disappearing in the 1920s (Chafer *et al.* 1999) though a colony has recently been found in the Huntley Area (C. Chafer, pers. comm., NPWS 2002b). The Crimson Rosella may be present in higher numbers in Wollongong due to supplementary feeding by locals and at locations such as Sublime Point.

Table 20: Results of a SIMPER analysis of the bird assemblages of wet sclerophyll forest from the Wollongong Area and the Watagan Ranges. Assemblages were different at the P<0.05 level.

Areas	Richness (av. no. of species per site)	Diversity (Shannon H')	Wet Sclerophyll Bird Assemblage
Wollongong (21 sites)	13	3.51	Lewin's Honeyeater (76%), White-browed Scrubwren (76%), Grey Fantail (71%), White-throated Treecreeper (62%), Eastern Yellow Robin (57%), Brown Gerygone (57%), Golden Whistler (57%), Brown Thornbill (48%), Black-faced Monarch (48%), Crimson Rosella (48%), Eastern Spinebill (48%), Striated Thornbill (48%), Eastern Whipbird (43%), Silvereye (43%), Spotted Pardalote (43%),
Watagan Ranges (16 sites)	13	3.2	Lewin's Honeyeater (75%), Grey Fantail (75%), White-browed Scrubwren (69%), Brown Gerygone (63%), Brown Thornbill (63%), Eastern Spinebill (63%), Eastern Yellow Robin (63%), White-throated Treecreeper (56%), Golden Whistler (50%), Bell Miner (44%), Striated Thornbill (38%), Yellow-faced Honeyeater (38%), Black-faced Monarch (38%), Silvereye (38%), Rufous Fantail (38%), Red-browed Finch (31%), Eastern Whipbird (31%)

Coastal Sandstone Woodland-Open Forest

The Central Coast of New South Wales has many features of the geology and climate that are similar to Wollongong. Both exist on Narrabeen and Hawkesbury Sandstones and exhibit a strong maritime influence. Floristically there is significant overlap, although the Central Coast has many North Coast plant species that do not cross the Hawkesbury or Hacking Rivers. The analysis shows that there are also significant differences between the bird assemblages of these two areas (ANOSIM R=0.45, P<0.001) (Table 21). There were many differences in the frequency of common species, with the Spotted Pardalote (*Pardalotus punctatus*) and White-eared Honeyeater (*Lichenostomus leucotis*) present at two to three times the number of Central Coast sites than Wollongong sites. Additionally, Brown Thornbill, Eastern Spinebill (*Acanthorhynchus tenuirostris*) and Grey Fantail were all far more frequent in Wollongong than the Central Coast. The White-cheeked Honeyeater (*Phylidonyris nigra*), a species known to be more common north of Port Jackson (Higgins *et al.* 2001), was absent from Wollongong but a feature of the Central Coast sandstone environs.

Table 21: Results of a SIMPER analysis of the bird assemblages of Sandstone Woodland-Open Forest from the Wollongong Area and the Central Coast. Assemblages were different at the P<0.05 level.

Areas	Richness (av. no. of species per site)	Diversity (Shannon H')	Sandstone Woodland Bird Assemblage
Wollongong (29 sites)	8	3.1	Eastern Spinebill (83%), Brown Thornbill (83%), Grey Fantail (69%), Rufous Whistler (66%), New Holland Honeyeater (55%), White-throated Treecreeper (45%), Crimson Rosella (38%), Eastern Yellow Robin (34%), Grey Shrike-thrush (31%), Variegated Fairy-wren (28%)
Central Coast (18 sites)	8	3.02	Spotted Pardalote (72%), White-eared Honeyeater (61%), Little Wattlebird (56%), Eastern Spinebill (50%), White-cheeked Honeyeater (50%), New Holland Honeyeater (44%), White-browed Scrubwren (39%), Eastern Yellow Robin (33%), Brown Thornbill (28%), Grey Fantail (28%)

4.4.2 *The Blue Mountains Area*

Moist Eucalypt Forests

In the Sydney Basin Bioregion Mount Coricudgy is the western-most example of a large patch of warm temperate rainforest and Moist Eucalypt Forests. At 1200 metres altitude, it is also the highest example of this habitat type within the Bioregion. Mount Coricudgy is a basalt cap that overlays the sandstones of the Sydney Basin. Differences in geology and climate between Coricudgy and Wollongong lead to many differences in the vegetation. The rainforests and wet sclerophyll are structurally similar, but the cold

temperature of Mount Coricudgy results in a depauperate plant community dominated by Coachwood (*Ceratopetalum apetalum*) and Ribbon Gum (*Eucalyptus viminalis*).

Wollongong and Mount Coricudgy were not found to have any significant differences in their Moist Eucalypt Forest bird assemblages (ANOSIM, R=0.01, P=not significant) (Table 22). Again, the prevalence of typical rainforest edge species such as the White-browed Scrubwren overpowered small differences. The most obvious feature of the wet sclerophyll forest of Mount Coricudgy was the Crescent Honeyeater (*Phylidonyris pyrrhoptera*), a species that occurs at higher altitudes within the Sydney Basin, present at 100 percent of sites. A larger sample of sites from Coricudgy may illustrate some significant differences.

Table 22: Results of a SIMPER analysis of the bird assemblages of wet sclerophyll forest from the Wollongong Area and Mount Coricudgy. There was no significant difference between the wet sclerophyll bird assemblages at these two localities.

Areas	Richness (av. no. of species per site)	Diversity (Shannon H')	Wet Sclerophyll Bird Assemblage
Wollongong (21 sites)	13	3.51	As Above (Table 20)
Coricudgy (5 sites)	14	2.7	White-browed Scrubwren (100%), Silvereye (100%), Crescent Honeyeater (100%), Brown Thornbill (80%), Striated Thornbill (80%), Yellow-faced Honeyeater (80%), Eastern Spinebill (80%), Eastern Yellow Robin (60%), Spotted Pardalote (60%), Grey Fantail (60%), Crimson Rosella (60%)

Sandstone Woodland-Open Forests

Wollemi is part of a vast Narrabeen and Hawkesbury Sandstone plateau to the north west of Sydney. Narrabeen and Hawkesbury Sandstones are the same sandstones that form the Woronora Plateau, but Wollemi is at a significantly higher elevation and has a considerably drier climate. The difference in elevation, and hence climate may account for the different suite of honeyeaters present and the significant difference in the sandstone bird assemblage (ANOSIM R=0.347, P<0.001) (Table 23). Although there was some similarity between the assemblages, with species such as the Eastern Spinebill common in both, there were many species that did not overlap. For example, the New Holland Honeyeater (*Phylidonyris novaehollandiae*), Little Wattlebird (*Anthochaera chrysoptera*) and Brown-headed Honeyeater (*Melithreptus brevirostris*) were absent from sites in Wollemi. Conversely, Wollemi featured Noisy Friarbird, White-naped Honeyeater, Scarlet Robin (*Petroica boodang*) and Yellow-tufted Honeyeater (*Lichenostomus melanops*) which were absent, or nearly so from Wollongong.

Table 23: Results of a SIMPER analysis of the bird assemblages of Sandstone Woodland-Open Forest from the Wollongong Area and Wollemi. Assemblages were different at the P<0.05 level.

Areas	Richness (av. no. of species per site)	Diversity (Shannon H')	Sandstone Woodland Bird Assemblage
Wollongong (29 sites)	8	3.1	As Above (Table 21)
Wollemi (10 sites)	11	2.9	White-throated Treecreeper (100%), Yellow-faced Honeyeater (80%), White-eared Honeyeater (70%), Eastern Spinebill (70%), Brown Thornbill (70%), Striated Thornbill (70%), Spotted Pardalote (40%), White-naped Honeyeater (40%), Rufous Whistler (40%), Grey Fantail (40%)

4.4.3 Western Sydney

Coastal Grassy Woodlands

The Cumberland Plain of Western Sydney is comprised of shale-derived soil and has many features in common with the Coastal Plain of Wollongong. Both are flat to undulating, higher fertility plains that originally supported open grassy woodlands dominated by Forest Red Gum (*Eucalyptus tereticornis*) and Boxes (*E. moluccana* and *E.*

bosistoana). The vegetation of both these areas exists only in remnants that have usually suffered some degree of disturbance. There are some significant differences in climate, with the Cumberland Plain receiving approximately half of the average rainfall of Wollongong. Additionally, the Cumberland Plain is further from the coast and experiences more extreme temperatures. NPWS (2002a) found that the vegetation of the Wollongong Coastal Plain was different in many ways to that of the Cumberland Plain. Although both were dominated by Forest Red Gum, there were significant variations in other species of *Eucalyptus* and *Acacia,* and in the grasses present.

Table 24: Results of a SIMPER analysis of the bird assemblages of the Coastal Plain of Wollongong Area and the Cumberland Plain. There was no significant difference between the assemblages tested.

Areas	Richness (av. no. of species per site)	Diversity (Shannon H')	Coastal Plain Grassy Woodland Bird Assemblage
Wollongong (8 sites)	12	3.23	Yellow Thornbill (75%), Mistletoebird (63%), Grey Butcherbird (63%), Noisy Miner (50%), Eastern Rosella (50%), White-throated Gerygone (50%), Rufous Whistler (50%), Yellow-faced Honeyeater (50%), Grey Fantail (50%), Eastern Yellow Robin (50%), Silvereye (38%), Brown Thornbill (38%), Black-faced Cuckoo-shrike (38%), Spotted Pardalote (38%)
Cumberland Plain (45 sites)	9	3.3	Noisy Miner (69%), Superb Fairy-wren (51%), Grey Butcherbird (42%), Eastern Yellow Robin (44%), Eastern Rosella (38%), Grey Fantail 42%), Silvereye (38%), Australian Magpie (27%), Mistletoebird (33%), Magpie-lark (31%), Yellow Thornbill (31%), Common Myna (27%), Rufous Whistler (27%), Red-browed Finch (24%), Red-whiskered Bulbul (24%), Weebill (22%), Black-faced Cuckoo-shrike (18%)

There are only minor differences between the bird assemblages of the Cumberland Plain and the Illawarra Coastal Plain (ANOSIM R=0.07, P=not significant) (Table 24). The dominant species present in both areas are similar, with differences only occurring in the frequency that species were observed. Birds that favour open, grassy environments such as the Noisy Miner, Grey Butcherbird and Eastern Rosella dominated both assemblages. It appears superficially that small species such as the Silvereye, Mistletoebird, White-throated Gerygone and Yellow Thornbill might be more common on the Wollongong Coastal Plain. There was also a lower frequency of introduced species in the Wollongong remnants. Another difference was that the Wollongong Coastal Plain Grassy Forests occasionally supported more mesic species, such as the Lewin's Honeyeater. This might be responsible for the higher species richness score and relates to the remnant Lowland Dry-Subtropical Rainforest and dense Lantana shrubs that intersperse the grassy forests in Wollongong.

4.5 DISTURBANCE

There has been considerable discussion in recent years regarding the value of remnant vegetation in urban settings. It is well known that larger remnant patches retain a greater proportion of their original faunal diversity (Blake & Karr 1987; Andrén 1994). This is an extension of the theory of island biogeography which suggests that the smaller and more isolated an island, the fewer species it will support (MacArthur & Wilson 1967). In addition, there are many other factors that may affect the value of remnant vegetation. These include time since isolation, distance from large vegetation reserves, the degree of connectivity and the proportion of remnant forest that remains in a landscape (Hames *et al.* 2001; Mörtberg 2001).

The vegetation remnants of the Yallah-Calderwood area were selected for a qualitative investigation into disturbance. This area has also been identified as the best east-west corridor of remnant vegetation in the Wollongong area (this is explored further in section 4.6.1 and Map 8). There were 31 systematic surveys conducted within the Yallah-Calderwood area. All sites were classified as having some level of disturbance, from either grazing, weed invasion, clearing or a combination of these.

The biodiversity of the Yallah-Calderwood remnants is of interest for several reasons:

1. These remnants are mostly of vegetation communities that are restricted in distribution (the majority having been cleared),
2. Many of the remnants have been isolated for a long time,
3. Almost all the remnants are on private land and none are part of conservation reserves, and
4. The remnants are potentially under development pressure for housing.

In this section the average level of species richness and diversity of the Yallah-Calderwood remnants was determined for birds, reptiles, bats and arboreal mammals. Ideally, this would be compared to results in similar, but undisturbed and unfragmented vegetation. Unfortunately there are no examples of undisturbed coastal plain vegetation in the Wollongong Area so a rigorous analysis was not possible. Nevertheless it is thought that there may be value in a qualitative comparison of the richness and diversity of the remaining vegetation in this area to that of the region in general. This cannot give an accurate indication of the biodiversity that has been lost, or even if any has been lost at all, but it does allow judgement of its current levels compared those of the other undisturbed habitats of the area.

Systematic sites conducted in the Yallah-Calderwood remnants were analysed to determine their species richness (average number of species per site) and diversity (Shannon-Weiner H') (Table 25). These can then be compared to the species richness and diversity of the remainder of the Wollongong Area (assessed in section 4.3 in the assemblage analysis). The results indicate that the Yallah-Calderwood remnants retain a medium to high level of species richness and diversity.

Table 25: Results of systematic surveys in the Yallah-Calderwood Fauna Linkage. Species richness and diversity has been averaged for systematic sites conducted in the Linkage and given a ranking based on the results in the assemblage analysis (section 4.3).

Yallah-Calderwood Fauna Linkage	Number of sites	Number of Species (systematic sites only)	Richness (average no. of species per site)	Diversity (Shannon H')
Diurnal Birds	11	58	13 (high)	3.5 (high)
Reptiles	9	8	2 (medium)	1.2 (medium)
Arboreal Mammals	7	3	1 (medium)	1.0 (medium)
Bats (harp trapping)	4	5	3 (high)	1.4 (medium)

In general there is a surprising variety of species surviving in the Yallah-Calderwood Fauna Linkage (Table 27). These include large mammalian species such as the Swamp Wallaby (*Wallabia bicolor*) that were found surviving in a number of remnants in the Yallah area that were separated from contiguous vegetation. Swamp Wallabies are known to prefer denser vegetation (Merchant 1995) and are either persisting with a limited gene pool, or are travelling between remnants. Other interesting mammal records from this area include the Sugar Glider, Platypus, Water Rat (*Hydromys chrysogaster*), Short-beaked Echidna (*Tachyglossus aculeatus*) and Long-nosed Bandicoot (*Parameles nasuta*).

Bats and birds appear to be surviving particularly well within the Yallah-Calderwood Fauna Linkage. Presumably their ability to fly enables some of the more mobile species to travel between remnants. Bird communities were very diverse in the Yallah-Calderwood remnants. This is primarily due to the variety of habitats encompassed. Despite the level of disturbance, these remnants maintain an average of thirteen species per site compared to nine species per site in the majority of the Woodland (an almost entirely undisturbed environment) above the escarpment (Table 7; Table 25).

Ekerciolu *et al.* (2002) noted that with birds in forest isolates, it is the understorey insectivores that will disappear first and that the birds that best survive are the ones that utilise the surrounding deforested country. Many sites in these remnants still supported small insectivorous birds. Examples of some bird species that are reliant on understorey vegetation include the Eastern Yellow Robin (*Eopsaltria australis*) (64 percent of sites in remnants), Brown Thornbill (64 percent of sites) and White-browed Scrubwren (36 percent of sites). The White-throated Treecreeper (*Cormobates leucophaeus*) is a highly territorial species that will not move large distances (Higgins *et al.* 2001). This behavioural characteristic may make it highly sensitive to fragmentation. The only site in the disturbed remnants of Yallah-Calderwood where the White-throated Treecreeper was found was one of the largest and least disturbed patches. Examples of species that will move easily between remnants include the Silvereye (73 percent of sites), Rufous Whistler (*Pachycephala rufiventris*) (34 percent of sites), Lewin's Honeyeater (54 percent of sites) and White-throated Gerygone (30 percent of sites).

There have been ten species of bat recorded in these remnants, including the threatened Large-footed Myotis and Common Bent-wing Bat. The Georges River Catchment study found the Large-footed Myotis and Common Bent-wing Bat followed creeklines through cleared environments of the Cumberland Plain, and were even found using farm dams in paddocks (NPWS 2001c, C.R. Williams pers. comm). It may be that these species are less sensitive to disturbance than some others and able to use remnant vegetation in altered environments such as is found in the Yallah-Calderwood area.

It is important to note this project was some of the first systematic fauna survey work to be done in the Yallah-Calderwood area. In this area the vegetation remnants are mostly privately owned and access was limited because of this. Further survey work will doubtless uncover more species that use this area, particularly for bats, frogs and reptiles.

At present the remnants of the Yallah-Calderwood area still provide habitat for a multitude of species. If fragmentation and disturbance are allowed to continue, it is likely that the value of these remnants to fauna will decrease.

4.6 CORRIDORS AND LINKAGES

It is thought that isolated patches of vegetation may retain a greater proportion of their original faunal diversity if they have corridors of vegetation linking them (Noss 1993). Proponents of this theory maintain that the ability of faunal species to move in and out of a patch decreases the risk of inbreeding and local extinction. It has been proven that certain species will use corridors (see review by Tucker 2000), with corridors that are comprised of original vegetation being more useful than others (Bolger *et al.* 2001). The extent to which corridors are used by threatened species continues to be debated.

In the Wollongong LGA there are two main areas where vegetation may function as a corridor for fauna. These are 1) a corridor connecting the remnant vegetation of the Coastal Plain with the protected lands of the escarpment and plateau and 2) a corridor linking the escarpment moist forests of Royal NP with those of the Illawarra Escarpment SCA and Macquarie Pass NP and eventually the Shoalhaven Valley.

4.6.1 The Yallah-Calderwood Fauna Linkage

In the Wollongong LGA there are only a handful of east-west running corridors of vegetation. These usually exist in thin bands along creeks and rivers where the vegetation has not been cleared or has regrown. The best example of this is along the Macquarie Rivulet. These narrow riparian corridors provide habitat for some birds and reptiles. However, their narrowness means they are probably not used by larger or more sensitive species.

Corridors can also take the form of series of closely spaced remnants that form a 'linkage' of patches. This is the situation with the remnants in the Yallah-Calderwood area. These remnants run in a band from Lake Illawarra through the Calderwood Valley to the Escarpment (hereafter referred to as the Yallah-Calderwood Fauna Linkage) (Map 8).

The Yallah-Calderwood Fauna Linkage is the most extensive series of remnants on the Coastal Plain of Wollongong. Vegetation is contiguous for almost four kilometres from the escarpment along the spur that runs east west from Mars Pass (between Avondale Colliery and Duck Creek). Vegetation then continues in patches that are never separated by more than 550 metres all the way to the estuary at the mouth of Duck Creek. The other arm of this linkage runs towards the ocean along Johnstons Ridge for over nine kilometres (Map 8).

Large areas that are devoid of vegetation provide significant barriers to dispersal. Conversely, small patches of habitat interspersed in a modified environment allow species to move through and recent research suggests this is a key component in retaining the faunal diversity of an area (Mörtberg 2001). Currently vegetation in the Yallah-Calderwood Area still covers much of the landscape with approximately 50 percent of the landscape remaining vegetated, albeit often in small patches (Map 8, Table 26). The high proportion of the landscape that remains vegetated is the most important feature of this linkage.

The boundary of the Yallah-Calderwood Fauna Linkage was defined by mapping the edge of the mostly forested land and the cleared land to the north and south (Map 8). The linkage is comprised of a number of different forested environments and wetlands (the latter are not included in the figure). Table 26 shows the proportions of the various vegetation types that make up the Yallah-Calderwood Fauna Linkage.

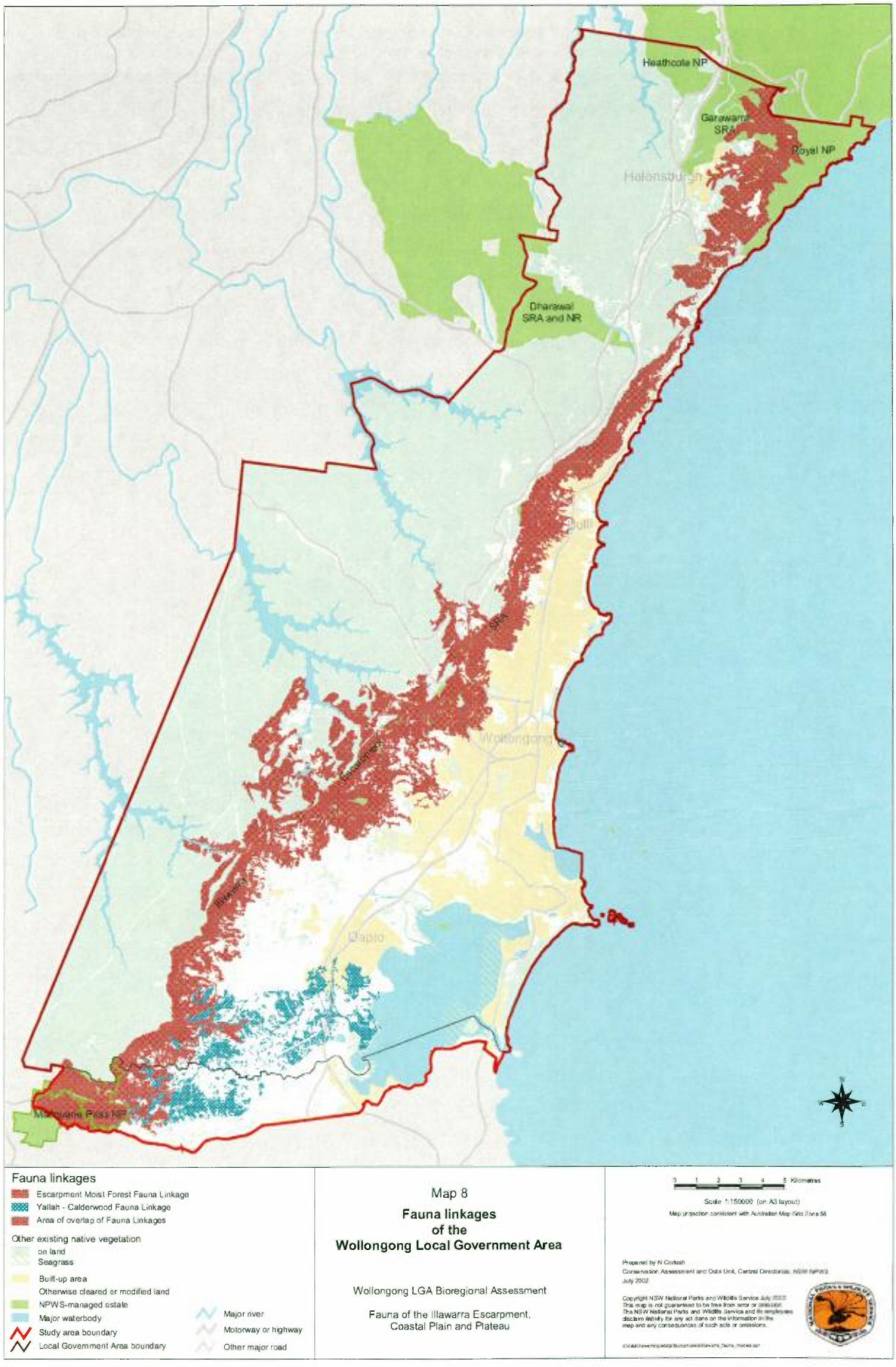
The total numbers of fauna species that are known from the Yallah-Calderwood Fauna Linkage are listed in Table 27. This affords us some insight into the numbers of species that currently use the area. A large proportion (54 percent) of Wollongong's terrestrial bird species are known from this fairly small area. The Linkage also supports a large numbers of species of frogs, bats and other mammals. Many species of reptiles are restricted to the sandstone of the plateau and would never have occurred in this corridor hence the proportion that have been recorded for this group is rather less than others. It is clear that this corridor continues to provide suitable habitat for a large percentage of the species known from Wollongong. The number of species that rely on the relatively well-connected nature of these remnants is uncertain.

Table 26: The different vegetation types of the Yallah-Calderwood Fauna Linkage. The names of the vegetation types, the area (in hectares) and the level of disturbance within the linkage are given.

Vegetation Community	Disturbance (Level ha)				Total Area (ha)	Percentage of Total Area (%)
	Low	Moderate	High	Scattered Trees		
Coastal Grassy Red Gum Forest		225.02	108.58	118.52	452.1	9.2
Moist Box-Red Gum Foothills Forest	46.37	130.25	186.91	1.24	364.8	7.4
Weeds and Exotics					320.5	6.5
Lowland Woollybutt-Melaleuca Forest		89	91.99	118.52	299.5	6.1
Lowland Dry-Subtropical Rainforest	22.9	149.27	116.15		288.3	5.9
Moist Gully Gum Forest	120.18	52.81	34.45		207.4	4.2
Acacia Scrub					136.7	2.8
Coachwood Warm Temperate Rainforest	42.32	57.83	10.9		111.1	2.3
Coastal Swamp Oak Forest		24.41	7.54	0.9	32.9	0.7
Riparian River Oak Forest			22.88		22.9	0.5
Wetlands (natural only)					16.3	0.3
Other (all < 20ha combined)					49.6	1.0
Cleared					2612.5	53.2
Total					4914.4	100

Table 27: The total number of species known from the Yallah-Calderwood Fauna Linkage and a list of the priority species that are known from the linkage.

	Yallah-Calderwood Fauna Linkage		
	Number of species	Proportion of total species in Wollongong (terrestrial only)	Priority Species
Birds	102 (5 introduced)	54%	Green Catbird, Logrunner, Powerful Owl
Reptiles	11	23%	Golden-crowned Snake, Highlands Forest-skink
Frogs	8	35%	Green and Golden Bell Frog
Bats	10	53%	Grey-headed Flying-fox, Common Bent-wing Bat, Large-eared Pied Bat (ultrasound only)
Other Mammals	16 (5 introduced)	40%	Greater Glider, Mountain Brushtail Possum, Platypus


Heathcote NP
Garawarra SRA
Royal NP
Helensburgh
Dharawal SRA and NR
Bulli
Wollongong
Illawarra
Escarpment SRA
Dapto
Macquarie Pass NR
Fauna linkages
Escarpment Moist Forest Fauna Linkage
Yallah - Calderwood Fauna Linkage
Area of overlap of Fauna Linkages
Other existing native vegetation
on land
Seagrass
Built-up area
Otherwise cleared or modified land
NPWS-managed estate
Major waterbody
Study area boundary
Local Government Area boundary
Major river
Motorway or highway
Other major road
Map 8
Fauna linkages
of the
Wollongong Local Government Area
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corbish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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map and any consequences of such acts or omissions.

4.6.2 *The Escarpment Moist Forest Fauna Linkage*

The moist forests (rainforests and wet sclerophyll forests) of the Wollongong Escarpment and Foothills are a major feature of the region. They run in a narrow band between the Shoalhaven and Hacking River Valleys. Wollongong LGA contains a significant proportion of this band of moist vegetation that currently links three reserves: Royal NP, the many parts of the Illawarra Escarpment SCA and Macquarie Pass NP (Map 8).

A key concept in reserve design is that isolation can lead to local extinction (Hames *et al.* 2001). In this section the point is made that planners must recognise that many species are restricted to a particular habitat type and may not use open woodland, for example, to disperse between patches of rainforest. Therefore, the band of moist forest that is seen along the escarpment in Wollongong should be treated as a corridor. This is particularly important given that some reserves in the area have suffered significant human impact and some species occurring in these reserves may be vulnerable to local extinction. In Royal NP, the local extinction of several species including the Greater Glider, may have already occurred (NPWS 2001d). If the Greater Glider is to recolonise Royal NP then it is important that a link of moist vegetation be retained between the Hacking River Valley and the remaining tall moist forests of Wollongong. Further to this, a corridor of rainforest and moist eucalypt forest may allow recolonisation of the Wollongong LGA by some of the fauna species that may be locally extinct, such as the Spotted-tailed Quoll and Stuttering Frog. Both these species are known to occur further south and could potentially reestablish populations in the Wollongong LGA if a link to those populations is retained. In order to ensure that this is possible the connection to other moist forests such as Macquarie Pass, where they are extant, needs to be retained.

Table 28: Contiguous tracks of the following vegetation types were included in the Escarpment Moist Forest Fauna Linkage Also given is the number of hectares and the level of disturbance

	Disturbance (Level ha)					
Vegetation Community	Low	Moderate	High	Scattered Trees	Total Area (ha)	Percentage of Total Area (%)
Coachwood Warm Temperate Rainforest	1715.1	600.9	340.9		2656.9	25.6
Escarpment Blackbutt Forest	1435.0	413.5	262.0	252.5	2363.0	22.7
Moist Gully Gum Forest	1089.7	296.5	94.6	23.5	1504.3	14.5
Acacia Scrub					928.0	8.9
Moist Coastal White Box Forest	207.0	338.8	106.1	22.5	674.4	6.5
Escarpment Moist Blue Gum Forest	149.2	201.9	177.8	60.7	589.6	5.7
Moist Box-Red Gum Foothills Forest	46.7	183.6	194.2	33.1	457.6	4.4
Lowland Dry-Subtropical Rainforest	55.2	161.5	156.8		373.5	3.6
Moist Blue Gum-Blackbutt Forest	179.8	98.2	20.8	17.5	316.2	3.0
Illawarra Escarpment Subtropical Rainforest	88.9	123.1	79.0		291.0	2.8
Moist Brown Barrel Forest	98.7				98.7	1.0
Turpentine Regeneration					54.9	0.5
Cliffline Coachwood Scrub	54.1				54.1	0.5
Moist Shale Messmate Forest	5.1	14.7			19.8	0.2
Robertson Basalt Brown Barrel Forest	2.5				2.5	0.0
Fig Trees				2.2	2.2	0.0
Robertson Cool-Warm Temperate Rainforest	1.8				1.8	0.0
Total					10388.4	100

The Escarpment Moist Forest Fauna Linkage was created by highlighting all vegetation types that have a rainforest component (NPWS 2002a) (Table 28) and that are contiguous or separated by less than 80 meters from the core escarpment band of moist forest. The vegetation communities that are included in the linkage are listed in Table 28 along with the number of hectares and level of disturbance. The moist forests contain a diverse and unique assemblage of species (section 4.3). Many animals are strictly tied to rainforest or moist forest and will not be found outside it. Many rainforest species are also

considered priority species in the Wollongong area. Those priority species that are thought to primarily or largely rely on moist forest cover have been listed in Table 29.

Roads often impair the movement of animals between patches of vegetation. This may be a particular issue for the Wollongong LGA where there are many high-use roads dissecting high-value habitat. To prevent further local extinction, and to facilitate recolonisation of species such as Long-nosed Potoroo and Spotted-tailed Quoll, road underpasses may be appropriate. Road mortality has been shown to be a significant cause of local extinction, both in Australia and the USA (see Goosem *et al.* 2001 for a synopsis). While the value of tunnels continues to be debated, it is becoming increasingly apparent that well-constructed underpasses will be used by a variety of faunal species (Goosem *et al.* 2001).

Table 29: The priority species that have core habitat in the escarpment moist forests that run between Macquarie Pass and Royal National Parks.

	Escarpment Moist Forest faunal linkage (total no. of species)	Priority Species that are solely or mostly restricted to Moist Forests in the Wollongong Area
Birds	107 (6 introduced)	Green Catbird, Logrunner, Sooty Owl, Rose-crowned Fruit-dove, Wompoo Fruit-dove, Superb Fruit-dove, Australian Brush-turkey
Reptiles	23	Highlands Forest-skink, Golden-crowned Snake
Frogs	15	Stuttering Frog
Bats	14	Grey-headed Flying-fox (roosting and feeding)
Other Mammals	22 (7 introduced)	Greater Glider, Mountain Brushtail Possum, Spotted-tailed Quoll (not exclusive)

4.7 FAUNA AND CONSERVATION PLANNING

There are several ways in which to address conservation priorities pertaining to fauna. Generally, the conservation of 'priority species' is the principal way in which this is carried out. Priority species, in this instance, refers not only to species listed as vulnerable or endangered at a national or state level, but also to species that have been nominated by experts as being of local or regional conservation concern.

The habitats of priority species can be presented in the form of point localities or by modelling predicted distribution (section 4.2). Once core habitat has been predicted, priority species can be ranked in order of their level of reservation, both locally and bioregionally. The priority species for this project for which habitat models have been generated are ranked in order of their level of reservation (Table 30). The Green and Golden Bell Frog is one of the least reserved priority species in the Wollongong Area and one of the least reserved species bioregionally (with only 12.3 percent reserved across the Sydney Basin Bioregion).

The conservation priority of species can also be investigated at a local level by examining the percentage of high quality habitat that occurs within the Study Area compared to the Bioregion. For this project this was assessed for the Sydney Basin Bioregion. This is a way of ranking the importance of Wollongong LGA to the conservation of the species across the entire Bioregion. For instance, of those species that have been ranked as the least conserved in the Wollongong Area, the Sooty Owl has nearly ten percent of its habitat in the Sydney Basin Bioregion within Wollongong, while the Regent Honeyeater has only 0.04 percent of its predicted habitat occurring within the Wollongong area. This indicates that the conservation of the Sooty Owl within Wollongong is of greater importance bioregionally than conservation of the Regent Honeyeater. It is important to note that this should only be used as a rough guide as some of the Bioregion models did not cover the entire area, or were done at a far coarser scale than the Wollongong Area models.

Table 30: Priority species for which habitat models have been generated, in order of their level of reservation within the Wollongong Area. Also included are estimates of the percentage of total high quality habitat in the Bioregion that occurs in the Wollongong Area.

	High Quality Habitat in Wollongong (ha)	Percentage of HQH reserved in Wollongong (%)	High Quality Habitat in Bioregion (ha)	Percentage of bioregional HQH that occurs in Wollongong (%)	Percentage of HQH reserved in Bioregion (%)
Australasian Bittern	150	9.3	no model		
Green and Golden Bell Frog	76	11.8	103921	0.07	12.3
Platypus	1694	12.2	no model		
Black Bittern	384	16.7	118330	0.32	27.6
Regent Honeyeater	48	25	116713	0.04	7.7
Swift Parrot	48	25	126515	0.04	20.8
Green Catbird	5049	43.4	no model		
Grey-headed Flying-fox	3500	45.5	486264	0.72	35.1
Golden-crowned Snake	6097	51.1	no model		
Large-footed Myotis	1590	54.5	25666	6.12	50.8
Sooty Owl	7382	54.7	78630	9.39	40.5
Highlands Forest-skink	2010	55.6	29191	6.89	34.9
Logrunner	5733	55.9	no model		
Stuttering Frog	3635	58.1	69883	5.27	62.4
Mountain Brushtail Possum	5952	59.7	no model		
Greater Glider	10384	63.7	293589	3.54	59
Powerful Owl	5996	75.2	339200	1.77	48.2
Red-crowned Toadlet	1483	77.5	no model		
Olive Whistler	1949	78.6	8500	22.93	13.9
Red browed Treecreeper	3505	83.1	20032	16.99	29.3
Eastern Pygmy-possum	6184	85.9	444327	1.39	58.3
Broad headed Snake	25427	86.3	157100	16.19	55.2
Long-nosed Potoroo	2766	86.6	117525	2.35	21.8
Ground Parrot	2766	86.6	no model		
Pheasant Coucal	2766	86.6	no model		
Grey Currawong	3591	89.3	no model		
Giant Burrowing Frog	20039	90.3	950320	2.11	56.6
Rosenberg's Goanna	13375	91.2	1302712	1.03	67.4
Eastern Bristlebird	1222	93.9	19145	6.38	42.9

Another way to address fauna conservation is through assemblages, where assemblages are suites of species that share similar habitat preferences and are generally found together in the landscape. Species assemblages reflect, and hence can be used as a surrogate for, the total biodiversity of an area. The species assemblages that are less than 60 percent reserved are ranked in Table 31. The most poorly conserved assemblages are all from the Coastal Plain and Foothills of Wollongong.

The conservation of a proportion of the habitat for all priority species and all the faunal assemblages of an area should maximise the probability of the biodiversity of an area being maintained. Regardless, it is important to remember that reservation is only one approach to the conservation of fauna. For many species, threats to survival may be unrelated to land tenure and without consideration such impacts will continue. Threats that are generally unrelated to land tenure include predation from feral predators, weed invasion, disease and inappropriate fire regimes. An example from the Wollongong Area of a species that is declining regardless of the level of conservation in formal reserves is the Stuttering Frog. The Stuttering Frog has been calculated as having 59 percent of its high-quality habitat within formal reserves in the Wollongong Area. Nevertheless, this species has declined to the point of near-extinction in the Illawarra and elsewhere. It is likely that other issues, such as the introduction of the Chytrid fungus are the primary factors affecting this species (see Species Profile 5.3).

Management strategies, guided by the recovery planning process, will remain important in the persistence of many of the threatened species of Wollongong.

Table 31: The most poorly reserved species assemblages in the Wollongong LGA. All assemblages that have less than 50 percent of their total extent reserved have been included.

Assemblage Name	Area in Wollongong (ha)	Percentage in formal reserves in Wollongong Area (%)
Coastal Grassy Forests Bird Assemblage	1254	4.3
Coastal Grassy Environments Reptile Assemblage	1254	4.3
Coastal Grassy Forests Bat Assemblage	1254	4.3
Moist Eucalypt Forests Bird Assemblage	7352	46.8
Moist Eucalypt Forests Arboreal Mammal Assemblage	7352	46.8
Moist Eucalypt Forest Reptile Assemblage	7352	46.8
Moist Eucalypt Forests Bat Assemblage	7352	46.8

5 PRIORITY SPECIES PROFILES

5.1 INTRODUCTION TO SPECIES PROFILES

Profiles have been written for each of the priority species that are listed in Table 1. Each species profile has a number of sections under which information has been entered. These are:

1. Species Profile - Contains background biological information, such as identification, distribution and general habits.
2. Study Area Map - Shows records of the species, sourced mainly from the Atlas of NSW Wildlife, and if generated, a model showing suitable habitat within the Wollongong Study Area.
3. Threats - Lists actual or potential threats at both the state and local level.
4. Local and Regional Conservation Status - A discussion of the level of protection of the species and special considerations for its conservation. If habitat models have been generated then tables summarising the model predictions and areas reserved, along with notes explaining how the model for Wollongong was created are included. The vegetation communities used to create habitat models are from NPWS (2002a) and NPWS (2003). The tables below (for Sooty Owl) are used as an example, and all the categories are listed here as a reference.

Bioregional Scale Models

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence Only*	3.5	65248	-	28279	-
Central CRA	Presence/ Absence	Excellent	13382	-	3541	-
Combined Models	-	-	78630	2.2	31820	40.5

As part of the CRA process in both Southern and Northern Regional Forestry Agreements (RFA), a series of habitat models were generated for priority species. Though these models were generated to determine areas of conservation significance in forested land, it is a useful guide to the area of land that is considered suitable habitat. More details of the modelling procedure are listed in NPWS (1999d) for the Central CRA and NPWS (2000a) for the Southern.

The types of models generated during the CRA were:

1. Presence/Absence - generated using records from systematic sites, including those where the species wasn't recorded.
2. Presence Only - generated using all available records.
3. Presence Only without Eden - generated using all available records, except those within the Eden CRA area.
4. Expert Model - generated by overlaying GIS layers, based on expert knowledge of the species.
5. Buffers - Buffer zones were created around known records.
6. No Suitable Model - A model could not be generated that was considered suitable.
7. Not Modelled - Not considered a priority species.

An asterisk (*) after model type indicates modifications were made during validation and or at response to disturbance.

Once models were completed, they were assessed by experts to determine their predictive quality. For the Southern CRA, the reliability of the model was ranked on a one to five scale, with the higher the number, the better the model. Experts assessed the Central CRA models and assigned a quality that varied between Poor and Excellent, with a number of classes in between.

The areas of high quality habitat were calculated from each of the modelled areas and added to give a figure for the Sydney Basin Bioregion. However, the areas modelled did not overlap, resulting in an area of 128059ha (3.5 percent of the Bioregion) that has not had suitable modelling undertaken (northern Wingecarribee and coastal Shellharbour and Kiama LGAs). Therefore, the total area of high quality habitat may be an underestimate for some species, but gives an indication of the species' distribution in the Bioregion. The amount of predicted habitat occurring in lands managed by NPWS within the Bioregion is also given to indicate how well reserved the species is likely to be.

Local Scale Models

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
7382	9.6	3693	2366	1439	40	90	4035	54.7

If the species has been modelled for the Study Area, then figures summarising the amount of potential habitat are also included. The reservation status of the high quality habitat is included to indicate how well the species is protected within the Study Area. Land tenures set aside for conservation purposes include NPWS managed land, Special Areas managed by the SCA, Kembla State Forest (SF), which is currently managed as a non-production forest, and land managed by Wollongong City Council. Although the Study Area also incorporates a small area of Shellharbour City Council, a data layer describing council reserves is currently not available. Each table includes figures indicating the total area and proportion of high quality habitat that is reserved in the Study Area.

5.2 GIANT BURROWING FROG

Species Profile

The Giant Burrowing Frog (*Heleioporus australiacus*) is a rotund, ground-dwelling frog. It can attain a maximum length of over ten centimetres. Its powerful limbs are used to excavate burrows where they can aestivate for long periods of time during unfavourable conditions. This species has a large black tadpole with a purple ventral surface that takes up to eleven months to metamorphose (Anstis 2002). The species has two disjunct populations, with one restricted to sandstone geology of the Sydney Basin as far south as Jervis Bay, and the other to the south between Narooma and eastern Victoria (NPWS 2001a).

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Map 9 shows the records of the Giant Burrowing Frog along with its predicted distribution.

Threats

The primary threat to the Giant Burrowing Frog is development of the sandy ridgetops that are its preferred habitat (NPWS 2001a). Within the Wollongong LGA most of the Giant Burrowing Frog's prime habitat is protected within the Metropolitan and Woronora Catchment Areas. However, further development of Maddens Plains, Darkes Forest and Helensburgh would impact on the habitat of this species. Other threats to this species are not well known. Some threats that might be relevant within the Wollongong LGA include fire, road mortality, feral predators, and alterations to the drainage patterns of the plateau.

Local and regional conservation status

The Giant Burrowing Frog is listed as a Vulnerable species on Schedule 2 of the NSW TSC Act (1995) and Vulnerable under the Commonwealth EPBC Act (1999). The Sydney Basin population is thought to have declined considerably, with tadpoles being encountered far less frequently than in the past (Anstis 2002). During the current survey, both adult frogs and tadpoles were recorded at a number of locations in the Catchment lands.

The models created during the CRA show that the most important areas of habitat for this species include the Jervis Bay region in the south, the Woronora Plateau and the sandstone areas around the Hawkesbury River mouth. Within these areas this species is protected by a number of NPWS managed reserves, including NSW Jervis Bay, Royal, Ku-ring-gai Chase and Brisbane Waters NPs. The central part of the Blue Mountains and Wollemi NPs is also predicted as potential habitat, but is supported by fewer records. The local area habitat model for this species was derived from various Upland Swamp and Sandstone Heath and Woodland communities. These were Exposed Sandstone Scribbly Gum Woodland, Upland Swamps: Sedgeland-Heath Complex, Upland Swamps: Fringing Eucalypt Woodland, Upland Swamps: Banksia Thicket, Exposed Hawkesbury Scribbly Gum Woodland, Silvertop Ash Ironstone Woodland, Woronora Tall Mallee-Heath, Sandstone Heath-Woodland, Tall Dry Forest (Garrawarra) Upland Swamps: Mallee-Heath, Upland Swamps: Tea-Tree Thicket Sandstone Heath and Low Woronora

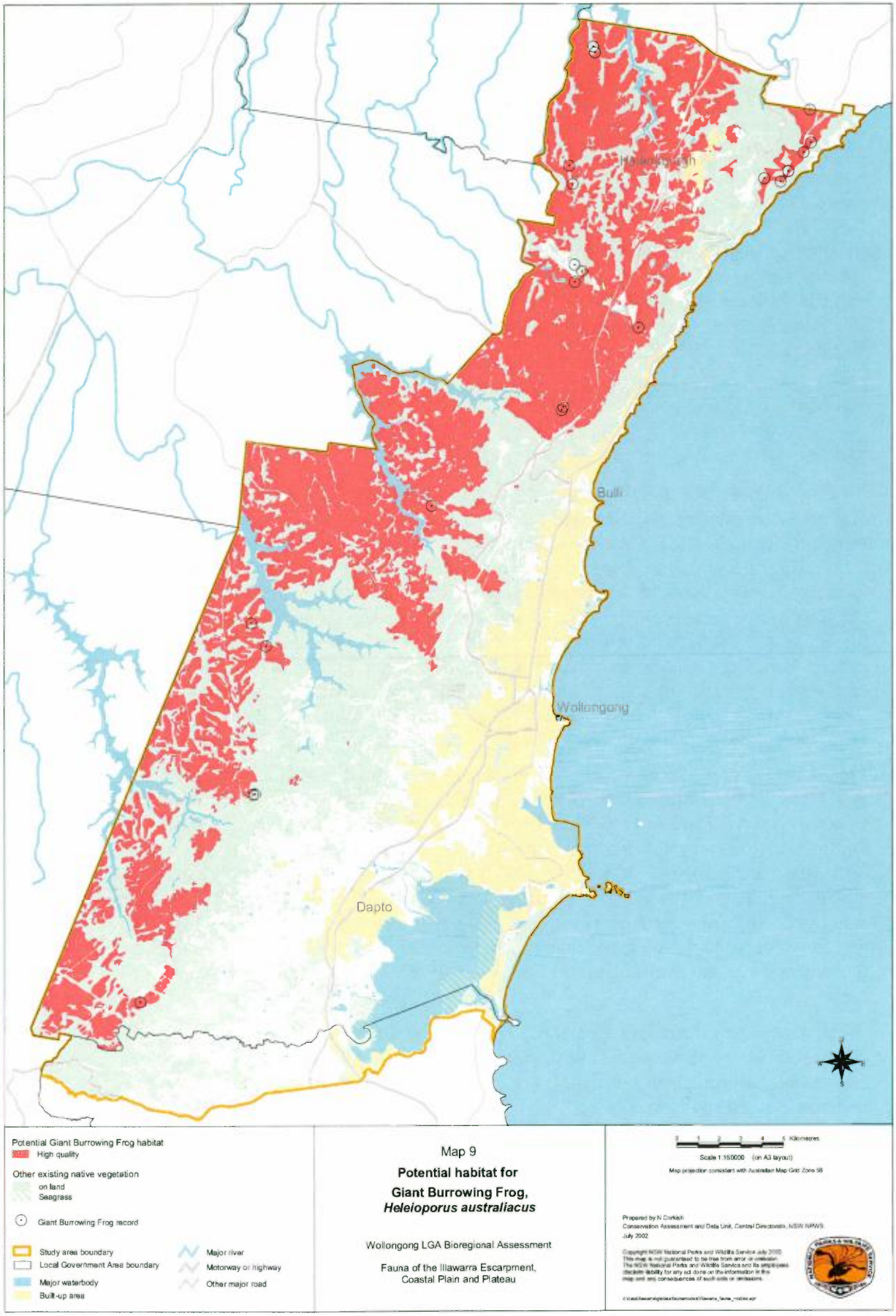
Heathland vegetation communities. As these communities are widespread above the escarpment, the predicted habitat is well protected, particularly in the Sydney Catchment Authority Special Areas.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence Only without Eden	3	89450	-	39438	-
Central CRA	Presence Only	Adequate	860870	-	49889	-
Combined Models	-	-	950320	26.1	538327	56.6

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
20039	26.1	0	1926	16131	16	20	18093	90.3


Wollongong
Dapto
Potential Giant Burrowing Frog habitat
High quality
Other existing native vegetation
on land
Seagrass
Giant Burrowing Frog record
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 9
Potential habitat for
Giant Burrowing Frog,
Heleioporus australiacus
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corkish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002

5.3 STUTTERING FROG

Species Profile

The Stuttering Frog (*Mixophyes balbus*) is a large (up to eight centimetres), rainforest-dwelling frog that is highly camouflaged in the wet leaf-litter of the forest floor. After summer rains the males make a call that includes a soft stuttering, from which the species gets its common name. The thin barring on the limbs in combination with the blue crescent above the iris distinguishes it from other *Mixophyes* in NSW (Barker *et al.* 1995, NPWS 2000b). It is usually associated with flowing streams, where it feeds on insects and smaller frogs (Gilmore & Parnaby 1994). It breeds in spring and summer and has extremely long-lived tadpoles. It was formerly found along the coast and ranges between northern New South Wales and far-eastern Victoria. It appears to have disappeared from the latter state, and is now only found patchily throughout the rest of its former distribution (Anstis 2002).

Map 10 shows current locations of the Stuttering Frog and sites where it was found in the past with the areas of potential habitat.

Threats

It is not known what the major threats to this species are. It is likely that habitat degradation due to logging, siltation, pollution, changes in water flow and reduction in leaf litter due to burning affect this species (NPWS 2000b). Chytrid fungus is likely to be playing a major part in the declines that have been observed in this species, as it is known to have seriously affected populations of the closely related Fleay's Barred Frog (*M. fleayi*) (Berger *et al.* 1998). For a more detailed discussion on Chytrid fungus, see the Green and Golden Bell Frog (Species Profile 5.5). The Stuttering Frog is a large, slow moving frog and it is possible that it may suffer predation from introduced carnivores such as cats and foxes, and introduced fish may predate eggs and tadpoles.

Local and regional conservation status

The Stuttering Frog was recently listed as Endangered on Schedule 1 of the NSW TSC Act (1995) (previously it was considered Vulnerable) and Vulnerable under the Commonwealth EPBC Act (1999). In the Wollongong area it was once present in rainforest creeks from Helensburgh in the north to Macquarie Pass. An intensive search for this species in 1999-2000 revealed that it was only present at the southern sites in Macquarie Pass NP. During this survey, a male called weakly in response to an amplified owl call-playback survey on a creekline in the southern part of the LGA, but this record needs to be confirmed under more favourable conditions. It is possible that a few other remote and undisturbed localities along the escarpment continue to support this species.

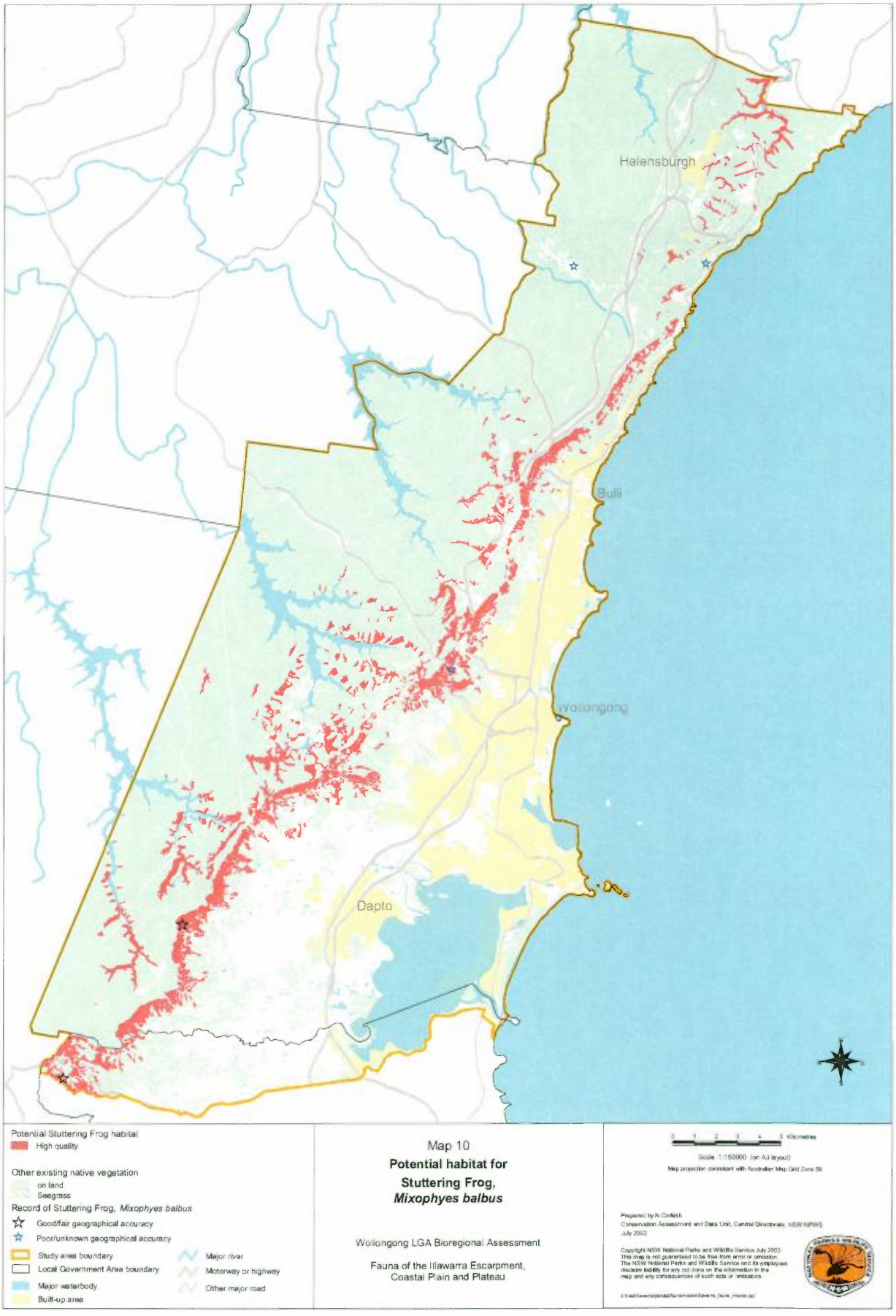
Within the Sydney Basin Bioregion, this species has declined significantly in range. The population in the Blue Mountains seems to have disappeared, and the Illawarra population has been greatly reduced. The population in the Watagan Ranges may have undergone fluctuations in size, although there are a number of recent records from Watagans NP and State Forests in that area. A habitat model based on Illawarra Escarpment Subtropical Rainforest and Coachwood Warm Temperate Rainforest was developed for this species. This probably reflects potential habitat in the past, and over-estimates the current distribution in the Study Area. Much of these vegetation communities are protected in the Illawarra Escarpment SCA and the Sydney Catchment Authority Special Areas.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence Only*	5 for 1c	57440	-	40657	-
Central CRA	Presence Only	Good	12443	-	2929	-
Combined Models	-	-	69883	1.9	43586	62.4

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
3635	4.7	0	984	1038	28	87	2137	58.1


Helensburgh
Bulli
Wollongong
Dapto
Potential Stuttering Frog habitat
High quality
Other existing native vegetation
on land
Seagrass
Record of Stuttering Frog, Mixophyes balbus
Good/fair geographical accuracy
Poor/unknown geographical accuracy
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 10
Potential habitat for
Stuttering Frog,
Mixophyes balbus
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corrish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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5.4 RED-CROWNED TOADLET

Species Profile

The Red-crowned Toadlet (*Pseudophryne australis*) is a small, strikingly coloured litter-dwelling frog. It is fairly restricted in its distribution, only occurring on the sandstone geologies of the Sydney Basin. The Red-crowned Toadlet lays its eggs in moist leaf litter, relying on rain to wash the eggs into a temporal pond where they can complete their development (NPWS 2001b).

Map 11 shows records of the Red-crowned Toadlet with areas of predicted habitat.

©Dave Hunter/NPWS

Threats

Development of ridgetop land is the primary threat to the Red-crowned Toadlet. Other threats may include habitat alteration due to fire, bush rock removal, water pollution and Chytrid fungus (NPWS 2001b). Due to their size and morphology, this species has only a limited ability to disperse. This probably makes them vulnerable to local extinction.

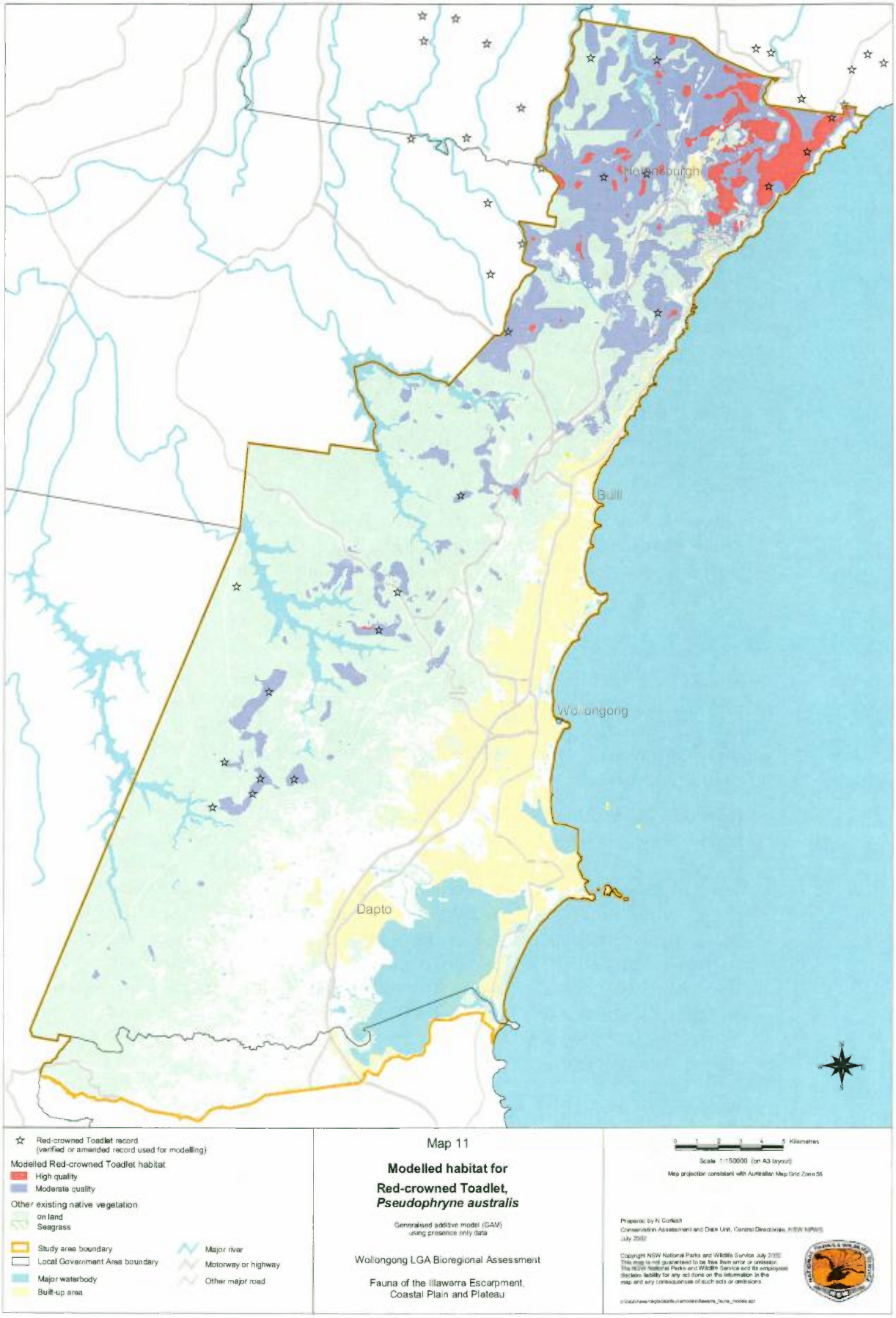
Local and regional conservation status

The Red-crowned Toadlet is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). Currently there is an investigation regarding the possibility that there are several genetically distinct populations in the Sydney Basin (NPWS 2001b). During the current survey, it was detected at a number of different locations above the escarpment, south to Cordeaux Reservoir.

No models were developed during either CRA process, but this species is restricted to the Sydney Basin, and there appear to be three population centres; the Blue Mountains (which may extend to include the population in Wollemi NP), the mouth of the Hawkesbury River and the Woronora Plateau. Many records occur in the NPWS managed lands in these areas, but many individuals also occur on unprotected land that is threatened by development. The predictive model developed for the Study Area predicted on fertility index (indicating infertile sandstone soils) and easting (Appendix D). Though only a relatively small area of high quality habitat was predicted for the Study Area, Wollongong LGA represents the southern extent of its distribution. There are extensive tracts of land just to the north in Royal NP and Holsworthy Military Area providing suitable habitat, with a large number of records known from these areas.

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
1483	1.9	9322	988	161	0	1	1150	77.5


Helensburgh
Bulli
Wollongong
Dapto
Red-crowned Toadlet record
(verified or amended record used for modelling)
Modelled Red-crowned Toadlet habitat
High quality
Moderate quality
Other existing native vegetation
on land
Seagrass
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 11
Modelled habitat for
Red-crowned Toadlet,
Pseudophryne australis
Generalised additive model (GAM)
using presence only data
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection: consistent with Australian Map Grid Zone 56
Prepared by N Corkish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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5.5 GREEN AND GOLDEN BELL FROG

Species Profile

The Green and Golden Bell Frog (*Litoria aurea*) is a large species that was once ubiquitous in the coastal areas of NSW. It was formerly distributed on the coast and tablelands between Brunswick Heads (northern NSW) and East Gippsland in Victoria, but is now present only in isolated populations, usually close to the coast. It inhabits marshes, dams and streamsides, particularly where reeds (*Typha* and *Eleocharis* spp.) are present, though many of the remaining populations inhabit highly disturbed areas, such as disused industrial sites and landfills (NPWS 1999e). Breeding males call while floating amongst vegetation between spring and autumn, though often in January and February (Anstis 2002).

©Stuart Cohen/NPWS

Map 12 shows recent records of the Green and Golden Bell Frog and areas of predicted habitat.

Threats

The Green and Golden Bell Frog was, until about 30 years ago, one of the most common frogs in the Greater Sydney Basin (White & Pyke 1996) and was abundant on the Coastal Plain of Wollongong (G. Daly pers. comm). It once occupied a broad range of habitats, but has disappeared from most of its former range, persisting in a few isolated pockets, often in urban areas. The reasons behind the decline of this species are various, though a significant reason is likely to be the introduction of Chytrid fungus. Chytridomycosis, caused by the fungus *Batrachochytrium dendrobatidis*, has been linked to declines in frog populations worldwide, and has been listed as a key threatening process under the Environment Protection and Biodiversity Conservation Act (1999). It may be that the Green and Golden Bell Frog is particularly susceptible to this fungus, and can only survive in areas where Chytrid fungus has never been introduced, or is unable to survive (R. Wellington pers. comm.). Other threats that have been linked to the decline in this species are the disappearance of suitable breeding habitat, changes to water quality and predation by feral animals. The introduced Plague Minnow (*Gambusia holbrookii*) are known to consume the tadpoles of the Green and Golden Bell Frog (White & Pyke 1996) and they have been listed as a key threatening process in NSW.

Local and regional conservation status

The Green and Golden Bell Frog is listed as Endangered on Schedule 1 of the NSW TSC Act (1995) and Vulnerable under the Commonwealth EPBC Act (1999). Both Pyke & White (1996) and Hamer *et al.* (2002) found it difficult to predict the presence of Green and Golden Bell Frogs by looking at features of the habitat. Pyke & White (1996) suggested the absence of Plague Minnow was important, though at Coomaditchy Lagoon Green and Golden Bell Frog are found with Plague Minnow (G. Daly pers. comm.). Hamer *et al.* (2002) found a few species of plant to be adequate predictors (*Juncus kraussii* subsp. *australiensis, Schoenoplectus litoralis, Sporobolus virginicus*). They

found that colonies were aggregated and suggested that new colonies be established within close proximity of existing colonies. No new colonies of the Green and Golden Bell Frog were found during this survey, however the species is well known from Port Kembla and Woonona.

It is difficult to construct a map of 'suitable habitat' for this species, as its distribution is now a vast contraction of what was once suitable. Within the Sydney Basin, most of the remaining populations occur within a few kilometres of the coast, with very few in formal conservation reserves. The habitat for the Study Area model was derived from wetland communities with known recent records (obtained from Ross Wellington), plus a 100 metre buffer around records in non-wetland habitats. Moderate habitat was generated from other wetland habitats, some of which were known to be suitable in the past. These areas may still have populations, but need to be assessed under suitable conditions. Very little of this habitat is protected, with many locations within industrial areas.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Not Modelled					
Central CRA	Presence Only	Adequate	103921	-	12767	-
Combined Models	-		103921	2.9	12767	12.3

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
76	0.1	329	0	0	0	9	9	11.8


Helensburgh
Bulli
Wollongong
Dapto
Potential Green and Golden Bell Frog habitat
High quality
Moderate quality
Other existing native vegetation
on land
Seagrass
Green and Golden Bell Frog record
(verified or amended post-1990 record used for modelling)
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 12
Potential habitat for
Green and Golden Bell Frog,
Litoria aurea
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corfield
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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5.6 LITTLEJOHN'S TREE FROG

Species Profile

Littlejohn's Tree Frog (*Litoria littlejohni*) is a poorly known species that was only recently separated taxonomically from the Jervis Bay Tree Frog (*L. jervisiensis*) (White *et al.* 1994). It is confined to the coastal environs at scattered locations between Central NSW and eastern Victoria. Littlejohn's Tree Frog was formerly called the Heath Frog, though this is a misnomer as this species is generally associated with forested environments. The males call mainly in late winter and spring, from elevated positions beside ponds and creeks (Anstis 2002).

Map 13 shows known localities of Littlejohn's Tree Frog in the Wollongong Area.

Threats

This is a poorly known species, but the NSW Scientific Committee (2000) listed the following as potential threats: limited dispersal from small populations, which increases the risk of local extinction; clearing of native vegetation and reduced habitat availability; and inappropriate fire practices (including pre- and post-logging burns and control burning) that disturb breeding habitat. It is possible that this species is another that is particularly susceptible to infection by the Chytrid fungus (see Species Profile 5.5).

Local and regional conservation status

Littlejohn's Tree Frog has recently been listed on Schedule 2 (Vulnerable) of the NSW TSC Act (1995) and is also listed as Vulnerable under the Commonwealth EPBC Act (1999). In the final determination, the NSW Scientific Committee (2000) reports that it is known from only thirteen locations. Several of these are from the Plateau region of the Wollongong LGA. They have been found near Darkes Forest/Dharawal area in the past, and have been regularly recorded at Barren Grounds Nature Reserve (NR) to the south. The only records from the current survey were an individual captured in the Metropolitan Catchment near Loddon Falls, and another two heard calling from a tributary of Stoney Creek on the Forest Walk above Wombarra.

The Central CRA model predicted four areas of potential habitat - central Blue Mountains, the Watagan Ranges, the Ku-ring-gai area south of the Hawkesbury River (where there are no current records) and the Woronora Plateau. Much of this habitat is within NPWS reserves, but it is probably an overestimation of its level of protection. This species has declined significantly and is not found in large numbers, even within protected areas. No model was generated for the Study Area, due to the paucity of records.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Buffer	0	37	-	36	-
Central CRA	Presence Only	Good	120833	-	64989	-
Combined Models	-	-	120870	3.3	65025	53.8


Helensburgh
Bulli
Wollongong
Dapto
Record of Littlejohn's Tree Frog, Litoria littlejohni
Existing native vegetation
on land
seagrass
Study area boundary
Local Government Area boundary
Built-up area
Motorway or highway
Other major road
Major waterbody
Major river
Map 13
Records of
Littlejohn's Tree Frog (Heath Frog)
Mixophyes balbus
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corbosh
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5.7 ROSENBERG'S GOANNA

Species Profile

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Rosenberg's Goanna or Heath Monitor (*Varanus rosenbergi*) is a large, powerful lizard with an unusual distribution. It is superficially similar to the commonly encountered Lace Monitor (*V. varius*) though morphologically and taxonomically it is closer to the Sand Monitor (*V. gouldii*). It occurs in the Greater Sydney Basin but then occurs discontiguously through Victoria, South Australia and south western Western Australia. The population of the Sydney Basin may or may not be genetically distinct. It is known to be associated with sandstone environments, and is usually found in heath and woodlands where it shelters in burrows, hollow logs and rock crevices (Cogger 1996).

Map 14 shows records of Rosenberg's Goanna along with the predicted habitat in the Wollongong Area.

Threats

Rosenberg's Goanna is subject to pressure from development of the flat sandstone ridgetops that are its preferred habitat. Other threats would include predation by dogs, and road mortality. Of the ten records from within the Wollongong LGA, at least three were hit by cars.

Local and regional conservation status

Rosenberg's Goanna are listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). It is a poorly understood species and we are still learning about its distribution in the Sydney Basin. A number of sightings were made after the December 2001 fires, particularly in the Cordeaux area.

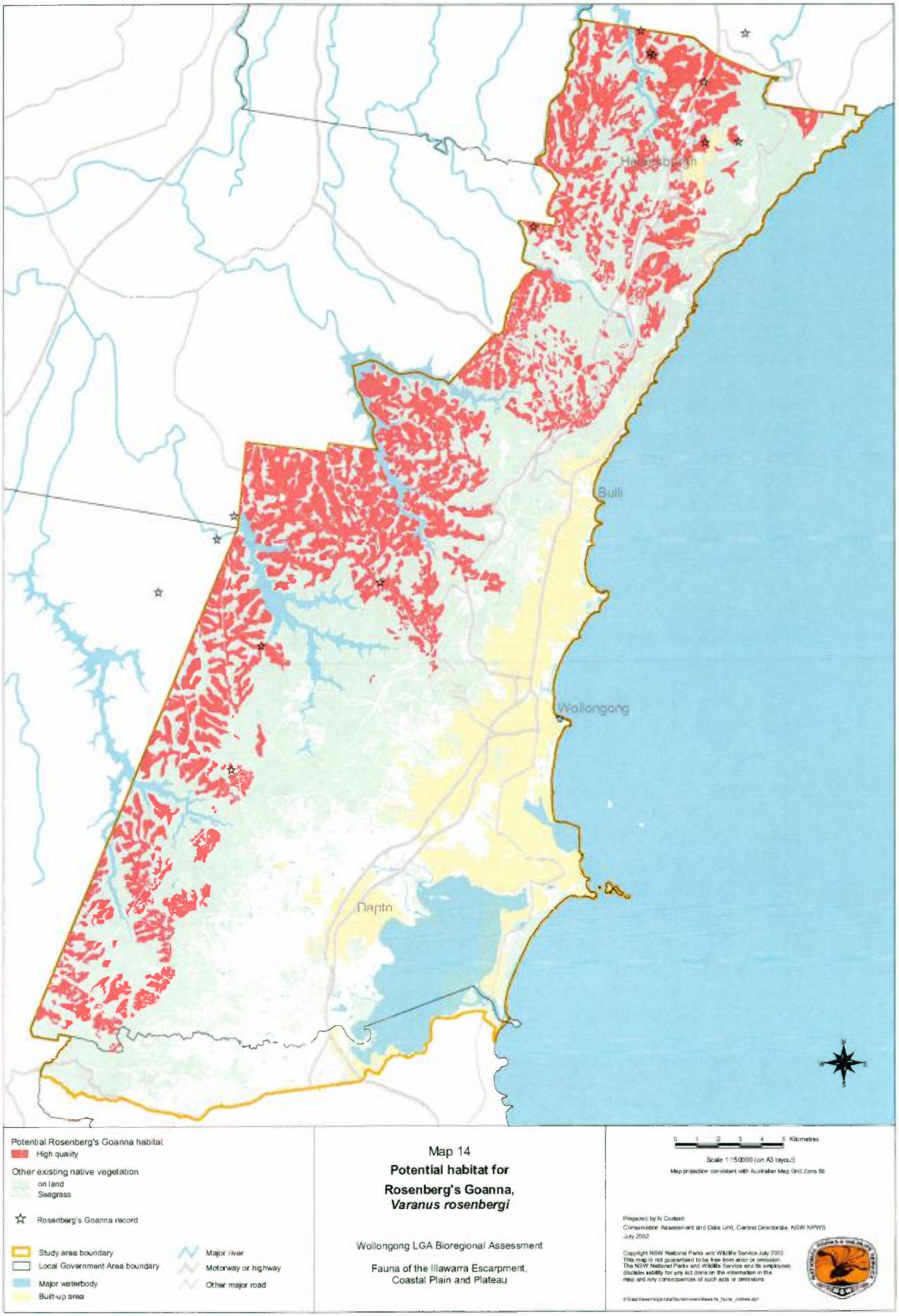
Extensive areas of the Sydney Basin Bioregion are sandstone and this has led to a large area of predicted habitat, though Rosenberg's Goanna seems to occur only sparsely through this area. Much of this land is included within NPWS managed lands, with records from numerous reserves including Morton, Heathcote and Wollemi NPs and Berowra Valley Regional Park (RP). A habitat model was created from the only vegetation communities that the species has been recorded in: Exposed Hawkesbury Scribbly Gum Woodland and Exposed Sandstone Scribbly Gum Woodland.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence Only without Eden*	5	188716	-	88819	-
Central CRA	Presence Only	Adequate	1113996	-	789145	-
Combined Models	-	-	1302712	35.8	877964	67.4

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
13375	17.4	0	1086	11095	9	3	12193	91.2


Helensburgh
Bulli
Wollongong
Dapto
Potential Rosenberg's Goanna habitat
High quality
Other existing native vegetation
on land
Seagrass
Rosenberg's Goanna record
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 14
Potential habitat for
Rosenberg's Goanna,
Varanus rosenbergi
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection: consistent with Australian Map Grid Zone 56
Prepared by N Corbett
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July 2002
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5.8 HIGHLANDS FOREST-SKINK

Species Profile

©Alex Dudley

The Highlands Forest-skink or Maccoy's Skink (*Nannoscincus maccoyi*) is an enigmatic species that inhabits the dense rainforests along the escarpment. It is one of the few species of reptile to exist in the low light conditions of the rainforest floor, where it is found under logs and rocks. It is often brilliantly marked with orange and red. This species is a thermo-conformer, meaning that it can be active and breed at colder temperatures, and is reliant on moist retreat areas. It occurs between northern Wollongong through to eastern Victoria, with disjunct populations in western Victoria, though there is some conjecture that there may be two separate species - one at higher altitudes and the other in more temperate regions (R. Wellington, pers. comm.).

Map 15 shows the predicted distribution of the Highlands Forest-skink in the Wollongong Area along with locations at which it was located during systematic diurnal herpetofauna searches.

Threats

As this species seems to be restricted to a fairly specialised habitat, and is relatively immobile, the greatest potential threat is disturbance and fragmentation of habitat.

Local and regional conservation status

The Highlands Forest-skink is listed as Protected under the NSW NP&W Act (1974). It reaches the limit of its distribution within the Wollongong LGA, with the northern-most record at Scarborough. It only occurs above the escarpment where there is a break in the cliffline and it does not occur on the coastal plain. The Highlands Forest-skink was recorded at a number of systematic survey sites in moist forest during the current survey.

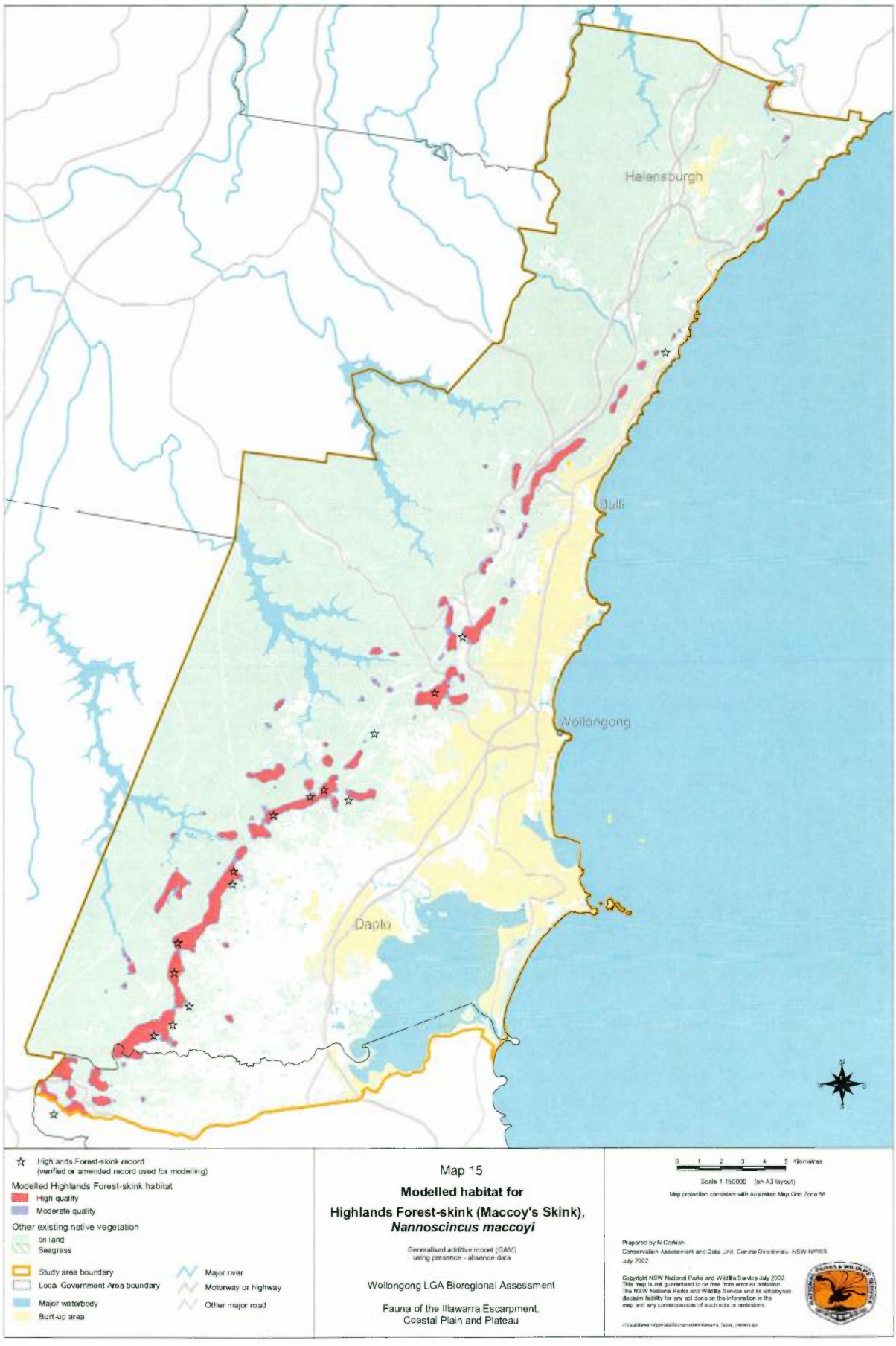
This species was only modelled during the Southern CRA. It has been recorded in only a few NPWS reserves, including Macquarie Pass and Budderoo NPs, but is predicted to occur in others. The model for the Study Area predicted on proximity to Rainforest and Moist Forest, showing the affinity of this species to wet forests. Much of the predicted habitat is within the Illawarra Escarpment SCA.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence Only Without Eden	4	29191	-	10201	-
Central CRA	Not Modelled					
Combined Models	-	-	29191	0.8	10201	34.9

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
2010	2.6	616	754	304	4	56	1118	55.6


Helensburgh
Dulli
Wollongong
Dapto
Highlands Forest-skink record
(verified or amended record used for modelling)
Modelled Highlands Forest-skink habitat
High quality
Moderate quality
Other existing native vegetation
on land
Seagrass
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 15
Modelled habitat for
Highlands Forest-skink (Maccoy's Skink),
Nannoscincus maccoyi
Generalised additive model (GAM)
using presence - absence data
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corkish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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5.9 GOLDEN-CROWNED SNAKE

Species Profile

©Kylie Madden

The Golden-crowned Snake (*Cacophis squamulosus*) is a small, nocturnal snake that is identified by a yellowish stripe around the head that does not join to form a nuchal band and a reddish belly. During the day it shelters under stones, logs and in leaf-litter in the wet forests that are its preferred habitat. It lays up to fifteen eggs and feeds mainly on small skinks. It is venomous, but not considered dangerous, and when it is cornered will often strike, but rarely bites (Cogger 1996). It is distributed between south eastern Queensland and central New South Wales (Cogger 1996) with the southern limit appearing to be about the Shoalhaven River (NPWS 2002b).

Map 16 shows records of the Golden-crowned Snake along with its predicted distribution.

Threats

The Golden-crowned Snake was listed as a species that may become threatened by continued bush rock removal (NSW Scientific Committee 1999a). Other potential threats may be habitat destruction and increased mortality from dogs, humans, and cars, as this snake is often seen foraging at night on roads.

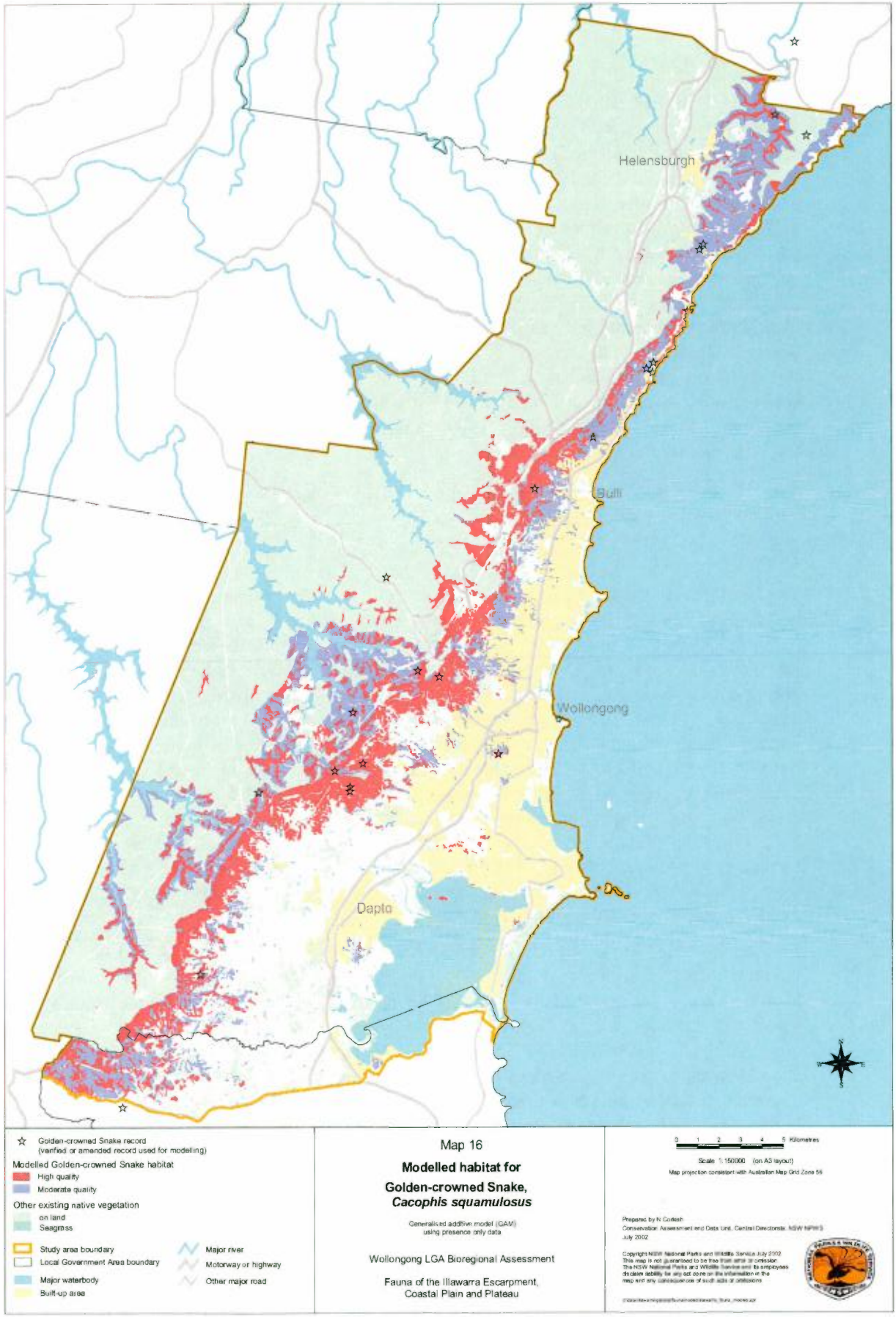
Local and regional conservation status

The Golden-crowned Snake is listed as Protected under the NSW NP&W Act (1974). It was nominated as a priority species as it is at the southern edge of its range. This species is uncommon elsewhere in the Bioregion while remaining fairly common in Wollongong. Therefore, the continued survival of the Wollongong population may be important in the conservation of the species regionally. It was found at a number of locations during the current survey, including one during a diurnal reptile search in the isolated remnant at Mangerton Park.

No models were generated for this species during the CRA, but the main areas of population in the Sydney Basin Bioregion occur along the Illawarra Escarpment and the northern suburbs of Sydney, with scattered records from the Central Coast and the sandstone areas of the Blue Mountains. There are relatively few records from reserves, with most coming from Royal and Ku-ring-gai Chase NPs and Illawarra Escarpment SCA. The model created for the Study Area predicted on Fruit, which is a surrogate for areas with either a mesic understorey or rainforest, showing its preference for wet forests. The species is protected within the NPWS and Sydney Catchment Authority managed lands along the escarpment.

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
6097	8.0	6720	1495	1438	28	154	3115	51.1


Helensburgh
Bulli
Wollongong
Dapto
Golden-crowned Snake record
(verified or amended record used for modelling)
Modelled Golden-crowned Snake habitat
High quality
Moderate quality
Other existing native vegetation
on land
Seagrass
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 16
Modelled habitat for
Golden-crowned Snake,
Cacophis squamulosus
Generalised additive model (GAM)
using presence only data
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corkish
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5.10 BROAD-HEADED SNAKE

Species Profile

©Alex Dudley

The Broad-headed Snake (*Hoplocephalus bungaroides*) is a semi-arboreal species that spends a portion of the year under sandstone exfoliations, and a part of the year in tree hollows. It averages about 60 centimetres in length and is recognisable by its black and yellow patterning. It is restricted to the sandstone environments of the Sydney Basin between Wollemi NP and the Clyde River Catchment, south west of Nowra. Within this range it has disappeared from such areas as Port Jackson and Middle Harbour, and on the western edge of its distribution around Bathurst. It is primarily a nocturnal ambush predator (NPWS 1999f) and is known to prey on Lesueur's Velvet Gecko (*Oedura lesueurii*).

Map 17 shows records of the Broad-headed Snake within the Wollongong Area along with predicted habitat.

Threats

The key threat to the Broad-headed Snake is likely to be the collection of bush rock for landscaping (Shine & Fitzgerald 1989). This activity, although now either prohibited or requiring permits in most local government areas, is still widely practiced illegally. Removal of rock not only threatens this species directly, but removes habitat for its main prey species, Lesueur's Velvet Gecko. Webb & Shine (2000) investigated the addition of concrete pavers to degraded rock platforms to augment the habitat of this species and its prey. In addition, the Broad-headed Snake is colourful, rare and venomous, making it prized by snake-collectors. Collection of specimens from the wild is also likely to be a threat to this species (NPWS 1999f), particularly on the peripheries of urban areas, such as Wollongong. Other potential threats include urbanisation of sandstone ridgetops, impacts of feral animals, through both predation and disturbance, and altered fire regimes that may affect the snake when it is utilising tree hollows (NPWS 1999f).

Local and regional conservation status

The Broad-headed Snake, which is listed on Schedule 1 of the NSW TSC Act (1995), is far rarer than it once was. A targeted search by the NPWS in 1998 revisited known localities, and investigated likely habitat. This project failed to locate many individuals anywhere, and none within the Wollongong LGA, an area considered one of four key areas within its distribution (NPWS 1999f). The current survey located one juvenile Broad-headed Snake in the Sydney Catchment Authority Metropolitan Catchment. This important discovery makes a total of only three individuals found in the Wollongong LGA within the last ten years, despite numerous targeted searches.

Rather than use the CRA models to predict suitable habitat, a more recent model created for the species recovery plan over the entire distribution was utilised. This showed that though the Broad-headed Snake is virtually restricted to the Sydney Basin, only a relatively small area is high quality habitat. Much of this habitat is within NPWS managed land, with a number of records from Morton, Royal and Blue Mountains NPs. This model was also used to predict the suitable habitat in the Study Area. The predicted habitat primarily occurs within Sydney Catchment Authority Special Areas or Dharawal

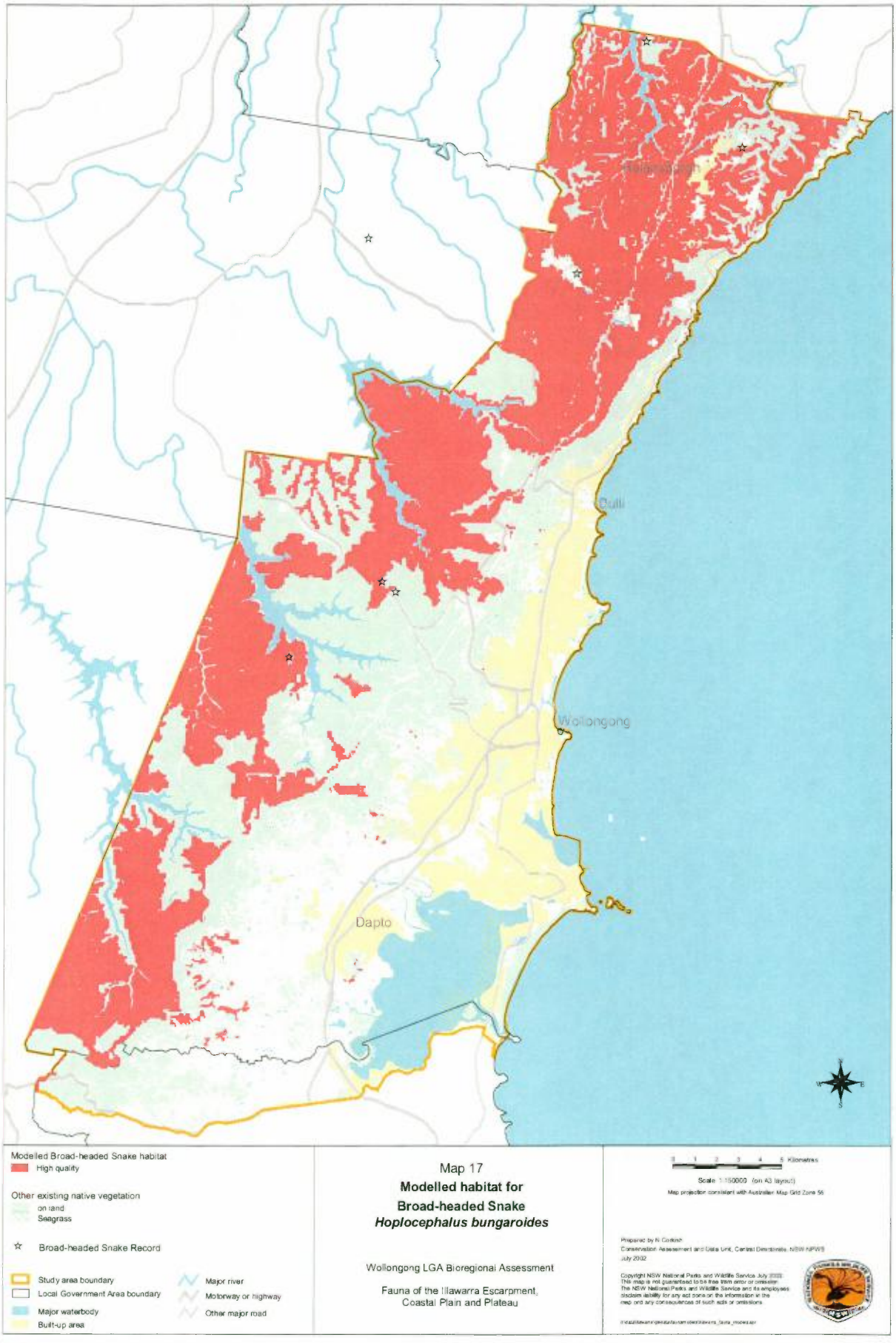
SCA. In these areas they are well protected from development, but they are still vulnerable to poaching and bush rock collection.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA Central CRA Combined Models	Expert Model* Expert Model Presence Only	4 Adequate -	157100	4.3	86717	55.2

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
25427	33.2	0	2728	19060	101	57	21946	86.3


Bulli
Wollongong
Dapto
Modelled Broad-headed Snake habitat
High quality
Other existing native vegetation
on land
Seagrass
Broad-headed Snake Record
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 17
Modelled habitat for
Broad-headed Snake
Hoplocephalus bungaroides
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Codosh
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
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5.11 MAINLAND TIGER SNAKE

Species Profile


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The Mainland Tiger Snake (*Notechis scutatus*) is a large, highly variable snake that sometimes has the banding suggested by its common name. Though found in a wide number of habitats (Cogger 1996), they are commonest in wetland and riparian habitats as their main food source is frogs, though they will eat other vertebrates (Anon. 2000). They are usually diurnal or crepuscular, but will be active at night during hot weather (Cogger 1996). This species is highly venomous, but is usually only aggressive if provoked. It is found between the highlands of south eastern Queensland through to Murray River area of South Australia, with the closely related Black Tiger Snake (*N. ater*) found in Tasmania, South Australia and Western Australia (Cogger 1996).

Map 18 shows records of the Mainland Tiger Snake from the Wollongong Area.

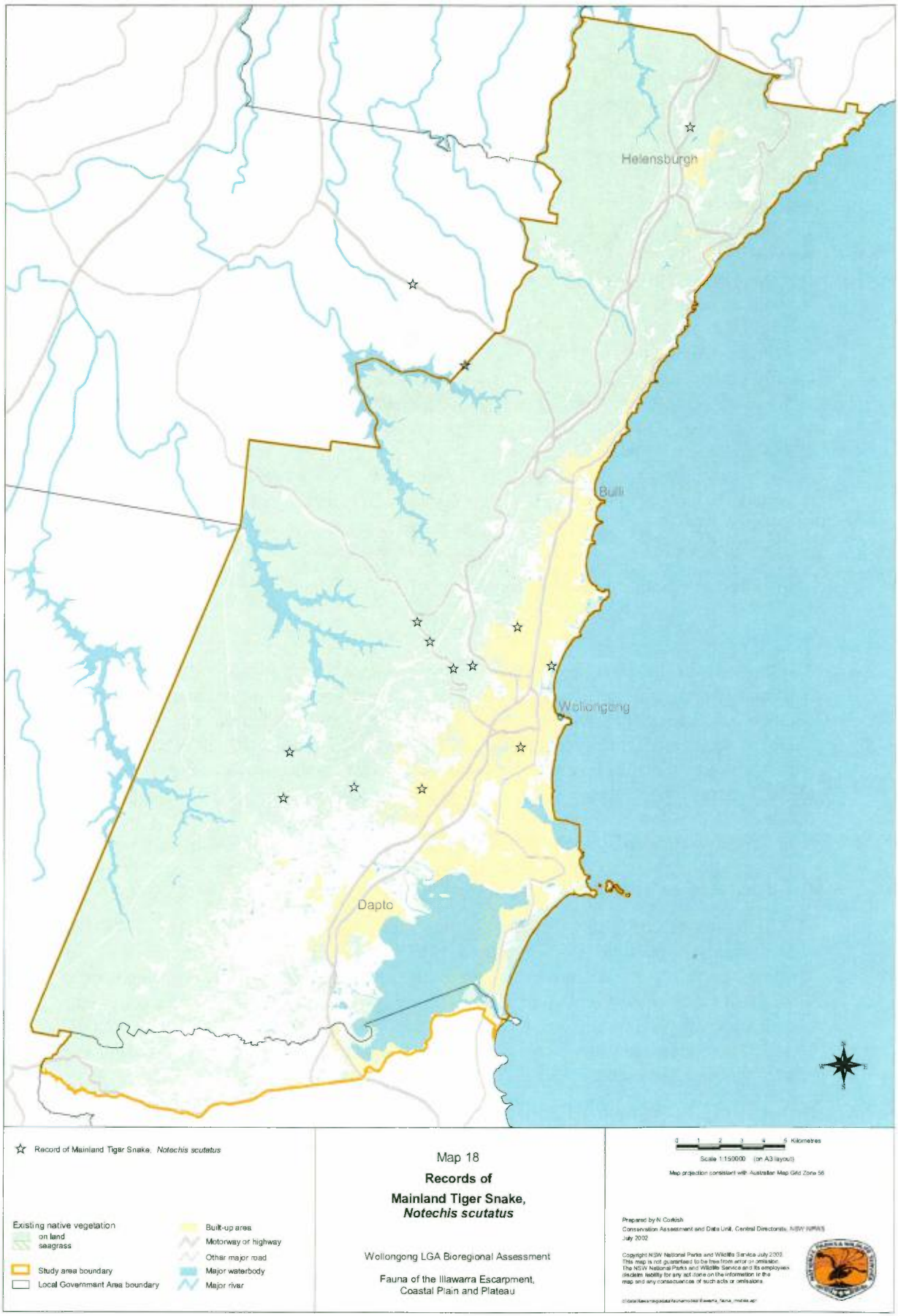
Threats

The two species of Tiger Snakes used to be the main cause of snakebite fatalities in Australia (Anon. 2000). This has often lead to direct persecution by humans. Snake numbers, and hence bites, appear to have declined in correlation with a reduction in frog numbers, which is due to habitat modification and disease (Anon. 2000). It is believed that the Green and Golden Bell Frog, which occurred in vast numbers prior to the introduction of the Chytrid fungus, may have been an important food source for the Mainland Tiger Snake. It is hypothesised that the massive declines in the numbers of this frog may have seen a concomitant decline in the Mainland Tiger Snake (R. Wellington, pers. comm.).

Local and regional conservation status

The Mainland Tiger Snake is listed as Protected under the NSW NP&W Act (1974). It was nominated as a priority species due to the decline in numbers observed in Wollongong and elsewhere in recent years. It was recorded on only one occasion during the current survey near Loddon Creek next to a frog-filled dam. This species is thought to still exist near the swamps at the base of the escarpment in the Dombarton area (J. Wade pers. comm.) and two were captured to the north west of Mt. Keira during the eastern gas pipeline process (NPWS 2002b).

No model has been generated for this species for the bioregional scale. Localities of this species are scattered throughout the Bioregion, particularly at higher elevations. There are a number of recent records for Royal NP, though whether this reflects a significant population or high survey effort is unknown. No model was derived for the Wollongong Study Area, as there were too few accurate records.


Helensburgh
Bulli
Wollongong
Dapto
☆ Record of Mainland Tiger Snake, Notechis scutatus
Existing native vegetation
on land
seagrass
Study area boundary
Local Government Area boundary
Built-up area
Motorway or highway
Other major road
Major waterbody
Major river
Map 18
Records of
Mainland Tiger Snake,
Notechis scutatus
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with: Australian Map Grid Zone 56
Prepared by N Corfield
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5.12 AUSTRALIAN BRUSH-TURKEY

Species Profile

©P. Green

The Australian Brush-turkey (*Alectura lathami*) is a large, ground-dwelling bird that has a mostly black body and a bright red head and neck. It utilises forests and wooded areas, usually rainforest, where it feeds on the ground but roosts at night in trees. It prefers to breed in rainforest, where the canopy provides shade and leaf-litter for the construction of a large mound. It readily adapts to urban areas, and is often considered a pest because of damage done to gardens and commercial crops. The two subspecies are endemic to the east coast of Australia between Cape York and the Illawarra, with the nominate race *lathami* occurring in New South Wales (Marchant & Higgins 1993).

Map 19 shows records of the Australian Brush-turkey in the Wollongong Area.

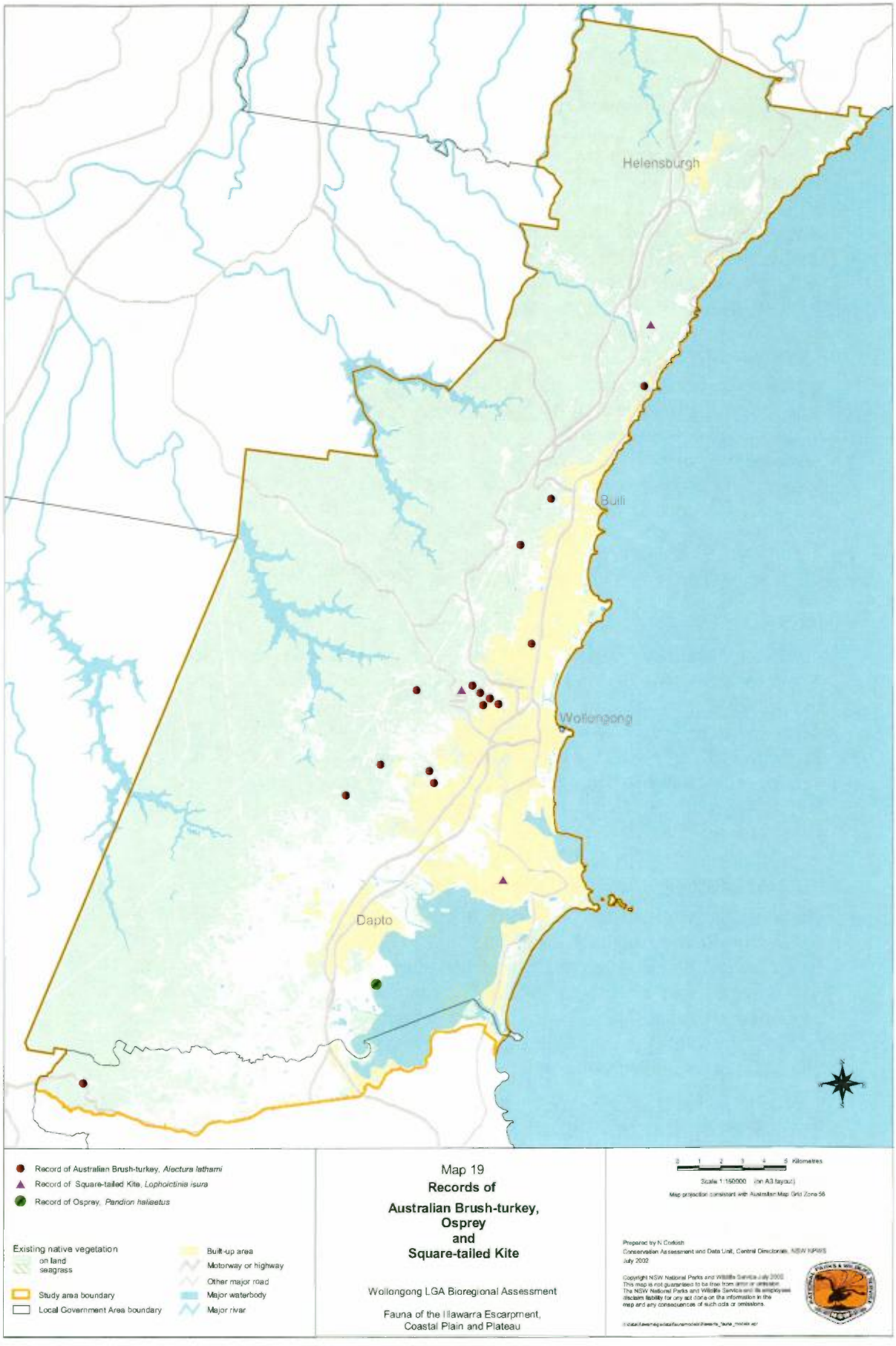
Threats

Population fluctuations have occurred in the past due to habitat destruction and shooting (Marchant & Higgins 1993). It is one of the species that has been identified as using the Endangered Ecological Community of Lowland Rainforest on Floodplain in the NSW North Coast Bioregion that has been greatly reduced by clearing (NSW Scientific Committee 1999b). Habitat clearance in other lowland areas may also have had an affect on population numbers. The decline in the Wollongong population may have been due to hunting for food. Predation by foxes, particularly of young birds, also seems to be a major threat (C. Chafer, pers. comm.).

Local and regional conservation status

The Australian Brush-turkey is listed as Protected under the NSW NP&W Act (1974). In the Illawarra it was moderately common during the 19th century, but by 1900 was close to extinction. The species has re-established a small breeding population, assisted by the release (or escape) of birds in 1948 and during the 1980s (Chafer *et al.* 1999). This southern-most population, between Mt. Cambewarra and Royal NP (recent observation by S. Anyon-Smith) is now isolated, with the nearest records from around Ku-ring-gai Chase NP on the northern side of the Sydney urban area (NPWS 2002b).

This species has not been modelled at either the regional or local scale. At the bioregional scale, it is relatively widespread, particularly north of the Hawkesbury River and is protected in a number of reserves, most of which are near the coast (including Bouddi, Dharug and Watagans NPs), though it is occasionally recorded in some tableland reserves, such as Blue Mountains and Wollemi NPs. Within the Study Area, there are too few records to generate a model, but it has been recorded at a number of locations along the escarpment, including within Illawarra Escarpment SCA (NPWS 2002b).


Helensburgh
Bulli
Wollongong
Dapto
Record of Australian Brush-turkey, Alectura lathami
Record of Square-tailed Kite, Lophoictinia isura
Record of Osprey, Pandion haliaetus
Existing native vegetation
on land
seagrass
Study area boundary
Local Government Area boundary
Built-up area
Motorway or highway
Other major road
Major waterbody
Major river
Map 19
Records of
Australian Brush-turkey,
Osprey
and
Square-tailed Kite
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corbish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002

5.13 AUSTRALASIAN BITTERN

Species Profile

The Australasian Bittern (*Botaurus poiciloptilus*) is a large, secretive heron with a mottled dark brown, light brown and buff plumage. It is usually found singly, and is often betrayed by its distinctive booming call during the breeding season. It usually inhabits freshwater swamps with dense reeds and rushes (*Phragmites, Typha, Eleocharis,* etc.) though it may also occur in similar habitats in estuarine situations. It is found between southern Queensland and Tasmania in eastern Australia and in south western Western Australia, as well as New Zealand and New Caledonia (Marchant and Higgins 1990)

Map 20 shows all records of the Australian Bittern in Wollongong LGA along with predicted habitat.

Threats

NPWS (1999a), summarising Smith *et al.* (1995) and Garnett (1992) lists that most threats to the Australasian Bittern involve habitat alteration, though predation of the eggs and young by foxes is also included. Habitat in the Wollongong LGA may be altered for the following reasons: alteration of flooding regimes, clearing of riparian vegetation for agriculture, grazing and trampling of riparian vegetation by livestock and the drainage, salinisation, siltation and pollution of wetlands caused by urbanisation. As the Illawarra probably in part acts as a drought refuge, the degradation of the available habitat may affect the population of this species outside the local area.

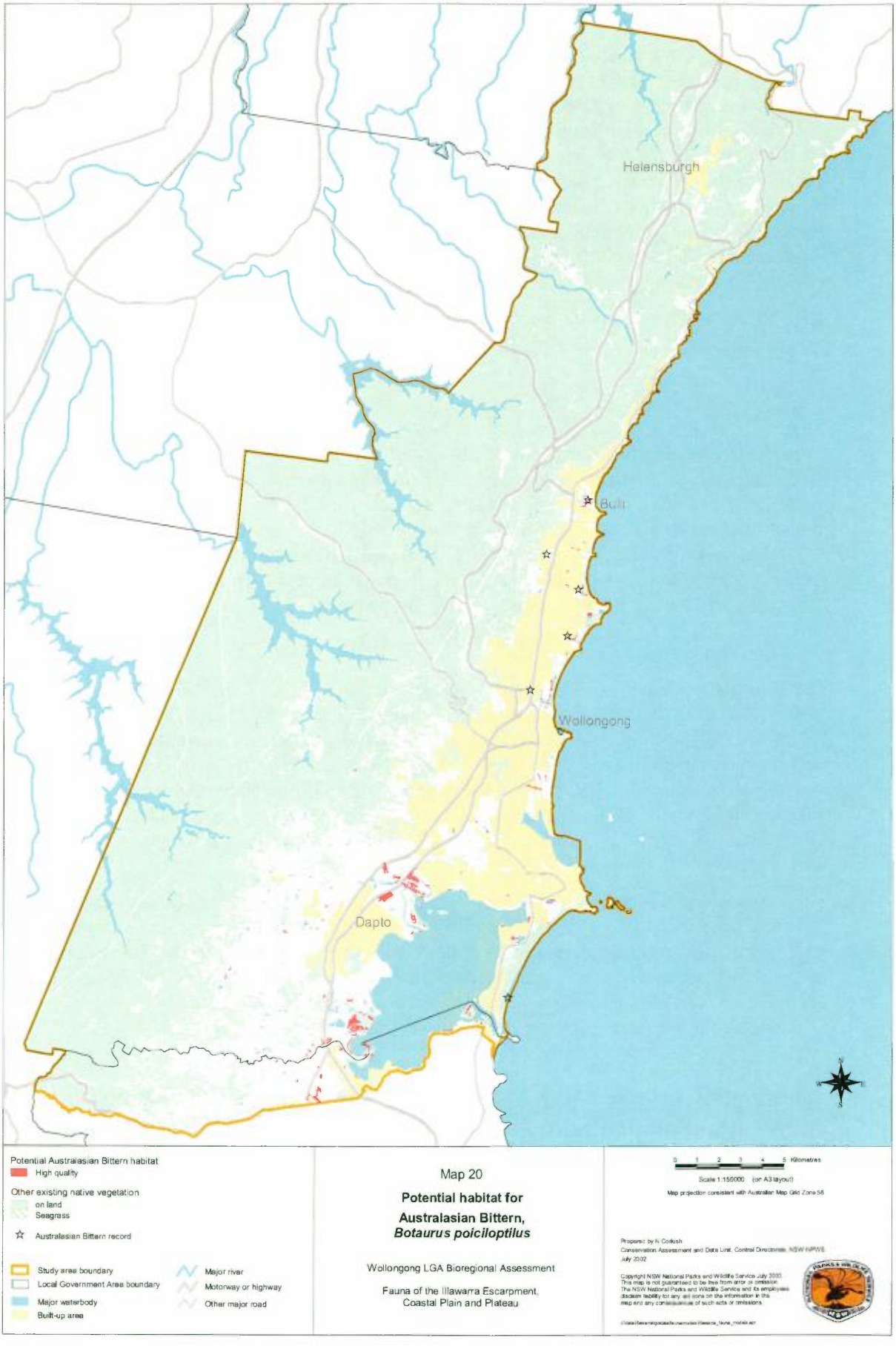
Local and regional conservation status

The Australasian Bittern is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). Chafer *et al.* (1999) lists it as a rare visitor, with more records in drought years. Within the Wollongong LGA it has been recorded at a number of scattered locations, with the most recent records at Woonona (Chafer 2002) and Sandon Point, Thirroul (D. Mackay, pers. comm.). The nearest breeding site is at Commonderry Swamp (near Shoalhaven Heads to the south) and Wingecarribee Swamp to the west (Chafer 2002). The Australasian Bittern probably has an annual population in the Illawarra region of less than twenty birds (Chafer *et al.* 1999).

This species has not been modelled at a regional scale. Within the Sydney Basin Bioregion, most of the records are confined to coastal areas, with very few records protected in NPWS managed lands. A habitat model was generated using the following categories of vegetation: Floodplain Wetlands, Estuarine Alluvial Wetlands and Coastal Sand Freshwater Wetlands. The remaining areas of potential habitat in Wollongong LGA are highly fragmented, heavily disturbed and poorly conserved (NPWS 2002a).

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
150	0.2	0	0	0	0	14	14	9.3


Helensburgh
Bulli
Wollongong
Dapto
Potential Australasian Bittern habitat
High quality
Other existing native vegetation
on land
Seagrass
Australasian Bittern record
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 20
Potential habitat for
Australasian Bittern,
Botaurus poiciloptilus
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corkish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
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5.14 BLACK BITTERN

Species Profile

The Black Bittern (*Ixobrychus flavicollis*) is a medium-sized, dark grey-black heron, with a distinctive yellow stripe on the head and neck. It is usually found singly or in pairs in thick vegetation at the margins of freshwater and estuarine wetlands, with breeding occurring in thick leafy trees overhanging water (Marchant & Higgins 1990). In the Illawarra it is usually recorded in watercourses with either Swamp (*Casuarina glauca*) or River Oak (*C. cunninghamiana* subsp. *cunninghamiana*) (Chafer *et al.* 1999). Within Australia, it is widespread coastally between the Kimberleys, Western Australia and extreme north eastern Victoria, though rare south of Sydney, with an isolated declining population in south western Western Australia (Garnett & Crowley 2000). The subspecies *australis* is also found in New Guinea and surrounding islands, while two other subspecies occur in the Solomon Islands, and between northern Indonesia and India (Marchant & Higgins 1990).

Map 21 shows all records of the Black Bittern in the Wollongong Area along with predicted habitat.

Threats

Habitat alteration would seem to be the greatest threat to the Black Bittern. Practices that have affected the species in Western Australia and are likely to have similar impacts in New South Wales include clearing of riparian vegetation for agriculture and urbanisation, and the resulting increase in salinity and sedimentation (Marchant & Higgins 1990; Garnett & Crowley 2000).

Local and regional conservation status

The Black Bittern is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). It is a rare breeding resident in the Illawarra, with an estimated regional population of less than twenty birds. Most records in the Wollongong LGA come from lower Duck Creek, with other sightings scattered at various wetlands. There is a nesting record for West Dapto (Chafer *et al.* 1999).

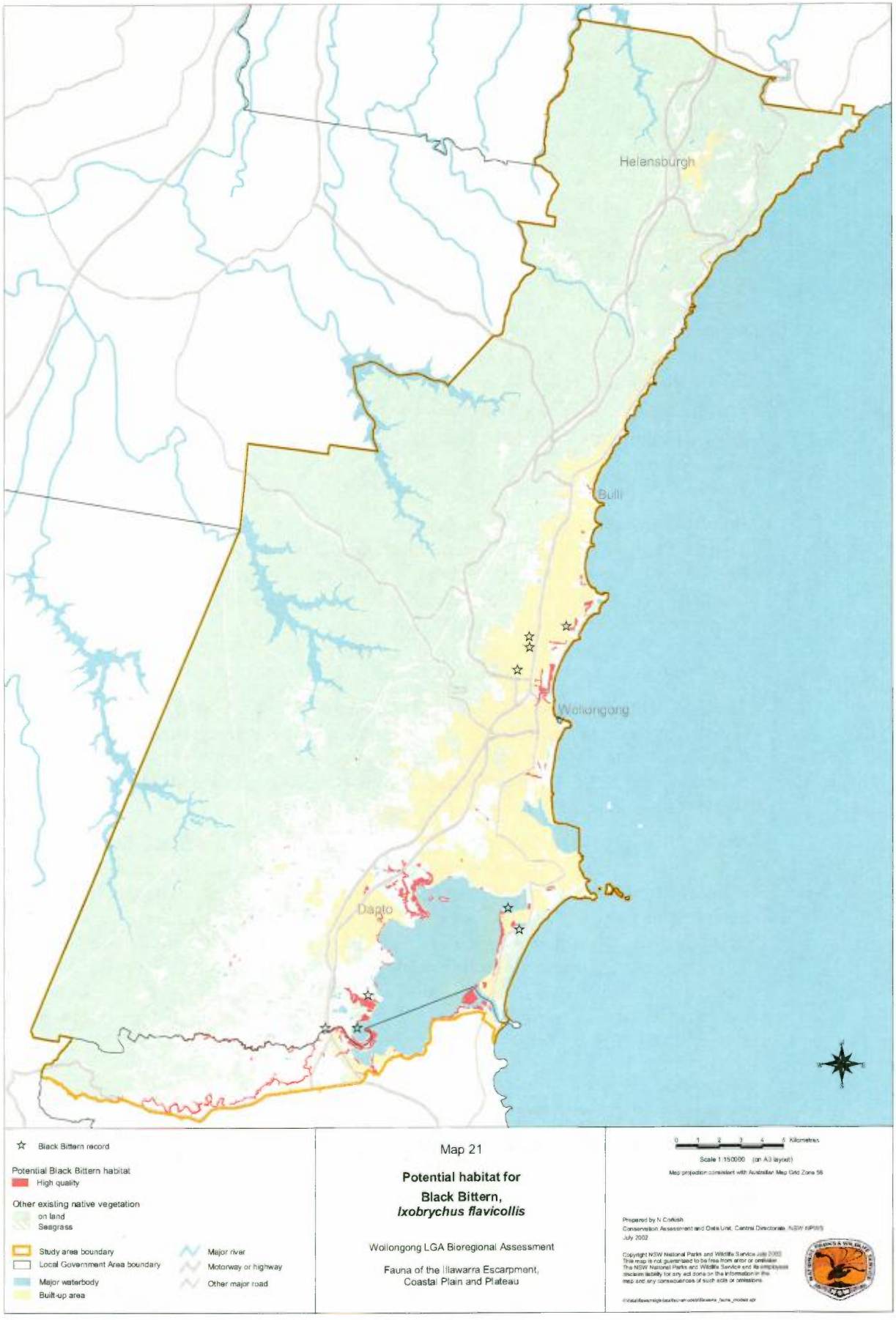
No model was generated during the Southern CRA, but as the Black Bittern is rarely recorded south of the Shoalhaven River, the Central CRA model is a good indicator of habitat with the Sydney Basin. A small percentage of the Bioregion is high quality habitat, and only a moderate amount is protected in NPWS managed lands, such as Scheyville and Dharug NPs. A habitat model was derived for the Study Area using the following communities: Coastal Swamp Oak Forest, Riparian River Oak Forest, Estuarine Alluvial Wetland and Coastal Sand Freshwater Wetland. The remaining areas of potential habitat in Wollongong LGA are generally highly disturbed and poorly conserved (NPWS 2002a).

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Not Modelled			-		-
Central CRA	Presence Only	Adequate	118330	-	32743	-
Combined Models	-	-	118330	3.3	32743	27.6

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
384	0.5	0	3	0	0	61	64	16.7

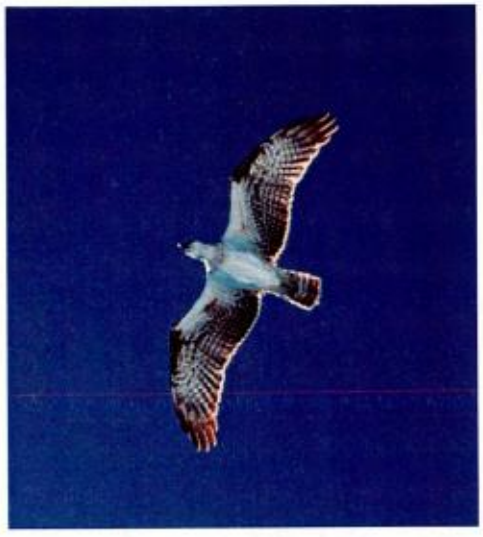

Helensburgh
Bulli
Wollongong
Dapto
Black Bittern record
Potential Black Bittern habitat
High quality
Other existing native vegetation
on land
Seagrass
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 21
Potential habitat for
Black Bittern,
Ixobrychus flavicollis
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corkish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002

5.15 OSPREY

Species Profile

The Osprey (*Pandion haliaetus*) is a medium-sized, pale-headed raptor that feeds mainly on fish. It usually inhabits estuarine and coastal waters, though it will travel inland up rivers and use lakes and dams. It uses dead trees for roosting and breeding. The subspecies *leucocephalus* occurs around most of the coast of Australia, though it is rare in Victoria, Tasmania and the Nullarbor coast. This subspecies is also found between New Caledonia and Indonesia, with three other subspecies occurring throughout much of the rest of the world (Marchant & Higgins 1993).

Map 19 shows the record of Osprey within the Wollongong Area.



©G. Robertson/NPWS

Threats

Clancy (1991) lists the potential threats for the Osprey in New South Wales as including loss of traditional nest trees, disturbance at nest sites, changes to food supply, affects of pesticides, and shooting.

Local and regional conservation status

The Osprey is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). It may have always been a transient species in the Wollongong LGA, with few sightings and no breeding recorded (Chafer *et al.* 1999). With the apparent increase in sightings in the areas south of Wollongong (Chafer *et al.* 1999; NPWS 2002b) it might be expected that the number of records within the LGA may increase over the next few years.

Being a coastal species, the model derived during the Central CRA shows a very small area of high quality habitat. It was not modelled during the Southern CRA, and although there are an increasing number of records in the area, they would probably not add significant areas of high quality habitat to the Bioregion. It is moderately well reserved, with records from a number of reserves, including Cockle Bay NR and Munmorah SCA. No model was generated for the Study Area, but the Osprey would likely to be seen in coastal and estuarine locations, such as Lake Illawarra.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Not Modelled	?	-	-	-	-
Central CRA	Presence Only		27296		6682	
Combined Models			27296	0.8	6682	24.5

5.16 SQUARE-TAILED KITE

Species Profile

The Square-tailed Kite (*Lophoictinia isura*) is a medium-sized, long-winged raptor with a diagnostic white face (Marchant & Higgins 1993). It is endemic to the Australian mainland, where it is most often recorded within 250 kilometres of the coast (Garnett & Crowley 2000). In southern Australia it is most regularly recorded in open eucalypt forest and woodland, where it hunts at canopy level, feeding on birds, including eggs and nestlings, and insects (Marchant & Higgins 1993). Breeding pairs utilise a large (up to 100 square kilometre) home range during the breeding season. Square-tailed Kites migrate to northern Australia after breeding has completed, though the dispersal route is unknown (Marchant & Higgins 1993)

Map 19 shows the records of Square-tailed Kite in the Wollongong Area.

Threats

NPWS (1999b) and Garnett & Crowley (2000) both list loss of habitat through land clearance as a major threat, with the latter also saying that the Square-tailed Kite may have benefited from partial land clearance. NPWS (1999b) also lists illegal shooting, egg collection, disturbance of nest trees and inappropriate fire regimes as other potential threats.

Local and regional conservation status

The Square-tailed Kite is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). Within the Illawarra it is a rare summer breeding migrant (Chafer *et al.* 1999). Though it is known to breed in the Shoalhaven region, the only records for the Wollongong LGA are one from Maddens Plains (Chafer *et al.* 1999), an individual foraging in Lake Heights in 2001 (C. Chafer, pers. comm.) and a possible sighting at Mt. Keira during this study. Records from Wollongong are possibly of birds migrating to and from breeding sites on the south coast.

Within the Sydney Basin Bioregion, this species has a relatively large area of potential habitat, particularly when the Southern CRA predicted no suitable habitat. Recent records from the Shoalhaven, including breeding, would indicate that this model is underestimating potential habitat. Within the Bioregion its breeding habitat appears to be restricted to drier areas, such as the Capertee Valley and Upper Hunter River. Within this distribution there are only occasional records of birds seen within NPWS managed lands. As it is not core habitat for the species and there are very few records, it was not possible to model Square-tailed Kite habitat for the Study Area.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Expert Model	1	0	-	0	-
Central CRA	Presence Only	Adequate	321821	-	67416	-
Combined Models	-	-	321821	8.8	67416	21.0

5.17 WOMPOO FRUIT-DOVE

Species Profile

The Wompoo Fruit-dove (*Ptilinopus magnificus*) is a large, colourful rainforest pigeon. It is most regularly found in large patches of tall subtropical or tropical rainforest, where it utilises the middle strata for breeding. It feeds on fruits from a wide variety of trees, vines and palms, usually in the dense canopy where it is often first detected by its distinctive call. A number of subspecies occur along the eastern coast of Australia and New Guinea, with the largest race (*magnificus*) in New South Wales (Higgins & Davies 1996).

Map 22 shows historic and unconfirmed recent records of the Wompoo Fruit-dove for the Wollongong Area.

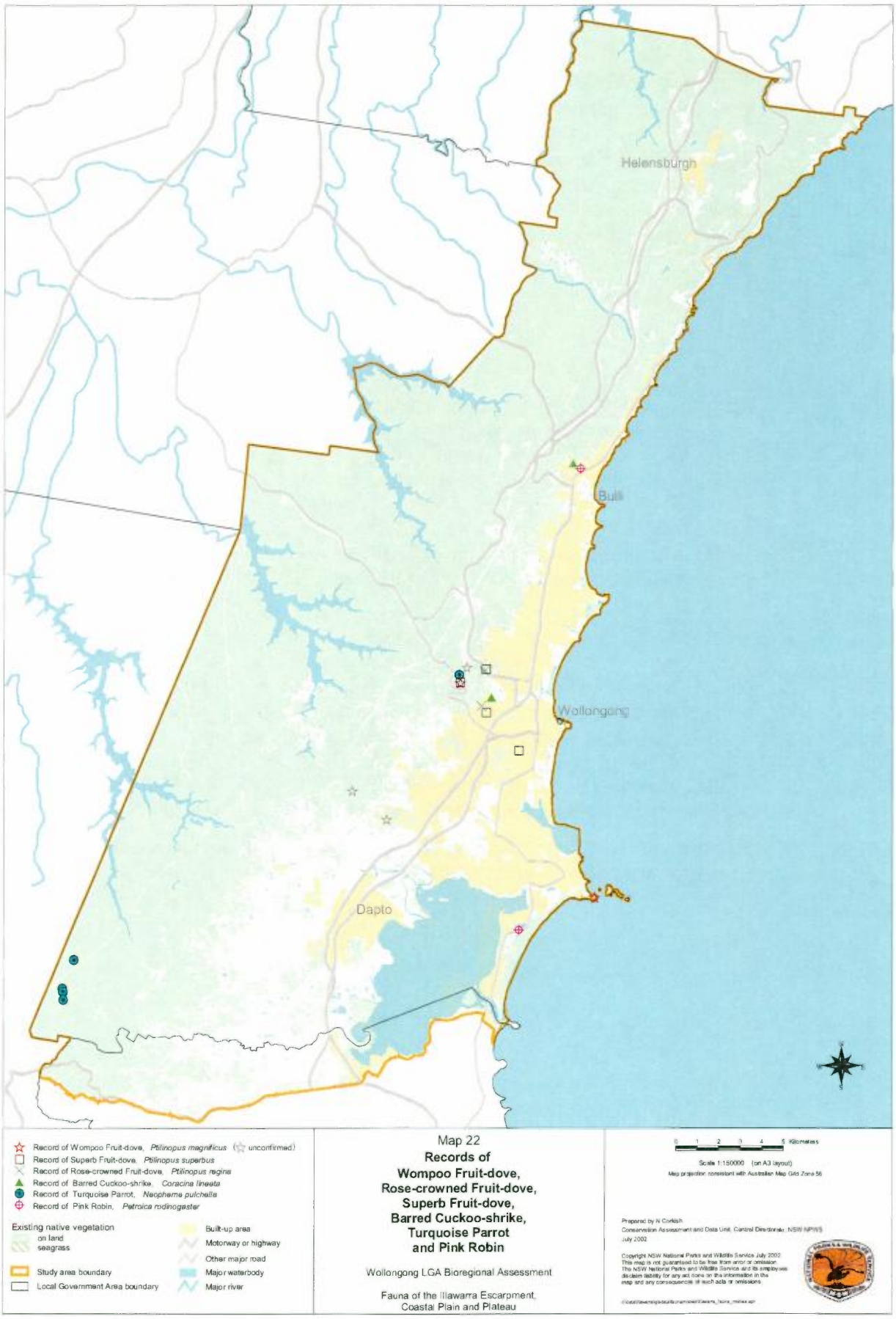
Threats

Chafer *et al.* (1999) state that the population within the Illawarra was reduced by "hunting, museum collecting and habitat destruction." It was formerly regularly hunted for food, sport and to prevent damage to fruit crops (Higgins & Davies 1996). Removal of lowland rainforest, which it utilises in the non-breeding season, may limit the population size in northern New South Wales (Recher *et al.* 1995). It is one of the species that has been identified as using the Endangered Ecological Community of Lowland Rainforest on Floodplain in the NSW North Coast Bioregion that has been greatly reduced by clearing (NSW Scientific Committee 1999b).

Local and regional conservation status

The Wompoo Fruit-dove is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). It was originally described from a specimen from Red Point, Port Kembla, and was a moderately common breeding resident in the 1840s. It is now considered extinct in the Wollongong LGA, with the last sighting being at Mt. Keira in 1920. All recent records are considered unconfirmed (Chafer *et al.* 1999). As this is essentially a sedentary species (Higgins & Davies 1996) it is unlikely to re-establish naturally in the Wollongong LGA from the nearest resident population in the Barrington Tops area.

Because it is now a vagrant at the southern extreme of its distribution the Wompoo Fruit-dove was not modelled at either the bioregional or local scale.


Helensburgh
Bulli
Wollongong
Dapto
Record of Wompoo Fruit-dove, Ptilinopus magnificus (unconfirmed)
Record of Superb Fruit-dove, Ptilinopus superbus
Record of Rose-crowned Fruit-dove, Ptilinopus regina
Record of Barred Cuckoo-shrike, Coracina lineata
Record of Turquoise Parrot, Neophema pulchella
Record of Pink Robin, Petroica rodinogaster
Existing native vegetation
on land
seagrass
Study area boundary
Local Government Area boundary
Built-up area
Motorway or highway
Other major road
Major waterbody
Major river
Map 22
Records of
Wompoo Fruit-dove,
Rose-crowned Fruit-dove,
Superb Fruit-dove,
Barred Cuckoo-shrike,
Turquoise Parrot
and Pink Robin
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection: consistent with Australian Map Grid Zone 56
Prepared by N Corkish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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5.18 SUPERB FRUIT-DOVE

Species Profile

The Superb Fruit-dove (*Ptilinopus superbus*) is a small, colourful rainforest pigeon. It usually feeds on fruit in the canopy of its dense rainforest habitat, where, apart from call, it may be difficult to detect. It is found on the east coast of Australia, with records as far south as Tasmania, though it is less common south of 18°S, which is thought to be the southern limit of breeding. It also occurs from eastern Indonesia, through New Guinea to the Solomon Islands (Higgins & Davies 1996).

Map 22 shows records of the Superb Fruit-dove for the Wollongong Area.

Threats

Clearance of rainforest, particularly in lowland areas, may limit the number of birds visiting New South Wales in the non-breeding season. Migration seems to occur at night, and collisions with objects, such as lighthouses and windows, are common (Higgins & Davies 1996). Two of the records from Wollongong LGA are birds that flew into windows (Chafer *et al.* 1999).

Local and regional conservation status

The Superb Fruit-dove is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). The population of New South Wales may be as low as 100 individuals, possibly migrants from the northern breeding population (Recher *et al.* 1995). In the Illawarra it is a rare nomad with ten records between 1880 and 2000 (Chafer 2001). Individuals would be expected to occasionally turn up in the Wollongong LGA.

The Superb Fruit-dove is at the extreme south of its range in the Sydney Basin Bioregion, and hence only a small area was considered high quality habitat in the CRA process. Nearly half of this habitat occurs in NPWS managed land. The few, incidental records of this species in the Study Area meant that a model could not be generated for it.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Not Modelled			-		-
Central CRA	Presence Only	Good	21929		9869	
Combined Models	-	-	21929	0.6	9869	45.0

5.19 ROSE-CROWNED FRUIT-DOVE

Species Profile

The Rose-crowned Fruit-dove (*Ptilinopus regina*) is a small, colourful pigeon similar to the Superb Fruit-dove. It inhabits tropical and subtropical rainforests, especially with dense growth of vine, though it will also utilise adjoining habitats such as eucalypt forests and mangroves. It is frugivorous, with small groups feeding in the canopy on various species of trees, palms and vines. The nominate subspecies *regina* breeds between Torres Strait and central New South Wales, with vagrants further south as far as Tasmania. Other subspecies occur between the Gulf of Carpentaria and the Kimberleys in northern Australia, and on various islands in eastern Indonesia (Higgins & Davies 1996).

Map 22 shows records for the Rose-crowned Fruit-dove in the Wollongong Area.

Threats

Clearance of habitat may be the greatest restriction on population size, though birds will fly to isolated patches with one or two fruiting trees (Higgins & Davies 1996). Clearing of lowland habitats may also add additional pressures increased disturbance through visitation and increased nest predation by species such as Pied Currawongs (*Strepera graculina*) and corvids (*Corvus* spp.) (Recher *et al.* 1995). Birds are often injured or killed by flying into windows or lighthouses (Higgins & Davies 1996).

Local and regional conservation status

The Rose-crowned Fruit-dove is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). It is a rare visitor to the Illawarra region, with the two records in the Wollongong LGA both being individuals flying into windows (Chafer *et al.* 1999). Individuals or small groups may be expected to occur infrequently in areas with fruiting trees, including gardens.

Once again, as this species is a rare vagrant in the Sydney Basin Bioregion, no models have been generated for it at either the Bioregion or for the Wollongong Study Area.

5.20 GLOSSY BLACK-COCKATOO

Species Profile

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

Threats

Habitat destruction for agriculture or residential development appears to be one of the main threats, due to both removal of nesting and feeding sites, and also from competition from more open habitat species such as Galahs (*Eolophus roseicapillus*). Many *Allocasuarina* species are fire sensitive, hence inappropriate burning regimes may affect food supplies. Illegal trapping for aviculture may be a localised, minor threat (Garnett & Crowley 2000).

Local and regional conservation status

The Glossy Black-cockatoo is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). Chafer *et al.* (1999) lists it as a scarce resident in the Illawarra region, but with all records to the south or west of Wollongong City Council. It may occur in small numbers, particularly in the Catchment areas above the escarpment, with a recent record within two kilometres of the western boundary of the LGA on Fire Trail 6A between Avon and Cordeaux Reservoirs (C. Chafer, pers. comm.).

Relatively large areas of the Sydney Basin are suitable for Glossy Black-cockatoos. It is widely recorded, apart from in the urban areas of Sydney and Wollongong and the sections of the Bioregion that have been extensively cleared. It is well protected, occurring in numerous NPWS reserves, including Morton, Nattai, Ku-ring-gai Chase and Wollemi NPs. No model was developed for Glossy Black-cockatoo for the Wollongong Area, due to the lack of records. However, vegetation communities that are *Allocasuarina* dominant, such as Escarpment Edge Silvertop Ash Forest, Escarpment Blackbutt Forest and Nepean Sandstone Gully Forest may be occasionally utilised as habitat above the escarpment.

Note: In the post-fire and drought affected months of early 2003, there have been several sightings of Glossy Black Cockatoo in *Allocasuarina* in the Darkes Forest area at Bulli, below the escarpment (C. Chafer, A. Reid, K. Madden pers comm). It is possible that these areas are important during years where food is scarce elsewhere.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence Only Without Eden*	3.5	50815	-	20705	-
Central CRA	Presence Only	Good	378106	-	153597	-
Combined Models	-	-	422621	11.6	174302	41.2

5.21 SWIFT PARROT

Species Profile


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The Swift Parrot (*Lathamus discolor*) is a medium-sized, green parrot with distinctive red and blue head markings. It favours open eucalypt forest and woodland where it feeds on nectar and lerp (Higgins 1999). In the Illawarra, it is mainly recorded within coastal forests, where it favours Swamp Mahogany (*Eucalyptus robusta*) (Chafer *et al.* 1999). It breeds only in Tasmania, and migrates to the mainland as far north as southern Queensland during autumn and winter. During the non-breeding season it is nomadic, with small to large flocks congregating at suitable food sources (Higgins 1999).

Map 23 shows all records of the Swift Parrot in the Wollongong Area along with predicted habitat.

Threats

The Swift Parrot has a small population of approximately 2000 individuals (Tzaros 2002) which may still be declining (Garnett & Crowley 2000). Outside the breeding area the main threat is from habitat destruction (Garnett & Crowley 2000). It is nomadic during the non-breeding season (Higgins 1999) due to the variable nature of the flowering of its favoured feeding trees, including Mugga Ironbark (*Eucalyptus sideroxylon*), White Box (*E. albens*) and Spotted Gum (*Corymbia maculata*), which makes it sensitive to clearance of areas that it may rely on only once every few years. Due to its rapid flight, the species often is killed in collisions with windows, vehicles and fences, though this occurs more regularly in Tasmania (Garnett & Crowley 2000).

Local and regional conservation status

The Swift Parrot is listed as Endangered on Schedule 1 of the NSW TSC Act (1995) and as Endangered on the Commonwealth EPBC Act (1999). In the Illawarra it is a rare visitor (Chafer *et al.* 1999) with the most recent records being at Primbee in May 2000 (Chafer 2000) and up to twenty birds roosting in Wollongong University in July 2002 (C. Chafer, pers. comm.).

Most of the records of Swift Parrots in the Sydney Basin are near the coast, reflecting the areas of concentrated distribution of preferred habitat. It has been recorded in small numbers in a number of reserves, including Botany Bay and Wyrrabalong NPs, and Castlereagh NR. A habitat model was developed for this species with high quality habitat derived from vegetation communities dominated by Swamp Mahogany (Alluvial Swamp Mahogany Forest and Coastal Sand Swamp Mahogany Forest), and with communities with high presence of Coast Banksia (*Banksia integrifolia* subsp. *integrifolia*) (Exposed Bangalay-Banksia Woodland, Coastal Sand Scrub, Coastal Headland Banksia Scrub and Hind-dune Littoral Rainforest) included as moderate quality. The coastal habitats that it prefers in Wollongong have probably been greatly reduced by urban development, and the remaining fragments are highly disturbed and poorly reserved (NPWS 2002a).

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Expert Model	3	0	-	0	-
Central CRA	Presence Only	Adequate	126515	-	26342	-
Combined Models	-	-	126515	3.5	26342	20.8

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
48	0.1	751	0	0	0	12	12	25.0


Helensburgh
Bulli
Wollongong
Dapto
Potential habitat
High quality
Moderate quality
Other existing native vegetation
on land
Seagrass
Swift Parrot record
Regent Honeyeater record
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 23
Potential habitat for
Swift Parrot, Lathamus discolor
and
Regent Honeyeater, Xanthomyza phrygia
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
Kilometres
Scale 1:150000 (on A3 layout)

5.22 TURQUOISE PARROT

Species Profile

©NPWS

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

Map 22 shows the records of the Turquoise Parrot from the Wollongong Area.

Threats

Garnett & Crowley (2000) summarise the main threats as: past clearing for agriculture, which has greatly reduced the overall distribution; predation by cats and foxes; loss of hollows that are used for nesting in managed forests; and inappropriate burning regimes that may favour a shrubby rather than a grassy understorey.

Local and regional conservation status

The Turquoise Parrot is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). In the Illawarra it is a rare visitor, though it was possibly more common in drier areas, such as Camden, in the past (Chafer *et al.* 1999). Until recently, there was only one record in Wollongong LGA, though following the December 2001 fires, a number of sightings have been made in the Avon Catchment in the south west of the Study Area.

A relatively large area of high quality habitat has been modelled for the Turquoise Parrot, though its abundance in the Bioregion seems to be highest in the west and north. This is also reflected in the reserves it has been recorded in which include Yengo and Wollemi NPs, and Yerranderie SCA. Due to the paucity of records within the Study Area, no model was created at this scale.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Expert Model	1	0	-	0	-
Central CRA	Presence Only	Good	255093	-	61110	
Combined Models	-	-	255093	7.0	61110	24.0

5.23 GROUND PARROT

Species Profile

The Ground Parrot (*Pezoporus wallicus*) is a slender, long-tailed, terrestrial parrot of low heaths and sedgelands. Its plumage is dominated by green, with black and yellow barring and a distinctive red lower forehead. Most often seen when flushed from its thick, wet habitat, though readily detected at dawn and dusk when it undertakes call-flights. It feeds on a wide variety of seeds, and nests in a depression scratched in the ground, usually under a clump of vegetation (Higgins 1999). The subspecies *wallicus* is restricted to eastern Australia, between Fraser Island (Queensland) and formerly south eastern South Australia. Within this range, the overall population has contracted to about six isolated sub-populations. Other subspecies occur in Tasmania (*leachii*) and the south west of Western Australia (*flaviventris*) (Garnett & Crowley 2000).

Map 24 shows all records and predicted habitat for the Ground Parrot within the Wollongong Area.

Threats

Its range in the past has contracted due to habitat destruction and fragmentation through clearing for grazing, agriculture and development (Higgins 1999). Within its current distribution, inappropriate fire regimes are the main threat, with Ground Parrots requiring a mosaic of different age classes, including areas that have not been left unburnt for too long (Garnett & Crowley 2000). Due to its terrestrial behaviour, particularly during breeding, it is susceptible to predation by foxes and cats (Higgins 1999).

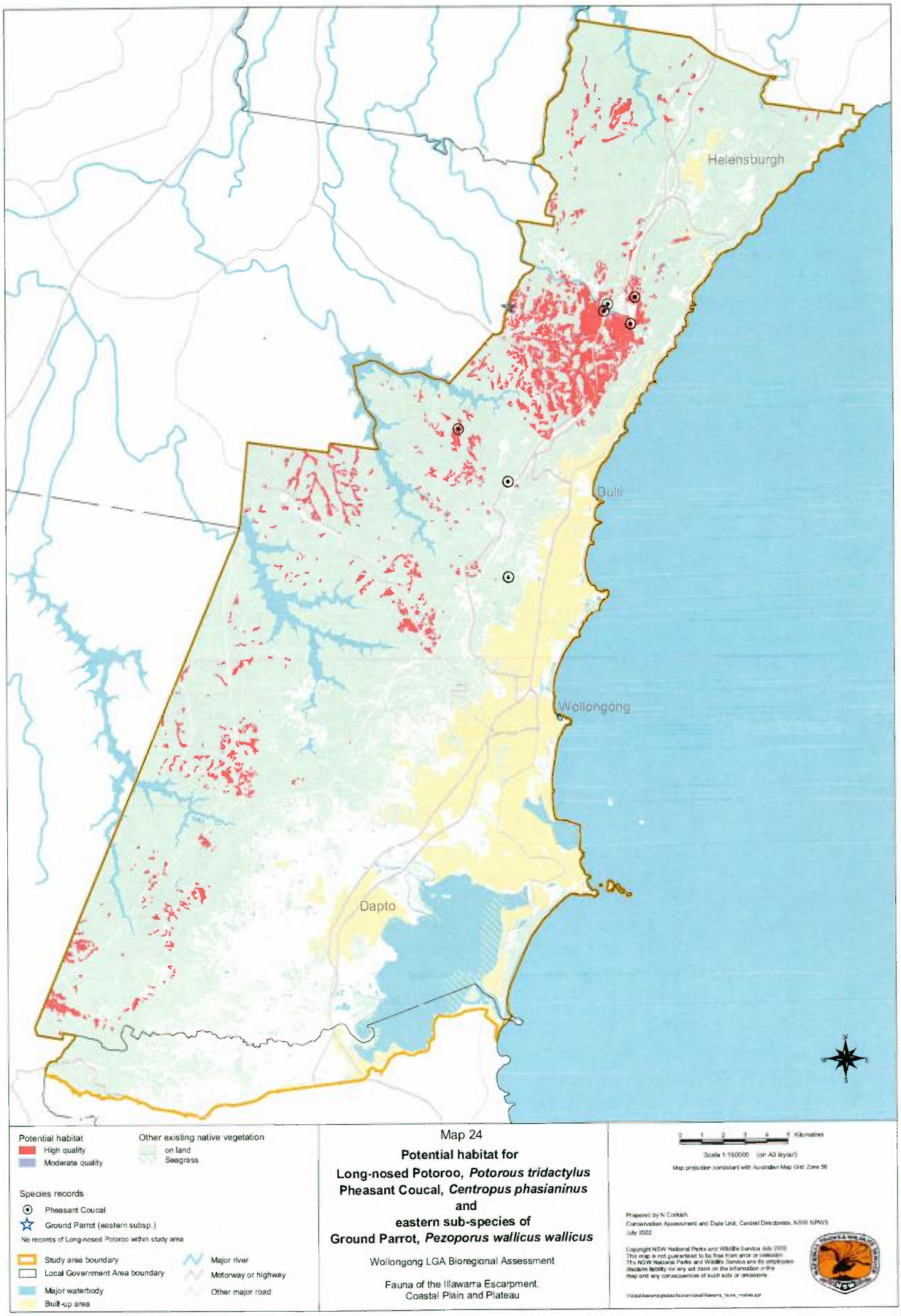
Local and regional conservation status

The Ground Parrot is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). It is a moderately common, breeding resident in the Illawarra (Chafer *et al.* 1999), though all current populations are south of the Wollongong LGA. The species may possibly still survive in the catchment areas, particularly around Maddens Plains from where the Australian Museum has a number of specimens, though there have been no records for at least the last twenty years (Chafer *et al.* 1999; Baker 1997). No sightings were made during the current surveys.

As this is not a forest species, it was not modelled during the CRA process. Within the Bioregion, the main populations are in and adjoining Morton NP, Jervis Bay (in both state and federally managed NPs) and Barren Grounds NR. Potential habitat was modelled based on Upland Swamps: Sedgeland-Heath Complex, though this almost certainly over predicts the area that may have once been utilised.

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
2766	3.6	0	337	2045	7	5	2394	86.6


Helensburgh
Bulli
Wollongong
Dapto
Potential habitat
High quality
Moderate quality
Other existing native vegetation
on land
Seagrass
Species records
Pheasant Coucal
Ground Parrot (eastern subsp.)
No records of Long-nosed Potoroo within study area
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 24
Potential habitat for
Long-nosed Potoroo, Potorous tridactylus
Pheasant Coucal, Centropus phasianinus
and
eastern sub-species of
Ground Parrot, Pezoporus wallicus wallicus
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corkish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002

5.24 PHEASANT COUCAL

Species Profile

©P. Green

The Pheasant Coucal (*Centropus phasianinus*) is a large, long-tailed pheasant-like cuckoo, which during breeding season has a black head and underbody, with fine brown and white barring on the back, wings and tail. Usually seen singly or in pairs, it inhabits woodlands, often around wetlands, with a dense understorey of grasses or sedges, and heathlands. It spends most of the time on the ground, where it feeds mainly on insects, but also on small vertebrates. Unlike other Australian cuckoos, it builds its own nest, which is usually well concealed in a grass tussock, and lays three to five eggs. The subspecies *phasianinus* occurs in eastern Australia, south of the Burdekin River, whilst five other subspecies occur in northern Australia, Timor and New Guinea (Higgins 1999).

Map 24 shows records of the Pheasant Coucal and predicted habitat within the Wollongong Area.

Threats

The impact of clearing on the Pheasant Coucal is variable. Clearing can provide dense clumps of vegetation that provide suitable habitat. Complete removal of vegetation, such as for urban development, can result in local extinction. Cattle grazing can reduce the amount of dense vegetation available (Higgins 1999). Fires in 1968 apparently eliminated a population in heathland on the Mt. Keira/Wilton Road (Chafer *et al.* 1999).

Local and regional conservation status

The Pheasant Coucal is listed as Protected under the NSW NP&W Act (1974). There are only scattered records south of the Hunter River (Higgins 1999), with the southernmost record being Conjola (Blakers *et al.* 1984). In the Illawarra, it is considered a rare, possible resident (Chafer *et al.* 1999) which appears to be isolated from the nearest population, which is in the northern suburbs of Sydney (NPWS 2002b). Most records from the south are during spring, possibly due to movements prior to breeding (Mills 1987). Numbers of this species seem to have fluctuated in the Sydney region (Higgins 1999) so recent records (Chafer *et al.* 1999; Chafer 2001, 2002) may be the species returning to original numbers in the Illawarra. No sightings were made during the current surveys, though a couple of incidental records have been made in the Study Area since completion of survey work.

Regional scale models are not available for this species. Current knowledge suggests that it is poorly reserved in the Sydney Basin, with much of its habitat reduced through urban consolidation. Within the Study Area, a habitat model based on Upland Swamps: Sedgeland-Heath Complex has been used to indicate high quality habitat, though it is difficult to verify whether this is an adequate representation of the species' distribution.

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
2766	3.6	0	337	2045	7	5	2394	86.6

5.25 BARKING OWL

Species Profile

The Barking Owl (*Ninox connivens*) is a medium-sized owl of intermediate size between the larger Powerful Owl (*N. strenua*) and the Southern Boobook (*N. boobook*). It has a dark brown upperparts and a white underbody with coarse brown streaking, although it is often identified by its call, which is a distinctive, dog-like barking. It usually inhabits dry open eucalypt forests and woodlands, preferring riparian vegetation, where it roosts in dense foliage during the day. It nests in hollows, usually of large eucalypts, where it usually lays one to three eggs. It is an opportunistic feeder, eating more insects than other large forest owls, but consumes small mammals and birds during the breeding season. The race *connivens* occurs east of a line connecting Cooktown (Queensland) and the Flinders Ranges (South Australia) with an isolated population in the south west of Western Australia. Other races occur across northern Australia, in New Guinea and the Moluccas (Indonesia) (Higgins 1999).

Map 25 shows records of the Barking Owl in the Wollongong Area.

Threats

The main threat is the past and continued destruction of habitat (Garnett & Crowley 2000; Higgins 1999). Remaining habitat is also subject to further degradation through forestry and collection of firewood, which often involves the removal of large hollows. May also suffer some competition from feral honeybees (*Apis mellifora*) (Garnett & Crowley 2000). The long generation time (ten years) means that the species may take a long time to recover (NSW Scientific Committee 1998).

Local and regional conservation status

The Barking Owl is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). It is listed as a scarce resident in Chafer *et al.* (1999), though most records are to the south of Wollongong LGA. Individuals may occasionally occur as vagrants, particularly on the plains in the southern part of the LGA.

The Barking Owl has been sporadically recorded throughout the Sydney Basin, though it is more frequently encountered in drier woodlands. Most of the modelled high quality habitat occurs in the north eastern quarter of the Bioregion. Just over a quarter of this habitat is reserved, with the species being recorded in Yengo and Wollemi NPs, amongst others. Because of the small number of records in the Study Area, a model was not created for this species.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	No Suitable Model			-		-
Central CRA	Presence Only	Adequate	222279		60574	
Combined Models	-	-	222279	6.1	60574	27.3


Helensburgh
Bulli
Wollongong
Dapto
Record of Masked Owl, Tyto novaehollandiae
Record of Barking Owl, Ninox connivens
Existing native vegetation
on land
seagrass
Study area boundary
Local Government Area boundary
Built-up area
Motorway or highway
Other major road
Major waterbody
Major river
Map 25
Barking Owl, Ninox connivens
and
Masked Owl, Tyto novaehollandiae
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection: consistent with Australian Map Grid Zone 56
Prepared by N Corfield
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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5.26 POWERFUL OWL

Species Profile

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

Map 26 shows predicted habitat for the Powerful Owl in the Wollongong Area and all records from which the model was generated.

Threats

Past land clearance for agriculture has reduced the area of habitat available for the Powerful Owl (Garnett & Crowley 2000). It can, however, manage to survive in areas with some levels of disturbance, such as in selectively logged forests (Kavanagh 1997). It is also recorded in suburban areas of Brisbane, Sydney and Melbourne (Garnett & Crowley 2000).

Local and regional conservation status

The Powerful Owl is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). Chafer *et al.* (1999) list it as an uncommon resident, being present in many forested environments, including urban bushland, such as Mangerton Park (D. Fischer, pers. comm.). Breeding has been recorded in Royal NP near Helensburgh (Chafer, 1992). Two individuals were recorded opportunistically above the escarpment during the current survey.

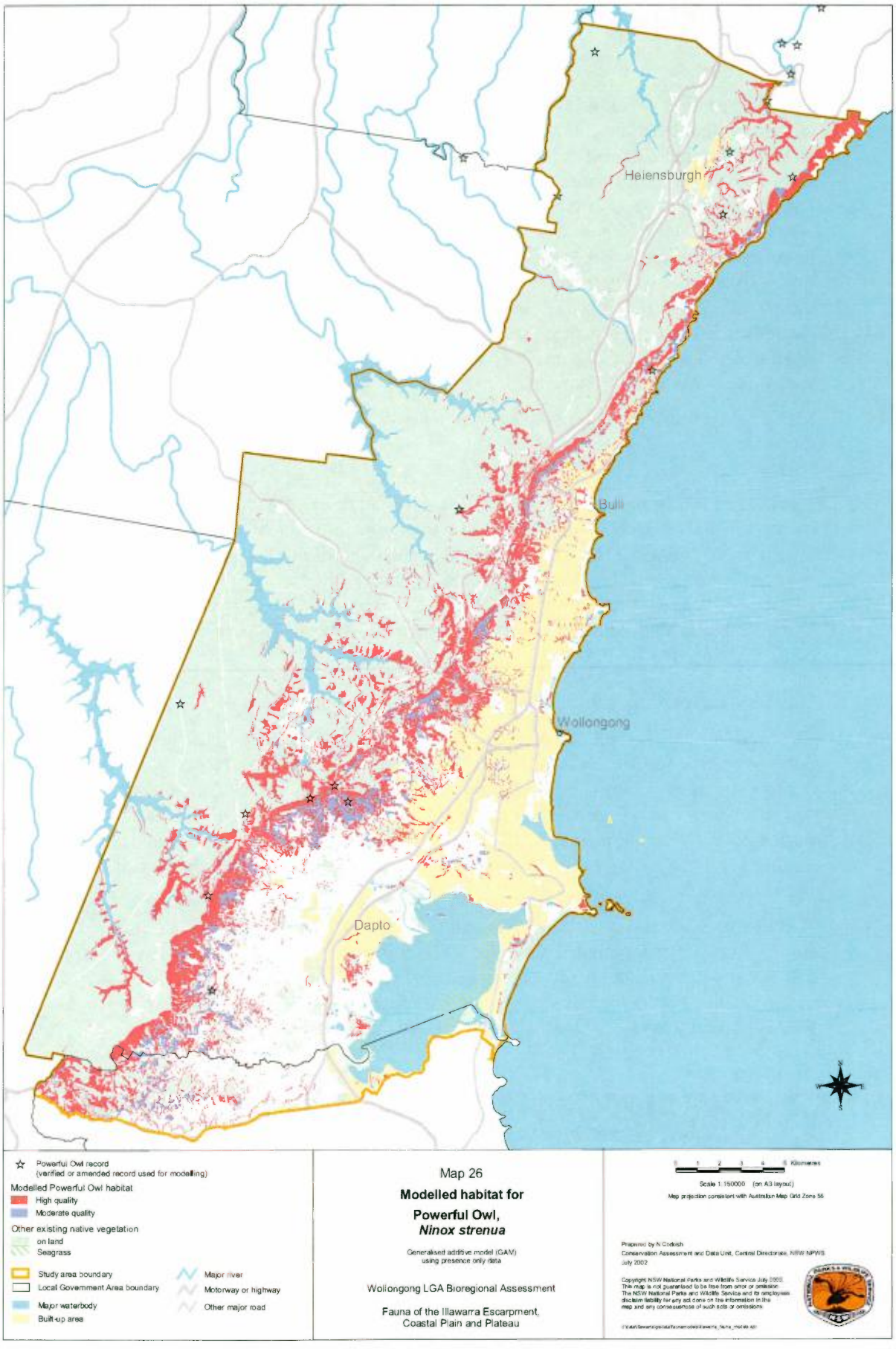
As this species has a large home range and seems to be able to survive in heavily disturbed vegetation, it can be difficult to model. However, it was modelled adequately during both CRA processes, with a relatively large area of suitable habitat being predicted with the Bioregion. Nearly half of this predicted habitat is reserved and this is reflected in records from many NPWS managed reserves, including Royal, Lane Cove and Brisbane Waters NPs and Berowra Valley RP. Within the Wollongong Study Area a model was derived, with habitat predicted on fruit index (in the intermediate values) and smooth eucalypt index (with lower values slightly more frequent). This is difficult to interpret, but may be suggesting that the distribution of prey is a determining factor with tall escarpment forests with some mesic influence being important. Chafer (1992) states that the habitat within the Illawarra is quite varied, with the determining factor being the presence of prey species, particularly Common Ringtail Possum and Sugar Glider. Most of this habitat occurs along and just above the escarpment and is well protected in both Illawarra Escarpment SCA and the Sydney Catchment Authority Special Areas.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence Only	3	121976	-	60093	-
Central CRA	Presence/ Absence	Adequate	217224	-	103466	-
Combined Models	-	-	339200	9.3	163559	48.2

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
5996	7.8	1361	1375	2277	50	808	4510	75.2


Helensburgh
Bulli
Wollongong
Dapto
Powerful Owl record
(verified or amended record used for modelling)
Modelled Powerful Owl habitat
High quality
Moderate quality
Other existing native vegetation
on land
Seagrass
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 26
Modelled habitat for
Powerful Owl,
Ninox strenua
Generalised additive model (GAM)
using presence only data
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Codrish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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5.27 MASKED OWL

Species Profile

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

Map 25 shows records of the Masked Owl in the Wollongong Area.

Threats

Land clearance for agriculture has affected the abundance of Masked Owls (Garnett & Crowley 2000), though as long as remnant trees remain, it can still survive in disturbed areas (Higgins 1999). The reason for low population densities is unknown, though the species may be affected by logging, through removal of hollows or reduction in foraging habitat due to vigorous regrowth (Garnett & Crowley 2000). Nocturnal habits and problems with identifying from Barn Owl may mean that this species is under-recorded, particularly by amateur bird-watchers.

Local and regional conservation status

The Masked Owl is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). It is listed as rare resident in the Illawarra by Chafer *et al.* (1999). None were detected during the current surveys, though during CRA surveys in spring 1997, three responses to owl playback occurred, and following the December 2001 fires, call playback elicited responses at two unburnt sites within the catchments. It may occur in small numbers throughout these areas above the escarpment, particularly along the edges of the more open woodlands.

Within the Sydney Basin Bioregion, most of the modelled habitat occurs around the Hawkesbury River mouth and Central Coast through to the lower Hunter River Valley and also coastally south of Jervis Bay. In these areas it has been recorded in a number of conservation reserves including Brisbane Waters and Conjola NPs, and Berowra Valley RP. No model was created for the Study Area, due to the few available records.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence Only	3.5	87569	-	33149	-
Central CRA	Presence/ Absence	Very Good	156854	-	26060	-
Combined Models	-	-	244423	6.7	59209	24.2

5.28 SOOTY OWL

Species Profile

The Sooty Owl (*Tyto tenebricosa*) is a medium to large 'barn' owl, with sooty grey plumage that is finely spotted and flecked with white. It is found in tall wet forests, including wet sclerophyll and rainforest, where it is often first detected by its distinctive 'falling bomb' call. It roosts and breeds in hollows, often located in emergent trees, which may be greater than 100 years of age. Pairs probably maintain permanent territories that are between 200 and 800 hectares in area. It feeds most commonly on nocturnal mammals such as Common Ringtail Possums and Bush Rats (*Rattus fuscipes*). In Australia the subspecies *tenebricosa* is distributed along the east coast between the Conondale Ranges (Queensland) to north east of Melbourne (Victoria). A smaller subspecies (*arfaki*) occurs in New Guinea (Higgins 1999).

Map 27 shows records of the Sooty Owl and its predicted habitat in the Wollongong Area.

Threats

Garnett & Crowley (2000) list the main threat as habitat clearance for agriculture, with additional fragmentation or degradation caused by logging, burning, dieback and urbanisation. The effects of logging have been particularly well studied, though the overall effect is not entirely clear (Higgins 1999). Due to its nocturnal habits, the Sooty Owl is not often recorded using established bird detection methods. Recent improvements in survey technique have greatly improved the detectability of this and other owl species (Kavanagh 1997).

Local and regional conservation status

The Sooty Owl is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). During the current surveys it was detected at a number of locations including Macquarie Pass NP, Bulli Pass Scenic Reserve and the Forest Walk behind Coalcliff.

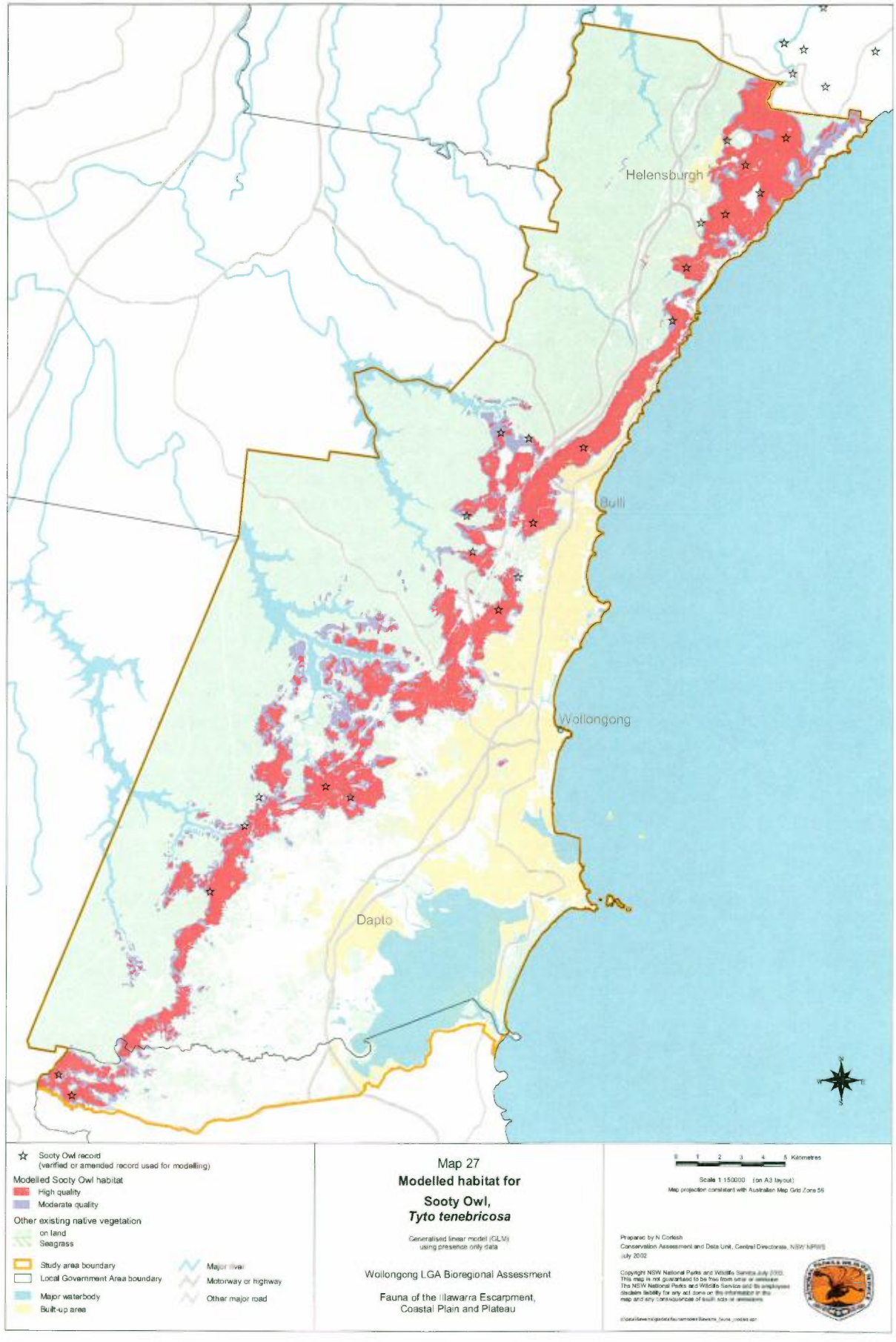
Models generated as part of the CRA indicate that the Illawarra is one of the two important areas for Sooty Owls in the Sydney Basin Bioregion, the other being the Watagan Ranges area to the north and west of Gosford. Within these areas, protection is provided in reserves such as Royal and Bouddi NPs, though in the Gosford area many records are also within State Forests. For the model generated for the Wollongong area, the factors of significance for predicting habitat were Fruit (indicating a mesic understorey and/or fruiting rainforest trees which is probably important for prey), Eucalypt Height (indicating large trees for roosting and breeding), Rainforest within 1000 metres (indicating feeding areas) and Easting (indicating proximity to the coast). The areas of predicted habitat occur along and just above the escarpment, and this is well protected in Illawarra Escarpment SCA and the Sydney Catchment Authority Special Area.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence Only*	3.5	65248	-	28279	-
Central CRA	Presence/ Absence	Excellent	13382	-	3541	-
Combined Models	-	-	78630	2.2	31820	40.5

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
7382	9.6	3693	2366	1439	40	90	4035	54.7


Helensburgh
Bulli
Wollongong
Dapto
Sooty Owl record
(verified or amended record used for modelling)
Modelled Sooty Owl habitat
High quality
Moderate quality
Other existing native vegetation
on land
Seagrass
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 27
Modelled habitat for
Sooty Owl,
Tyto tenebricosa
Generalised linear model (GLM)
using presence only data
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection: consistent with Australian Map Grid Zone 56
Prepared by N Corlesh
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002

5.29 RED-BROWED TREECREEPER

Species Profile

The Red-browed Treecreeper (*Climacteris erythrops*) is a small treecreeper, which is generally dark, with a pale throat and diagnostic rufous-brown eye-patch. Overall, it is darker and more streaked than the similar White-throated Treecreeper (*Cormobates leucophaeus*), which has a very different call. It is found in both wet and dry sclerophyll forests, though prefers areas with smooth-barked eucalypts where it forages for insects on the upper branches, rarely coming to the ground. It is endemic to south eastern Australia between the Conondale Range (Queensland) and central Victoria (Higgins *et al.* 2001).

Map 28 shows the records of the Red-browed Treecreeper and predicted habitat in the Wollongong Area.

Threats

While suitable habitat may restrict the distribution of this species, it does not appear to have any current threats. Individuals seen away from resident populations may be dispersing birds (Higgins *et al.* 2001) that would allow recolonisation of areas that may have suffered from disturbance events, such as from fire.

Local and regional conservation status

The Red-browed Treecreeper is listed as Protected under the NSW NP&W Act (1974). Within the Illawarra it is an uncommon resident, scattered throughout areas with suitable habitat (Chafer *et al.* 999). Within Wollongong LGA it appears to be restricted to a few areas above the escarpment, though it may be under-recorded due to restricted access to water catchment lands.

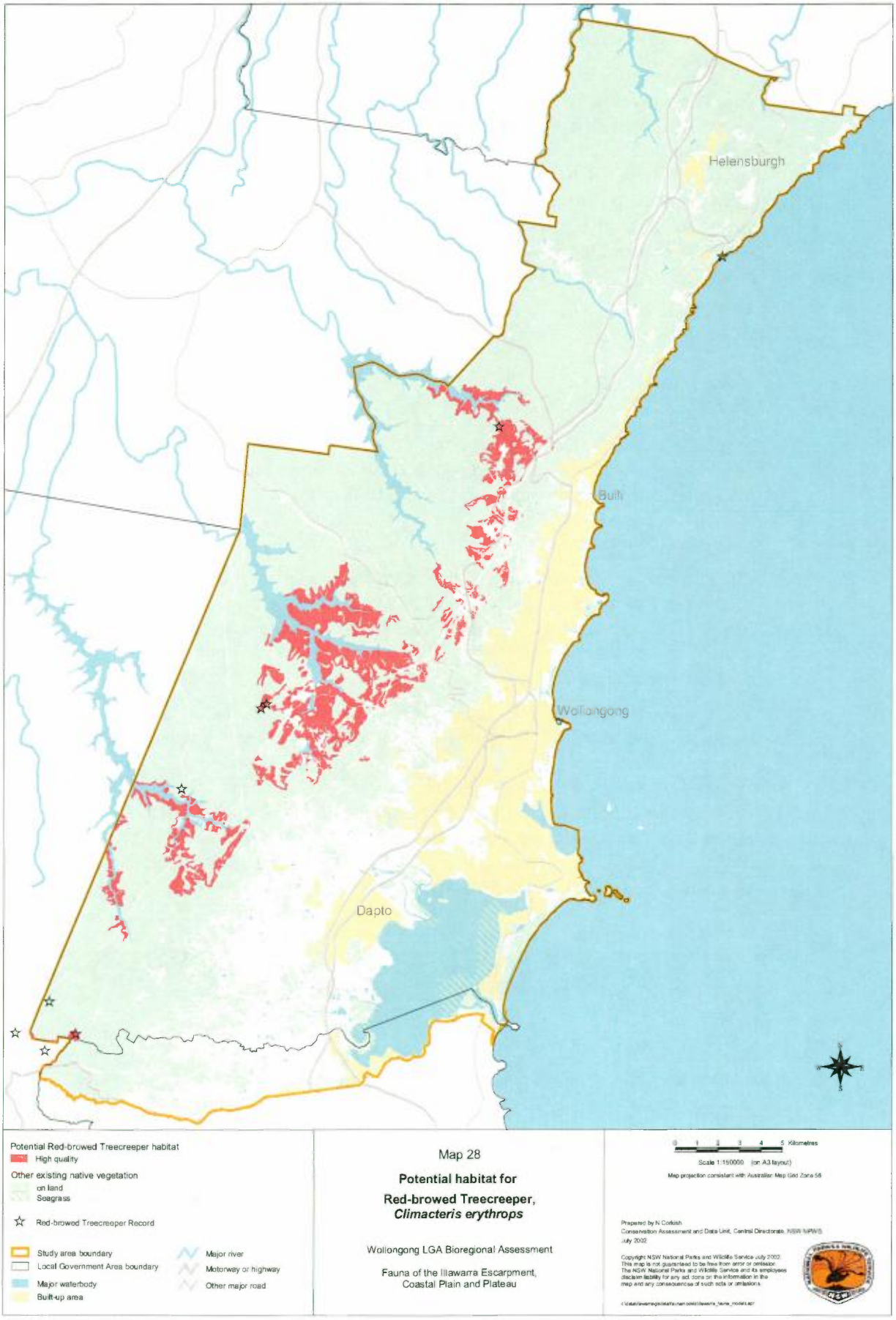
Though the Red-browed Treecreeper was only modelled during the Southern CRA it is widespread but scattered throughout the Sydney Basin. It has been recorded in reserves as diverse as Barren Grounds and Munghorn Gap NRs, and Blue Mountains and Watagans NPs. A habitat model was derived for the Study Area using Tall Open Peppermint-Blue Gum Forest, Tall Open Gully Gum Forest, Moist Blue-Gum Blackbutt Forest and Moist Shale Messmate Forest vegetation communities, though this may not predict the habitat requirements well. A large proportion of this vegetation is protected within the Sydney Catchment Authority land above the escarpment.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence Only Without Eden	2	20632		6053	
Central CRA	Not Modelled					
Combined Models			20632	0.6	6053	29.3

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
3505	4.6	0	19	2892	0	0	2911	83.1


Helensburgh
Bulli
Wollongong
Dapto
Potential Red-browed Treecreeper habitat
High quality
Other existing native vegetation
on land
Seagrass
Red-browed Treecreeper Record
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 28
Potential habitat for
Red-browed Treecreeper,
Climacteris erythrops
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corfield
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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5.30 REGENT HONEYEATER

Species Profile

The Regent Honeyeater (*Xanthomyza phrygia*) is a medium-sized honeyeater with striking black and yellow plumage. It typically favours box-ironbark woodland, though it also utilises on River Oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*) Forests and coastal habitats such as Swamp Mahogany or Spotted Gum. The population seems to undertake complex movements, generally dependent on where flowering food trees are available. It feeds mainly on nectar, and nests in the crowns of eucalypts where it usually lays two or three eggs. It is endemic to south eastern Australia, formerly between Rockhampton (Queensland) and Adelaide, though it is now rare in Queensland and probably extinct in South Australia, with a general contraction of range in the other two states (Higgins *et al.* 2001).

Map 23 shows predicted habitat of the Regent Honeyeater and areas considered potential habitat.

Threats

Land clearance for agriculture has removed about three quarters of the suitable habitat of the Regent Honeyeater. The remaining vegetation is fragmented, and is still being affected by the removal of larger trees. Habitat alteration may also advantage more aggressive honeyeaters, such as miners (*Manorina* spp.) and friarbirds (*Philemon* spp.) with resulting competition. The total population of this species is estimated to be no more than 1500 individuals (Garnett & Crowley 2000; Higgins *et al.* 2001).

Local and regional conservation status

The Regent Honeyeater is listed as Endangered on Schedule 1 of the NSW TSC Act (1995) and as Endangered on the Commonwealth EPBC Act (1999). It is a rare visitor to the Illawarra with only one recent record from the Wollongong LGA (Chafer *et al.* 1999). Most records appear to be in late spring and summer, so it may continue to be a casual visitor to flowering trees in the area, though the winter-flowering Swamp Mahogany is also an important resource in other localities.

The models generated for the CRA reflect the import areas of habitat in the Sydney Basin Bioregion, such as the Box-Ironbark areas of the Capertee and Wollondilly River Valleys, the northern Cumberland Plain and the Central Coast. Much of this area is outside formal reserves, but there are occasional records from Wollemi NP and Cockle Bay NR. Within the Wollongong Study Area the same model as Swift Parrot was used to predict habitat, though this may be an over-estimation, particularly in terms of moderate quality habitat.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Expert Model	3	0	-	0	-
Central CRA	Presence Only	Adequate	116713	-	8994	-
Combined Models	-	-	116713	3.2	8994	7.7

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
48	0.1	751	0	0	0	12	12	25.0

5.31 EASTERN BRISTLEBIRD

Species Profile

The Eastern Bristlebird (*Dasyornis brachypterus*) is a cryptic, long-tailed bird that occurs in dense heaths and woodlands of both the coast and plateau. It is generally brownish above and lighter grey-brown below, with small wings. It is more often heard than seen, but may occasionally use a lookout perch when alarmed. It feeds mainly on insects, particularly ants. Two eggs are laid, but only one young is raised, and breeding failure often occurs (Pizzey & Knight 1997; Baker 1998; NPWS 1999c). The nominate subspecies *brachypterus* formerly occurred between the Myall (New South Wales) and Gippsland (Victoria) Lakes, though the northern limit is now around Barren Grounds NR and the population is fragmented (Garnett & Crowley 2000; NPWS 1999c). An isolated population that occurs in upland grass tussocks in northern New South Wales and southern Queensland has recently been described as a new subspecies (Schodde & Mason 1999; Garnett & Crowley 2000).

Map 29 shows predicted habitat of the Eastern Bristlebird along with the record from Maddens Plains.

Threats

Habitat clearance has reduced the original distribution of the Eastern Bristlebird, with the species now restricted to a number of isolated sub-populations. These isolated and disjunct populations are threatened by catastrophic events, particularly severe wildfire. Due to its poor flight capacity, if large, contiguous areas of habitat are burnt, it is often unable to successfully re-colonise. Highest densities occur in areas that have generally had small areas burnt, with long breaks (30+ years) between fires (NPWS 1999c). Other possible threats include habitat alteration by grazing and weeds, predation by foxes and cats (Garnett & Crowley 2000) and deaths caused by vehicles when crossing roads (NPWS 1999c).

Local and regional conservation status

The Eastern Bristlebird is listed as Endangered on Schedule 1 of the NSW TSC Act (1995) and as Endangered on the Commonwealth EPBC Act (1999). The Illawarra region is one of the remaining strongholds of this species, with large populations in the vicinity of Barren Grounds NR and in the Jervis Bay area (Chafer *et al.* 1999). The Australian Museum has specimens north to Sydney, including one undated specimen from Maddens Plains (B7399). It was last recorded in Wollongong LGA west of Mt. Kembla during the 1960s (Chafer *et al.* 1999). There is a remote possibility that the species may still exist in the catchment areas of wet heath or mallee, but none were detected during the current survey, or in other targeted searches in recent years.

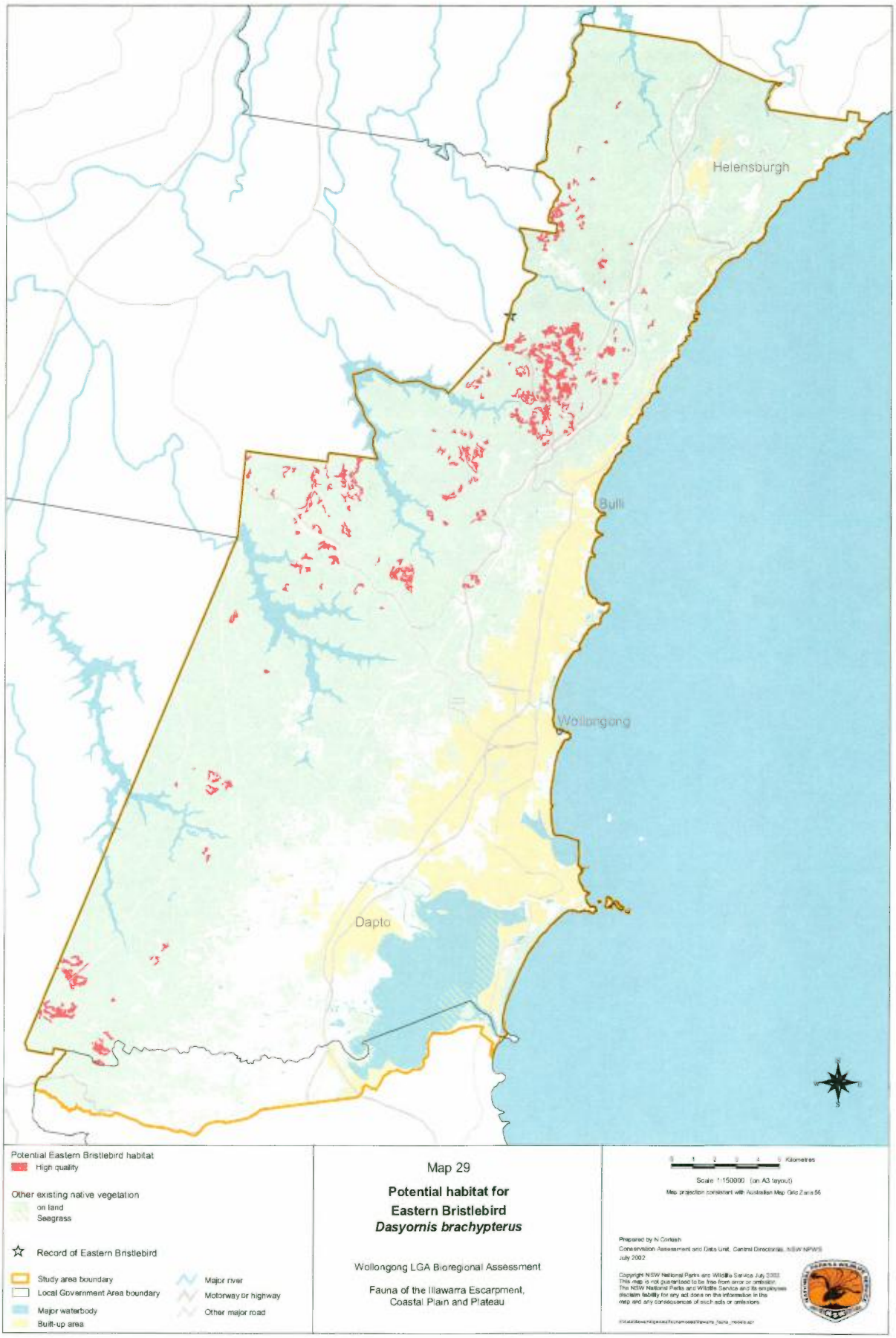
Though the Eastern Bristlebird was not modelled for the Central CRA, the area of habitat predicted for the South Coast region highlights the majority of the habitat within the Bioregion. This is mainly concentrated on the Jervis Bay area, the Budderoo Plateau and Red Rocks NR. The area of habitat reserved is an under-estimate because it does not include Booderee NP, administered by Environment Australia at Jervis Bay. The habitat model for the Study Area is based on Upland Swamps: Fringing Eucalypt Woodland and Upland Swamps: Mallee-Heath, though it has been known to use other habitats such as lantana (Chafer *et al.* 1999), so this may be an under-estimate of the original distribution within the LGA. This vegetation community is well-protected in the Sydney Catchment Authority lands above the escarpment.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Buffer		19145	-	8210	-
Central CRA	Not Modelled					
Combined Models	-	-	19145	0.5	8210	42.9

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
1222	1.6	0	29	1119	0	0	1148	93.9


Helensburgh
Bulli
Wollongong
Dapto
Potential Eastern Bristlebird habitat
High quality
Other existing native vegetation
on land
Seagrass
Record of Eastern Bristlebird
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 29
Potential habitat for
Eastern Bristlebird
Dasyornis brachypterus
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corbish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002

5.32 LOGRUNNER

Species Profile

The Logrunner (*Orthonyx temminckii*) is a small, ground-dwelling bird with plumage consisting of black, grey, buff and white patterns. It inhabits the floor of rainforests where pairs or small family parties feed on insects amongst leaves, logs and ferns. It is often first detected by its distinctive call. The large domed nest in which two eggs are layed is placed on the ground, usually against a structure such as a bank or log (Pizzey & Knight 1997). The subspecies *temminckii* is endemic to eastern Australia between south eastern Queensland (Blackall Ranges) and the Illawarra. Three other subspecies occur in New Guinea (Schodde & Mason 1999), though recent research suggests these may be a separate species (Joseph *et al.* 2001).

Map 30 shows the predicted habitat of the Logrunner and the records that were used to derive this model.

Threats

The Logrunner is sensitive to habitat clearance, though it can survive in small remnants surrounded by cleared land. It also utilises weed species such as lantana (*Lantana camara*) and blackberry (*Rubus* spp.) as habitat and for movement through cleared land (Blakers *et al.* 1984).

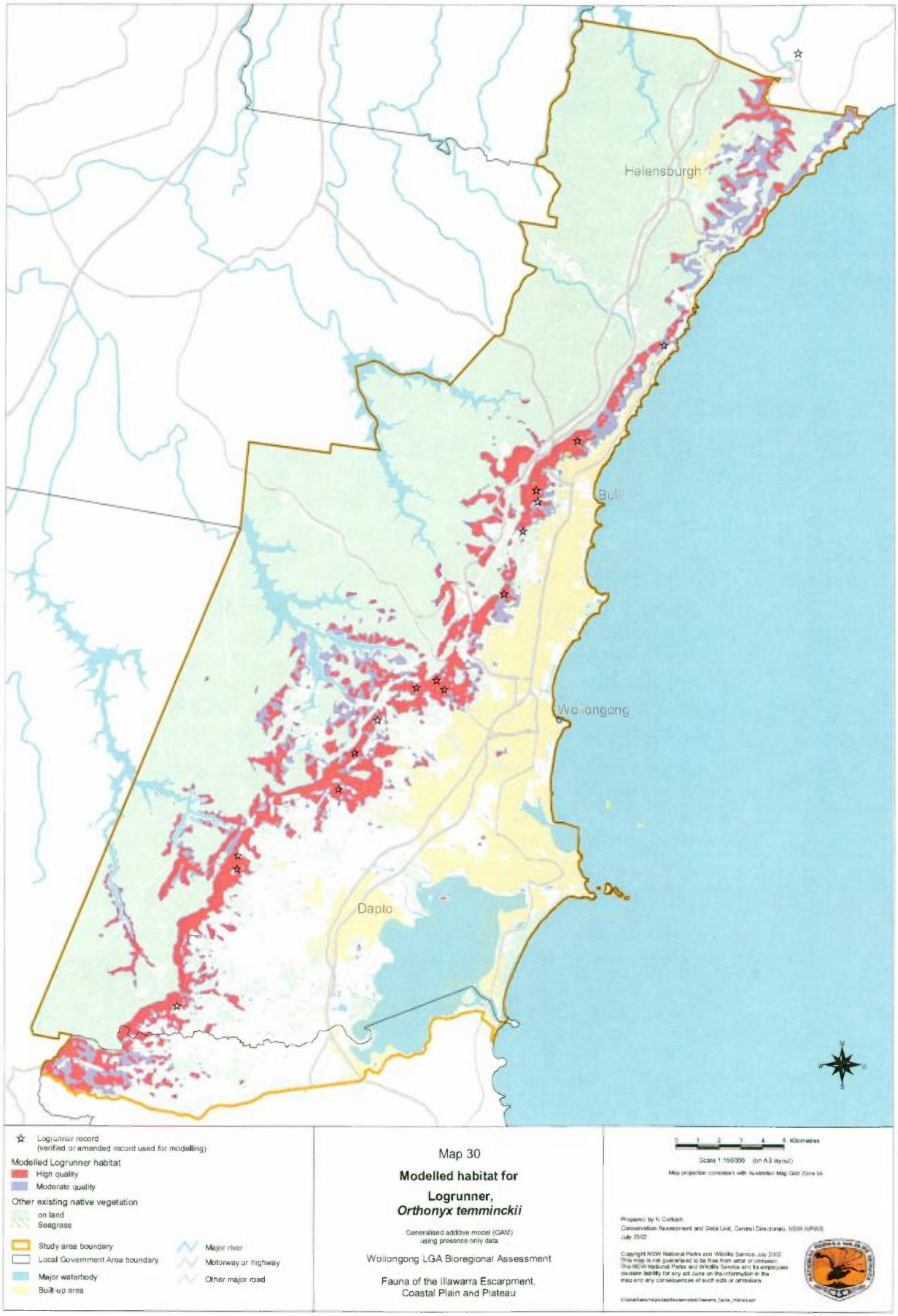
Local and regional conservation status

The Logrunner is listed as Protected under the NSW NP&W Act (1974). It is listed as an uncommon resident of the Illawarra (Chafer *et al.* 1999). The population in the Illawarra is isolated from other populations, which occur north of the Hunter River, with a small remnant population in the Watagans NP (NPWS 2002b; A. Morris, pers. comm.). This southern population extends from Mt. Cambewarra north to Royal NP, where it has been recently reported (D. Andrew, pers. comm.).

Bioregional scale models were not available for this species. As the Illawarra is the major population in the Sydney Basin, it occurs over a very small proportion of the Bioregion. Within the Study Area, the predictive model is strongly correlated with the higher values fruit index variable, indicating the requirement for a highly mesic understorey, under either a rainforest or wet sclerophyll canopy. This habitat occurs chiefly along the escarpment, and is well represented in Illawarra Escarpment SCA.

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
5733	7.5	3505	1712	1316	40	138	3206	55.9


Helensburgh
Bull
Wollongong
Dapto
Logrunner record
(verified or amended record used for modelling)
Modelled Logrunner habitat
High quality
Moderate quality
Other existing native vegetation
on land
Seagrass
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 30
Modelled habitat for
Logrunner,
Orthonyx temminckii
Generalised additive model (GAM)
using presence only data
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection: consistent with Australian Map Grid Zone 56
Prepared by N Corkish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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5.33 PINK ROBIN

Species Profile

The Pink Robin (*Petroica rodinogaster*) is a small, sexually dimorphic bird of rainforest and eucalypt forests, where it is often associated with gullies (Blakers *et al.* 1984). The male is sooty black above and on the upper throat, with a dusky rose-pink breast, while the female is generally olive-brown with a rich-tan wing mark. Both sexes can be identified from the similar Rose Robin (*P. rosea*), by their shorter tail that has no white on the outer feathers (Pizzey & Knight 1997). It feeds on insects, usually near the ground (Blakers *et al.* 1984). It disperses in winter to drier woodlands and gardens (Pizzey & Knight 1997), though its breeding distribution may be restricted by the plants that it requires to make its nest (Newman & Bratt 1976). The subspecies *inexpectata* breeds in eastern Victoria and south eastern New South Wales (Schodde & Mason 1999) with birds dispersing as far as Sydney and Adelaide during the non-breeding season (Blakers *et al.* 1984). The nominate race, *rodinogaster*, is only found in Tasmania (Schodde & Mason 1999).

Map 22 shows records of the Pink Robin from the Wollongong Area.

Threats

NRE (1999) lists the main threats in the Gippsland area as timber harvesting, particularly where the understorey is disturbed, and tree dieback, particularly in Myrtle Beech (*Nothofagus cunninghamii*) forest. Other threats include land clearance, prescribed and uncontrolled burning and climatic change (NRE 1999; Ayers *et al.* 1996).

Local and regional conservation status

The Pink Robin is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). In the Illawarra it is a rare visitor with individual birds recorded at a number of locations (Chafer *et al.* 1999). Individuals may be expected to occur in forested areas every few years, particularly during the winter dispersal.

This species only occurs as a vagrant in the Bioregion, and this is supported by a poor quality model derived during the Southern CRA, that predicts no suitable habitat. No model was derived for Wollongong as there were insufficient records.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Expert Model	0.5	0	-	0	-
Central CRA	Not Modelled					
Combined Models	-	-	0	0	0	0

5.34 OLIVE WHISTLER

Species Profile

The Olive Whistler (*Pachycephala olivacea*) is a large, plain whistler that is typically found in the understorey and on the ground. The male has greyish upperparts, with a scalloped whitish throat and buffish underparts, while the female is generally duller. It is often elusive and is only detected by its loud, monotonous call (Pizzey & Knight 1997). It inhabits forests, including rainforests, and woodlands, particularly those dominated by Tea-trees, with a partial migration to lower altitudes during winter (Blakers *et al.* 1984). The nominate subspecies *olivacea* occurs in eastern Victoria and southern New South Wales (Schodde & Mason 1999), formerly as far north as Sydney (Blakers *et al.* 1984). Four other subspecies occur in Victoria, South Australia, Tasmania and cool temperate rainforest in northern New South Wales and south east Queensland (Schodde & Mason 1999; Gilmore & Parnaby 1994).

Map 31 shows records of the Olive Whistler and predicted habitat in the Wollongong Area.

Threats

The threats for the subspecies in New South Wales are poorly known, though habitat clearance, particularly of vegetated gullies, may have an effect. Burning of the undergrowth may also adversely effect this species.

Local and regional conservation status

The Olive Whistler is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). Listed as a rare nomad in the Illawarra (Chafer *et al.* 1999) it may occur irregularly in small numbers, particularly in the high elevation moist forests in the south of Wollongong LGA. The presence of a pair during the current survey in spring indicates that breeding may occur locally.

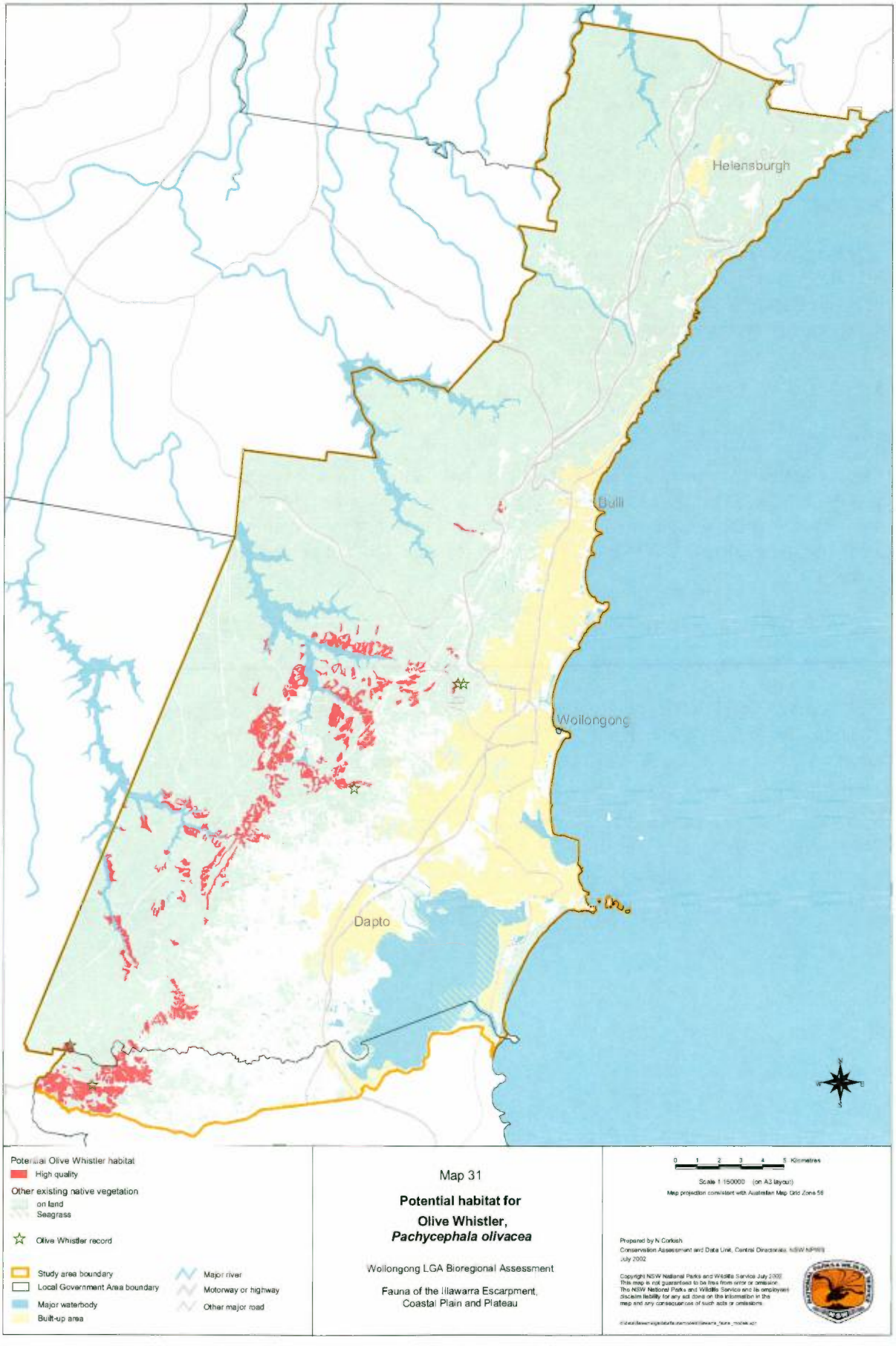
Models created during the CRA showed that only small areas of the Sydney Basin are suitable habitat for the Olive Whistler, with most of this area occurring in the Illawarra. The vegetation communities Moist Gully Gum Forest and Moist Shale Messmate Forest were selected to represent a habitat model for this species, though it may only occur occasionally in this habitat. Much of these communities are protected in Macquarie Pass NP and the Sydney Catchment Authority Special Areas.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence/ Absence*	4	961	-	161	-
Central CRA	Presence Only	Good	7533	-	1020	-
Combined Models	-	-	8500	0.2	1181	13.9

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
1949	2.5	0	428	1028	49	26	1531	78.6


Helensburgh
Bulli
Wollongong
Dapto
Potential Olive Whistler habitat
High quality
Other existing native vegetation
on land
Seagrass
Olive Whistler record
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 31
Potential habitat for
Olive Whistler,
Pachycephala olivacea
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corkish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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5.35 BARRED CUCKOO-SHRIKE

Species Profile

The Barred Cuckoo-shrike (*Coracina lineata*) is a small, dark cuckoo-shrike with characteristic pale yellow eyes and finely barred underparts (Pizzey & Knight 1997). It is restricted to lowland (below 500 metres) rainforests, including subtropical, dry and littoral, and isolated fruiting trees (Gilmore & Parnaby 1994). It feeds on fruit, particularly figs, and insects in the outer canopy (Gilmore & Parnaby 1994; Pizzey & Knight 1997). May be a latitudinal migrant (Gilmore & Parnaby 1994) though its apparent absence may be as a result of decreased conspicuousness during the non-breeding season (Blakers *et al.* 1984). The subspecies *lineata* occurs in Eastern Australia between Cape York and Port Macquarie (Blakers *et al.* 1984), whilst at least two other subspecies (sometimes considered separate species) occur in New Guinea and adjacent islands.

Map 22 shows records of the Barred Cuckoo-shrike in the Wollongong Area

Threats

Land clearance for agriculture and urbanisation has reduced the potential habitat for this species in New South Wales (Gilmore & Parnaby 1994). Most of the reserved lands of coastal areas of the north coast are of heathland or eucalypt forest, with relatively small areas of rainforest (Recher *et al.* 1995), so this species may not be well represented in reserves.

Local and regional conservation status

The Barred Cuckoo-shrike is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). There are two recent records of this species in the Wollongong LGA: Wollongong Botanic Gardens, December 1998 (Chafer *et al.* 1999) and in a garden at Thirroul, November 2000 (Chafer 2002). With odd birds turning up south of the usual range (Morris *et al.* 1981), the occasional individual may be expected to occur in Wollongong, particularly in fruiting fig trees.

No models have been derived for either the Sydney Basin Bioregion or the Wollongong Study Area, as this species is a vagrant in both areas.

5.36 GREEN CATBIRD

Species Profile

The Green Catbird (*Ailuroedus crassirostris*) is large, mainly green bowerbird, with a sturdy off-white bill, red eyes and distinctive cat-like call. It usually inhabits moist forests, including rainforest, though will venture into more open habitats, including gardens. Usually in pairs, but sometimes gathering in small flocks during the non-breeding season, it feeds mainly on fruit (Pizzey & Knight 1997; Blakers *et al.* 1984). Formerly, the Green Catbird was considered to be restricted to the east coast of Australia between about Gladstone (Queensland) and Narooma (New South Wales). Schodde & Mason (1999) however, have lumped this with taxa formerly called the Spotted Catbird (*A. melanotis*) meaning that a number of subspecies occur through northern Queensland and New Guinea.

Map 32 shows records of the Green Catbird with predicted habitat.

Threats

The Green Catbird is one of the species that has been identified as using the Endangered Ecological Community of Lowland Rainforest on Floodplain in the NSW North Coast Bioregion that has been greatly reduced by clearing (NSW Scientific Committee 1999b). Habitat clearance in other lowland areas may also have had an effect on population numbers. However, it will feed in gardens and orchards near moist forest (Pizzey & Knight 1997). This, along with being apparently good eating, has meant that it has also been illegally hunted in the past (Blakers *et al.* 1984).

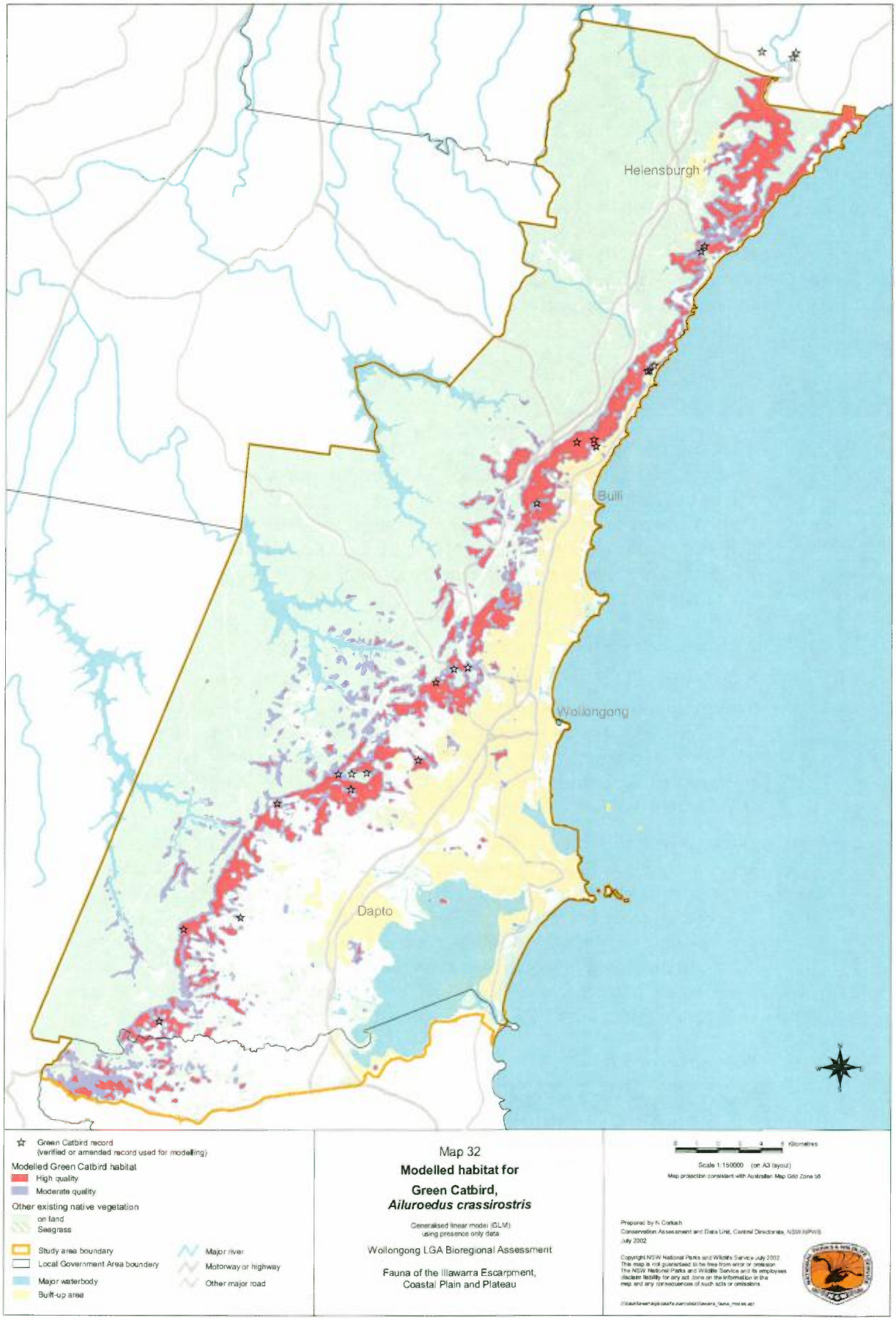
Local and regional conservation status

The Green Catbird is listed as Protected under the NSW NP&W Act (1974). It is listed as an uncommon resident in the Illawarra. The population is near the southern extreme of the species' range and is considered scarce south of the Shoalhaven River (Chafer *et al.* 1999). To the north of Royal NP, there are only scattered records in the Sydney metropolitan area, with the nearest breeding population being in the Gosford region (NPWS 2002b).

Bioregional scale models were not available. The majority of records in the Bioregion either occur in the Illawarra or around the Watagans region of the Central Coast. Within this region it is fairly poorly represented in NPWS managed reserves, though it has been recorded in Royal and Watagans NPs, and Wambina NR. The model for the Study Area predicts on Fruit Index, indicating a preference for mesic habitats and Annual Mean Temperature, possibly suggesting a gradual reduction in habitat quality in the cooler temperature southern areas. Nearly half the high quality habitat is protected, particularly in Illawarra Escarpment SCA.

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
5049	6.6	4397	1706	287	0	197	2190	43.4


Helensburgh
Bulli
Wollongong
Dapto
Green Catbird record
(verified or amended record used for modelling)
Modelled Green Catbird habitat
High quality
Moderate quality
Other existing native vegetation
on land
Seagrass
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 32
Modelled habitat for
Green Catbird,
Ailuroedus crassirostris
Generalised linear model (GLM)
using presence only data
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corkish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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5.37 GREY CURRAWONG

Species Profile

The Grey Currawong (*Strepera versicolor*) is a large, grey bird with a robust bill and yellow eye. It can be identified from the superficially similar Pied Currawong (*S. graculina*) by its paler colour, lack of white at the base of the tail and different, 'ringing' call. It usually occurs singly or in pairs, though it may flock in autumn and winter. It is typically found in drier woodlands, including mallee, and heaths. It is omnivorous, including insects, birds and fruit within its diet, and often feeds on the ground (Pizzey & Knight 1997; Blakers *et al.* 1984). The eastern subspecies *versicolor* occurs in subcoastal areas in eastern Australia between about the Blue Mountains (New South Wales) and the Grampians (Victoria), with five other subspecies occurring in southern South and Western Australia and in Tasmania (Schodde & Mason 1999).

Map 33 shows all records of the Grey Currawong and the areas of predicted habitat.

Threats

Clearance of habitat may have lead to a contraction in range in 1940s in Western Australia (Blakers *et al.* 1984). The Grey Currawong was considered to be sensitive to habitat simplification, such as removal of understorey species or disturbance of ground layers, in the Boorowa area, though it was recorded at less than three sites (Freudenberger 2001).

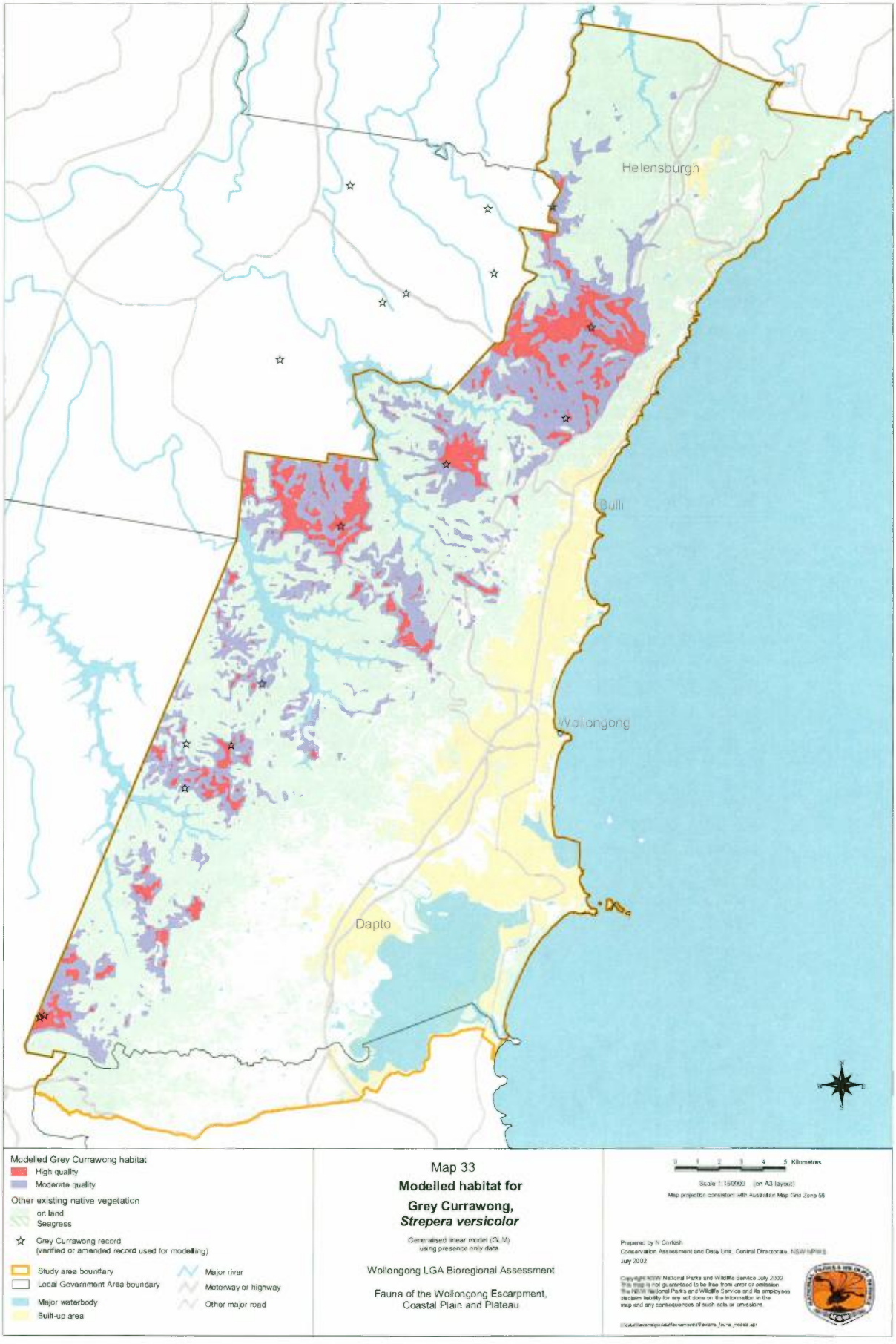
Local and regional conservation status

The Grey Currawong is listed as Protected under the NSW NP&W Act (1974). Chafer *et al.* (1999) lists it as an uncommon resident in the Illawarra, with possible movements to the Woronora plateau in winter. Systematic surveys, including this one, have found small numbers in this area in spring and summer in several different years. The Cumberland Plain to the west and Royal NP to the north do not appear to support suitable habitat with few records in either area (NPWS 2002b; Anyon-Smith 2001).

The Grey Currawong has not been modelled for the Sydney Basin Bioregion, but its stronghold appears to be the higher altitudes of the Blue Mountains, with numerous records in both Blue Mountains and Kanangra-Boyd NPs. The Hunter Valley appears to be the northern limit of its distribution. Within the Wollongong Study Area, a model was generated with low values of Annual Mean Temperature and Ruggedness suggesting areas with cooler temperatures on the plateau are the preferred habitat. This predicts most of the high quality habitat to be on the Woronora Plateau, which is well reserved in the Sydney Catchment Authority Special Areas.

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
3591	4.7	9576	406	2797	2	0	3205	89.3


Helensburgh
Bulli
Wollongong
Dapto
Modelled Grey Currawong habitat
High quality
Moderate quality
Other existing native vegetation
on land
Seagrass
Grey Currawong record
(verified or amended record used for modelling)
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 33
Modelled habitat for
Grey Currawong,
Strepera versicolor
Generalised linear model (GLM)
using presence only data
Wollongong LGA Bioregional Assessment
Fauna of the Wollongong Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
July 2002

5.38 PLATYPUS

Species Profile

The Platypus (*Ornithorhynchus anatinus*) is a semi-aquatic mammal with an interesting life history. As one of only three egg-laying mammals in the world and as a venomous mammal, is of considerable scientific interest. This species is long-lived with a slow rate of reproduction (Grant 1995). The Platypus feeds on aquatic invertebrates, such as crayfish, and possibly fish and amphibians. It resides in an oval burrow in the riverbank that usually opens to the outside just above water level (Carrick 1995). It is distributed between north Queensland and the mouth of the Murray River, including Tasmania, though it now appears to be extinct in South Australia except for an introduced population on Kangaroo Island. Within this range it occurs in virtually all aquatic environments, though its distribution west of the Great Dividing Range is poorly known (Carrick 1995).

Map 34 shows creeks that potentially contain habitat of the Platypus based on catchments where the Platypus has been sighted in the last 30 years.

Threats

The Platypus will survive in creeks that have suffered significant clearing (Grant 1995). However, it is vulnerable to local extinction when populations become isolated from one another. The species has already been lost from South Australia and the opportunities for recolonisation are minimal (Carrick 1995). A decline in water quality and predation are also thought to be threats but the main problem is habitat destruction (Grant 1995, 1998). Stream bank erosion, dam construction and insensitive fishing techniques are also likely to impact on this species (Carrick 1995).

Local and regional conservation status

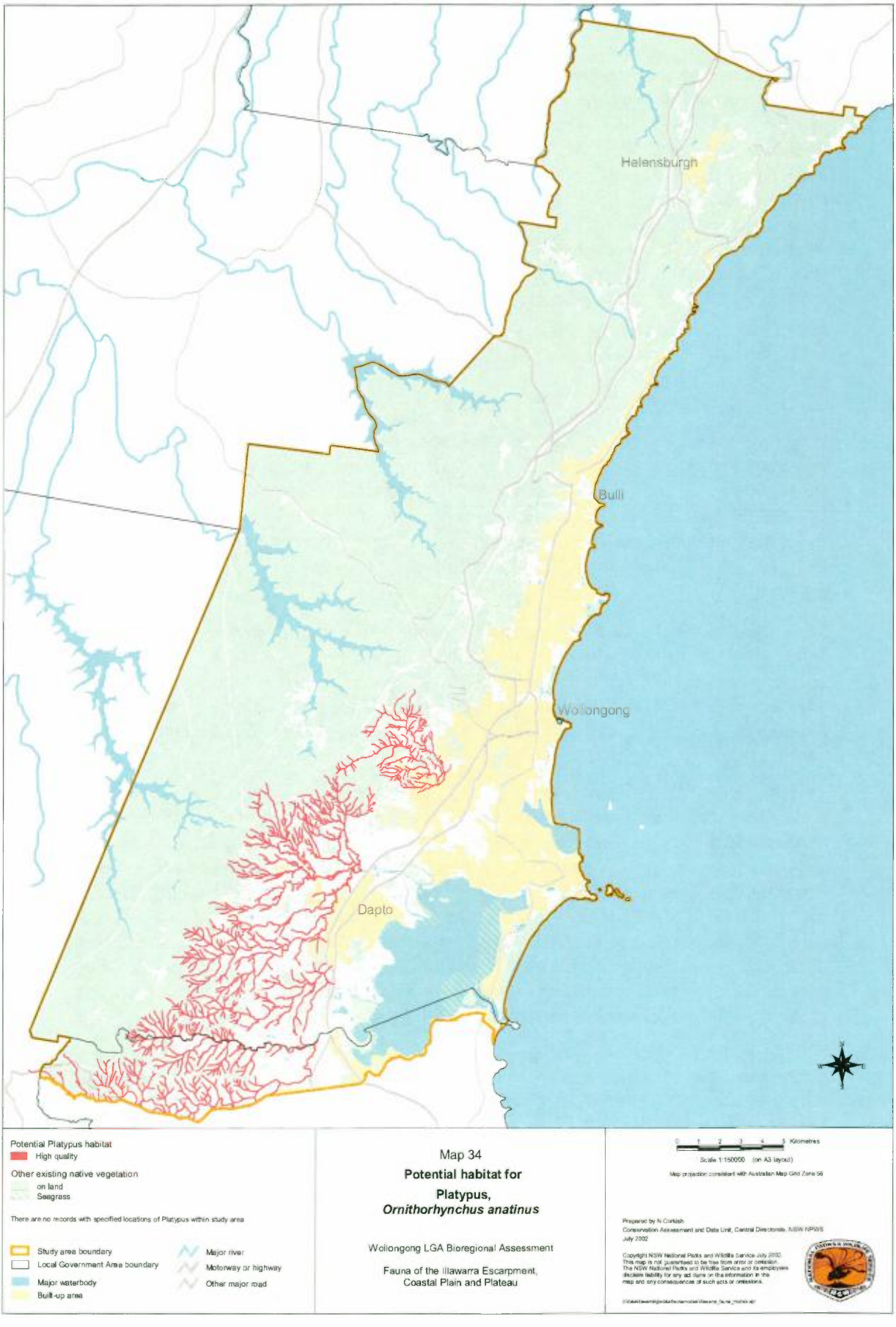
While the Platypus persists in reasonable numbers in parts of its range (Grant *et al.* 2000), it has declined significantly in the Sydney Basin Bioregion (Grant 1998). There are very few recent records within the Bioregion and many of those are from the Illawarra (Grant 1998). From this we might surmise that, along with the populations in Ku-ring-gai Chase NP and the Warragamba area, the Illawarra's Platypus are of considerable regional importance.

The Platypus has declined considerably within the Wollongong LGA, hence its nomination as a Priority Species. This species was once common in the creeks and rivers of the coastal plain but has slowly disappeared from many, some quite recently. In Yellow Rock and Duck Creeks, the last Platypus were seen as recently as the mid 1980's. The only documented sightings from the last ten years are from the Macquarie Rivulet, Mullet Creek and the upper reaches of America Creek (Grant 1998; T. Grant pers. comm., K. Mills pers. comm., M. Gregory pers. comm.). It should be highlighted that in the Illawarra there has been very little recent work focused on the Platypus and that they may continue to exist in a number of the creeks where they have not been seen for some time. Targeted survey work is needed to confirm the presence of this species.

No models for the Platypus were generated during the CRA. A habitat model has been constructed that identifies creekline systems that support observations of the animal within the last 20 years. A twenty metre buffer was constructed around American, Marshall Mount, Duck and Mullet Creeks and Macquarie Rivulet. This is only a small proportion of the Study Area, which is generally highly disturbed and poorly conserved.

Wollongong Study Area

Model Type	High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
Habitat	1694	2.2	0	128	0	14	64	206	12.2


Helensburgh
Bulli
Wollongong
Dapto
Potential Platypus habitat
High quality
Other existing native vegetation
on land
Seagrass
There are no records with specified locations of Platypus within study area
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 34
Potential habitat for
Platypus,
Ornithorhynchus anatinus
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection: consistent with Australian Map Grid Zone 56
Prepared by N.Corkish
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July 2002
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5.39 SPOTTED-TAILED QUOLL

Species Profile

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The Spotted-tailed or Tiger Quoll (*Dasyurus maculatus*) is a medium-sized marsupial carnivore that is identifiable by its rufous to dark brown fur and white spots which are present on the body and tail. It is essentially terrestrial, but is also an agile climber. It feeds on a wide variety of birds, reptiles, mammals and invertebrates and it uses several 'latrines' within its territory for defecation (NPWS 1999g). There are three populations of this species. The first is in far north Queensland, the second extends from Southern Queensland to Victoria, and a final genetically distinct population occurs in Tasmania (Firestone *et al.* 1999). Map 35 shows Spotted-tailed Quoll records from the Wollongong Area.

Threats

The main problems confronting the Spotted-tailed Quoll are believed to be habitat loss, habitat degradation, predation and competition by introduced cats and foxes, and direct mortality at the hands of humans (Mansergh 1984). Quolls were heavily persecuted as killers of domestic fowl, and have been hunted and trapped to extinction in many parts of the country. In more recent years, baiting for foxes, dogs and dingoes may have taken a toll on this species (D. Andrew pers. comm.).

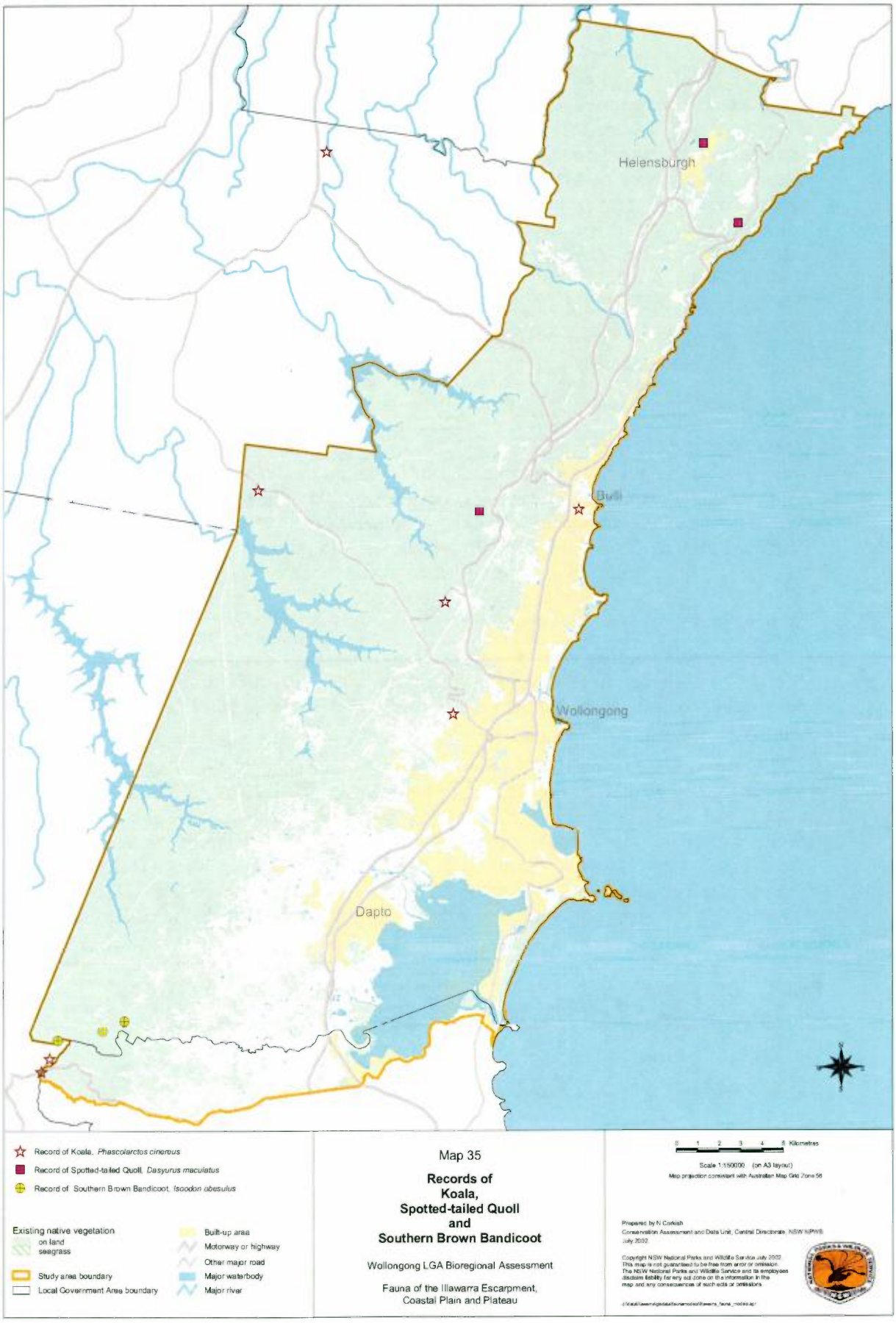
Local and regional conservation status

The Spotted-tailed Quoll is listed as Vulnerable on Schedule 2 on the NSW TSC Act (1995) and as Vulnerable on the Commonwealth EPBC Act (1999). The southern populations are believed to have declined in range by up to 50 percent (Maxwell *et al.* 1996). The last record for Spotted-tailed Quoll in the Wollongong LGA is from the Bellambi Creek area in 1972. Targeted trapping efforts in 1998 and 2001 did not capture this species, suggesting that it may be locally extinct in the northern half of Wollongong LGA. Interviews with property owners confirm that foxes appear to have replaced quolls as predators of their fowl, though quolls have been present in the Calderwood Valley in the last ten years. There are also recent records from Macquarie Pass NP and Barren Grounds NR. If existing corridors of vegetation are maintained between these areas and forests to the north, recolonisation may be possible.

Bioregional scale models show a number of core areas for Spotted-tailed Quolls within the Sydney Basin Bioregion - the area around the Hawkesbury River mouth, north through the Watagan Ranges, the area to the south of Port Stephens, the central Blue Mountains Region and the Budderoo Plateau. A reasonable percentage of this land is protected in reserves, though most of the recent records have only been from Blue Mountains and Brisbane Waters NPs, and Barren Grounds NR. No model was derived for the Wollongong Study Area due to too few records but it may still exist in the forested catchment lands above and along the escarpment at extremely low densities.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence Only*	3	25362	-	11682	-
Central CRA	Presence Only	Good	137160	-	37007	-
Combined Models	-	-	162522	4.5	48689	30.0


Helensburgh
Bulli
Wollongong
Dapto
Record of Koala, Phascolarctos cinereus
Record of Spotted-tailed Quoll, Dasyurus maculatus
Record of Southern Brown Bandicoot, Isoodon obesulus
Existing native vegetation
on land
seagrass
Study area boundary
Local Government Area boundary
Built-up area
Motorway or highway
Other major road
Major waterbody
Major river
Map 35
Records of
Koala,
Spotted-tailed Quoll
and
Southern Brown Bandicoot
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
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5.40 SOUTHERN BROWN BANDICOOT

Species Profile

The Southern Brown Bandicoot (*Isoodon obesulus*) is a nocturnal mammal, which lives in areas of sandy soil with low vegetation that is used as cover. This species is morphologically very similar to the Northern Brown Bandicoot (*I. macrourus*) but a genetic test has recently been devised to separate the two (Johnston *et al.* 2002). It feeds on invertebrates, fungi and plant material that are extracted from the ground by digging with its powerful foreclaws. It is currently believed that the Southern Brown Bandicoot occurs discontiguously across southern Australia between the Hawkesbury River and south western Western Australia, including Tasmania, with an isolated subspecies on Cape York Peninsula (Braithwaite 1995).

Map 35 shows the records in the Wollongong area where the Southern Brown Bandicoot has possibly been detected.

Threats

The habitat of the Southern Brown Bandicoot has been greatly reduced by clearing and grazing of the vegetation by sheep and cattle (Braithwaite 1995). Inappropriate fire regimes, which reduce the dense ground layer, may make available habitat unsuitable. Remnant populations are vulnerable to long-term genetic insecurity and individuals may be preyed upon by foxes (NPWS 1999i). It may be susceptible to 1080 poisoning from baits laid for foxes and rabbits, though doses required are relatively high (McIlroy 1983).

Local and regional conservation status

The Southern Brown Bandicoot is listed as Endangered on Schedule 1 of the NSW TSC Act (1995). Though historically known from a wide area in New South Wales, it possibly only remains in the northern suburbs of Sydney and around the Eden area on the south coast (NPWS 1999i).

The bioregional scale model for the South Coast area appears to over-predict habitat, as there are no known extant populations in the area predicted. The population within Garigal and Ku-ring-gai Chase NPs may be the only remaining population in the Bioregion, though it is possible individuals remain in the Catchment Areas of the Woronora Plateau. It was not modelled for Wollongong Study Area due to the lack of records. The current surveys did not detect this species and the three existing records are from a single environmental consultant with no details as to the method of identification.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Expert Model	2	157677		59082	
Central CRA	Not Modelled					
Combined Models			157677	4.3	59082	37.5

5.41 KOALA

Species Profile

The Koala (*Phascolarctos cinereus*) is a distinctive, iconic arboreal mammal of eucalypt forest and woodland. It feeds on a wide range of eucalypt and other tree species, though in a local area a few species will be preferred almost exclusively. Individuals spend most of the day resting in the forks of trees, and are most active following sunset (NPWS 1999h). They generally move about a home range, the size of which varies on the density of food trees and population size, though individuals, particularly dispersing juveniles, are known to travel up to 50 kilometres (Martin & Handasyde 1995; NPWS 1999h). Three subspecies occur between north Queensland and the Eyre Peninsula in South Australia. However, the distribution is now fragmented and introductions, such as to Phillip Island, have possibly reduced the genetic diversity of many of the populations (Martin & Handasyde 1995; NPWS 2002c).

©Cameron Smith/NPWS

Map 35 shows all records of the Koala from the Wollongong Area.

Threats

NPWS (1999h) summarises the threats to the Koala as follows: destruction of habitat by clearing for urban development, agriculture and mining; degradation of habitat through fragmentation and disturbance such as fire or weed invasion; direct mortality from dogs and motor vehicles; and infection by *Chlamydia* which causes keratoconjunctivitis (an infection of the eyes) and infertility. The latter appears to occur naturally in Koalas in NSW, and symptoms are displayed when animals are stressed (NPWS 2002c). In Victoria, populations that have been transferred from Phillip Island appear to have lost their immunity and rates can be high, but it does not appear to be a major threat (Menkhorst 1995b).

Local and regional conservation status

The Koala is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). It has declined in the Illawarra where it was regularly recorded until at least the 1960s (Robinson 1988). Two populations occur to the west of the Study Area in the Wedderburn area and the Nepean Catchment. Individuals can be expected to be occasionally seen above the escarpment, particularly young dispersing individuals from the Nepean and Wedderburn populations.

Within the Bioregion, most high quality habitat was predicted around the Hawkesbury River mouth, the Central Coastal and the Port Stephens area north east of Newcastle, though sightings are scattered throughout. The sandstone habitats are well protected (such as Brisbane Water and Yengo NPs), but some coastal habitats are poorly conserved in NPWS reserves apart from Tomaree NP. A model was generated for the Study Area suggests that high quality habitat for the species is not present in the Wollongong LGA. Predictors of habitat quality for Koala were rainfall and fertility, highlighting the Wedderburn and Avon populations.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence Only Without Eden*	2.5	4026	-	3390	-
Central CRA	Presence Only	Adequate	116714	-	30909	-
Combined Models	-	-	120740	3.3	34299	28.4

5.42 EASTERN PYGMY-POSSUM

Species Profile

The Eastern Pygmy-possum (*Cercartetus nanus*) is a small (between 14 and 21 centimetre) possum that is found in a wide variety of habitats, including rainforest, sclerophyll forest and heaths. It is generally nocturnal, and is an opportunistic omnivore, including nectar, pollen, insects, seeds and fruit in its diet. Each individual has a number of nests, which are usually constructed in tree hollows, throughout their territory, and will move up to 125 metres, through tree, shrub and ground layers (Turner & Ward 1995). It is distributed between extreme south east Queensland and South Australia, and Tasmania, though it is only found at higher at higher altitudes in northern New South Wales and is generally commoner in southern latitudes (Bowen & Goldingay 2000; Menkhorst 1995b).

©K. Gillett/NPWS

Map 36 shows predicted habitat of the Eastern Pygmy-possum and the records that were used to derive this model.

Threats

The NSW Scientific Committee (2001) listed the potential threats to the Eastern Pygmy-possum. They include isolated sub-populations with little dispersal potential which increase the risk of local extinction, habitat loss and fragmentation by clearing, inappropriate fire regimes that may effect understorey plants, the loss of nest sites through intensive forestry and firewood collection, and predation by foxes and cats.

Local and regional conservation status

The Eastern Pygmy-possum has recently been added to Schedule 2 (Vulnerable) of the NSW TSC Act (1995). This appears to be chiefly based on Bowen & Goldingay (2000) which showed that despite intensive survey effort throughout the known distribution, relatively few individuals have been detected. The survey techniques used in many of these surveys, however, may have underestimated the abundance of this species. Over a two week period in early 2000, 22 individuals were removed from a ten kilometre stretch of trench dug as part of a natural gas pipe laying procedure between Cataract and Cordeaux Reservoirs (NPWS 2002b). During the current survey, one individual was spotlit in the Woronora Catchment and another was caught in an elliot trap on two separate nights at the same site in Avon Catchment.

Bioregional scale models generated indicate that most of the suitable habitat occurs in the sandstone areas surrounding the Sydney metropolitan area. Two of the six areas listed by the NSW Scientific Committee (2001) are in the Sydney Basin Bioregion, being Barren Grounds NR-Budderoo NP, and Royal and Heathcote NPs. The latter area may extend south into the Catchment Areas in Wollongong LGA. Other recent records have been made in the Blue Mountains and Ku-ring-gai Chase NPs. The model generated for the Study Area predicts on Shrub Nectar and Slope, indicating the heathy areas above the

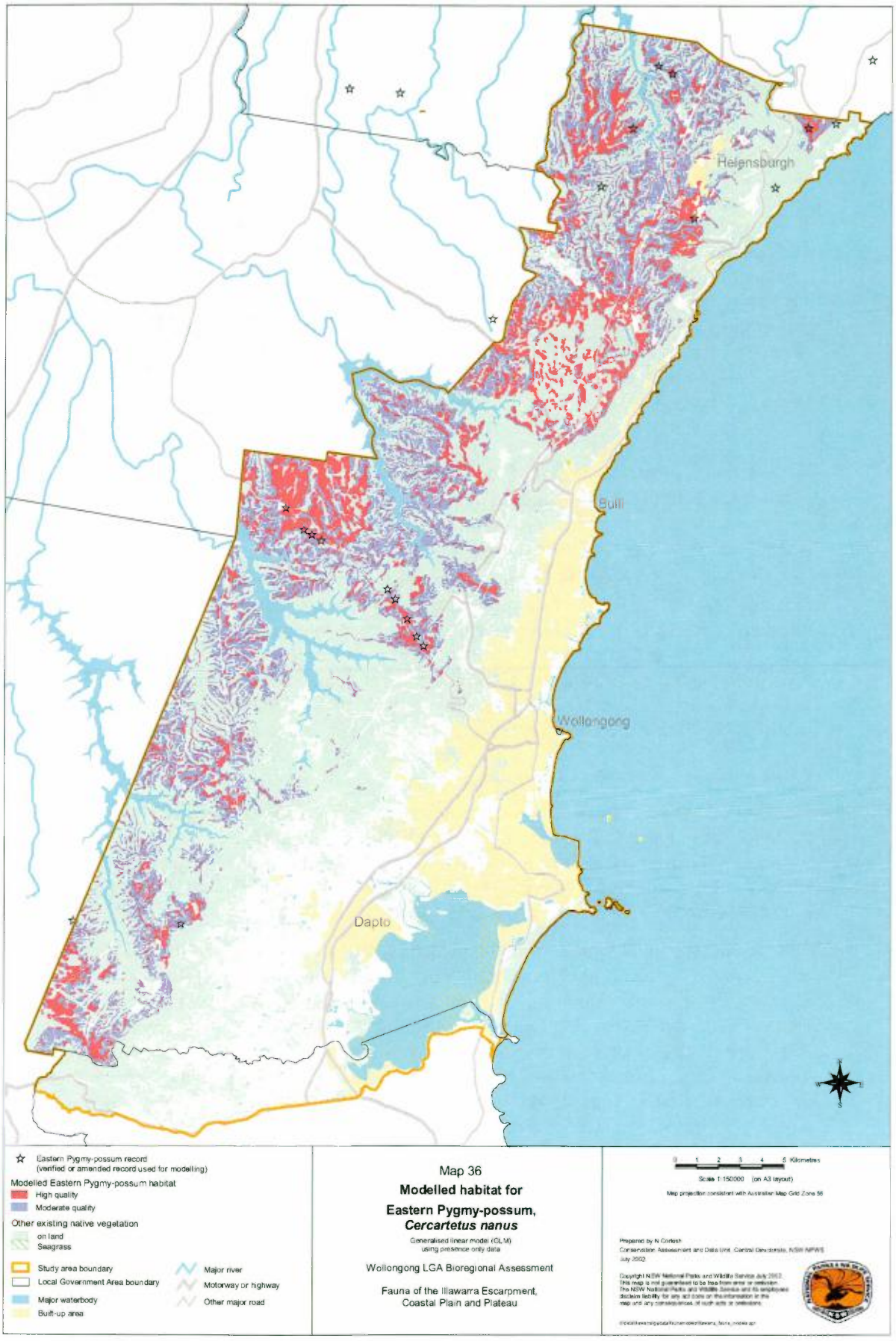
escarpment as the highest quality habitat. This is well protected in the Sydney Catchment Authority Special Areas and in Dharawal SCA and Royal NP.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	No Suitable Model					
Central CRA	Presence Only	Coarse	444327	-	258834	
Combined Models	-	-	444327	12.2	258834	58.3

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
6184	8.1	7430	504	4785	11	9	5309	85.9


Helensburgh
Bulli
Wollongong
Dapto
Eastern Pygmy-possum record
(verified or amended record used for modelling)
Modelled Eastern Pygmy-possum habitat
High quality
Moderate quality
Other existing native vegetation
on land
Seagrass
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 36
Modelled habitat for
Eastern Pygmy-possum,
Cercartetus nanus
Generalised linear model (GLM)
using presence only data
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corkish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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5.43 GREATER GLIDER

Species Profile

The Greater Glider (*Petauroides volans*) is the largest of the gliding possums, and can be identified by its strongly reflective eye shine, large ears and long fluffy tail (Henry 1995; McKay 1995). They vary in colour between white and black, but are always white below. It feeds on eucalypt leaves and the species eaten varies throughout its entire distribution. They utilise a den in a large hollow during the day and often rest during the night to aid in digestion. It is found in various eucalypt forests on and east of the Great Dividing Range between north Queensland and central Victoria (McKay 1995).

©K. Gillett/NPWS

Map 37 shows predicted habitat of the Greater Glider and all records from the Wollongong Area.

Threats

Greater Gliders are known to be vulnerable to some types of disturbance (Kavanagh & Bamkin 1995). They are sensitive to logging practices that do not leave trees of sufficient age to produce the hollows that are required for roosting (Lindenmayer *et al.* 1990). Fire may lead to local extinctions, such as has been reported in Royal NP (NPWS 2001d), through direct death, loss of food resources, exposure to predation, particularly by Powerful Owls, and loss of hollows either directly by burning or trees being felled for public safety. Foxes predate upon this species when it is on the ground (McKay 1995).

Local and regional conservation status

The Greater Glider is listed as Protected under the NSW NP&W Act (1974). It once occurred in the eucalypt forests along the entire Illawarra escarpment, but seems to have suffered local extinctions in Royal NP (NPWS 2001d) and the northern escarpment around Coalcliff (Robinson 1988). During the current survey it was recorded at a number of locations between Cataract Reservoir and Macquarie Pass.

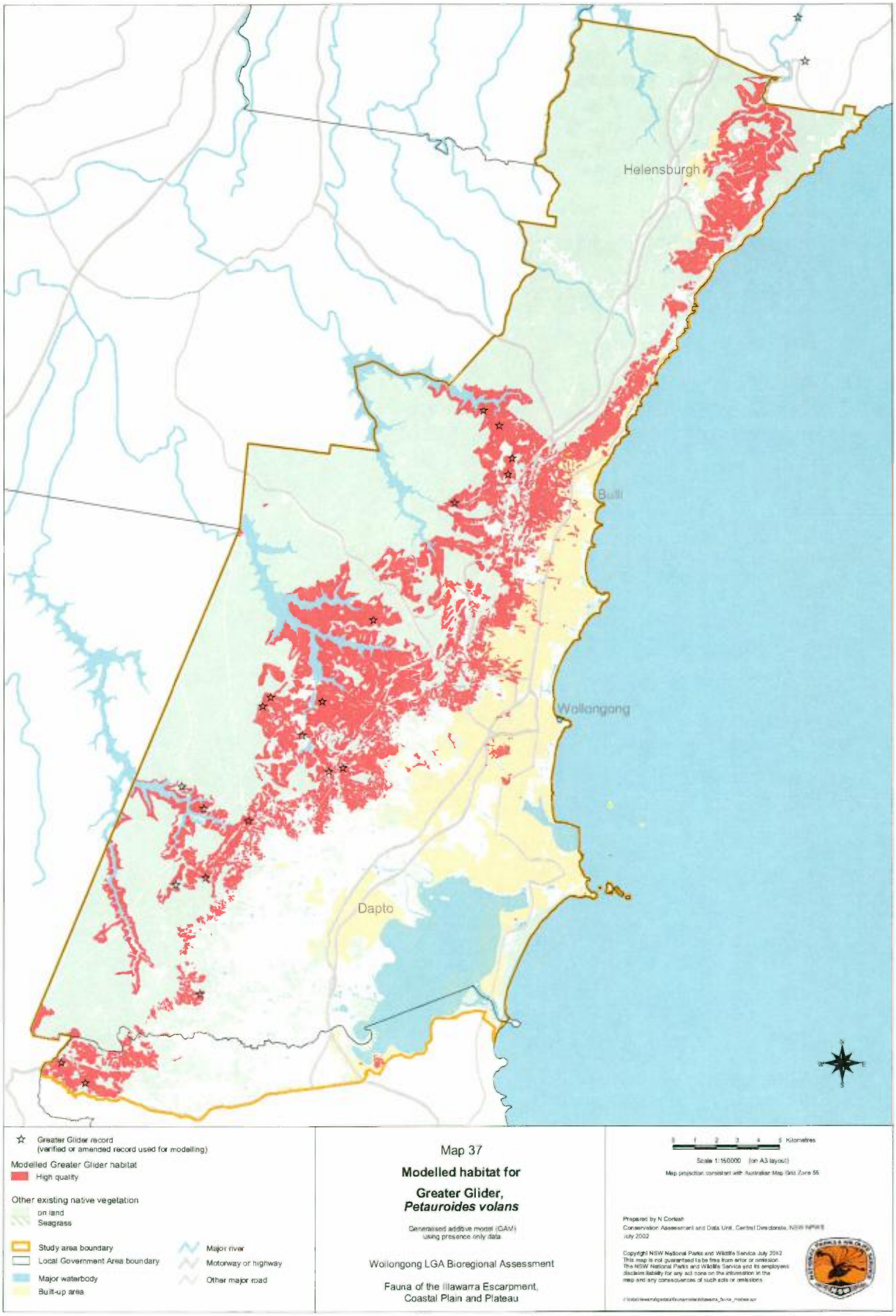
Bioregional scale models suggest that high quality habitat is widely distributed, with the core areas being the Blue Mountains/Wollemi region, the Watagan Ranges and the Illawarra Escarpment. Much of the habitat is protected, with records from numerous reserves including Seven Mile Beach, Blue Mountains, Gardens of Stone and Watagans NPs. The model created for the Study Area was strongly correlated with tall eucalypt forests showing the importance of tall trees to this species. The model may over predict the current distribution as it was generated using records from Royal NP, though it probably indicates the potential distribution in the absence of fires reasonably well.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence/ Absence	4	14834	-	9633	-
Central CRA	Presence Only	Adequate	278755	-	163639	-
Combined Models	-	-	293589	8.1	173272	59.0

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
10384	13.5	0	1549	4790	49	228	6616	63.7


Helensburgh
Wollongong
Dapto
Greater Glider record
(verified or amended record used for modelling)
Modelled Greater Glider habitat
High quality
Other existing native vegetation
on land
Seagrass
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 37
Modelled habitat for
Greater Glider,
Petauroides volans
Generalised additive model (GAM)
using presence only data
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection: consistent with Australian Map Grid Zone 56
Prepared by N Corkish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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5.44 MOUNTAIN BRUSHTAIL POSSUM

Species Profile

The Mountain Brushtail Possum or Bobuck (*Trichosurus caninus*) is a possum of tall, open and closed forests, particularly wet forest and rainforest (How 1995; Menkhorst 1995d). It is distinguished from the Common Brushtail Possum (*T. vulpecula*) by its generally darker colour above, and its smaller rounded ears (How 1995). Dens are usually located in hollows, but feeding occurs both arboreally and terrestrially. It feeds on a wide variety of foods including leaves, fruits, buds and fungi (How 1995). It is distributed east of the Great Dividing Range between south eastern Queensland and central Victoria.

Map 38 shows all records of the Mountain Brushtail Possum and the predicted distribution in the Wollongong Area.

Threats

The Mountain Brushtail Possum is sensitive to logging practices that do not leave trees of sufficient age to produce hollows that are required for roosting (Lindenmayer *et al.* 1990). It may be less susceptible to logging as it prefers gullies, which may not be as heavily impacted (Menkhorst 1995d). It has been hunted in the past when open seasons were held for possums, its pelt often preferred to that of the Common Brushtail (How 1995). It spends a considerable amount of time on the ground (How 1995) and may be susceptible to predation by foxes and cats.

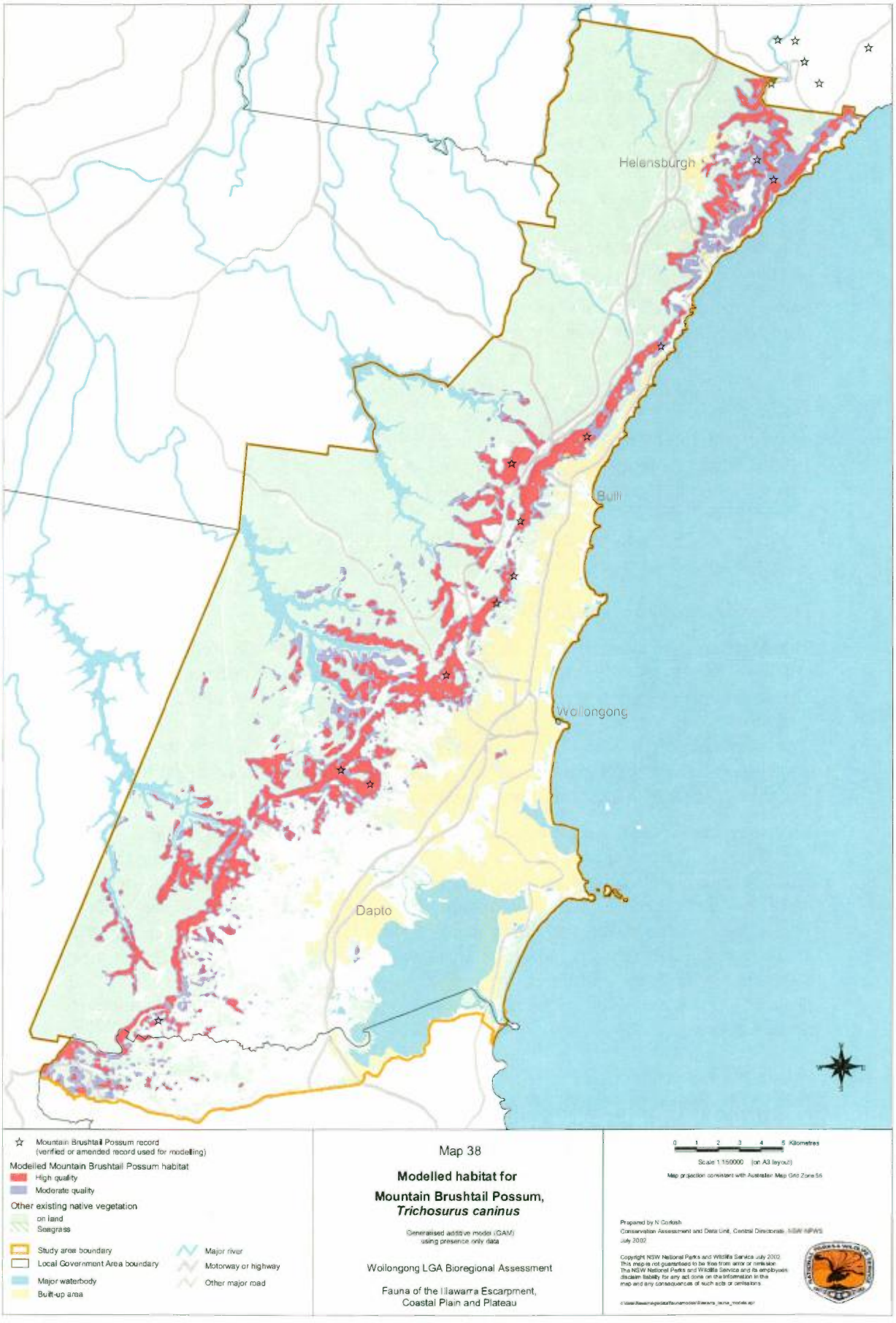
Local and regional conservation status

The Mountain Brushtail Possum is listed as Protected under the NSW NP&W Act (1974). There is recent evidence that the species is actually two different taxa, but the distribution of the two species remains unclear (Lindenmayer *et al.* 2002). It is likely that the Mountain Brushtail Possum in Wollongong are in fact the newly described species (*T. cunninghamii*) as this species has recently been trapped in the Kangaroo Valley (D. Lindenmayer pers. comm.). During the current survey individuals were located at a number of locations along the escarpment.

Bioregional scale models were not available for this species. The Illawarra Escarpment and Watagan Ranges appear to be the areas of importance in the Sydney Basin, with fewer records from the northern Blue Mountains. This is also reflected in the reserves that it has been found in, with most records from Royal, Wollemi and Watagans NPs. The model generated for the Study Area predicted using variables describing fruit abundance and soil fertility, indicating areas with mesic understorey on higher fertility soils, chiefly rainforest and the moist escarpment forests. This habitat is relatively well protected in both Illawarra Escarpment SCA and the Sydney Catchment Authority Special Areas.

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
5952	7.8	3948	1686	1730	47	93	2556	59.7


Helensburgh
Bulli
Wollongong
Dapto
Mountain Brushtail Possum record
(verified or amended record used for modelling)
Modelled Mountain Brushtail Possum habitat
High quality
Moderate quality
Other existing native vegetation
on land
Seagrass
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 38
Modelled habitat for
Mountain Brushtail Possum,
Trichosurus caninus
Generalised additive model (GAM)
using presence only data
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corfield
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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5.45 LONG-NOSED POTOROO

Species Profile

The Long-nosed Potoroo (*Potorous tridactylus*) is the smallest macropod in New South Wales, with an overall body length of about 38 centimetres and a tail up 26 centimetres long. They have brown to grey fur, and a long tapering nose and small ears. It is recorded in a wide variety of habitats, but generally require a dense understorey of ferns, grasses or shrubs and a sandy loam substrate. This species is generally nocturnal and feeds on fungi, insects, roots and insects (NPWS 2000b). The subspecies *tridactylus* occurs at scattered locations between Gladstone, Queensland and extreme eastern South Australia, where until very recently it was believed to be extinct. Other subspecies, sometimes considered separate species, occur in Tasmania and in Western Australia, where it has recently been rediscovered at Two People's Bay NR (CALM 2002)

Map 24 shows potential habitat for the Long-nosed Potoroo in the Wollongong Area.

Threats

The area of habitat for Long-nosed Potoroos has been reduced dramatically by land clearance (Johnston 1995). Inappropriate fire regimes may affect local populations, but the species seems to have the capacity to recover rapidly, particularly in the absence of grazing or logging (Seebeck 1995). Other threats are alteration to ground cover through grazing or introduced pasture species, and predation by foxes, cats and dogs (NPWS 2000b).

Local and regional conservation status

The Long-nosed Potoroo is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). Though there are no records within the NPWS Atlas of NSW Wildlife, Robinson (1988) reports that this species at least previously occurred in Wollongong LGA. A population persists on the Budderoo Plateau to the south of the Study Area.

The bioregional scale models predicted four areas of habitat, Watagans and Central Coast, Budderoo Plateau and Cambewarra Range and the Illawarra Escarpment and Jervis Bay, though recent records are only present in the first two areas. Most records are from Barren Grounds, Red Rocks and Wambina NRs. A habitat model was derived from the Sedgeland-Heath complex community, which is well protected in the Sydney Catchment Authority Special Areas above the escarpment, though the species may be locally extinct.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence Only Without Eden	4	41733	-	13174	-
Central CRA	Presence Only	Good	75792	-	12434	-
Combined Models	-	-	117525	3.2	25608	21.8

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
2766	3.6	0	337	2045	7	5	2394	86.6

5.46 GREY-HEADED FLYING-FOX

Species Profile

The Grey-headed Flying-fox (*Pteropus poliocephalus*) is a large fruit bat that has dark grey body fur, a slightly paler grey head and a russet collar. It is the largest bat in the Study Area, with a wingspan of up to one metre. It is a highly mobile species and numbers roosting at specific camps may vary depending on season and food availability. They feed on nectar and pollen of various trees including *Eucalyptus, Melaleuca* and *Banksia* as well as fruits, originally of rainforest species, but now including commercial and garden crops. They can travel up to twenty kilometres to a food source, and are an important pollinator and disperser of native plants. It is endemic to the east of Australia between Melbourne, Victoria and Bundaberg in Queensland, though it formerly ranged as far north as Rockhampton (NPWS 2001c).

©Linda Broome/NPWS

Map 39 shows records of the Grey-headed Flying-fox in the Wollongong Area and predicted habitat.

Threats

The main threats to the Grey-headed Flying-fox are destruction of habitat, particularly of foraging habitat, by clearing for urban development and agriculture, disturbance at roosting sites, particularly of pregnant females, unregulated shooting, particularly when feeding on commercial crops and electrocution on power lines, particularly in urban areas (NPWS 2001c).

Local and regional conservation status

The Grey-headed Flying-fox is a recent listing on the TSC Act (1995) as Vulnerable and is also listed as Vulnerable on the Commonwealth EPBC Act (1999). It has declined in numbers across the entire state of NSW and is considered to be vulnerable to further declines. In Wollongong, historical accounts tell of a breeding colony at Flying-Fox Creek in the Avon Catchment, however this camp is no longer occupied. This species is still a regular visitor to the Wollongong LGA, and there is a small camp in the Mount Kembla area over summer (P. Eby, H. Jessup, pers. comm.). In autumn 2003 a camp was set up in the Bulli Scenic Reserve (K. Madden, pers. comm.) confirming historical reports of a temporary camp in this area. The nearest regular camps are Cabramatta Creek in western Sydney, Whispering Gallery near Dunmore, near Jamberoo and Comerong Island (C. Chafer, pers. comm, NPWS 2002b). In this study, most animals were recorded feeding on flowering Blackbutt, but following the December 2001 fires, some individuals were seen feeding on the flower spikes of *Xanthorrhoea* at Maddens Plains.

Eby *et al.* (1999) estimated that there are approximately sixteen camps within the Sydney Basin Bioregion, three of which were occupied in July 1998. The models generated for the CRA indicate high quality habitat is centred on the Sydney metropolitan area, though this is not supported by records in the lower Blue Mountains. Records have been made from a number of NPWS reserves, including Royal and Wyrrabalong NPs. The model

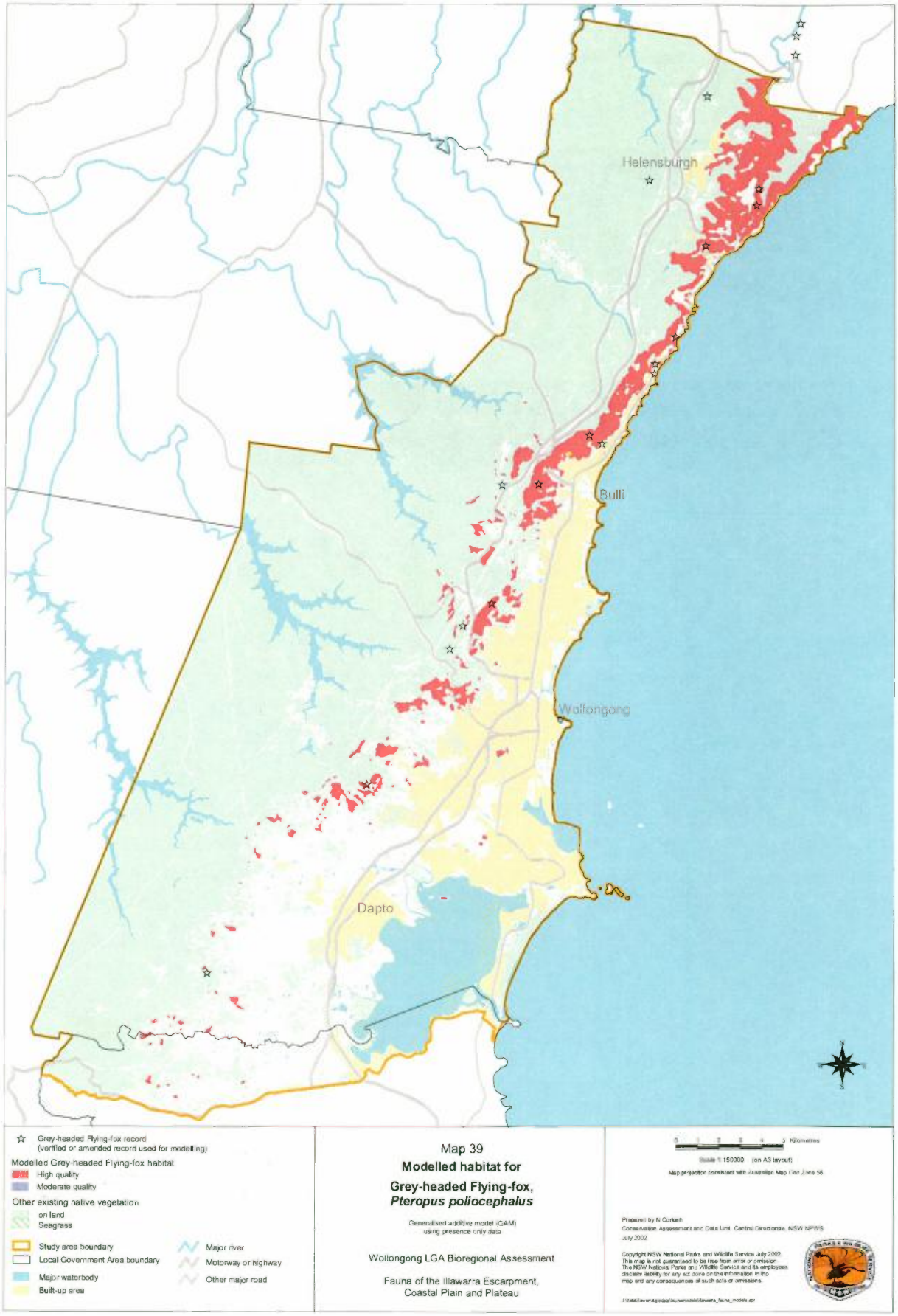
generated for the Study Area suggested a strong correlation with vegetation supporting an abundance of fruit and warmer, coastal temperatures. A significant proportion of this habitat occurs along the escarpment and is protected in both Royal NP and Illawarra Escarpment SCA.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Expert Model	3	375	-	137	-
Central CRA	Presence Only	Coarse	485889	-	170708	-
Combined Models	-	-	486264	13.4	170845	35.1

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
3500	4.6	0	1334	117	0	137	1588	45.4


Helensburgh
Bulli
Wollongong
Dapto
Grey-headed Flying-fox record
(verified or amended record used for modelling)
Modelled Grey-headed Flying-fox habitat
High quality
Moderate quality
Other existing native vegetation
on land
Seagrass
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 39
Modelled habitat for
Grey-headed Flying-fox,
Pteropus poliocephalus
Generalised additive model (GAM)
using presence only data
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
Kilometres
Scale 1: 150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N Corfield
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002
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5.47 EASTERN FREETAIL-BAT

Species Profile

The Eastern Freetail-bat (*Mormopterus norfolkensis*) is a member of a complex group of bats that still retain considerable taxonomic uncertainty. Within this group this species is readily distinguished by its long forearm, more upright ears and less robust build (Allison & Hoye 1995; Parnaby 1992). Reinhold *et al.* (2001) describes the call as "a pattern of alternating pulses" making it unique among *Mormopterus*, though it can also call without this pattern so it should only be identified from long call sequences. There are very few specimens of this species, but it seems to be restricted to east of the Great Dividing Range between approximately Brisbane (Queensland) and Picton (New South Wales) (Duncan *et al.* 1999; Parnaby 1992). It appears to favour dry eucalypt forest and woodland though it has been captured in rainforest (Churchill 1998). It usually roosts in tree hollows (Gilmore & Parnaby 1994) though it has been recorded in the roof of a hut and under the metal caps of telegraph poles (Churchill 1998).

Map 40 shows all records of the Eastern Freetail-bat in the Wollongong Area.

Threats

The threats to this species are poorly known, though it is suspected that clearing for agriculture and development, and logging may pose a serious threat. Threats may be increased because the species' distribution is an area of concentrated population growth. More research in such areas as taxonomy, field identification and habitat requirements would allow better understanding of the species' status (Duncan *et al.* 1999).

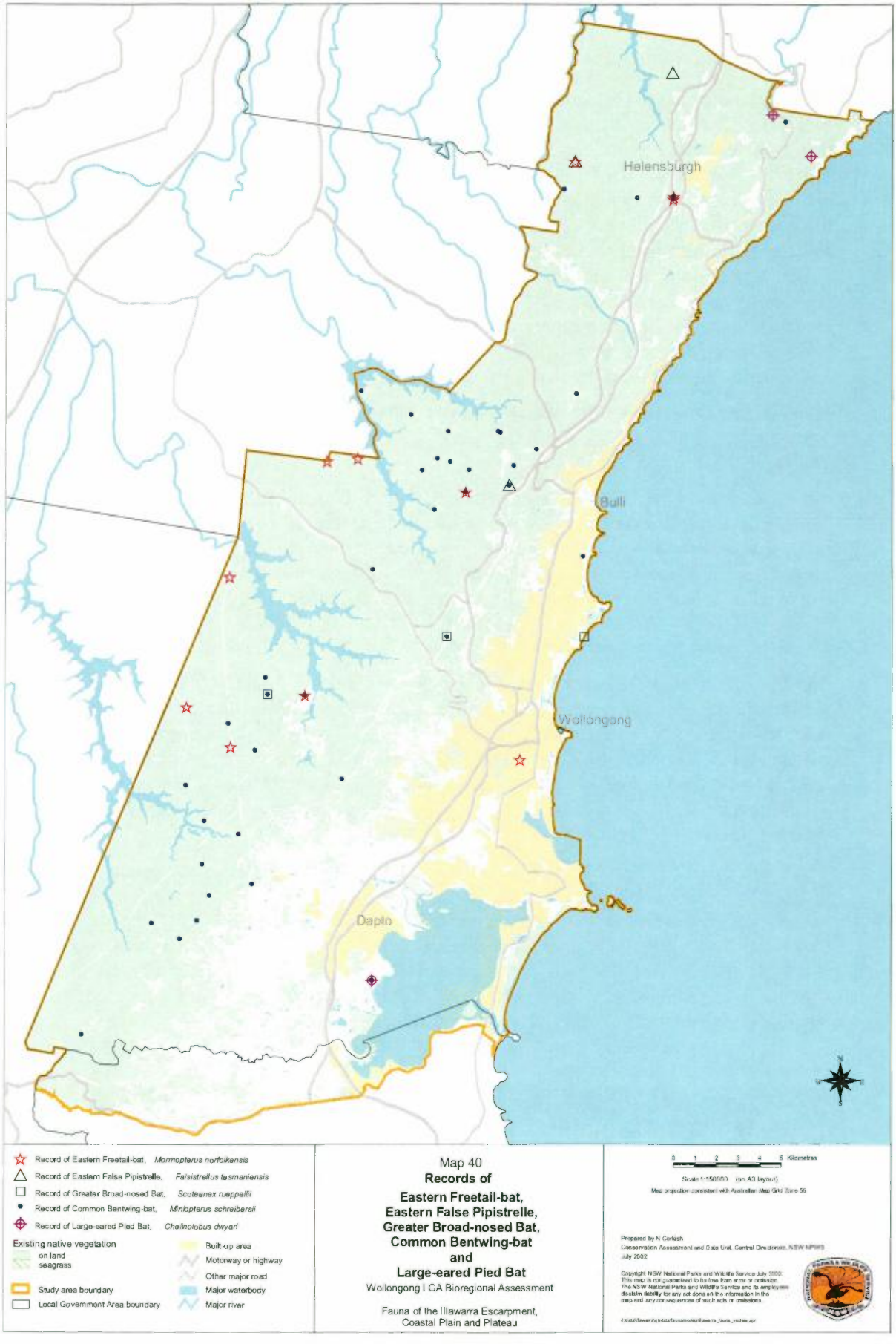
Local and regional conservation status

The Eastern Freetail-bat is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). There are a number of records of this species in the Wollongong LGA, mainly recorded using anabat call detection (NPWS 2002b). No records were made during the current survey. Based on these records, it may be expected to occur in small numbers in areas of woodland above the escarpment. As with all bats, better understanding of habitat requirements and more accurate identification, particularly of calls, is needed to establish its level of abundance in Wollongong LGA.

The South Coast region model suggests that vegetation occurring on coastal lowlands is of highest quality, while further north the model predicts the highest quality habitat occurring in dry inland valleys and hinterlands such as the areas around Yengo and Goulburn River NPs. This is further complicated with most recordings on the Cumberland Plain and Central Coast areas. This probably reflects the low levels of knowledge regarding this species. Due to this, and the few records available, a model could not be generated for the Wollongong Study Area.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence Only	3	169104	-	81490	-
Central CRA	Presence Only	Coarse	312432	-	188806	-
Combined Models	-	-	481536	13.2	270296	56.1


Helensburgh
Bulli
Wollongong
Dapto
Record of Eastern Freetail-bat, Mormopterus norfolkensis
Record of Eastern False Pipistrelle, Falsistrellus tasmaniensis
Record of Greater Broad-nosed Bat, Scoteanax rueppellii
Record of Common Bentwing-bat, Miniopterus schreibersii
Record of Large-eared Pied Bat, Chalinolobus dwyeri
Existing native vegetation
on land
seagrass
Study area boundary
Local Government Area boundary
Built-up area
Motorway or highway
Other major road
Major waterbody
Major river
Map 40
Records of
Eastern Freetail-bat,
Eastern False Pipistrelle,
Greater Broad-nosed Bat,
Common Bentwing-bat
and
Large-eared Pied Bat
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
0 1 2 3 4 5 Kilometres
Scale 1:150000 (on A3 layout)
Map projection: consistent with Australian Map Grid Zone 56
Prepared by N Corkish
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5.48 LARGE-EARED PIED BAT

Species Profile

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

Map 40 shows records of the Large-eared Pied Bat in the Wollongong Area.

Threats

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

Local and regional conservation status

The Large-eared Pied Bat is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995) and also as Vulnerable on the Commonwealth EPBC Act (1999). Within Wollongong LGA it has been trapped twice in Royal NP and detected using Anabat near Tallawarra power station (NPWS 2002b). During the current survey it was detected using this technique in the Calderwood Valley, though identification was only made to the level of possible. The population in the Illawarra may be the southernmost population, and may be dependent on mines for roosting. As with all bats, better understanding of habitat requirements and more accurate identification, particularly of calls, is needed to establish its level of abundance in Wollongong LGA.

It would appear that the Sydney Basin supports a significant proportion of the Large-eared Pied Bat's distribution. Though there is a concentration of records in the Central Tablelands, particularly Blue Mountains and Wollemi NPs, there are records scattered through the Bioregion, including Royal and Morton NPs. The bioregional scale model suggests that a relatively large area of habitat is suitable, with much of this occurring in NPWS managed reserves. No local scale model was derived due to the small number of confirmed records.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Buffer		0	-	0	-
Central CRA	Presence/ Absence	Good	307804	-	248866	-
Combined Models	-	-	307804	8.5	248866	80.9

5.49 EASTERN FALSE PIPISTRELLE

Species Profile

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The Eastern False Pipistrelle (*Falsistrellus tasmaniensis*) is a relatively large (up to 70 millimetres) bat that is similar to the Greater Broad-nosed Bat (*Scoteanax rueppellii*), though it has two pairs of upper incisors, a gap between the incisors and the canines, and larger ears (Parnaby 1992; Churchill 1998). Its calls can be confused with various species of *Scotorepens* and the Greater Broad-nosed Bat, though good quality calls can be separated (Reinhold *et al.* 2001). It is found in small numbers throughout its range in south eastern Australia, between south east Queensland and western Victoria, and Tasmania. It seems to prefer wet habitats, particularly riparian or high rainfall areas, with large trees (greater than 20 metres) (Menkhorst & Lumsden 1995). It may be more common at cool elevations (Phillips 1995), though it has been recorded between sea level and 1500 metres in Victoria (Menkhorst & Lumsden 1995). It usually roosts in hollows in *Eucalyptus*, though it has been recorded in caves (Churchill 1998). It may hibernate over winter and has been known to travel at least twelve kilometres from its roost site (Churchill 1998).

Map 40 shows all records for the Eastern False Pipistrelle in the Wollongong Area.

Threats

The main threat would appear to be destruction of roosting sites, through land clearance and logging (Gilmore & Parnaby 1994).

Local and regional conservation status

The Eastern False Pipistrelle is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). Within Wollongong LGA it has only been recorded at a few locations using Anabat ultrasonic call detection. A possible identification of this species was made near Wongawilli using this method during the current survey. It may be expected to occur in small numbers, particularly in taller forests associated with creeklines above the escarpment. As with all bats, better understanding of habitat requirements and more accurate identification, particularly of calls, is needed to establish its level of abundance in Wollongong LGA.

The model from the Central CRA predicts a scattered distribution in the Sydney Basin, with the main areas of suitable habitat predicted for the Blue Mountains, Watagan Ranges and Woronora Plateau. A large number of sightings have been made in Wollemi NP. Insufficient records were available to generate a local scale model.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence Only Without Eden	4	1	-	0	-
Central CRA	Presence Only	Adequate	210385	-	123438	-
Combined Models	-	-	210386	5.8	123438	58.7

5.50 COMMON BENT-WING BAT

Species Profile

The Common Bent-wing Bat (*Miniopterus schreibersii*) is the most widely distributed bat in the world, occurring through Europe, Africa and Australasia (Churchill 1998) though recent research suggests that there may be three taxa in Australia (Duncan *et al.* 1999). The subspecies *oceanensis* is the relevant taxa for New South Wales and extends at least between central Victoria and Cape York Peninsula, Queensland (Duncan *et al.* 1999). This species is distinguished from most others by the long last bone in the third wing digit and from the Little Bent-wing Bat (*M. australis*) by the longer forearm (greater than 44 millimetres) (Parnaby 1992). The call can be distinctive, although it is often inseparable from *Vespadelus darlingtoni* and *V. regulus* (Reinhold *et al.* 2001). It utilises a wide variety of habitats where it usually roosts in caves, though it has been known to use mines and road culverts (Churchill 1998). It is a fast flying species that usually feeds above the canopy (Churchill 1998) and has been known to travel up to 65 kilometres in a night (Dwyer 1966 in Ayers *et al.* 1996) and up to 1300 kilometres in total (Churchill 1998). Though individuals often use numerous roosts, it congregates in large numbers at a small number of caves to breed and hibernate (Churchill 1998).

Map 40 shows records of the Common Bent-wing Bat in the Wollongong Area.

Threats

Damage and disturbance to roosting sites are the greatest threats to this species. Because only relatively few nursery caves are used, significant population changes can occur if these sites are damaged (Dwyer 1995). Disturbance of hibernating colonies can lead to starvation due to loss of energy reserves (Gilmore & Parnaby 1994). Disturbance of smaller roosts by recreational caving and tourism may also be significant as may modification to feeding habitat by agriculture and urban development (Gilmore & Parnaby 1994). Some individuals are preyed upon by feral cats and, less often, foxes (Dwyer 1995).

Local and regional conservation status

The Common Bent-wing Bat is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995) under the name of Eastern Bentwing-bat. It appears to be the most widespread of the threatened microchiropteran bats in the Wollongong LGA, with numerous records both above and below the escarpment (NPWS 2002b). During the present survey it was trapped at two locations, and recorded using Anabat at up to nine other locations (six probable and three possible identifications). The species probably utilises much of the LGA for feeding, with possible temporary roosts in caves and mines on and above the escarpment. The closest maternity colony would appear to be at Bungonia, to the south west of the Study Area.

Bioregional scale models highlight a very large area of suitable habitat, reflecting the large distances that this species can travel whilst foraging. Individuals have been captured in a diverse range of National Parks including Nattai, Blue Mountains and Popran. Due to its high mobility, this species proved very difficult to predict in the Wollongong Study Area, and hence no model was generated.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Buffer		1	-	0	-
Central CRA	Presence Only	Adequate	1404680	-	724985	-
Combined Models	-	-	1404681	38.7	724985	51.6

5.51 LARGE-FOOTED MYOTIS

Species Profile

The Large-footed Myotis (*Myotis adversus*) is another bat species for which the taxonomy is currently undergoing review. The Australian specimens are now considered to consist of two or three species. The southern species (*M. macropus*) is recorded coastally and along the Murray River from south eastern South Australia to south east Queensland. However, the northern limit of this species and the area of overlap with *M. moluccarum* are poorly known (Duncan *et al.* 1999; Churchill 1998). Even though it can be recorded from up to 20 metres using Anabat, it can be difficult to identify from *Nyctophilus* species (Reinhold *et al.* 2001). It is easily distinguished from other species by its disproportionately large feet, which it uses to rake its prey of insects and small fish from the surface of water (Churchill 1998). It occurs in a wide variety of habitats as long as water is nearby. It normally roosts in caves, though will also use tree hollows, vegetation, and man-made structures, such as bridges and mines (Churchill 1998).

Map 41 shows records and predicted habitat for the Large-footed Myotis in the Wollongong Area.

Threats

The threats to this species are poorly known, but it is probably most sensitive to changes in water quality. These may be sedimentation (from vegetation clearing and logging), eutrophication (sewage and fertiliser run-off), pollution and altered flow regimes (Duncan *et al.* 1999). Roosting sites may be susceptible to disturbance by such activities as recreational caving or roadworks (Duncan *et al.* 1999; Gilmore & Parnaby 1994).

Local and regional conservation status

The Large-footed Myotis is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). Within Wollongong LGA it has been both trapped and identified by call at a number of locations above the escarpment (NPWS 2002b). During the current survey, one was trapped on Bellambi Creek, and it was also identified from Anabat recordings in the same vicinity. Because it is usually only trapped directly over water (Lumsden & Menkhorst 1995) it may be more widespread than current records suggest. It may be likely to occur in small colonies along a number of creeklines in the catchment areas above the escarpment.

As this species has specialist habitat requirements, only a small area of the Bioregion has been predicted to be high quality habitat, with most records located within the coastal third. The representation in NPWS Reserves is relatively poor, with most of the captures on park occurring in Nattai, Royal and Popran NPs. Within the Illawarra, a habitat model based on twenty metre buffers along major streamlines was created. Where the streams are above the escarpment, this habitat is protected with the Sydney Catchment Authority Special Area. However, on the coastal areas, this habitat is less protected, with many areas already highly urbanised.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	No Suitable Model					
Central CRA	Presence Only	Adequate	25666	-	13049	-
Combined Models	-	-	25666	0.7	13049	50.8

Wollongong Study Area

High Quality Habitat (ha)	Percentage of Study Area HQH	Moderate Quality Habitat (ha)	HQH in NPWS Reserve (ha)	HQH in SCA Land (ha)	HQH in SF (ha)	HQH in WCC Reserve (ha)	Reserved HQH (ha)	Percentage of HQH Reserved
1590	2.1	0	117	687	4	58	866	54.5


Helensburgh
Bulli
Wollongong
Dapto
Potential Large-footed Myotis habitat
High quality
Other existing native vegetation
on land
Seagrass
Large-footed Myotis record
Study area boundary
Local Government Area boundary
Major waterbody
Built-up area
Major river
Motorway or highway
Other major road
Map 41
Potential habitat for
Large-footed Myotis,
Myotis adversus
Wollongong LGA Bioregional Assessment
Fauna of the Illawarra Escarpment,
Coastal Plain and Plateau
Kilometres
Scale 1:150000 (on A3 layout)
Map projection consistent with Australian Map Grid Zone 56
Prepared by N. Cordish
Conservation Assessment and Data Unit, Central Directorate, NSW NPWS
July 2002

5.52 GREATER BROAD-NOSED BAT

Species Profile

The Greater Broad-nosed Bat (*Scoteanax rueppellii*) is a large microchiropteran that can only be confused with the Eastern False Pipistrelle (Parnaby 1992) (see Species Profile 5.49). Its calls can also be confused with this species, and with species of the genus *Scotorepens* (Reinhold 2001). It is usually found in gullies draining east from the Great Dividing Range between south east New South Wales and north Queensland (Atherton Tablelands), where it utilises creeks and clearings for hunting (Churchill 1998; Hoye & Richards 1995). Often said to be a lowland species, though Ayers *et al.* (1996) mention several examples of this species being recorded at higher altitudes. It usually roosts in tree hollows, though it may also utilise old buildings (Churchill 1998).

Map 40 shows all records of the Greater Broad-nosed Bat in the Wollongong Area.

Threats

The threats to this species are poorly known, though they probably include habitat clearance for agriculture and urban development, and logging, which may removal suitable hollows (Duncan *et al.* 1999).

Local and regional conservation status

The Greater Broad-nosed Bat is listed as Vulnerable on Schedule 2 of the NSW TSC Act (1995). It has only been recorded using Anabat in the Wollongong LGA and it was not recorded at all during the current surveys. It may occur in small numbers in forested areas above the escarpment. As with all bats, better understanding of habitat requirements and more accurate identification, particularly of calls, is needed to establish its level of abundance in Wollongong LGA.

The CRA models predict that the best quality habitat for the Greater Broad-nosed Bat occurs in the northern third and the extreme south of the Bioregion. This is reflected in the concentration of records, although a number of identifications of calls have been made on the Cumberland Plain. It is also reasonably well reported from NPWS Reserves, including Wollemi and Wyrrabalong NPs. Within the Wollongong Study Area there were insufficient records to derive a local habitat model.

Sydney Bioregion

Survey Region	Model Type	Quality	High Quality Habitat (ha)	Percentage of Bioregion HQH	HQH in NPWS Reserve (ha)	Percentage of HQH Reserved
Southern CRA	Presence Only	3	17794	-	8389	-
Central CRA	Presence Only	Good	352613	-	148500	-
Combined Models	-	-	370407	10.2	156889	42.4

5.53 OTHER THREATENED SPECIES RECORDED IN THE WOLLONGONG LGA.

Birds

Table 32 summarises the records of other threatened birds that have been made within the Wollongong Study Area. All records are from Chafer *et al.* (1999) unless otherwise referenced.

Table 32: Details of threatened species of birds recorded within the Wollongong Study Area. Legal Status is as defined under the NSW TSC Act (1995) V Vulnerable, E1 Endangered.

Common Name	Scientific Name	Legal Status	Notes
Blue-billed Duck	*Oxyura australis*	V	1 bird Wollongong Botanic Gardens, May 1996. Probably a drought visitor.
Freckled Duck	*Stictonetta naevosa*	V	Several records around Dapto/Albion Park, usually during inland droughts.
Southern Giant-petrel	*Macronectes giganteus*	E1	Uncommon winter visitor. Recorded between inshore and pelagic waters.
Providence Petrel	*Pterodroma solandri*	V	Common winter visitor, with most records pelagic.
Kermadec Petrel	*P. neglecta*	V	Rare summer visitor in pelagic waters.
Black-winged Petrel	*P. nigripennis*	V	Rare summer visitor in offshore and pelagic waters.
Gould's Petrel	*P. leucoptera*	E1	Uncommon summer visitor, usually singles in offshore and pelagic waters.
Flesh-footed Shearwater	*Puffinus carneipes*	V	Moderately common summer visitor, recorded in all marine habitats.
Little Shearwater	*P. assimilis*	V	Rare visitor with individuals seen all marine habitats.
Wandering Albatross	*Diomedea exulans*	E1	The various subspecies of Wandering Albatross have
Antipodean	*D. antipodensis*	V	recently been considered by some authors to be
Albatross	*D. gibsani*	V	separate species, which are not always identifiable
Gibson's Albatross			away from the breeding islands. Many records are of Wandering Albatross, which is described as a moderately common winter visitor, with the occasional summer record, with sightings made in all marine waters. The various subspecies are described as moderately common (*gibsoni*), uncommon (*exulans*) or scarce (*antipodensis*)
Black-browed Albatross	*D. [Thalassarche] melanophris*	V	Common winter visitor, regularly recorded from the shore, with two subspecies (sometimes species) present.
Shy Albatross	*D. [Thalassarche] cauta*	V	Moderately common winter visitor, with the race *cauta* being mostly recorded in offshore and pelagic waters.
Sooty Albatross	*Phoebetria fusca*	V	Rare winter visitor.
White-bellied Storm-petrel	*Fregetta grallaria*	V	Only two sightings have been made of this species in pelagic waters.
Red-tailed Tropicbird	*Phaethon rubricauda*	V	Rare visitor to inshore waters.
Black-necked Stork	*Ephippiorhynchus asiaticus*	E1	Rare visitor with the last record at Berkeley in November 1977.
Brolga	*Grus rubicunda*	V	Three sightings of possibly the same bird in 1957 during an inland drought.
Black-tailed Godwit	*Limosa limosa*	V	Scarce summer migrant, usually associating with the commoner Bar-tailed Godwit (*L. lapponica*).
Terek Sandpiper	*Xenus cinereus*	V	Rare summer migrant.
Great Knot	*Calidris tenuirostris*	V	Scarce summer migrant, most often at mouth of Lake Illawarra.
Sanderling	*C. alba*	V	Rare summer migrant, mainly on ocean beaches.
Broad-billed Sandpiper	*Limicola falcinellus*	V	Rare summer migrant.
Painted Snipe	*Rostratula benghalensis*	V	Rare nomad, that has been recorded in densely vegetated wetlands.
Beach Stone-curlew	*Esacus neglectus*	E1	Rare nomad, with the single Wollongong record being of one bird at Thirroul Beach, February 1998.
Pied Oystercatcher	*Haematopus longirostris*	V	Uncommon breeding resident of estuaries, beaches and tidal mudflats.
Sooty Oystercatcher	*H. fuliginosus*	V	Breeding resident with an Illawarra population of around 100 birds. Usually inhabits coastal rock platforms and offshore islands, and regularly breeds on the Five Islands.
Lesser Sand-plover	*Charadrius mongolus*	V	Scarce summer migrant to estuaries and adjacent beaches. Numbers have declined in the past 25 years.
Greater Sand-plover	*C. leschenaultii*	V	Rare summer migrant, with only one or two individuals any given year.
Hooded Plover	*Thinornis rubricollis*	E1	Breeds south of Jervis Bay, though a couple of juveniles have been recorded in Wollongong LGA.
Little Tern	*Sterna albifrons*	E1	A former breeding visitor, now a summer migrant to coastal waters, lakes and estuaries.
Sooty Tern	*S. fuscata*	V	Rare summer visitor, generally to offshore and pelagic waters.
Grey Ternlet	*Procelsterna cerulea*	V	Rare summer visitor to pelagic waters.
White Tern	*Gygis alba*	V	Rare summer visitor to pelagic waters.
Superb Parrot	*Polytelis swainsonii*	V	Occasional records are probably attributable to aviary escapees.

Mammals

Table 33 provides details on a number of species that either have only a few records or are locally extinct. Many of the species are from Robinson (1988).

Table 33: Details of threatened species of mammals recorded within the Wollongong Study Area. Legal Status is as defined under the NSW TSC Act (1995) or the NSW NP&W Act (1974) V Vulnerable, E1 Endangered, P Protected

Common Name	Scientific Name	Legal Status	Notes
Eastern Quoll	*Dasyurus viverrinus*	E1	This species is extinct on the mainland, with the last confirmed specimen from Vaucluse in 1963, though Robinson claims it may have been present in the Illawarra until about 1980. Formerly common on both the coastal flats and along the escarpment, it is now extinct in the Study Area.
White-footed Dunnart	*Sminthopsis leucopus*	V	The nearest records are from the Nowra/Jervis Bay area, though Robinson states one collected by a cat at Mt. Keira Scout Camp is this species mis-labelled as a Common Dunnart (*S. murina*).
Yellow-bellied Glider	*Petaurus australis*	V	More common on the ranges to the south of the LGA, Robinson reports of records in the 1960s from the Hacking River Valley. One possible record during the CRA at Avon Dam indicates the species may exist at very low densities in the Catchment areas, though this is usually a relatively easily detected species.
Squirrel Glider	*P. norfolcensis*	V	Robinson reports of sightings in the Cataract Catchment and Royal NP, and there is one sighting in the Atlas of NSW Wildlife from Avon Catchment and also recent records from the Wedderburn area. This species is often difficult to identify from the common Sugar Glider so it may exist in small numbers above the escarpment.
Parma Wallaby	*Macropus parma*	V	Reputedly common in the northern parts of LGA during 1920s, Robinson claims a sighting of two groups in Cataract Catchment in 1969.
Brush-tailed Rock-wallaby	*Petrogale penicillata*	V	May have existed in small numbers on the western edge of the LGA, but now extinct. The nearest population is in the upper Kangaroo Valley.
Red-necked Pademelon	*Thylogale thetis*	P	This species' distribution originally extended as far south as the Shoalhaven River, though it now appears to be extinct south of the Watagan Ranges. Robinson claimed that it still occurred along the escarpment in Wollongong, but no other records exist for the area.
Yellow-bellied Sheathtail-bat	*Saccolaimus flaviventris*	V	Two museum specimens exist for the Wollongong LGA, the most recent from 1964. This species may still exist in the area, since it is rarely captured, though its call is readily identifiable (Reinhold et al. 1999).

Marine mammals and reptiles

A number of marine mammals and a sea turtle have been recorded in the waters off Wollongong. The records of these species have been summarised in Table 34.

Table 34: Records of threatened species of marine mammals and reptiles within the Wollongong Study Area. Legal Status is as defined under the NSW TSC Act (1995) V Vulnerable, E1 Endangered. The number of records is derived from the NPWS Atlas of NSW Wildlife.

Common Name	Scientific Name	Legal Status	Number of Records
Australian Fur-seal	*Arctocephalus pusillus doriferа*	V	9
Dugong	*Dugong dugon*	E1	1
Humpback Whale	*Megaptera novaeangliae*	V	3
Southern Right Whale	*Eubalaena australis*	V	1
Sperm Whale	*Physeter macrocephalus*	V	2
Green Turtle	*Chelonia mydas*	V	1

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7 APPENDICES

7.1 APPENDIX A - SITE LOCATIONS

Site Number	Easting	Northing	Location Description	Bat Ultrasonic Call Detection	Diurnal Bird Count	Diurnal Reptile Search	Elliot Trapping	Harp Trapping	Nocturnal Call Playback	Nocturnal Streamside Search	Site Spot-lighting
wol-001	310700	6216575	Woronora catchment trail 9E		X						X
wol-002	309750	6216250	Woronora, junction FT 9E & 9D		X						X
Wol-003	308400	6214100	Woronora FT 9C		X						X
wol-004	309450	6214100	Woronora Fire Trail 9H						X		X
wol 005	306350	6214700	SCA FT 14								X
wol-006	307300	6213950	Woronora start fire Trail 9		X				X		X
wol-007	308850	6219550	Woronora Fire Trail 9		X						X
wol-008	308950	6218400	Woronora Fire Trail 9		X						X
Wol-009	310950	6213900	Woronora Fire Trail 9G		X						X
Wol-010	310300	6212450	Woronora Fire Trail 9G		X						X
Wol 011	308150	6209150	Dharawal Maddens Ck Crossing							X	X
Wol 012	307900	6207600	Dharawal Fire Trail 10								X
Wol 013	307100	6207300	Dharawal Fire Trail 10A								X
Wol-014	305000	6207000	Dharawal NR Fire Trail 10								X
Wol-015	304150	6205750	Cataract Creek tributary		X						X
Wol-016	306150	6203850	Loddon Falls Track		X						X
Wol-017	311350	6217250	Woronora end Fire Trail 9E		X	X			X		
wol-018	310100	6220150	Woronora end of 9 Fire Trail			X			X		
wol-019	311500	6213950	Woronora creek on FT 9G						X		
wol-020	308950	6207500	Dharawal - Fire Trail 10A near FWY						X		
wol-021	306100	6207250	Dharawal forest on Fire Trail 10A		X				X		
wol-022	312950	6212050	Helensburgh near Kellys Ck							X	
wol-023	309550	6214000	Woronora Waratah Rivulet							X	
wol-024	306150	6203800	Loddon Creek above Loddon Falls							X	
wol-025	303070	6205150	Cataract Catchment							X	
wol-026	292250	6189250	Avon catchment ridge			X					
Wol-027	304660	6199950	Cataract FT 7		X						X
Wol-028	303530	6200850	Cataract FT 7 near 7D jn		X						X
Wol-029	302050	6201350	Cataract jn 7J & 7L FT		X						X
WOL-030	300295	6203550	Cataract FT 7	X	X						X
Wol 031	303870	6203400	Cataract FT 7B end		X						X
Wol-032	307600	6203450	Maddens Plains Sth		X				X	X	X
Wol-033	308600	6205750	Maddens Plains Nth Loddon R		X				X		X
Wol-034	305050	6200800	Cataract FT 7A								X
Wol-035	301550	6199200	Bellambi Ck on FT 7D	X	X					X	X
Wol-036	302600	6197700	Fire Trail 7D								X
Wol-037	312250	6213950	Woronora FT 9J								X
wol-038	304880	6203220	Metro 2.6km down Fire Trail 7I								X
Wol-039	306720	6202550	Metro FT 7I 400m from gate								X
Wol-040	312180	6208480	Forest Walk near Stoney Ck								X

Site Number	Easting	Northing	Location Description	Bat Ultrasonic Call Detection	Diurnal Bird Count	Diurnal Reptile Search	Elliot Trapping	Harp Trapping	Nocturnal Call Playback	Nocturnal Streamside Search	Site Spot-lighting
wol-041	312340	6207170	Forest Walk above Coalcliff			X					X
Wol-042	311220	6206500	Forest Walk near Repeater								X
wol-043	306900	6212700	Darkes Forest FT14		X						
wol-044	302700	6202450	Metro between FT 7 & 7B		X				X		
wol-045	303500	6198600	Metro FT 7		X	X					
wol-046	308041	6202046	Bulli Scenic Reserve								X
wol-047	308712	6202036	Bulli Scenic Reserve, Gibson Tr								X
wol-048	307930	6204150	Maddens Plains 10Q							X	
wol-049	308080	6204450	Maddens Plains 10Q							X	
wol-050	308350	6205120	Maddens Plains 10Q							X	
wol-051	299980	6203380	Metro FT 7			X					
wol-052	299600	6202150	Metro FT 7L			X					
wol-053	302580	6197720	Metro FT 7D			X					
Wol-054	300650	6193200	Metro FT 8D		X				X		X
Wol-055	299800	6192990	Metro FT 8D					X			X
Wol-056	298700	6193750	Metro		X	X		X			X
Wol-057	296550	6197250	Metro FT 8I								X
Wol-058	298700	6193250	Metro FT 8								X
Wol-059	299550	6197250	Metro								X
Wol-060	296500	6187250	Near Kembla lookout								X
wol-061	287850	6193450	Metro FT6A								X
Wol-062	296350	6189950	Metro near upper Cordeaux No. 2		X				X		X
Wol-063	293550	6189750	Metro FT 6D		X						X
Wol-064	288550	6192820	Metro FT 6A								X
Wol-065	292850	6189480	Metro FT 6D								X
wol-066	290200	6188300	Metro FT 6A								X
wol-067	291600	6185150	Metro FT 6T								X
wol-068	289950	6189990	Metro FT 6A								X
wol-069	289850	6186050	Metro FT 6H beyond vent shaft			X					X
wol-070	292050	6182900	Avon FT15A		X						X
wol-071	290950	6181850	Avon FT 15H		X						X
wol-072	295250	6196900	Metro FT 8I						X		
wol-073	299800	6189800	Illawarra SCA below O'Briens Gap						X		
wol-074	297650	6191350	Avon FT15B			X			X		
wol-075	302050	6195350	Metro FT 8C							X	
wol-076	299810	6195490	Metro nth Picton Rl			X					
wol-077	293250	6197850	Cordeaux opp dam wall			X					
wol-078	297100	6196700	Trail off Mt. Keira Rd			X					
wol-079	299900	6192900	Metro FT 8D			X					
wol-080	298720	6196490	Metro FT 8A			X					
wol-081	294560	6197820	Metro FT 8C		X	X					
wol-082	300050	6198200	Metro FT 8B			X					
wol-083	293250	6189550	Metro FT 6D			X					
wol-084	292350	6195300	Metro FT 6C			X					
wol-085	296120	6187650	Upper Cordeaux Dam			X					
wol-086	296800	6199550	Metro Lizard Creek Crossing		X						
wol-087	296650	6201300	Lizard Creek near Colliery		X						
wol-088	292150	6193700	Metro FT 6C		X						

Site Number	Easting	Northing	Location Description	Bat Ultrasonic Call Detection	Diurnal Bird Count	Diurnal Reptile Search	Elliot Trapping	Harp Trapping	Nocturnal Call Playback	Nocturnal Streamside Search	Site Spot-lighting
wol-089	292200	6195900	Metro jn of 6C and 6F		X						
wol-090	298990	6193240	Metro FT 8D					X			
wol-091	299980	6197700	Metro FT 8B					X			
wol-092	298740	6196600	Metro near pipeline start FT 8B					X			
wol-093	299580	6197250	8B trail at fork					X			
wol-094	305300	6189150	Wisemans Park	X	X						X
wol-095	306950	6190450	Puckey's Lagoon	X	X	X					X
wol-096	304734	6186335	Coniston Woodlands	X	X	X					X
wol-097	305700	6179400	Windang	X	X	X					X
wol-098	304600	6187500	Mangerton Park	X	X	X					X
wol-099	288500	6175400	"The Retreat" Calderwood	X	X	X		X	X		X
wol-100	307750	6181000	Port Kembla beach dunes		X	X					
wol-101	303900	6176100	Picnic Island			X					
wol-102	307250	6169750	Bass Point - littoral rainforest	X	X	X					X
wol-103	302950	6172350	Blackbutt Reserve	X	X	X					X
wol-104	308850	6194550	Bellambi Point		X						
wol-105	297300	6171400	Cronme Rd		Y	X					
wol-106	287950	6182700	Avon FT 15G								X
wol-107	297300	6186900	Cordeaux Rd SCA Mt. Kembla	X							X
wol-108	289580	6181530	Avon end FT 15F								X
wol-109	295400	6188400	B/w upper & Cordeaux dam	X						X	X
wol-110	289900	6187020	Avon near Wongawilli mine shaft								X
wol-111	288100	6175330	"The Retreat" Calderwood	X	X	X		X			X
wol-112	289455	6184622	Avon FT 15G			X					
wol-113	287960	6182980	Avon FT 15G nth 15M			X					
wol-114	288269	6180414	Huntley Colliery trail off 15G		X						
wol-115	287981	6182682	Avon FT15G north of 15M		X						
wol-116	290000	6185300	Avon FT 15G at end		X						
wol-117	289846	6181349	Avon FT15		X						
wol-118	292570	6184360	Flying Fox no.3 creek					X			
wol-119	288269	6180414	Huntley Colliery trail off 15G					X			
wol-120	288808	6182264	Avon ft 15N					X			
wol-121	290000	6185300	Avon 15G					X			
wol-122	288481	6183308	Avon 15G					X			
wol-123	296440	6176400	Yallah Transgrid land	X	X	X		X	X		X
wol-124	294967	6176847	Yallah private property	X	X	X		X	X	X	X
wol-125	294800	6177450	Yallah private property		X						
wol-126	296987	6183091	Sheaffes Rd		X	X				X	
wol-127	293175	6182110	Wongawilli Colliery	X	X	X			X		X
wol-128	292050	6175420	Marshall Mount private property		X	X		X			X
wol-129	289900	6179580	Huntley Colliery	X	X	X		X	X		X
wol-130	289750	6178230	Huntley Colliery		X	X		X			X
wol-131	292440	6182830	Wongawilli Colliery BHP	X	X	X					X
wol-132	292018	6176451	Marshall Mount private property			X					X
wol-133	298880	6189080	Illawarra SCA Kembla Heights		X	X					
wol-134	302938	6193441	Illawarra SCA Clive Bissel Dr		X	X					
wol-135	299823	6202028	Metro FT 7L					X			

Site Number	Easting	Northing	Location Description	Bat Ultrasonic Call Detection	Diurnal Bird Count	Diurnal Reptile Search	Elliot Trapping	Harp Trapping	Nocturnal Call Playback	Nocturnal Streamside Search	Site Spot-lighting
wol-136	301685	6201532	Metro FT7	X				X			
wol-137	302564	6199075	Metro FT 7C					X			
wol-138	299472	6189889	Illawarra SCA O'Briens Gap		X			X			
wol-139	292088	6189431	Metro FT 6F	X				X			X
wol-140	293319	6188200	Metro FT6G	X				X			X
wol-141	290010	6180332	Avon FT 15A				X				X
wol-142	290670	6180422	Avon FT 15A	X							
wol-144	287604	6175651	Avon FT 15				X				
wol-146	291246	6181558	Avon FT 15A	X			X				X
wol-148	285043	6175261	Avon catchment				X				
wol-149	290800	6180900	Avon FT15A				X				
wol-150	289308	6177099	Avon FT15				X				
wol-151	288050	6181250	Avon FT15G	X							X
Wol-152	316350	6214850	Royal NP Lady Wakehurst Drive			X					
wol-153	316600	6213580	Royal NP Lady Wakehurst Drive	X							X
wol-154	316880	6212600	Royal NP in Littoral RF			X					X
wol-155	317100	6215200	Royal NP Lady Wakehurst Drive	X		X				X	X
wol 156	284070	6177057	Avon		X						
wol-157	283778	6176275	Avon		X						
WOL-158	281809	6176375	Avon		X						
wol-159	282227	6174848	Avon		X						
wol-160	292490	6185604	Avon		X						
wol-161	292731	6184289	Avon		X						
wol-162	290731	6180433	Bong Bong Pass		X						
wol-163	289175	6179390	Avon		X						
wol-164	288705	6176400	Avon		X						
wol-165	286297	6174756	Avon		X						
wol-166	284985	6174795	Avon FT 15		X						
wol-167	283590	6174030	Avon FT 15		X						
wol-168	287011	6179619	Avon		X						
wol-169	311140	6204190	Coledale Beach littoral RF								X
Wol-170	312498	6207820	Forest Walk above Coalcliff						X		
Wol-171	299600	6182300	Brownsville Mullet Ck		X	X					
Wol-172	307400	6193400	Towradgi Creek		X	X					
Wol-173	304600	6191400	Mt. Ousley Cabbage Tree Creek		X	X					
Wol-174	300900	6187300	Cordeaux Heights		X	X					
wol-175	306350	6200000	Rixons Pass Trail					X			X
wol-176	306150	6198650	Woonona Heights					X			
wol-177	317300	6218265	Royal NP - valley track			X					
wol-178	304200	6194500	Brokers Point		X			X			X
wol-179	302700	6191500	Mount Keira					X			
wol-180	303450	6190950	Mount Keira					X			
wol-181	299060	6189200	O'Briens Gap					X		X	X
wol-182	293304	6182138	Wongawilli BHP land					X			
wol-183	298640	6186250	Mt. Kembla ring track					X			X
wol-184	294274	6185363	Kembla Grange private property		X	X		X			
wol-185	308500	6202150	Bulli Pass Scenic Res, Gibson Tk					X		X	
wol-186	308700	6202250	Bulli Pass Scenic Res, Gibson Tk								X
wol-187	302250	6192400	Mt. Keira								X
wol-188	302843	6193451	Mt. Keira								X

Site Number	Easting	Northing	Location Description	Bat Ultrasonic Call Detection	Diurnal Bird Count	Diurnal Reptile Search	Elliot Trapping	Harp Trapping	Nocturnal Call Playback	Nocturnal Streamside Search	Site Spot-lighting
wol-189	305366	6191016	Mount Ousley base remnant bush		X	X					
wol-190	303400	6181600	Berkeley Wollamai Point		X	X					
wol-191	297985	6178488	Dapto, Mt. Brown		X	X					
wol-192	297600	6179700	Dapto, Brooks Creek		X	X					
wol-193	302300	6188350	Branch Creek, Nareena Hills		X	X					
wol-194	302484	6191547	Mt. Kera loop track		X	X					
wol-195	297000	6177000	Tallawarra Rd, near Duck Creek		X						
wol-196	297300	6173500	Albion Park Airport			X					
wol-197	297300	6172400	Illawarra Light Railway		X	X					
wol-198	290800	6180700	West Dapto Mullet Creek		X						
Wol-199	290160	6186580	near Wongawilli ventalation shaft	X							
Wol-200	285300	6172500	Macquarie Pass Clover Hill Rd			X					
Wol-201	284200	6171800	Macquarie Pass Clover Hills Rd			X					
wol-202	284600	6173200	Upper Macquarie Pass			X					
wol-203	286400	6171700	Bottom of Macquarie Pass			X					
wol-204	317342	6216849	Royal NP Lady Wakehurst Dr			X					
wol-205	318700	6218830	Royal NP on Bola Cr			X					
wol-206	315067	6210719	Stanwell Park			X					
wol-207	284926	6172399	Macquarie Pass Clover Hill Rd						X		X
wol-208	284300	6173857	Macquarie Pass						X		X
wol-209	308175	6193854	Bellambi Point			X					
Grand Total				**27**	**90**	**70**	**6**	**34**	**23**	**17**	**92**

7.2 APPENDIX B - HABITAT CHARACTERISTICS

WOLLONGONG LGA FAUNA SURVEYS *SITE ATTRIBUTES*

Survey Period..... Surveyors.....

Area of Survey: ..... Site No.: _____ Date: ____/____/____

Locality description: .....

.....

Map code: _ _ _ _ _ _ Map name: .....

From 1:25,000 topo. map: AMG: _ _ (zone) / _ _ _ _ _ _ (E) / _ _ _ _ _ _ _ (N)

From GPS reading: AMG: _ _ (zone) / _ _ _ _ _ _ (E) / _ _ _ _ _ _ _ (N)

Land tenure (circle) Nat. Park Nature Res. State Rec. Area Crown leasehold State Forest Flora Res.

Vacant Crown Land Private (freehold) Water Catchment

NPWS Estate, State Forest or Reserve Name: .....

Physical details

Altitude _ _ _ _ (m) Slope _ _ degrees Aspect _ _ _ degrees

Topographic Position (circle best morphology and element)

Morphology / Element								
	Crest	Simple Sl.	Upper Sl.	Mid Slope	Lower Sl.	Flat	Open Depr.	Closed Depr.
	Hillcrest	Streambank	Cliff	Cliff	Cliff-foot	Plain	Gully	Lake
	Summit	Cliff	Hill slope	Hill slope	Hill slope	Valley	Drainage	Lagoon
	Plateau	Hill slope	Scarp	Scarp	Scarp-foot	Fan	Depression	Swamp
		Scarp					Stream channel	
							Stream bed	

Disturbance History	Severity (0=no evid., 1=light, 2=mod., 3=severe)	Time since last event (where appropriate)	Accuracy (e.g. +/- 2 years)	Observation type 1=visual est, 2=written record, 3=informant
Fire				
Logging (inc. ringbarking)				
Grazing				
Weeds				
Other (specify)				

Soil:

Depth				Type				
	Deep	Shallow	Skeletal		Clay	Loam	Sand	Organic

% projected foliage cover: (circle most appropriate class)

	100-75%	75-50%	50-25%	25-5%	<5%, many individuals	<5%, few individuals	none
Tree or shrub Acacias	6	5	4	3	2	1	0
Tree or shrub Banksias	6	5	4	3	2	1	0
Tree or shrub Allocasuarinas	6	5	4	3	2	1	0
Palms	6	5	4	3	2	1	0
Vines	6	5	4	3	2	1	0
Weeds	6	5	4	3	2	1	0

Logged stumps	no. present on 20x20m plot:	>10	9 to 6	3 to 5	1 to 2	none
Large (>10cm dbh) stags	no. present on 20x20m plot:	>10	9 to 6	3 to 5	1 to 2	none

Dominant shrub growth form					
	Mesic	Mixed	Heathy	Treefern	Grass Tree

Dominant ground layer growth form						
	Tussock grass	Hummock grass	Sod grass	Fern	Moss	Herb/ grass
	Lichen	Liverwort	Sedge	Rush	Vine	

Strata (fill in only for those strata present	Crown Cover (%)	Height Rnge	Composition	Species Present	

on the site and add strata when necessary)	(as McDonald et al.)	(see below)	(rf, non rf, mixed)				
Emergent	%						
Tree layer 1	%						
Tree layer 2	%						
Shrub	%						
	%						
	%						

Height range: 1 - 3m, 3 - 5m, 5 - 12m, 12 - 20m, 20 - 35m, >35m

Ground layer		% cover		% cover		% cover
Projective cover (%)	veg.		soil		litter	
(total % cover = 100%)	rock		log			

Litter	>10cm	10-2 cm	2-0 cm	0 cm
Litter depth	Deep	Mod.	Shallow	Absent
Humus	Deep	Mod.	Shallow	Absent

Stream or water body characteristics (at gully sites and other frog survey sites) (circle or tick)

Stream order (from map)	1	2	3	4	N/A		
Stream width (between fringing vegetation)		m	OR	Pond/Dam/Swamp diameter (m)			
Waterbody substrate	gravel	rock	sand	soil			
Riparian Vegetation (more than one OK)	Absent	RF	WSF	DSF	she-oak	swamp scler.	ferns
	grass	sedges	Other				
Fringing ground environment (more than one OK)	Absent	ferns	grass	sedges	floating		
	rocky	soil	sand				
Water Movement	still	flowing					
Water Colour	clear	stained					

Water body (circle one)	Specify (eg Dam/River/Soak)
	1) Temporary and Natural (ephemeral soaks, ephemeral streams etc.)
	2) Temporary and Human-made (eg. roadside ditches)
	3) Permanent and natural (streams and swamps with water >80% of time)
	4) Permanent and human made (eg. Dam)

7.3 APPENDIX C - COMPLETE SPECIES LIST

Appendix C – a complete species list for the Wollongong Area from the NPWS Atlas of NSW Wildlife. Records have been included from the current survey, other NPWS surveys, incidental records submitted by the public and licensed datasets. This list contains records of various levels of reliability; for example bat ultrasound recordings have been included. Species where there is doubt about the reliability of the identification have been marked with an asterix.

Family	Scientific Name	Common Name	Legal Status	Current Survey	Other Surveys	Incidental Records	Licensed Datasets
FROGS							
Myobatrachidae	*Crinia signifera*	Common Eastern Froglet	P	57	54	116	52
Myobatrachidae	*Heleioporus australiacus*	Giant Burrowing Frog	V	6	5	15	19
Myobatrachidae	*Limnodynastes dumerilii*	Bullfrog	P	13	3	30	58
Myobatrachidae	*Limnodynastes peronii*	Striped Marsh Frog	P	14	18	31	37
Myobatrachidae	*Limnodynastes tasmaniensis*	Spotted Marsh Frog	P	0	0	2	0
Myobatrachidae	*Mixophyes balbus*	Stuttering Frog	E1	0	0	0	13
Myobatrachidae	*Paracrinia haswelli*	Haswell's Froglet	P	4	0	15	18
Myobatrachidae	*Pseudophryne australis*	Red-crowned Toadlet	V	8	35	7	3
Myobatrachidae	*Pseudophryne bibronii*	Bibron's Toadlet	P	0	1	0	0
Myobatrachidae	*Uperoleia laevigata*	Smooth Toadlet	P	4	4	13	0
Hylidae	*Litoria aurea*	Green and Golden Bell Frog	E1	0	1	14	10
Hylidae	*Litoria caerulea*	Green Tree Frog	P	0	0	4	11
Hylidae	*Litoria citropa*	Blue Mountains Tree Frog	P	26	6	14	60
Hylidae	*Litoria dentata*	Keferstein's Tree Frog	P	5	9	9	64
Hylidae	*Litoria fallax*	Eastern Dwarf Tree Frog	P	1	0	7	0
Hylidae	*Litoria freycineti*	Freycinet's Frog	P	0	1	12	90
Hylidae	*Litoria jervisiensis*	Jervis Bay Tree Frog	P	1	2	7	0
Hylidae	*Litoria lesueuri*	Lesueur's Frog	P	26	10	11	24
Hylidae	*Litoria littlejohni*	Littlejohn's Tree Frog	V	2	0	0	62
Hylidae	*Litoria peronii*	Peron's Tree Frog	P	22	21	29	46
Hylidae	*Litoria phyllochroa/nudidigitus*	Green Stream Frog	P	32	25	24	34
Hylidae	*Litoria tyleri*	Tyler's Tree Frog	P	0	0	4	0
Hylidae	*Litoria verreauxii*	Verreaux's Tree Frog	P	4	7	18	123
REPTILES							
Chelonidae	*Chelonia mydas*	Green Turtle	V	0	0	1	0
Chelidae	*Chelodina longicollis*	Eastern Snake-necked Turtle	P	1	3	4	0
Gekkonidae	*Diplodactylus vittatus*	Eastern Stone Gecko	P	0	0	1	1
Gekkonidae	*Oedura lesueurii*	Lesueur's Velvet Gecko	P	9	2	8	5
Gekkonidae	*Phyllurus platurus*	Broad-tailed Gecko	P	0	9	6	7
Gekkonidae	*Underwoodisaurus milii*	Thick-tailed Gecko	P	1	0	0	0
Pygopodidae	*Pygopus lepidopodus*	Southern Scaly-foot	P	0	1	2	1
Agamidae	*Amphibolurus muricatus*	Jacky Lashtail	P	10	9	48	3
Agamidae	*Physignathus lesueurii*	Eastern Water Dragon	P	8	12	16	5
Agamidae	*Tympanocryptis diemensis*	Mountain Heath Dragon	P	10	7	24	2
Varanidae	*Varanus rosenbergi*	Rosenberg's Goanna	V	1	1	4	4
Varanidae	*Varanus varius*	Lace Monitor	P	0	1	4	0
Scincidae	*Bassiana platynota*	Red-throated Cool-skink	P	10	12	12	0
Scincidae	*Cryptoblepharus virgatus*	Cream-striped Shinning-skink	P	0	1	5	1
Scincidae	*Ctenotus robustus*	Robust Ctenotus	P	1	1	0	0

Family	Scientific Name	Common Name	Legal Status	Current Survey	Other Surveys	Incidental Records	Licensed Datasets
Scincidae	*Ctenotus taeniolatus*	Copper-tailed Ctenotus	P	20	13	29	7
Scincidae	*Cyclodomorphus michaeli*		P	1	0	5	12
Scincidae	*Egernia cunninghami*	Cunningham's Spiny-tailed Skink	P	3	1	4	0
Scincidae	*Egernia saxatilis*	Black Crevice-skink	P	0	4	1	5
Scincidae	*Egernia whitii*	White's Rock-skink	P	4	4	4	9
Scincidae	*Eulamprus heatwolei*	Warm-temperate Water-skink*	P	0	0	18	5
Scincidae	*Eulamprus quoyii*	Eastern Water-skink	P	33	27	17	7
Scincidae	*Eulamprus tenuis*	Bar-sided Forest-skink	P	3	1	2	4
Scincidae	*Hemiergis decresiensis*	Three-toed Earless Skink*	P	0	7	7	0
Scincidae	*Lampropholis delicata*	Dark-flecked Garden Sunskink	P	53	48	31	38
Scincidae	*Lampropholis guichenoti*	Pale-flecked Garden Sunskink	P	20	15	19	24
Scincidae	*Nannoscincus maccoyi*	Highlands Forest-skink	P	9	8	1	19
Scincidae	*Pseudemoia entrecasteauxii*	Tussock Cool-skink*	P	0	0	2	0
Scincidae	*Saiphos equalis*	Yellow-bellied Three-toed Skink	P	19	14	5	21
Scincidae	*Saproscincus mustelinus*	Weasel Shadeskink	P	13	17	11	12
Scincidae	*Tiliqua scincoides*	Common Bluetongue	P	3	2	15	0
Typhlopidae	*Ramphotyphlops nigrescens*	Blackish Blind Snake	P	4	3	0	8
Boidae	*Morelia spilota spilota*	Diamond Python	P	4	3	6	6
Colubridae	*Boiga irregularis*	Eastern Brown Tree Snake	P	0	0	0	2
Colubridae	*Dendrelaphis punctulata*	Green Tree Snake	P	0	1	1	0
Elapidae	*Austrelaps ramsayi*	Highlands Copperhead	P	0	0	0	1
Elapidae	*Cacophis squamulosus*	Golden-crowned Snake	P	4	7	3	17
Elapidae	*Demansia psammophis*	Yellow-faced Whipsnake	P	2	0	1	2
Elapidae	*Drysdalia rhodogaster*	Mustard-bellied Snake	P	0	1	2	6
Elapidae	*Furina diadema*	Red-naped Snake	P	0	0	0	1
Elapidae	*Hemiaspis signata*	Marsh Snake	P	3	2	4	15
Elapidae	*Hoplocephalus bungaroides*	Broad-headed Snake	E1	1	1	1	5
Elapidae	*Notechis scutatus*	Mainland Tiger Snake	P	1	0	2	6
Elapidae	*Pseudechis porphyriacus*	Red-bellied Black Snake	P	7	12	16	5
Elapidae	*Pseudonaja textilis*	Eastern Brown Snake	P	0	0	0	2
Elapidae	*Rhinoplocephalus nigrescens*	Small-eyed Snake	P	6	1	2	20
Elapidae	*Suta spectabilis dwyeri*	Variable Black-naped Snake*	P	0	0	1	0
Elapidae	*Vermicella annulata*	Eastern Bandy-bandy	P	0	0	3	4
Hydrophiidae	*Pelamis platurus*	Yellow-bellied Seasnake	P	0	0	0	8
BIRDS							
Megapodiidae	*Alectura lathami*	Australian Brush-turkey	P	1	0	10	2
Phasianidae	*Coturnix chinensis*	King Quail	P	0	0	0	2
Phasianidae	*Coturnix ypsilophora*	Brown Quail	P	0	0	0	1
Phasianidae	*Phasianus colchicus*	Common Pheasant*	U	0	0	1	0
Anatidae	*Anas castanea*	Chestnut Teal	P	2	2	13	43
Anatidae	*Anas gracilis*	Grey Teal	P	0	0	14	34
Anatidae	*Anas platyrhynchos*	Mallard	U	0	0	2	9
Anatidae	*Anas rhynchotis*	Australasian Shoveler	P	0	0	8	1
Anatidae	*Anas superciliosa*	Pacific Black Duck	P	0	6	10	88
Anatidae	*Aythya australis*	Hardhead	P	0	0	2	5

Family	Scientific Name	Common Name	Legal Status	Current Survey	Other Surveys	Incidental Records	Licensed Datasets
Anatidae	*Biziura lobata*	Musk Duck	P	0	0	8	0
Anatidae	*Cereopsis novaehollandiae*	Cape Barren Goose	P	0	0	2	0
Anatidae	*Chenonetta jubata*	Australian Wood Duck	P	3	5	4	50
Anatidae	*Cygnus atratus*	Black Swan	P	0	1	18	21
Anatidae	*Malacorhynchus membranaceus*	Pink-eared Duck	P	0	0	7	1
Anatidae	*Stictonetta naevosa*	Freckled Duck	V	0	0	3	0
Anatidae	*Tadorna tadornoides*	Australian Shelduck	P	0	0	3	0
Podicipedidae	*Podiceps cristatus*	Great Crested Grebe	P	0	0	5	0
Podicipedidae	*Poliocephalus poliocephalus*	Hoary-headed Grebe	P	0	0	14	0
Podicipedidae	*Tachybaptus novaehollandiae*	Australasian Grebe	P	0	0	1	16
Spheniscidae	*Eudyptula minor*	Little Penguin	P	0	0	4	37
Procellariidae	*Calonectris leucomelas*	Streaked Shearwater	P	0	0	2	1
Procellariidae	*Daption capense*	Cape Petrel	P	0	0	0	4
Procellariidae	*Fulmarus glacialoides*	Southern Fulmar	P	0	0	0	1
Procellariidae	*Halobaena caerulea*	Blue Petrel	P	0	0	0	2
Procellariidae	*Macronectes giganteus*	Southern Giant-Petrel	E1	0	0	1	2
Procellariidae	*Pachyptila belcheri*	Slender-billed Prion	P	0	0	1	4
Procellariidae	*Pachyptila desolata*	Antarctic Prion	P	0	0	2	4
Procellariidae	*Pachyptila salvini*	Salvin's Prion	P	0	0	0	1
Procellariidae	*Pachyptila turtur*	Fairy Prion	P	0	0	2	2
Procellariidae	*Pachyptila vittata*	Broad-billed Prion	P	0	0	0	1
Procellariidae	*Pelecanoides georgicus*	South Georgian Diving-Petrel	P	0	0	0	1
Procellariidae	*Pelecanoides urinatrix*	Common Diving-Petrel	P	0	0	0	1
Procellariidae	*Procellaria aequinoctialis*	White-chinned Petrel	P	0	0	1	0
Procellariidae	*Procellaria westlandica*	Westland Petrel	P	0	0	0	1
Procellariidae	*Pterodroma inexpectata*	Mottled Petrel	P	0	0	2	1
Procellariidae	*Pterodroma lessonii*	White-headed Petrel	P	0	0	1	3
Procellariidae	*Pterodroma leucoptera leucoptera*	Gould's Petrel	E1	0	0	1	5
Procellariidae	*Pterodroma macroptera*	Great-winged Petrel	P	0	0	3	4
Procellariidae	*Pterodroma solandri*	Providence Petrel	V	0	0	0	2
Procellariidae	*Puffinus assimilis*	Little Shearwater	V	0	0	2	2
Procellariidae	*Puffinus bulleri*	Buller's Shearwater	P	0	0	0	2
Procellariidae	*Puffinus carneipes*	Flesh-footed Shearwater	V	0	0	1	2
Procellariidae	*Puffinus gavia*	Fluttering Shearwater	P	0	0	0	3
Procellariidae	*Puffinus griseus*	Sooty Shearwater	P	0	0	0	2
Procellariidae	*Puffinus huttoni*	Hutton's Shearwater	P	0	0	0	2
Procellariidae	*Puffinus pacificus*	Wedge-tailed Shearwater	P	0	0	3	36
Procellariidae	*Puffinus tenuirostris*	Short-tailed Shearwater	P	0	0	5	19
Diomedeidae	*Diomedea exulans*	Wandering Albatross	E1	0	0	1	13
Diomedeidae	*Phoebetria fusca*	Sooty Albatross	V	0	0	0	1
Diomedeidae	*Thalassarche bulleri*	Buller's Albatross	P	0	0	1	1
Diomedeidae	*Thalassarche cauta*	Shy Albatross	V	0	0	0	2
Diomedeidae	*Thalassarche chrysostoma*	Grey-headed Albatross	P	0	0	0	1
Diomedeidae	*Thalassarche melanophris*	Black-browed Albatross	V	0	0	1	3
Hydrobatidae	*Garrodia nereis*	Grey-backed Storm-Petrel	P	0	0	0	1
Hydrobatidae	*Pelagodroma marina*	White-faced Storm-Petrel	P	0	0	5	1
Phaethontidae	*Phaethon lepturus*	White-tailed Tropicbird	P	0	0	3	3

Family	Scientific Name	Common Name	Legal Status	Current Survey	Other Surveys	Incidental Records	Licensed Datasets
Sulidae	*Morus serrator*	Australasian Gannet	P	0	1	3	5
Anhingidae	*Anhinga melanogaster*	Darter	P	4	1	2	13
Phalacrocoracidae	*Phalacrocarax carbo*	Great Cormorant	P	3	1	25	63
Phalacrocoracidae	*Phalacrocarax melanoleucos*	Little Pied Cormorant	P	2	2	23	101
Phalacrocoracidae	*Phalacrocarax sulcirostris*	Little Black Cormorant	P	2	3	17	72
Phalacrocoracidae	*Phalacrocarax varius*	Pied Cormorant	P	0	1	11	33
Pelecanidae	*Pelecanus conspicillatus*	Australian Pelican	P	4	3	26	143
Fregatidae	*Fregata ariel*	Lesser Frigatebird	P	0	0	1	0
Ardeidae	*Ardea alba*	Great Egret	P	1	0	14	42
Ardeidae	*Ardea ibis*	Cattle Egret	P	0	0	6	8
Ardeidae	*Ardea intermedia*	Intermediate Egret	P	0	1	0	2
Ardeidae	*Ardea pacifica*	White-necked Heron	P	0	1	0	4
Ardeidae	*Botaurus poiciloptilus*	Australasian Bittern	V	0	0	2	1
Ardeidae	*Butorides striatus*	Striated Heron	P	2	1	6	5
Ardeidae	*Egretta garzetta*	Little Egret	P	0	0	15	8
Ardeidae	*Egretta novaehollandiae*	White-faced Heron	P	2	2	20	75
Ardeidae	*Egretta sacra*	Eastern Reef Egret	P	0	0	4	9
Ardeidae	*Ixobrychus flavicollis*	Black Bittern	V	0	0	12	0
Ardeidae	*Ixobrychus minutus*	Little Bittern	P	0	0	0	1
Ardeidae	*Nycticorax caledonicus*	Nankeen Night Heron	P	0	2	3	1
Threskiornithidae	*Platalea flavipes*	Yellow-billed Spoonbill	P	0	1	8	0
Threskiornithidae	*Platalea regia*	Royal Spoonbill	P	0	0	15	18
Threskiornithidae	*Plegadis falcinellus*	Glossy Ibis	P	0	0	1	1
Threskiornithidae	*Threskiornis molucca*	Australian White Ibis	P	0	2	14	22
Threskiornithidae	*Threskiornis spinicollis*	Straw-necked Ibis	P	1	1	1	1
Accipitridae	*Accipiter cirrocephalus*	Collared Sparrowhawk	P	2	2	1	3
Accipitridae	*Accipiter fasciatus*	Brown Goshawk	P	2	3	6	10
Accipitridae	*Accipiter novaehollandiae*	Grey Goshawk	P	2	6	10	13
Accipitridae	*Aquila audax*	Wedge-tailed Eagle	P	2	2	3	1
Accipitridae	*Aviceda subcristata*	Pacific Baza	P	0	0	2	3
Accipitridae	*Circus approximans*	Swamp Harrier	P	1	1	1	2
Accipitridae	*Elanus axillaris*	Black-shouldered Kite	P	0	4	2	11
Accipitridae	*Haliaeetus leucogaster*	White-bellied Sea-Eagle	P	0	1	4	4
Accipitridae	*Haliastur indus*	Brahminy Kite	P	0	0	2	0
Accipitridae	*Haliastur sphenurus*	Whistling Kite	P	0	0	3	2
Accipitridae	*Hieraaetus morphnoides*	Little Eagle	P	0	1	0	1
Accipitridae	*Lophoictinia isura*	Square-tailed Kite	V	1	0	0	0
Accipitridae	*Milvus migrans*	Black Kite	P	0	0	1	0
Falconidae	*Falco berigora*	Brown Falcon	P	2	1	3	2
Falconidae	*Falco cenchroides*	Nankeen Kestrel	P	0	5	5	19
Falconidae	*Falco longipennis*	Australian Hobby	P	1	1	1	3
Falconidae	*Falco peregrinus*	Peregrine Falcon	P	1	8	4	8
Rallidae	*Fulica atra*	Eurasian Coot	P	0	0	12	19
Rallidae	*Gallinula tenebrosa*	Dusky Moorhen	P	4	2	12	62
Rallidae	*Gallinula ventralis*	Black-tailed Native-hen	P	0	0	0	1
Rallidae	*Gallirallus philippensis*	Buff-banded Rail	P	0	0	5	15
Rallidae	*Porphyrio porphyrio*	Purple Swamphen	P	0	2	1	32
Rallidae	*Porzana fluminea*	Australian Spotted Crake	P	0	0	9	0
Rallidae	*Porzana tabuensis*	Spotless Crake	P	0	0	1	2

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Rallidae	*Rallus pectoralis*	Lewin's Rail	P	0	0	10	5
Turnicidae	*Turnix varia*	Painted Button-quail	P	0	1	5	1
Turnicidae	*Turnix velox*	Little Button-quail	P	0	0	2	1
Scolopacidae	*Arenaria interpres*	Ruddy Turnstone	P	0	0	3	1
Scolopacidae	*Calidris acuminata*	Sharp-tailed Sandpiper	P	0	0	5	1
Scolopacidae	*Calidris alba*	Sanderling	V	0	0	13	0
Scolopacidae	*Calidris canutus*	Red Knot	P	0	0	10	1
Scolopacidae	*Calidris ferruginea*	Curlew Sandpiper	P	0	0	9	1
Scolopacidae	*Calidris fuscicollis*	White-rumped Sandpiper	P	0	0	2	0
Scolopacidae	*Calidris melanotos*	Pectoral Sandpiper	P	0	0	3	0
Scolopacidae	*Calidris ruficollis*	Red-necked Stint	P	0	0	10	5
Scolopacidae	*Calidris tenuirostris*	Great Knot	V	0	0	9	1
Scolopacidae	*Gallinago hardwickii*	Latham's Snipe	P	0	1	2	5
Scolopacidae	*Heteroscelus brevipes*	Grey-tailed Tattler	P	0	1	10	0
Scolopacidae	*Heteroscelus incanus*	Wandering Tattler	P	0	0	6	0
Scolopacidae	*Limicola falcinellus*	Broad-billed Sandpiper	V	0	0	1	0
Scolopacidae	*Limosa lapponica*	Bar-tailed Godwit	P	0	0	19	35
Scolopacidae	*Limosa limosa*	Black-tailed Godwit	V	0	0	1	0
Scolopacidae	*Numenius madagascariensis*	Eastern Curlew	P	0	0	13	11
Scolopacidae	*Numenius phaeopus*	Whimbrel	P	0	0	0	1
Scolopacidae	*Tringa nebularia*	Common Greenshank	P	0	0	20	9
Scolopacidae	*Tringa stagnatilis*	Marsh Sandpiper	P	0	0	5	0
Scolopacidae	*Xenus cinereus*	Terek Sandpiper	V	0	0	3	0
Haematopodidae	*Haematopus fuliginosus*	Sooty Oystercatcher	V	0	0	12	20
Haematopodidae	*Haematopus longirostris*	Pied Oystercatcher	V	0	0	9	5
Recurvirostridae	*Himantopus himantopus*	Black-winged Stilt	P	0	0	9	10
Recurvirostridae	*Recurvirostra novaehollandiae*	Red-necked Avocet	P	0	0	3	0
Charadriidae	*Charadrius bicinctus*	Double-banded Plover	P	0	0	20	8
Charadriidae	*Charadrius leschenaultii*	Greater Sand Plover	V	0	0	4	0
Charadriidae	*Charadrius ruficapillus*	Red-capped Plover	P	0	0	15	12
Charadriidae	*Elseyornis melanops*	Black-fronted Dotterel	P	0	1	2	2
Charadriidae	*Erythrogonys cinctus*	Red-kneed Dotterel	P	0	0	2	0
Charadriidae	*Pluvialis dominica*	Lesser Golden Plover	P	0	0	9	2
Charadriidae	*Pluvialis squatarola*	Grey Plover	P	0	0	14	0
Charadriidae	*Thinornis rubricollis*	Hooded Plover	E1	0	0	2	0
Charadriidae	*Vanellus miles*	Masked Lapwing	P	4	4	19	96
Laridae	*Anous stolidus*	Common Noddy	P	0	0	0	1
Laridae	*Catharacta skua*	Great Skua	P	0	0	2	0
Laridae	*Chlidonias hybridus*	Whiskered Tern	P	0	0	2	0
Laridae	*Chlidonias leucopterus*	White-winged Black Tern	P	0	0	16	0
Laridae	*Larus dominicanus*	Kelp Gull	P	0	0	22	49
Laridae	*Larus novaehollandiae*	Silver Gull	P	14	3	29	2105
Laridae	*Larus pacificus*	Pacific Gull	P	0	0	18	6
Laridae	*Stercorarius parasiticus*	Arctic Jaeger	P	1	0	3	1
Laridae	*Stercorarius pomarinus*	Pomarine Jaeger	P	0	0	0	1
Laridae	*Sterna albifrons*	Little Tern	E1	0	0	72	16
Laridae	*Sterna bergii*	Crested Tern	P	2	1	21	89
Laridae	*Sterna caspia*	Caspian Tern	P	0	0	18	22
Laridae	*Sterna fuscata*	Sooty Tern	V	0	0	0	3
Laridae	*Sterna hirundo*	Common Tern	P	0	0	5	2
Laridae	*Sterna paradisaea*	Arctic Tern	P	0	0	1	2

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Laridae	*Sterna striata*	White-fronted Tern	P	0	0	2	4
Columbidae	*Chalcophaps indica*	Emerald Dove	P	0	0	2	3
Columbidae	*Columba leucomela*	White-headed Pigeon	P	2	7	9	16
Columbidae	*Columba livia*	Rock Dove	U	0	0	0	18
Columbidae	*Geopelia humeralis*	Bar-shouldered Dove	P	1	0	0	9
Columbidae	*Geopelia placida*	Peaceful Dove*	P	0	0	0	2
Columbidae	*Leucosarcia melanoleuca*	Wonga Pigeon	P	20	29	3	27
Columbidae	*Lopholaimus antarcticus*	Topknot Pigeon	P	6	12	7	9
Columbidae	*Macropygia amboinensis*	Brown Cuckoo-Dove	P	16	21	4	35
Columbidae	*Ocyphaps lophotes*	Crested Pigeon	P	2	1	2	44
Columbidae	*Phaps chalcoptera*	Common Bronzewing	P	0	2	0	4
Columbidae	*Phaps elegans*	Brush Bronzewing	P	5	1	3	2
Columbidae	*Ptilinopus regina*	Rose-crowned Fruit-Dove	V	0	0	0	1
Columbidae	*Ptilinopus superbus*	Superb Fruit-Dove	V	0	0	3	1
Columbidae	*Streptopelia chinensis*	Spotted Turtle-Dove	U	14	2	3	211
Cacatuidae	*Cacatua galerita*	Sulphur-crested Cockatoo	P	19	20	16	150
Cacatuidae	*Cacatua sanguinea*	Little Corella	P	1	1	7	17
Cacatuidae	*Cacatua tenuirostris*	Long-billed Corella	P	0	1	1	26
Cacatuidae	*Callocephalon fimbriatum*	Gang-gang Cockatoo	P	13	7	12	22
Cacatuidae	*Calyptorhynchus funereus*	Yellow-tailed Black-Cockatoo	P	9	5	27	66
Cacatuidae	*Eolophus roseicapillus*	Galah	P	9	2	2	97
Psittacidae	*Alisterus scapularis*	Australian King-Parrot	P	10	14	6	76
Psittacidae	*Glossopsitta concinna*	Musk Lorikeet	P	1	0	1	24
Psittacidae	*Glossopsitta pusilla*	Little Lorikeet	P	0	0	1	3
Psittacidae	*Lathamus discolor*	Swift Parrot	E1	0	0	3	0
Psittacidae	*Neophema pulchella*	Turquoise Parrot	V	0	0	1	0
Psittacidae	*Pezoporus wallicus wallicus*	Ground Parrot	V	0	0	0	39
Psittacidae	*Platycercus adscitus eximius*	Eastern Rosella	P	8	4	6	23
Psittacidae	*Platycercus elegans*	Crimson Rosella	P	38	50	15	161
Psittacidae	*Psephotus haematonotus*	Red-rumped Parrot	P	1	1	2	0
Psittacidae	*Trichoglossus chlorolepidotus*	Scaly-breasted Lorikeet	P	0	0	5	5
Psittacidae	*Trichoglossus haematodus*	Rainbow Lorikeet	P	12	6	6	158
Cuculidae	*Cacomantis flabelliformis*	Fan-tailed Cuckoo	P	74	25	2	88
Cuculidae	*Cacomantis variolosus*	Brush Cuckoo	P	8	10	2	9
Cuculidae	*Chalcites basalis*	Horsfield's Bronze-Cuckoo	P	8	0	0	14
Cuculidae	*Chalcites lucidus*	Shining Bronze-Cuckoo	P	19	12	1	16
Cuculidae	*Cuculus pallidus*	Pallid Cuckoo	P	2	0	0	6
Cuculidae	*Eudynamys orientalis*	Pacific Koel	P	4	2	5	39
Cuculidae	*Scythrops novaehollandiae*	Channel-billed Cuckoo	P	6	2	4	26
Centropodidae	*Centropus phasianinus*	Pheasant Coucal	P	0	0	3	1
Strigidae	*Ninox boobook*	Southern Boobook	P	60	73	15	24
Strigidae	*Ninox connivens*	Barking Owl	V	0	0	1	0
Strigidae	*Ninox strenua*	Powerful Owl	V	2	10	12	1
Tytonidae	*Tyto alba*	Barn Owl	P	2	0	4	2
Tytonidae	*Tyto novaehollandiae*	Masked Owl	V	0	3	0	1
Tytonidae	*Tyto tenebricosa*	Sooty Owl	V	7	31	6	1
Podargidae	*Podargus strigoides*	Tawny Frogmouth	P	8	9	9	15
Caprimulgidae	*Eurostopodus mystacalis*	White-throated Nightjar	P	0	2	3	0

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Aegothelidae	*Aegotheles cristatus*	Australian Owlet-nightjar	P	13	14	5	0
Apodidae	*Hirundapus caudacutus*	White-throated Needletail	P	0	1	0	0
Alcedinidae	*Alcedo azurea*	Azure Kingfisher	P	3	3	1	2
Halcyonidae	*Dacelo novaeguineae*	Laughing Kookaburra	P	21	22	16	140
Halcyonidae	*Todiramphus sanctus*	Sacred Kingfisher	P	5	3	0	9
Coraciidae	*Eurystomus orientalis*	Dollarbird	P	8	1	1	16
Menuridae	*Menura novaehollandiae*	Superb Lyrebird	P	25	38	17	28
Climacteridae	*Climacteris erythrops*	Red-browed Treecreeper	P	4	2	1	3
Climacteridae	*Cormobates leucophaeus*	White-throated Treecreeper	P	46	63	5	25
Maluridae	*Malurus cyaneus*	Superb Fairy-wren	P	22	12	6	207
Maluridae	*Malurus lamberti*	Variegated Fairy-wren	P	21	19	2	47
Maluridae	*Stipiturus malachurus*	Southern Emu-wren	P	3	3	3	11
Pardalotidae	*Pardalotus punctatus*	Spotted Pardalote	P	33	27	10	134
Pardalotidae	*Pardalotus striatus*	Striated Pardalote	P	0	1	0	1
Acanthizidae	*Acanthiza chrysorrhoa*	Yellow-rumped Thornbill	P	2	1	0	12
Acanthizidae	*Acanthiza lineata*	Striated Thornbill	P	17	28	4	26
Acanthizidae	*Acanthiza nana*	Yellow Thornbill	P	21	3	1	69
Acanthizidae	*Acanthiza pusilla*	Brown Thornbill	P	58	56	6	112
Acanthizidae	*Acanthiza reguloides*	Buff-rumped Thornbill	P	0	2	0	0
Acanthizidae	*Calamanthus pyrrhopygius*	Chestnut-rumped Heathwren	P	1	0	1	4
Acanthizidae	*Dasyornis brachypterus*	Eastern Bristlebird	E1	0	0	0	1
Acanthizidae	*Gerygone mouki*	Brown Gerygone	P	17	44	5	73
Acanthizidae	*Gerygone olivacea*	White-throated Gerygone	P	7	0	0	3
Acanthizidae	*Origma solitaria*	Rockwarbler	P	1	3	1	1
Acanthizidae	*Pycnoptilus floccosus*	Pilotbird	P	11	8	3	1
Acanthizidae	*Sericornis citreogularis*	Yellow-throated Scrubwren	P	9	17	6	29
Acanthizidae	*Sericornis frontalis*	White-browed Scrubwren	P	56	67	9	329
Acanthizidae	*Sericornis magnirostris*	Large-billed Scrubwren	P	2	6	3	39
Acanthizidae	*Smicrornis brevirostris*	Weebill	P	0	0	1	0
Meliphagidae	*Acanthagenys rufogularis*	Spiny-cheeked Honeyeater	P	0	0	2	0
Meliphagidae	*Acanthorhynchus tenuirostris*	Eastern Spinebill	P	53	52	14	294
Meliphagidae	*Anthochaera carunculata*	Red Wattlebird	P	7	3	3	75
Meliphagidae	*Anthochaera chrysoptera*	Little Wattlebird	P	28	27	10	148
Meliphagidae	*Epthianura albifrons*	White-fronted Chat	P	0	0	1	2
Meliphagidae	*Gliciphila melanops*	Tawny-crowned Honeyeater	P	1	3	0	4
Meliphagidae	*Lichenostomus chrysops*	Yellow-faced Honeyeater	P	33	42	10	59
Meliphagidae	*Lichenostomus fuscus*	Fuscous Honeyeater	P	0	0	1	4
Meliphagidae	*Lichenostomus leucotis*	White-eared Honeyeater	P	7	0	3	1
Meliphagidae	*Lichenostomus melanops*	Yellow-tufted Honeyeater	P	0	1	0	2
Meliphagidae	*Lichenostomus penicillatus*	White-plumed Honeyeater	P	0	0	1	4
Meliphagidae	*Manorina melanocephala*	Noisy Miner	P	8	1	0	25
Meliphagidae	*Manorina melanophrys*	Bell Miner	P	0	0	1	3
Meliphagidae	*Meliphaga lewinii*	Lewin's Honeyeater	P	35	71	18	254
Meliphagidae	*Melithreptus brevirostris*	Brown-headed Honeyeater	P	6	0	1	2
Meliphagidae	*Melithreptus lunatus*	White-naped Honeyeater	P	0	3	3	18

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Meliphagidae	*Myzomela sanguinolenta*	Scarlet Honeyeater	P	1	1	2	14
Meliphagidae	*Philemon citreogularis*	Little Friarbird	P	0	0	1	0
Meliphagidae	*Philemon corniculatus*	Noisy Friarbird	P	4	2	1	7
Meliphagidae	*Phylidonyris nigra*	White-cheeked Honeyeater	P	0	0	0	3
Meliphagidae	*Phylidonyris novaehollandiae*	New Holland Honeyeater	P	35	11	7	180
Meliphagidae	*Phylidonyris pyrrhoptera*	Crescent Honeyeater	P	1	0	1	4
Petroicidae	*Eopsaltria australis*	Eastern Yellow Robin	P	46	54	5	168
Petroicidae	*Petroica boodang*	Scarlet Robin	P	0	0	0	4
Petroicidae	*Petroica phoenicea*	Flame Robin	P	0	0	0	1
Petroicidae	*Petroica rodinogaster*	Pink Robin	V	0	0	2	0
Petroicidae	*Petroica rosea*	Rose Robin	P	0	8	0	8
Orthonychidae	*Orthonyx temminckii*	Logrunner	P	3	13	8	5
Eupetidae	*Cinclosoma punctatum*	Spotted Quail-thrush	P	2	11	1	0
Eupetidae	*Psophodes olivaceus*	Eastern Whipbird	P	56	61	18	154
Neosittidae	*Daphoenositta chrysoptera*	Varied Sittella	P	2	0	0	1
Pachycephalidae	*Colluricincla harmonica*	Grey Shrike-thrush	P	39	37	6	44
Pachycephalidae	*Falcunculus frontatus*	Eastern Shrike-tit	P	2	1	0	3
Pachycephalidae	*Pachycephala olivacea*	Olive Whistler	V	1	0	4	0
Pachycephalidae	*Pachycephala pectoralis*	Golden Whistler	P	41	44	9	88
Pachycephalidae	*Pachycephala rufiventris*	Rufous Whistler	P	54	16	1	28
Dicruridae	*Dicrurus bracteatus*	Spangled Drongo	P	0	0	4	13
Dicruridae	*Grallina cyanoleuca*	Magpie-lark	P	10	1	3	157
Dicruridae	*Monarcha melanopsis*	Black-faced Monarch	P	26	37	5	30
Dicruridae	*Myiagra cyanoleuca*	Satin Flycatcher	P	0	0	2	0
Dicruridae	*Myiagra inquieta*	Restless Flycatcher	P	0	1	2	0
Dicruridae	*Myiagra rubecula*	Leaden Flycatcher	P	8	1	1	1
Dicruridae	*Rhipidura albiscapa*	Grey Fantail	P	72	65	9	157
Dicruridae	*Rhipidura leucophrys*	Willie Wagtail	P	14	1	3	125
Dicruridae	*Rhipidura rufifrons*	Rufous Fantail	P	0	22	7	57
Campephagidae	*Coracina lineata*	Barred Cuckoo-shrike	V	0	0	1	0
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike	P	22	19	5	100
Campephagidae	*Coracina papuensis*	White-bellied Cuckoo-shrike	P	0	0	1	1
Campephagidae	*Coracina tenuirostris*	Cicadabird	P	5	9	2	3
Campephagidae	*Lalage tricolor*	White-winged Triller	P	0	0	1	1
Oriolidae	*Oriolus sagittatus*	Olive-backed Oriole	P	5	4	3	2
Oriolidae	*Sphecotheres vieilloti*	Australasian Figbird	P	1	0	4	11
Artamidae	*Artamus cyanopterus*	Dusky Woodswallow	P	0	1	0	19
Artamidae	*Artamus superciliosus*	White-browed Woodswallow	P	0	0	0	1
Artamidae	*Cracticus nigrogularis*	Pied Butcherbird	P	0	0	2	0
Artamidae	*Cracticus torquatus*	Grey Butcherbird	P	19	27	9	123
Artamidae	*Gymnorhina tibicen*	Australian Magpie	P	15	12	5	214
Artamidae	*Strepera graculina*	Pied Currawong	P	29	42	12	230
Artamidae	*Strepera versicolor*	Grey Currawong	P	5	4	3	3
Corvidae	*Corvus coronoides*	Australian Raven	P	28	27	5	209
Corvidae	*Corvus mellori*	Little Raven	P	0	0	0	1
Ptilonorhynchidae	*Ailuroedus crassirostris*	Green Catbird	P	7	11	5	27
Ptilonorhynchidae	*Ptilonorhynchus violaceus*	Satin Bowerbird	P	24	34	8	128
Motacillidae	*Anthus australis*	Australian Pipit	P	1	0	2	15
Passeridae	*Passer domesticus*	House Sparrow	U	7	0	1	124
Fringillidae	*Carduelis carduelis*	European Goldfinch	U	3	0	1	42

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Estrildidae	*Neochmia temporalis*	Red-browed Finch	P	13	19	5	191
Estrildidae	*Stagonopleura bella*	Beautiful Firetail	P	4	2	3	13
Estrildidae	*Stagonopleura guttata*	Diamond Firetail	V	0	0	0	6
Estrildidae	*Taeniopygia bichenovii*	Double-barred Finch	P	0	0	0	2
Dicaeidae	*Dicaeum hirundinaceum*	Mistletoebird	P	11	9	2	7
Hirundinidae	*Hirundo neoxena*	Welcome Swallow	P	9	3	3	153
Hirundinidae	*Petrochelidon ariel*	Fairy Martin	P	1	0	1	2
Hirundinidae	*Petrochelidon nigricans*	Tree Martin	P	8	1	0	13
Pycnonotidae	*Pycnonotus jocosus*	Red-whiskered Bulbul	U	20	11	3	248
Sylviidae	*Acrocephalus australis*	Australian Reed-Warbler	P	3	1	2	42
Sylviidae	*Cisticola exilis*	Golden-headed Cisticola	P	1	0	1	17
Sylviidae	*Megalurus gramineus*	Little Grassbird	P	0	0	0	9
Sylviidae	*Megalurus timoriensis*	Tawny Grassbird	P	0	0	1	0
Zosteropidae	*Zosterops lateralis*	Silvereye	P	31	27	11	755
Muscicapidae	*Turdus merula*	Eurasian Blackbird	U	3	1	1	18
Muscicapidae	*Zoothera lunulata*	Bassian Thrush	P	3	8	3	1
Sturnidae	*Acridotheres tristis*	Common Myna	U	16	4	2	189
Sturnidae	*Sturnus vulgaris*	Common Starling	U	6	1	2	110
MAMMALS							
Ornithorhynchidae	*Ornithorhynchus anatinus*	Platypus	P	0	0	1	0
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked Echidna	P	4	7	14	2
Dasyuridae	*Antechinus flavipes*	Yellow-footed Antechinus*	P	U	U	16	0
Dasyuridae	*Antechinus stuartii*	Brown Antechinus	P	12	127	93	35
Dasyuridae	*Antechinus swainsonii*	Dusky Antechinus	P	1	0	3	1
Dasyuridae	*Dasyurus maculatus*	Spotted-tailed Quoll	V	0	0	0	3
Dasyuridae	*Sminthopsis murina*	Common Dunnart	P	0	2	0	0
Peramelidae	*Isoodon obesulus*	Southern Brown Bandicoot*	E1	0	0	3	0
Peramelidae	*Perameles nasuta*	Long-nosed Bandicoot	P	19	14	14	5
Phascolarctidae	*Phascolarctos cinereus*	Koala	V	0	0	6	1
Vombatidae	*Vombatus ursinus*	Common Wombat	P	20	25	20	0
Burramyidae	*Cercartetus nanus*	Eastern Pygmy-possum	V	3	20	29	2
Petauridae	*Petaurus australis*	Yellow-bellied Glider*	V	0	1	0	0
Petauridae	*Petaurus breviceps*	Sugar Glider	P	33	53	16	4
Petauridae	*Petaurus norfolcensis*	Squirrel Glider*	V	0	0	1	0
Pseudocheiridae	*Petauroides volans*	Greater Glider	P	12	26	4	1
Pseudocheiridae	*Pseudocheirus peregrinus*	Common Ringtail Possum	P	34	61	29	1
Acrobatidae	*Acrobates pygmaeus*	Feathertail Glider	P	1	1	0	0
Phalangeridae	*Trichosurus caninus*	Mountain Brushtail Possum	P	4	12	0	1
Phalangeridae	*Trichosurus vulpecula*	Common Brushtail Possum	P	U	8	8	1
Macropodidae	*Macropus giganteus*	Eastern Grey Kangaroo	P	1	0	6	1
Macropodidae	*Macropus rufogriseus*	Red-necked Wallaby	P	0	4	1	2
Macropodidae	*Thylogale thetis*	Red-necked Pademelon	P	0	0	1	1
Macropodidae	*Wallabia bicolor*	Swamp Wallaby	P	49	93	29	6
Pteropodidae	*Pteropus poliocephalus*	Grey-headed Flying-fox	V	9	6	4	6
Rhinolophidae	*Rhinolophus megaphyllus*	Eastern Horseshoe-bat	P	0	3	4	0
Emballonuridae	*Saccolaimus flaviventris*	Yellow-bellied Sheathtail-bat	V	0	0	0	2
Molossidae	*Mormopterus norfolkensis*	Eastern Freetail-bat	V	0	0	12	1
Molossidae	*Mormopterus sp 1*	Undescribed mastiff-	P	2	2	4	0

Family	Scientific Name	Common Name	Legal Status	Current Survey	Other Surveys	Incidental Records	Licensed Datasets
		bat					
Molossidae	*Nyctinomus australis*	White-striped Freetail bat	P	13	1	9	0
Vespertilionidae	*Chalinolobus dwyeri*	Large-eared Pied Bat	V	1	2	1	0
Vespertilionidae	*Chalinolobus gouldii*	Gould's Wattled Bat	P	12	3	40	0
Vespertilionidae	*Chalinolobus morio*	Chocolate Wattled Bat	P	56	36	31	0
Vespertilionidae	*Falsistrellus tasmaniensis*	Eastern False Pipistrelle	V	2	2	2	0
Vespertilionidae	*Miniopterus schreibersii*	Common Bentwing-bat	V	14	10	22	2
Vespertilionidae	*Myotis adversus*	Large-footed Myotis	V	2	17	5	0
Vespertilionidae	*Nyctophilus geoffroyi*	Lesser Long-eared Bat	P	5	0	1	0
Vespertilionidae	*Nyctophilus gouldi*	Gould's Long-eared Bat	P	24	14	19	4
Vespertilionidae	*Scoteanax rueppellii*	Greater Broad-nosed Bat	V	0	1	1	1
Vespertilionidae	*Scotorepens orion*	Eastern Broad-nosed Bat	P	4	1	5	0
Vespertilionidae	*Vespadelus darlingtoni*	Large Forest Bat	P	52	21	30	1
Vespertilionidae	*Vespadelus regulus*	Southern Forest Bat*	P	3	0	19	0
Vespertilionidae	*Vespadelus vulturnus*	Little Forest Bat	P	57	68	31	4
Muridae	*Hydromys chrysogaster*	Water-rat	P	2	2	1	3
Muridae	*Mus musculus*	House Mouse	U	0	8	1	4
Muridae	*Rattus fuscipes*	Bush Rat	P	12	268	95	23
Muridae	*Rattus lutreolus*	Swamp Rat	P	5	8	19	3
Muridae	*Rattus norvegicus*	Brown Rat	U	0	0	1	4
Muridae	*Rattus rattus*	Black Rat	U	2	3	4	5
Leporidae	*Lepus capensis*	Brown Hare	U	1	0	0	0
Leporidae	*Oryctolagus cuniculus*	Rabbit	U	8	10	11	0
Otariidae	*Arctocephalus pusillus*	Australo-African Fur-seal	V	0	0	7	1
Otariidae	*Arctocephalus tropicalis*	Subantarctic Fur-seal	P	0	0	1	1
Otariidae	*Neophoca cinerea*	Australian Sea-lion	P	0	0	1	0
Phocidae	*Hydrurga leptonyx*	Leopard Seal	P	0	0	12	2
Canidae	*Canis lupus*	Dingo/Domestic Dog	U	8	33	0	0
Canidae	*Vulpes vulpes*	Fox	U	25	59	20	0
Felidae	*Felis catus*	Cat	U	8	5	1	0
Balaenopteridae	*Balaenoptera acutorostrata*	Dwarf Minke Whale	P	0	0	1	1
Balaenopteridae	*Megaptera novaeangliae*	Humpback Whale	V	0	0	3	0
Balaenidae	*Eubalaena australis*	Southern Right Whale	V	0	0	1	0
Physeteridae	*Physeter macrocephalus*	Sperm Whale	V	0	0	2	0
Kogiidae	*Kogia breviceps*	Pygmy Sperm Whale	P	0	0	1	1
Ziphiidae	*Mesoplodon bowdoini*	Andrews' Beaked Whale	P	0	0	1	2
Ziphiidae	*Mesoplodon densirostris*	Blainville's Beaked Whale	P	0	0	1	0
Ziphiidae	*Mesoplodon layardii*	Strap-toothed Beaked Whale	P	0	0	1	2
Delphinidae	*Globicephala melas*	Long-finned Pilot Whale	P	0	0	1	0
Delphinidae	*Pseudorca crassidens*	False Killer Whale	P	0	0	0	1
Delphinidae	*Stenella coeruleoalba*	Striped Dolphin	P	0	0	2	2
Delphinidae	*Steno bredanensis*	Rough-toothed Dolphin	P	0	0	0	1
Delphinidae	*Tursiops truncatus*	Bottlenose Dolphin	P	0	0	2	1
Suidae	*Sus scrofa*	Pig	U	0	1	0	0
Bovidae	*Capra hircus*	Goat	U	0	1	1	0
Cervidae	*Cervus timorensis*	Rusa Deer	U	5	6	5	0

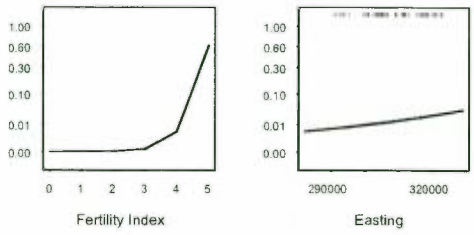
7.4 APPENDIX D - HABITAT MODELLING RESULTS

Pseudophryne australis

Red-crowned Toadlet

All records 56 Total pseudo sites 348
Null deviance 155.26 on 347 df
Residual dev. 111.21 on 345 df
Deviance explained 28.37 %
Model type: GAM

Predictors	DF	Dev	Sig
Fertility	1	39.79	0.000
Longitude	1	4.27	0.039

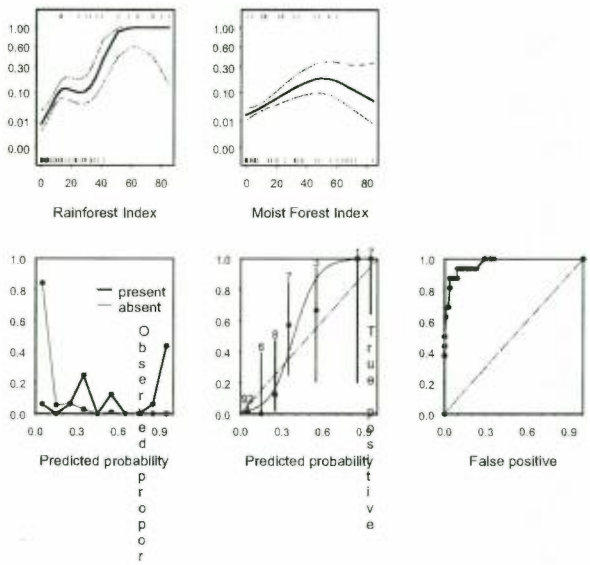


Nannoscincus maccoyi

Highlands Forest-skink

Presence sites 16 Total sites 124
Null deviance 95.37 on 123 df
Residual dev. 32.73 on 118 df
Deviance explained 65.68 %
Model type: GAM

Predictors	DF	Dev	Sig
Rforest500	2	957.96	0.000
Moist500	2	13.04	0.011

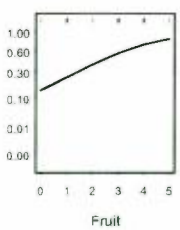


Cacophis squamulosus

Golden Crowned Snake

All records 26 Total pseudo sites 318
Null deviance 72.09 on 317 df
Residual dev. 50.88 on 316 df
Deviance explained 29.42 %
Model type: GAM

Predictors	DF	Dev	Sig
Fruit	1	21.21	0.000

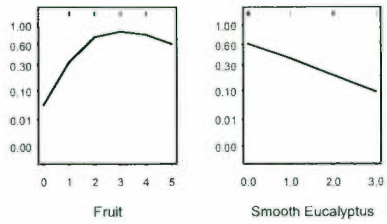


Ninox strenua

Powerful Owl

All records 32 Total pseudo sites 324
Null deviance 88.72 on 323 df
Residual dev. 61.54 on 320 df
Deviance explained 30.64 %
Model type: GAM

Predictors	DF	Dev	Sig
Fruit	2	19.12	0.001
Smoothgum	1	14.41	0.002

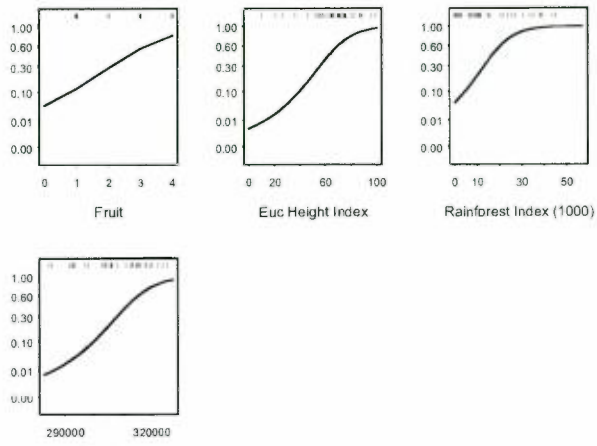


Tyto tenebricosa

Sooty Owl

All records 36 Total pseudo sites 94
Null deviance 99.81 on 93 df
Residual dev. 35.25 on 89 df
Deviance explained 64.68 %
Model type: GLM

Predictors	DF	Dev	Sig
Fruit	1	34.79	0.000
Euc500	1	9.45	0.002
Rforest000	1	4.92	0.027
Longitude	1	15.41	0.000

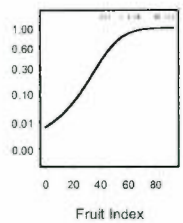


Orthonyx temminckii

Logrunner

All records 19 Total pseudo sites 311
Null deviance 52.68 on 310 df
Residual dev. 20.09 on 309 df
Deviance explained 61.86 %
Model type: GAM

Predictors	DF	Dev	Sig
Fruit100	1	32.59	0.000

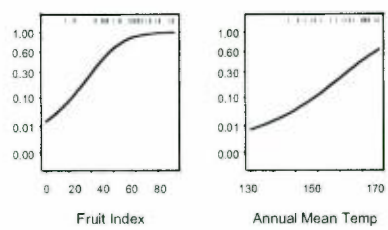


Ailuroedus crassirostris

Green Catbird

All records 35 Total pseudo sites 327
Null deviance 97.04 on 326 df
Residual dev. 47.5 on 324 df
Deviance explained 51.05 %
Model type: GLM

Predictors	DF	Dev	Sig
Fruit100	1	39.79	0.000
Anntemp	1	9.76	0.002

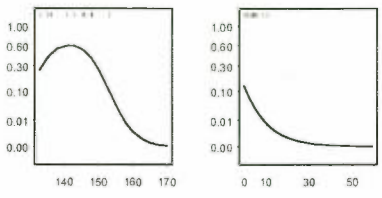


Strepera versicolor

Grey Currawong

All records 29 Total pseudo sites 261
Null deviance 55.45 on 260 df
Residual dev. 24.7 on 257 df
Deviance explained 55.46 %
Model type: GLM

Predictors	DF	Dev	Sig
Anntemp	1	21.05	0.000
Rugged300	1	9.7	0.002

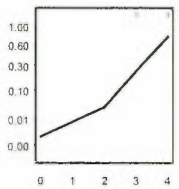


Petauroides volans

Greater Glider

All records 29 Total pseudo sites 87
Null deviance 80.41 on 86 df
Residual dev. 24.32 on 85 df
Deviance explained 69.75 %
Model type: GAM

Predictors	DF	Dev	Sig
Eucheight	1	56.53	0.000

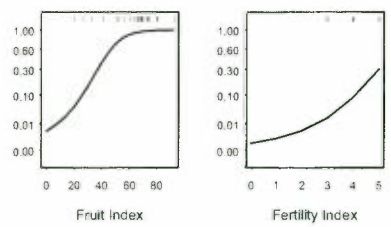


Trichosurus caninus

Mountain Brushtail Possum

All records 23 Total pseudo sites 315
Null deviance 63.77 on 314 df
Residual dev. 31.49 on 312 df
Deviance explained 50.63 %
Model type: GAM

Predictors	DF	Dev	Sig
Fruit100	1	28.06	0.000
Fertility	1	4.22	0.041

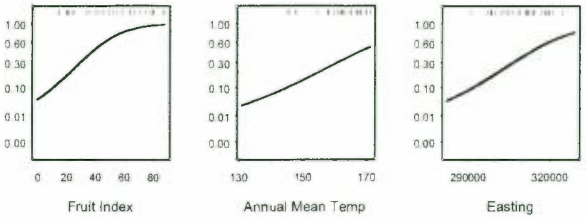


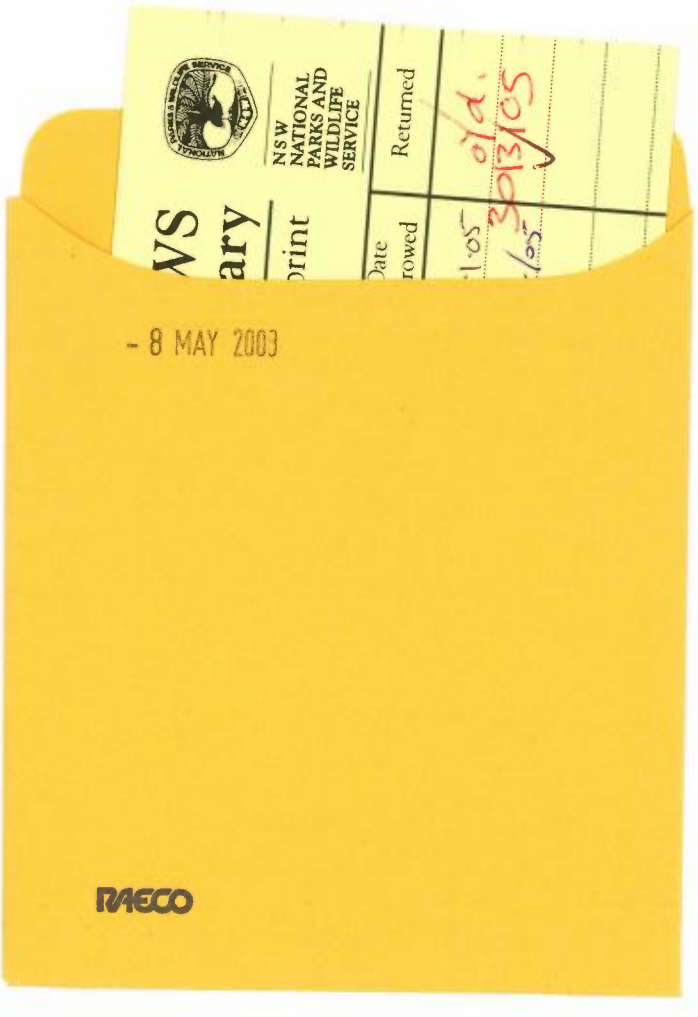
Pteropus poliocephalus

Grey-headed Flying-fox

All records 31 Total pseudo sites 323
Null deviance 85.95 on 322 df
Residual dev. 50.62 on 319 df
Deviance explained 41.1 %
Model type: GAM

Predictors	DF	Dev	Sig
Fruit100	1	20.73	0.000
Anntemp	1	20.29	0.000
Longitude	1	5.27	0.022

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