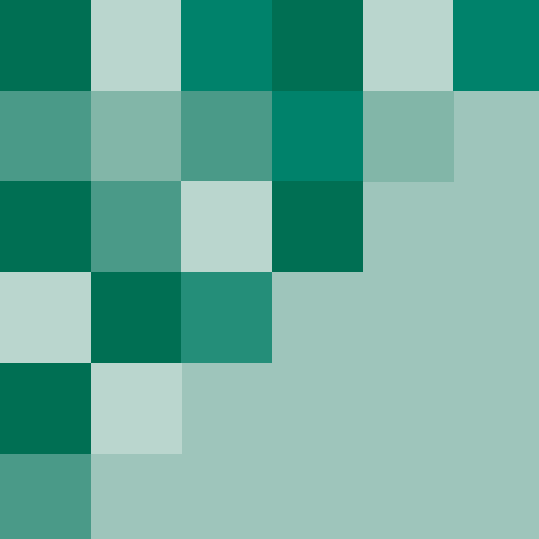




Environmental

Services

Flora and Fauna Assessment- Rezoning Investigations

Jerberra Estate
Tomerong

City of Shoalhaven

February 2007

Our Reference: 5046



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FLORA AND FAUNA ASSESSMENT

Our Reference: 5046

Rezoning Investigations

Jerberra Estate

Tomerong

Shoalhaven

Prepared February 2007

for

Shoalhaven City Council

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INVASION OF NATIVE PLANT COMMUNITIES BY EXOTIC PERENNIAL GRASSES

Acknowledgements

This Threatened Biodiversity Assessment Report was prepared under contract by Bushfire and Environmental Services Pty Ltd, 7/128 Island Point Road, St Georges Basin, NSW 2540, PO Box 106. The consulting team included Dimitri Young (Manager, Environmental Division), David Coombes (Project Officer/Ecologist), Paul O'Keefe (Botanist), Milton Lewis (Project Officer/Ecologist) and Patrick Grady (GIS Project Officer). Assistance with field surveys was provided by Rob Kielly, Peter Izzard, Terry Turner, Wendy Fuller and Kirsten Vine.

Eric Hollinger (Senior Project Planner – Planning Group, Shoalhaven City Council) supervised the preparation of the report and supplied essential background material and data.

Citation

This report is to be cited in the following manner:

Bushfire and Environmental Services 2007. *Flora and Fauna Assessment – Rezoning Investigations; Jerberra Estate, Tomerong, City of Shoalhaven*. Report prepared for Shoalhaven City Council.

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Acronyms

DEC	Department of Environment and Conservation
EPBC Act	Environment Protection and Biodiversity Conservation Act, 1999
FM Act	Fisheries Management Act, 1994
GIS	Geographic Information System
JBREP	Jervis Bay Regional Environmental Plan, 1996
PFC	Projected Foliage Cover
ROTAP	Rare or Threatened Australian Plants
SEPP	State Environmental Planning Policy
TSC Act	Threatened Species Conservation Act, 1995

EXECUTIVE SUMMARY

This report has described the biological environment of part of the land comprising Jerberra Estate, Tomerong, and determined the conservation significance of the flora and fauna species and habitats recorded there. The overall aim of the study was to identify areas of high conservation value that should be protected within the study area, in order to inform the rezoning process currently being undertaken by Shoalhaven City Council

The existing environment was examined in detail from a literature review and from data gathered during fieldwork between July 2005 and July 2006. Flora and fauna surveys resulted in the detection of 149 flora species and 89 fauna species in the study area.

Much of the native vegetation, particularly the understorey, has been disturbed by various clearing activities, however a reasonably intact canopy stratum persists throughout most of the study area.

Five vegetation communities were recorded in the study area: Large-fruited Red Mahogany Swamp Forest; Scribbly Gum Woodland; Blackbutt-Spotted Gum forest; Blue Gum x Bangalay Open Forest and; Melaleuca-Bangalay Swamp Forest.

Surveys resulted in the detection of 11 threatened species: the East Coast Freetail Bat *Mormopterus norfolkensis*, Eastern Bristlebird *Dasyornis brachypterus*, Gang-gang Cockatoo *Callocephalon fimbriatum*; Glossy Black-cockatoo *Calyptorhynchus lathami*, Greater Broad-nosed Bat *Scoteanax rueppellii*, Grey-headed Flying-fox *Pteropus poliocephalus*, Masked Owl *Tyto novaehollandiae*, Sooty Owl *Tyto tenebricosa*, Square-tailed Kite *Lophoictinia isura*, Yellow-bellied Glider *Petaurus australis*, and the Biconvex Paperbark *Melaleuca biconvexa*. All of these threatened species are listed as Vulnerable on Schedule 2 of the *NSW Threatened Species Conservation Act 1995*, apart from the Eastern Bristlebird, which is listed as Endangered on Schedule 1 of the *NSW Threatened Species Conservation Act 1995* and Endangered on the schedules of the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*. The Grey-headed Flying-fox and *Melaleuca biconvexa* are also listed as Vulnerable on the Schedules of the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*.

One endangered ecological community listed on the *TSC Act*, *Swamp sclerophyll forest on coastal floodplains in the North Coast, Sydney Basin and South East Corner bioregions*, was identified in the parts of the study area comprising the vegetation mapped as Large-fruited Red Mahogany Swamp Forest and Melaleuca-Bangalay Swamp Forest.

No migratory species listed on the schedules of the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999*, or important habitat for such species, were recorded within the study area.

The study area does not contain any potential Koala habitat pursuant to *NSW State Environmental Planning Policy No 44 – Koala Habitat Protection*.

The conservation significance of the vegetation communities was assessed and it was concluded that future development should avoid disturbances to the Swamp sclerophyll forest on coastal floodplains endangered ecological community and areas of *Melaleuca biconvexa*. These areas would require incorporation of appropriate vegetated buffers to maintain or enhance their integrity.

The conservation significance of fauna habitats was assessed and it was found that key habitat for several threatened fauna species occurred over much of the study area. However, given that these resources are largely contained within the canopy and sub-canopy, and given the current level of disturbance to understorey habitats, it was concluded that some future development within Jerberra Estate could proceed if key habitat was sustained by defining biodiversity conservation and control objectives for various areas.

Potential options for residential development have been discussed and recommendations to protect significant biodiversity values of Jerberra Estate have been made in this report.



Rod Rose
Managing Director

1. INTRODUCTION

1.1 Background

This report has been prepared by Bushfire and Environmental Services (BES) at the request of Shoalhaven City Council, to investigate the flora, fauna and habitat values associated with part of Jerberra Estate, Tomerong, and to identify areas of conservation significance which should be protected. The outcomes of this report will inform the rezoning investigations currently being undertaken by Council.

The study area comprises 153 privately owned lots from the Jerberra Estate subdivision which was registered in 1922. Lot sizes range from less than 0.09 ha to 1.76 ha. A number of these lots contain dwellings and/or other structures. Only one of the dwellings in the study area is authorised. Jerberra Estate comprises a total of approximately 80 ha located to the east of the township of Tomerong, as shown in Figure 1 (Appendix A).

This report is the outcome of flora and fauna survey work and desktop analyses undertaken by BES between August 2005 and July 2006.

1.2 The Study Area and Locality

The study area for the purposes of this report is the part of Jerberra Estate shown in Figure 2 (Appendix A).

The study area is located approximately 20 km south of Nowra and 6 km west of Jervis Bay. It is bounded by Pine Forest Road in the west, freehold rural land in the south and southeast, and Crown Land in the north and east. A number of un-maintained roads dissect the study area and the primary access is gained from Pine Forest Road to the west of the study area. The study area comprises approximately 80 ha of disturbed eucalypt forest and woodland and small areas of low-lying swampy vegetation.

The term locality for the purposes of this report describes the land within an area of 10 km x 10 km centred on the study area.

1.4 Aim and Objectives

The aim of this study was to investigate the ecological attributes of the study area, assess their conservation values, and consider options for the future rezoning of the study area.

The objectives of this study were to:

- a) identify and describe the flora species and vegetation communities present in the study area and their conservation significance;
- b) identify and describe the presence and condition of fauna habitats within the study area;

- c) identify the fauna species which are found to occur in the study area, and their conservation significance;
- d) identify and map threatened flora species, threatened fauna species, rare or threatened Australian plants and regionally significant flora species in the study area;
- e) identify and map habitat significant for the survival of threatened species (such as nest trees and feed trees);
- f) determine whether the study area provides potential or core Koala habitat pursuant to *NSW State Environmental Planning Policy No. 44 – Koala Habitat Protection*;
- g) identify and justify the preservation value of areas of important vegetation that are significant for the conservation of endangered and vulnerable species;
- h) identify and map ecological constraints to development;
- i) provide recommendations to protect any significant biodiversity values; and
- j) identify and review options for the future rezoning of the study area in accordance with current ecological constraints.

2. METHODOLOGY

2.1 Review of Existing Data

A review of relevant information was undertaken prior to the commencement of field studies, which involved:

- a) reviewing available literature including relevant flora and fauna studies, legislation, environmental planning instruments, topographic maps, and aerial photographs of the study area;
- b) searching the Atlas of NSW Wildlife for threatened flora and threatened fauna species recorded in the locality; and
- c) searching the Commonwealth Environment Protection & Biodiversity Conservation Act Protected Matters Search Tool for matters of national environmental significance recorded in the locality.

The data gathered during the field studies and from the review of literature were analysed and interpreted in accordance with the provisions of legislation and planning controls pertaining to flora and fauna.

2.2 Flora Survey Methods

A detailed botanical survey was conducted in the study area by BES between August 2005 and March 2006 in the locations shown in Figure 2 (Appendix A).

Community Identification and Floristic Audit

A previous vegetation mapping document for Jerberra Estate (Burcher 1997) was used as a basis for guiding the survey effort in terms of floristic classification and distribution of vegetation communities. Random walks and quadrat based surveys were undertaken within each community as identified by Burcher (1997).

The Random Meander technique as documented by Cropper (1993) was used to compile a list of the species present, including those of conservation significance, and to assist in determining the distribution of vegetation communities.

Full floristic survey was completed for five 20 m x 20 m quadrats in locations that appeared representative of the vegetation communities present in the study area. Species were recorded according to stratum and assigned an abundance score from 1-5. Height and cover were recorded for each stratum. The classification of the vegetation communities and the identification of community boundaries relied on a combination of field observations, random walks and quadrat surveys.

The boundaries of vegetation communities in the study area were marked onto a survey plan.

Targeted Searches

Specific searches for plant species of conservation significance known from the locality were conducted using the Random Meander method and by systematically walking along designated transects, targeting areas of potential or suitable habitat.

Three threatened orchids, the Leafless Tongue Orchid *Cryptostylis hunteriana*, the Thick-lip Spider Orchid *Caladenia tessellata* and Bauer's Midge Orchid *Genoplesium baueri*, were targeted by a combination of intensive surveys in patches of optimal habitat and random meanders through areas of sub-optimal, but potential habitat. Intensive surveys involved a team of experienced surveyors slowly walking along parallel transects at 5-10 m apart searching for the target species.

Cryptostylis hunteriana and *Genoplesium baueri* surveys were undertaken following confirmation of flowering at known populations in the locality. Surveys for *Caladenia tessellata* were undertaken during the known flowering period, but no local populations are known to allow confirmation of exact flowering time.

Targeted searches for the Biconvex Paperbark *Melaleuca biconvexa* were conducted using the Random Meander technique in areas of potential habitat, which was primarily close to drainage lines. The extent of the population or sub-population was defined by identifying the edges of the occurrence and capturing these locations with a Personal Digital Assistant XDA O2 linked to a bluetooth EMTAC S3 BTGPS Global Positioning System.

Limitations

The survey effort was designed primarily to determine vegetation community classification, extent and distribution. Due to the relatively small size of the survey area, stratification was based on previous vegetation mapping boundaries for the selection of random walks and quadrat survey locations. Multivariate data analysis was not undertaken due to the relatively small number of quadrats. Selection of sites for random walks and quadrats was subjectively made based on placing survey points within relatively homogeneous units.

The limitations of these methods include potential bias in site selection, not detecting full variation in vegetation patterns and distribution, and subjective classification of the vegetation communities. However, these limitations are considered acceptable given the size of the survey area and the purpose of the survey in identifying ecological constraints in regard to rural residential planning and management.

Nomenclature

Most of the plant species names in this report are the current names published in the Flora of NSW (Harden 1990-1993). The taxonomic names have been supplemented with common names obtained from various sources. The scientific and conservation significance of individual plant species was established with reference to Briggs and Leigh (1996) and the

Commonwealth Environment Protection and Biodiversity Conservation Act 1999 in the national context, and to the *NSW Threatened Species Conservation Act 1995* in the state context.

Flora Survey Effort

The flora survey effort employed a total of 94 person-hours as documented in Table 1.

Table 1: Flora survey effort employed over the study area

DATE	METHOD	EFFORT	TARGET SPECIES
30 August 2005	Random meander search	6.5 person-hours	All flora species
	Targeted flora survey	4 person-hours	<i>Caladenia tessellata</i> , <i>Melaleuca biconvexa</i>
	Vegetation community mapping	1.5 person-hours	Not applicable
	Vegetation plots	4 person-hours	All flora species
1 September 2005	Random meander search	1 person-hour	All flora species
	Targeted flora survey	4 person-hours	<i>Caladenia tessellata</i>
	Vegetation plots	2 person-hours	All flora species
	Vegetation community mapping	1 person-hour	Not applicable
29 November 2005	Targeted flora survey	24 person-hours	<i>Cryptostylis hunteriana</i>
2 December 2005	Targeted flora survey	2.5 person-hours	<i>Cryptostylis hunteriana</i>
13 December 2005	Targeted flora survey	9.5 person-hours	<i>Cryptostylis hunteriana</i>
13 March 2006	Targeted flora survey	34 person-hours	<i>Genoplesium baueri</i>
TOTAL FLORA SURVEY EFFORT		94 PERSON-HOURS	

2.3 Fauna Survey Methods

Field investigations for fauna were conducted in the study area by BES between July 2005 and July 2006 in the locations shown in Figure 3 (Appendix A).

Opportunistic Diurnal Surveys

Opportunistic fauna surveys involved observations of animal activity, habitat surveys and searches for indirect evidence of fauna.

Diurnal mammal searches were conducted in areas of potential habitat across the study area, with emphasis on searches for scats, tracks, burrows, diggings and scratchings. Specific bird, reptile and amphibian searches were conducted across the study area involving both visual and aural detection of species. Searches for feeding evidence were also conducted for various bird species including the Glossy Black-cockatoo.

Specific searches were conducted for habitats or resources of relevance for those threatened fauna species known from the general region, or species, which might be anticipated to occur

given the vegetation communities and habitats present. Opportunistic records of all fauna species observed were maintained throughout the survey period, and an inventory was compiled of all species recorded during the current investigations.

The locations of fauna species of conservation significance, or evidence of such species, were recorded with a Personal Digital Assistant XDA O2 linked to a bluetooth EMTAC S3 BTGPS Global Positioning System.

Nocturnal Spotlighting Surveys

Spotlighting was undertaken along roads and tracks throughout the study area but with particular focus on the less disturbed habitat or areas contained in the northern-eastern and western sections. In general each spotlighting session commenced two hours after dusk and continued for one to two hours. Field work for this component was carried out on 12, 16 August 2005 and following all stagwatching surveys (4 July, 30 September, 24 November and 19 December 2005). A Narva Colt 100 W hand-held spotlight with Faunatech battery pack was used in attempts to illuminate mammals, birds and amphibians. Binoculars were used to aid in the identification of species where necessary.

Call Playback Surveys

The calls of the Koala, Squirrel Glider, Yellow-bellied Glider, Sooty Owl, Powerful Owl, Masked Owl and Barking Owl were broadcast through a 15W Toa megaphone within central areas of appropriate habitat in the study area on a number of occasions. Calls were generally broadcast intermittently for a period of up to five minutes each, followed by a listening period of 15 minutes. Generally, a ten minute listening period was employed prior to commencing call playback.

Nocturnal AnaBat Survey

AnaBat echolocation recording was used to target microchiropteran bats in the study area. One AnaBat II bat detector linked to a ZCAIM digital data recorder was used in various habitats along walking transects and at stationary positions to record microchiropteran bat echolocation calls on three nights during summer. On 19 December 2005 the detector was employed for three hours from dusk during walking transects and then set to record overnight in forest in the north of the study area near a large dam. On 30 December 2005 the detector was employed for two hours after dusk during walking transects along roads throughout most of the study area. On 10 January 2006 the detector was set in forest near the centre of the southern section of the study area to record overnight.

During overnight recordings, the detector was placed in a wooden frame which was attached to a tree at a height of approximately 1.6m above the ground to reduce interference from insects on the ground. Overnight sites were selected to target preferred habitat such as large dams and/or obvious flyways. Recorded data was sent to Mr. Adam Fawcett of Forests NSW for analysis to identify species.

Trapping Surveys

Targeted surveys for terrestrial mammals were undertaken between 29 November and 1 December 2005 within sections of less disturbed vegetation within the study area, and involved the use of 35 small cage traps and 35 Type-A Elliott traps set along seven transects. Traps were placed on the ground at 30 m intervals and were baited with a mixture of peanut butter, honey and rolled oats. Each trap was covered with plastic to protect captured animals from rain, and the Elliott traps were lined with cotton wool to provide insulation for trapped animals. Trapping transects were marked with numbered flagging tape and the locations recorded using a Personal Digital Assistant XDA O2 linked to a bluetooth EMTAC S3 BTGPS Global Positioning System.

The traps were left in place for three consecutive nights yielding a trapping effort of 105 small cage trap-nights and 105 Elliott trap-nights. Traps were checked each morning soon after sunrise. Captured animals were identified and then released at the trap site.

Targeted Stag-watches for Large Forest Owls, Arboreal Mammals and Microchiropteran activity

Over a period of six nights on 4 July, 12 and 16 August, 30 September, 24 November and 19 December 2005 trees bearing hollows that were considered suitable for roosting and denning by forest dwelling owls and mammals were watched at dusk by staff from BES. Trees were initially assessed for suitability and prioritised for stag-watching using characters such as tree species and height, and the size and type of hollows.

Observation sessions commenced at sunset on each survey night and continued for a further 1.5 hours. During this period hollows were observed with the aid of binoculars and spotlights where necessary to facilitate confidence in data. All fauna activity at hollows was recorded during that period.

Targeted Stag-watches for Gang-gang Cockatoo and Glossy Black-cockatoo nesting activity

On 22 and 23 August, 21 and 28 October, 8, 24 and 29 November and 19 December 2005, areas containing hollow-bearing trees suitable for Gang-gang Cockatoo and Glossy Black-cockatoo nesting were searched and monitored over extended periods for the presence of nesting birds returning to hollows. These observation periods were undertaken between three hours and one hour prior to dusk. During these periods groups of hollow-bearing trees were monitored while listening for the loud characteristic vocalisations that are typical of these species as they return to the nest. The groups of trees monitored during these sessions were located throughout the study area. This work was supplemented by additional short afternoon and dusk periods of monitoring, when surveys for other species were being conducted.

Targeted Amphibian Surveys

Diurnal searches for the Green and Golden Bell Frog were undertaken within areas of suitable habitat in the study area. Emergent vegetation in a number of dams within the study area was searched during the day for basking frogs. During nocturnal spotlighting surveys, the edges of suitable dams and drainage lines were searched for foraging individuals using a 100 W handheld spotlight. At selected dams and creeks, the calls of the Green and Golden Bell Frog and Giant Burrowing Frog were played back via a small handheld tape recorder with internal speaker, for periods of approximately one minute each. A listening period of up to 15 minutes was employed at these sites, which included spotlight searches.

During July 2006, following heavy rainfall in the previous month, several sites along creeks in the south-west and north-east of the study area were searched for Giant Burrowing Frog tadpoles, as the species was known to be calling from the Vincentia area on at least several occasions during the previous month. Opportunistic listening for the calls of the Green and Golden Bell Frog and Giant Burrowing Frog occurred during all diurnal and nocturnal surveys. During wet or damp conditions at night, opportunistic searches for these species were made from vehicles slowly traversing roads in the study area.

Habitat Analysis

A description of the fauna habitats in the study area was prepared because the type of habitat in an area influences which animals occur there, as well as diversity and abundance. This habitat assessment also has an important role in predicting threatened fauna likely to occur in an area. The information collected usually includes the type of vegetation present, the presence/absence of rock outcrops, tree hollows, dams, ponds, streams, foraging substrates and other features likely to attract threatened fauna. The study area was traversed along a number of transects to identify habitat components, which were recorded and described. The locations of key habitat features were recorded with a Personal Digital Assistant XDA O2 linked to a bluetooth EMTAC S3 BTGPS Global Positioning System.

Limitations

The results of fauna surveys can be optimised by conducting investigations over a long period to compensate for the effect of unfavourable weather, seasonal changes and climatic variation. In general, the longer the survey the more species will be detected. Results can also be improved by using a wide range of techniques, since some species are more likely to be detected by a particular method. Such techniques include pitfall trapping, hair tubing and harp trapping.

However, surveys are subject to constraints that determine the amount of time allocated, the methods used and the timing of the work. Thus, the results should be viewed in the light of these limitations. Specifically, surveys for amphibians, particularly the Giant Burrowing Frog, were limited by the very dry conditions over most of the survey period, reducing the activity levels and thus detectability of these species.

The fauna detected in current survey work are a guide to the native fauna present, but are by no means a definitive list of the species occurring in the study area. Nevertheless, the techniques used in this investigation are considered adequate to gather the data necessary to identify areas and habitats of high conservation value within the study area.

Nomenclature

The nomenclature in this report is based on the Mammals of Australia (Strahan 1995), and Australian Bats (Churchill 1998), The Taxonomy and Species of Birds of Australia and its Territories (Christidis & Boles 1994) and Reptiles and Amphibians of Australia (Cogger 1996).

Survey Conditions

Survey conditions throughout the study period are detailed in Table 2.

Table 2: Fauna survey conditions.

DATE	SURVEY TYPE	TEMPERATURE	WIND	CLOUD	MOON	RAIN
12 August 2005	Stagwatch	6.5 °C – 10 °C	Nil	Nil	2/4	Nil
16 August 2005	Spotlight	9 °C – 12 °C	Nil	Nil	3/4	Nil
17 August 2005	Diurnal Habitat	10 °C – 18 °C	Light	2/8	N/A	Nil
18 August 2005	Diurnal Habitat	12 °C – 23 °C	Light	2/8	N/A	Nil
22 August 2005	Dusk Listen	14 °C – 10 °C	Nil	Nil	Nil	Nil
30 September 2005	Targeted Stagwatch	16.9 °C – 14.1 °C	Nil	Nil	Nil	Nil
	Call Playback	17.1 °C	Nil	Nil	Nil	Nil
21 October 2005	Targeted Stagwatch	17 °C – 14 °C	Nil	Nil	Nil	Light
28 October 2005	Targeted Stagwatch	17 °C – 19 °C	Mod	4/8	Nil	Nil
08 November 2005	Targeted Stagwatch	17 °C – 19 °C	Light	Nil	Nil	Nil
24 November 2005	Nocturnal	16 °C – 14 °C	Nil	8/8	Nil	Nil
	Targeted Stagwatch	18 °C – 15.5 °C	Nil	8/8	Nil	Nil
29 November 2005	Trapping	10.6 °C – 21.4 °C	Nil	8/8	N/A	Moderate showers
30 November 2005	Trapping	11.7 °C – 20 °C	Nil	8/8	N/A	Moderate showers

DATE	SURVEY TYPE	TEMPERATURE	WIND	CLOUD	MOON	RAIN
1 December 2005	Trapping	13.4 °C – 28.2 °C	Nil	2/8	N/A	Light
19 December 2005	Nocturnal AnaBat	18 °C – 9.5 °C	Nil	0/8	0/4	Nil
	Targeted Stagwatch	21 °C – 16.5 °C	Nil	0/8	0/4	Nil
	Nocturnal spotlighting	17 °C – 15.5 °C	Nil	0/8	0/4	Nil
	Nocturnal call playback	17 °C – 15.5 °C	Nil	0/8	0/4	Nil
30 December 2005	Nocturnal AnaBat	25 °C – 18 °C	Nil	0/8	0/4	Nil
	Nocturnal spotlighting	23 °C – 18 °C	Nil	0/8	0/4	Nil
	Nocturnal call playback	24 °C – 18 °C	Nil	0/8	0/4	Nil
10 January 2006	Nocturnal AnaBat	25 °C – 16 °C	Light	4/8	1/4	Nil
20 July 2006	Diurnal search	16 °C – 18 °C	Light	8/8	N/A	Nil

Survey Effort

The fauna survey effort employed a total of 145 person-hours, 210 trap-nights and two AnaBat detector nights as documented in Table 3.

Table 3: Fauna survey effort employed over the study area.

DATE	METHOD	EFFORT	TARGET SPECIES
4 July 2005	Stagwatch	2 person-hours	Mammals and birds
5 August 2005	Inspection	4 person-hours	All species
12 August 2005	Stagwatch	2 person-hours	Mammals and birds
	Nocturnal call playback	0.5 person-hours	Masked Owl, Squirrel Glider
	Spotlight	2.5 person-hour	Mammals, birds and amphibians
16 August 2005	Stagwatch / Dusk Listen	5.5 person-hours	Mammals and birds

DATE	METHOD	EFFORT	TARGET SPECIES
16 August 2005	Spotlight	1 person-hour	All species
17 August 2005	Diurnal Habitat	32 person-hours	All species
18 August 2005	Diurnal Habitat	18.75 person-hours	All species
22 August 2005	Dusk Listen	1 person-hour	Glossy Black-cockatoo, nocturnal birds and mammals
23 August 2005	Dusk Listen	1 person-hour	Glossy Black-cockatoo, nocturnal birds and mammals
30 August 2005	Diurnal Habitat	16 person-hours	All species
30 September 2005	Targeted Stag-watch	7.5 person-hours	Gliders and owls
	Nocturnal call playback	0.75 person-hour	Owls, gliders, koala
21 October 2005	Nesting assessment	11 person-hours	Gang-gang Cockatoo
28 October 2005	Nesting assessment	10 person-hours	Gang-gang Cockatoo
08 November 2005	Nesting assessment	4 person-hours	Gang-gang Cockatoo
24 November 2005	Nesting assessment	5.25 person-hours	Gang-gang Cockatoo
24 November 2005	Targeted Stag-watch	3 person-hours	Gliders and owls
	Nocturnal call playback	0.75 person-hour	Gliders and owls
	Nesting assessment	2 person-hours	Gang-gang Cockatoo
29 November 2005 to 1 December 2005	Small Cage trapping	105 trap-nights	Southern Brown bandicoot, Long-nosed Potoroo
	A-type Elliott trapping	105 trap-nights	Eastern Pygmy-possum, White-footed Dunnart
19 December 2005	Microchiropteran echolocation call recording	3 person-hours handheld + set overnight	Microchiropteran bats
	Stagwatch / Dusk Listen	2 person-hours	Gliders and owls
	Nocturnal spotlighting	2 person-hours	All species
19 December 2005	Nocturnal call playback	0.75 person-hours	Gliders, owls, koala

DATE	METHOD	EFFORT	TARGET SPECIES
30 December 2005	Microchiropteran echolocation call recording	2 person-hours handheld	Microchiropteran bats
	Nocturnal spotlighting	1.5 person-hours	All species
	Nocturnal call playback	0.75 person-hour	Gliders, owls and koala
10 January 2006	Microchiropteran echolocation call recording	Set overnight	Microchiropteran bats
20 July 2006	Diurnal tadpole search	2.5 person hours	Giant Burrowing Frog
TOTAL FAUNA SURVEY EFFORT		145 person-hours, 210 trap-nights, 2 AnaBat echolocation call recording nights	

3. THE EXISTING ENVIRONMENT

3.1 Topography, Geology, and Soils

The study area lies at an altitude between 10-30 metres Australian Height Datum. It contains undulating low hills with a hill crest running approximately east–west through the centre. The study area lies in the upper catchment of Moona Moona Creek and is drained by 1st and 2nd order streams flowing from west to east approximately along the northern and southern boundaries.

The study area is underlain by Permian deposits of Wandrawandian siltstone from the Shoalhaven Group (Ulladulla 1:250000 Geological Series Sheet S1 56-13). This formation is composed of siltstone, silty sandstone and pebble. In general the soils on the ridges are composed of weathered skeletal clays while the soils on the lower slopes contain more structured deposits of brown podzolics and humus.

3.2 Disturbances

Most of the study area has been moderately to highly disturbed, and a number of unauthorised dwellings, both permanent and temporary, exist on many lots. Sheds, caravans, vehicles, fencing, building materials and rubbish are also present on some lots. Several lots contain a range of introduced plants for landscaping and produce purposes. A number of lots contain constructed dams as a water source.

Parts of the study area have been significantly disturbed through clearing for landscaping and/or fuel reduction purposes.

An unformed and un-maintained road network, which is highly eroded in some sections, is used regularly by low numbers of vehicles. A relatively low number of weed species were present, usually where other disturbances are greatest. Exotic fauna species recorded during this study included the Black Rat, European Rabbit, Red Fox, domestic fowl, horses, goats, dogs and cats.

Wildfire within the last few years has affected a large proportion of the area.

3.3 Flora

The study area contains five native vegetation communities, as shown in Figure 4 (Appendix A). The level of homogeneity within the recognised floristic units varies according to landscape position and associated variation in abiotic parameters.

A narrow linear pattern of Large-fruited Red Mahogany Swamp Forest occurs in the north-eastern corner of the study area and is limited to a tributary of Moona Moona Creek. The adjacent Scribbly Gum Woodland occupies the drier crests and upper slope positions and

extends over the eastern third of the study area. The Blackbutt-Spotted Gum Forest occupies the central and western crests, upper slope and mid-slope positions. A Blue Gum/Bangalay Hybrid Open Forest occurs on the sheltered southern midslope and footslope positions in the south-western section of the study area. Below the Blue Gum/Bangalay Hybrid Open Forest, a drainage line consists of Melaleuca-Bangalay Swamp Forest. Blackbutt-Spotted Gum Forest occurs on a northern facing footslope to the south of the Melaleuca-Bangalay Swamp Forest. Each community is described below.

3.3.1 Scribbly Gum – Red Bloodwood Woodland

Scribbly Gum-Red Bloodwood Woodland occurs on the eastern third of the study area covering an area of approximately 23 ha. The main location is on crests and upper slopes, but it extends to mid-slope positions. The community is typical of Scribbly Gum Woodland in relatively good condition with high species richness and diversity and well-developed structural complexity. The canopy is of low to moderate density to a height of 20 m. The sub-canopy is of moderate density to a height of 6 metres. The understorey is to 2 metres, with moderate to high species richness and medium density cover. The groundcover contains high species richness and diversity and high density cover. Overall the community is in good condition where disturbances, particularly clearing, have not occurred. The species typical of this community include the two canopy species, Hard-leaved Scribbly Gum *Eucalyptus sclerophylla* and Red Bloodwood *Corymbia gummifera*. The understorey is dominated by Yellow Tea-tree *Leptospermum polygalifolium*, Hairpin Banksia *Banksia spinulosa*, Sweet Wattle *Acacia suaveolens*, Mountain Devil *Lambertia formosa* and Common Phyllota *Phyllota phyllicoides*. The groundcover is characterised by Heath Mirbelia *Mirbelia rubiifolia*, Wiry Panic *Entolasia stricta*, Swamp Banksia *Banksia paludosa*, Native Holly *Lomatia ilicifolia* and Coral Heath *Epacris microphylla*.

Some areas of Scribbly Gum-Red Bloodwood woodland are in poor condition. A typical example is where under-scrubbing of both the understorey and groundcover has occurred, usually in association with house sites.

3.3.2 Blue Gum/Bangalay Hybrid Open forest

The community is advanced regrowth in structure covering approximately 4.8 ha of sheltered southern aspects. No mature trees are present. The structure is open forest with a mesomorphic understorey. The canopy is dominated by Blue Gum/Bangalay Hybrid *Eucalyptus saligna/botryoides*, however the relatively small size of the floristic unit, the ecotone with Blackbutt trees (part of the Spotted Gum community) on the northern side, and an ecotone with a wetland community on the southern side, provide a high level of heterogeneity within the site. The canopy includes Blue Gum/Bangalay Hybrid and Turpentine *Syncarpia glomulifera* to a height of 20-25 metres with 10% cover. The sub canopy of the same species has a denser cover of approximately 20% to a height of 16 m. The understorey is a dense rainforest layer of 70% cover to a height of 4 metres characterised by Callicoma *Callicoma serratifolia*, Turpentine, Blueberry Ash *Elaeocarpus reticulatus*, Lilly Pilly *Acmena smithii*, Cheese Tree *Glochidion*

ferdinandi, Trailing Guinea-flower *Hibbertia scandens* and Apple Berry *Billardiera scandens*. The groundcover has a dense cover of about 90% to a height of 0.5 metres. Typical species include Bracken Fern *Pteridium esculentum*, Wiry Panic *Entolasia stricta*, Rough Guinea-flower *Hibbertia aspera*, Soft Bracken *Calochlaena dubia* and Austral Sarsaparilla *Smilax australis*. The community is moderately to highly disturbed. The presence of Biconvex Paperbark *Melaleuca biconvexa* is indicative of the heterogeneous nature of this map unit. This species is more typical of a swampy site or associated with a riparian area. More dense stands of Biconvex Paperbark occur adjacent to the drainage line south of the Blue Gum/Bangalay Hybrid Open Forest community.

3.3.3 Blackbutt - Spotted Gum Open Forest

Blackbutt–Spotted Gum Open Forest is the most common vegetation community in the study area covering approximately 53% (38.5 ha), dominating the higher slopes and crests, with Scribbly Gum forests occurring in similar landscape positions further east. Much of this community is highly disturbed due to clearing associated with the many house sites located in the higher landscape positions.

The canopy is dominated by Spotted Gum *Corymbia maculata*, Blackbutt *Eucalyptus pilularis* and Turpentine *Syncarpia glomulifera*. Canopy density varies according to the level of disturbance. Less disturbed sites have canopy cover to 25% with a height of 20 m. The sub-canopy has a similar density to a height of 15 m. Other canopy species occur throughout the Blackbutt–Spotted Gum Open Forest usually as co-dominants in a limited area. These include Large-fruited Red Mahogany *Eucalyptus scias*, Grey Ironbark *Eucalyptus paniculata* and White Stringybark *Eucalyptus globoidea*. The understorey is dominated by Two-veined Hickory *Acacia binervata*, Slender Rice-flower *Pimelea linifolia*, Black Wattle *Acacia mearnsii*, Large-leaved Bush Pea *Pultenaea daphnoides* and Turpentine. The understorey varies according to disturbances such as fire and clearing history. Several of the Blackbutt–Spotted Gum Open Forest sites have a dense understorey of approximately 50% cover to a height of 2.5 m. These are often in sites with a recent fire history (approximately two years since fire). The groundcover is dense (70%) to a height of 0.5 m. Dominant species include Blady Grass *Imperata cylindrica*, Large-leaved Bush-pea, Narrow-leaved Geebung *Persoonia linearis*, Lance-leaf Beard-heath *Leucopogon lanceolatus*, Wiry Panic, Trailing Guinea-flower and Love Creeper *Glycine clandestina*.

An area of Sydney Peppermint–Red Bloodwood association occurs in a small area in the southern central portion of the study area. Although there are differences in the canopy with the co-dominance of Sydney Peppermint *Eucalyptus piperita* with Red Bloodwood *Corymbia gummiifera*, and the absence of Spotted Gum, the general floristic composition is similar to other areas of Blackbutt–Spotted Gum Open Forest. The size of the Sydney Peppermint–Red Bloodwood Open Forest also does not warrant a separate mapping unit in terms of mapping scale for this project. The canopy has a relatively low cover of approximately 25% to a height of

25 m dominated by Red Bloodwood and Sydney Peppermint. The sub-canopy is dominated by Turpentine and Black She-oak *Allocasuarina littoralis* to a height of 10 m with approximately 10% cover. The understorey is approximately 3 m in height with 50% cover and is dominated by Turpentine, Handsome Flat-pea *Platylobium formosum*, Halo Bush-pea *Pultenaea linophylla* and Mountain Devil *Lambertia formosa*. The groundcover is characterised by Yellow Tea-tree *Leptospermum polygalifolium*, Paperbark Tea-tree *Leptospermum trinervium*, Blue Dampiera *Dampiera stricta*, Silky Purple Flag *Patersonia sericea* and Black-eyed Susan *Tetradlea thymifolia* to a height of one metre with 50% cover.

3.3.4 Large-fruited Red Mahogany Swamp Forest

Large-fruited Red Mahogany Swamp Forest is a small unit of approximately 4 ha occurring along a broad drainage depression in the north-east. It forms a clearly defined community exhibiting rapid transition from Scribbly Gum Woodland on the low rise to swamp forest in the drainage depression. The canopy is a sparse cover of Large-fruited Red Mahogany *Eucalyptus scias* to a height of 20 metres. The PFC is only 10%, however the site has been severely burnt in recent years. A similarly sparse mid-canopy of Snow-in-Summer *Melaleuca linariifolia* occurs to a height of 6 m. The understorey is a dense cover (100% PFC) of Snow in Summer *Melaleuca linariifolia*, Swamp Paperbark *Melaleuca ericifolia*, Bronze Bush-pea *Pultenaea villosa*, Halo Bush-pea *Pultenaea linophylla* and Devil's Twine *Cassytha pubescens*. The ground layer has a relatively dense cover of 70% to a height of 0.5 m. Dominant species include Germander Raspwort *Gonocarpus teucroides*, Blady Grass *Imperata cylindrica*, Stinkweed *Opercularia aspera* and Spiny-headed Mat-rush *Lomandra longifolia*.

3.3.5 Melaleuca-Bangalay Swamp Forest

This drainage line community occurs in the south-west of the study area covering approximately 4.1 ha. It covers a small linear pattern along a broad based drainage depression and has a large transition with the adjacent Blue Gum/Bangalay Hybrid Open Forest. The community is dominated Blue Gum/Bangalay Hybrid in the canopy with sub-dominants including Blackbutt *Eucalyptus pilularis* and Turpentine *Syncarpia glomulifera*. The understorey is dominated by Biconvex Paperbark *Melaleuca biconvexa*, Snow-in-Summer *Melaleuca linariifolia* and Swamp Paperbark *Melaleuca ericifolia*. Other common species include *Callicoma serratifolia* and Green Wattle *Acacia irrorata*. Common groundcover species include Wiry Panic *Entolasia stricta*, Tall Saw-sedge *Gahnia clarkei*, Bracken Fern *Pteridium esculentum*, False Bracken Fern *Calochlaena dubia* and Spiny-headed Mat Rush *Lomandra longifolia*.

3.3.6 Flora Species

A total of 149 species were recorded during the flora surveys, comprising 143 native species and six introduced species, and these are listed in Table 4.

Table 4: Plant species identified in the study area (* denotes introduced species)

SCIENTIFIC NAME	COMMON NAME
<i>Acacia binervata</i>	Two-veined Hickory
<i>Acacia brownei</i>	Prickly Moses
<i>Acacia irrorata</i>	Green Wattle
<i>Acacia longifolia</i>	Sydney Golden Wattle
<i>Acacia myrtifolia</i>	Myrtle Wattle
<i>Acacia suaveolens</i>	Sweet Wattle
<i>Acacia terminalis</i>	Sunshine Wattle
<i>Acacia ulicifolia</i>	Prickly Moses
<i>Acmena smithii</i>	Lilly Pilly
<i>Adiantum aethiopicum</i>	Maidenhair fern
<i>Allocasuarina littoralis</i>	Black She-oak
<i>Andropogon virginicus*</i>	Whiskey Grass
<i>Anisopogon avenaceus</i>	Spear Oat Grass
<i>Aristida vagans</i>	Three-awned Spear Grass
<i>Banksia paludosa</i>	Swamp Banksia
<i>Banksia spinulosa</i>	Hairpin Banksia
<i>Baumea juncea</i>	Twig Rush
<i>Billardiera scandens</i>	Apple Berry
<i>Boronia pinnata</i>	Pinnate Boronia
<i>Bossiaea obcordata</i>	Spiny Bossiaea
<i>Breynia oblongifolia</i>	Coffee Bush
<i>Brunoniella pumilio</i>	Dwarf Blue Trumpet
<i>Caladenia carnea</i>	Pink Fingers
<i>Callicoma serratifolia</i>	Callicoma
<i>Callistemon rigidus</i>	A bottle brush
<i>Calochlaena dubia</i>	False Bracken Fern
<i>Cassytha pubescens</i>	Common Devils Twine
<i>Cassytha glabella</i>	Slender Devils Twine
<i>Comesperma ericinum</i>	Match Heads
<i>Corymbia gummifera</i>	Red Bloodwood
<i>Corymbia maculata</i>	Spotted Gum
<i>Cymbidium suave</i>	Snake Flower

SCIENTIFIC NAME	COMMON NAME
<i>Dampiera stricta</i>	Blue Dampiera
<i>Daviesia ulicifolia</i>	Gorse Bitter-pea
<i>Dianella caerulea</i> var. <i>caerulea</i>	Paroo Lily
<i>Dianella caerulea</i> var. <i>producta</i>	Paroo Lily
<i>Dichelachne crinita</i>	Longhair Plume grass
<i>Dichelachne micrantha</i>	Plume Grass
<i>Dichondra repens</i>	Kidney Weed
<i>Dodonaea triquetra</i>	Hop Bush
<i>Drosera spathulata</i>	Sundew
<i>Drosera peltata</i>	Sundew
<i>Echinopogon caespitosus</i>	Tufted Hedgehog Grass
<i>Elaeocarpus reticulatus</i>	Blueberry Ash
<i>Empodisma minus</i>	Spreading Rope Rush
<i>Entolasia marginata</i>	Bordered Panic
<i>Entolasia stricta</i>	Wiry Panic
<i>Epacris microphylla</i>	Coral Heath
<i>Epacris pulchella</i>	Coral Heath
<i>Eragrostis brownii</i>	Brown's Lovegrass
<i>Exocarpos cupressiformis</i>	Native Cherry
<i>Eucalyptus globoidea</i>	White Stringybark
<i>Eucalyptus paniculata</i>	Grey Ironbark
<i>Eucalyptus pilularis</i>	Blackbutt
<i>Eucalyptus piperita</i>	Sydney Peppermint
<i>Eucalyptus saligna</i> x <i>botryoides</i>	Sydney Blue Gum x Bangalay hybrid
<i>Eucalyptus scias</i>	Large-fruited Red Mahogany
<i>Eucalyptus sclerophylla</i>	Hard-leaved Scribbly Gum
<i>Eustrephus latifolius</i>	Wombat Berry
<i>Gahnia aspera</i>	Rough Saw Sedge
<i>Gahnia clarkei</i>	Tall Saw Sedge
<i>Gahnia radula</i>	Thatch Saw Sedge
<i>Glochidion ferdinandi</i>	Cheese Tree
<i>Glycine clandestina</i>	Love Creeper
<i>Gompholobium grandifolium</i>	Broad-leaved Wedge-pea

SCIENTIFIC NAME	COMMON NAME
<i>Gompholobium pinnatum</i>	Pinnate Wedge-pea
<i>Gonocarpus teucrioides</i>	Germander Raspwort
<i>Goodenia hederacea</i> var. <i>hederacea</i>	Violet-leaved Goodenia
<i>Goodenia heterophylla</i> ssp <i>eglandulosa</i>	Variable-leaved Goodenia
<i>Hakea dactyloides</i>	Finger Hakea
<i>Hakea sericea</i>	Bushy Needlebush
<i>Hibbertia aspera</i>	Rough Guinea Flower
<i>Hardenbergia violacea</i>	Twining Pea
<i>Hibbertia scandens</i>	Trailing Guinea Flower
<i>Hydrocotyle</i> sp.	Pennywort
<i>Hydrocotyle tripartita</i>	Pennywort
<i>Hydrocotyle peduncularis</i>	Shining Pennywort
<i>Hypochaeris radicata</i> *	Flatweed*
<i>Imperata cylindrica</i>	Blady Grass
<i>Isopogon anemonifolius</i>	Drumsticks
<i>Juncus usitatus</i>	Common Rush
<i>Juncus</i> sp.	A rush
<i>Kennedia rubicunda</i>	Dusky Coral Pea
<i>Lambertia formosa</i>	Mountain Devil
<i>Lagenifera stipitata</i>	Blue Lagenophora
<i>Leptospermum polygalifolium</i>	Yellow Tea-tree
<i>Leptospermum trinervium</i>	Paperbark Tea-tree
<i>Leptospermum continentale</i>	A tea-tree
<i>Lepidosperma laterale</i>	Variable Sword-sedge
<i>Lepidosperma filiforme</i>	Common Rapier-sedge
<i>Leptocarpus tenax</i>	A sedge
<i>Lepyrodia scariosa</i>	Scale Rush
<i>Leucopogon lanceolatus</i>	Lance-leaved Beard-heath
<i>Lindsaea linearis</i>	Screw Fern
<i>Lindsaea microphylla</i>	Lacy Wedge Fern
<i>Lomandra longifolia</i>	Spiny-headed Mat-rush
<i>Lomandra multiflora</i>	Many-flowered Mat-rush
<i>Lomandra obliqua</i>	Twisted Mat-rush

SCIENTIFIC NAME	COMMON NAME
<i>Lomatia ilicifolia</i>	Holly Lomatia
<i>Melaleuca biconvexa</i>	Biconvex Paperbark
<i>Melaleuca ericifolia</i>	Swamp Paperbark
<i>Melaleuca linariifolia</i>	Snow in Summer
<i>Melaleuca thymifolia</i>	A paperbark
<i>Melaleuca decora</i>	White Feather Honey-myrtle
<i>Mirbelia rubiifolia</i>	Heath Mirbelia
<i>Notelaea venosa</i>	Mock Olive
<i>Olearia microphylla</i>	A daisy-bush
<i>Opercularia aspera</i>	Thin Stink Weed
<i>Oxalis perennans</i>	Oxalis
<i>Podolobium ilicifolium</i>	Native Holly
<i>Pandorea pandorana</i>	Wonga-wonga vine
<i>Patersonia sericea</i>	Silky Purple Flag
<i>Panicum simile</i>	Two-colour Panic
<i>Pennisetum clandestinum*</i>	Kikuyu
<i>Persoonia levis</i>	Broad-leaved Geebung
<i>Persoonia linearis</i>	Narrow-leaved Geebung
<i>Persoonia mollis</i> ssp <i>leptophylla</i>	Soft Geebung
<i>Petrophile pedunculata</i>	Conesticks
<i>Phyllota phyllicoides</i>	Common Phyllota
<i>Pimelea linifolia</i>	Slender Rice Flower
<i>Platylobium formosum</i>	Handsome Flat- pea
<i>Pultenaea daphnoides</i>	Large-leaved Bush Pea
<i>Poa</i> sp.	A tussock grass
<i>Pratia purpurascens</i>	White Root
<i>Prostanthera ovalifolia</i>	Mint Bush
<i>Pteridium esculentum</i>	Bracken Fern
<i>Ptilothrix deusta</i>	A sedge
<i>Pultenaea linophylla</i>	Halo Bush-pea
<i>Pultenaea rosmarinifolia</i>	Rosemary Bush-pea
<i>Pultenaea villosa</i>	Bronze Bush-pea
<i>Schoenus melanostachys</i>	A bog-rush

SCIENTIFIC NAME	COMMON NAME
<i>Selaginella uliginosa</i>	Swamp Selaginella
<i>Senecio sp</i>	A groundsel
<i>Senecio madagascariensis</i> *	Fireweed
<i>Smilax australis</i>	Austral Sarsaparilla
<i>Smilax glycyphylla</i>	Native Sarsaparilla
<i>Solanum nigrum</i> *	Blackberry Nightshade
<i>Sporobolus sp.</i> *	Parramatta Grass
<i>Stackhousia viminea</i>	Tiny Candles
<i>Syncarpia glomulifera</i>	Turpentine
<i>Tetradlea thymifolia</i>	Black-eyed Susan
<i>Thelymitra ixioides</i>	Sun Orchid
<i>Themeda australis</i>	Kangaroo Grass
<i>Veronica plebeia</i>	-
<i>Viola hederacea</i>	Native Violet
<i>Viminaria juncea</i>	Golden Spray
<i>Vittadinia sp.</i>	A fuzzweed
<i>Xanthosia tridentata</i>	Rock Xanthosia
<i>Xanthorrhoea resinosa</i>	Grass Tree

3.4. Fauna

3.4.1 Fauna Habitats

The fauna habitats present in the study area are those generally associated with forests, woodlands, small ephemeral drainages and small dams.

Although disturbed, forests and woodlands in the study area provide a range of important foraging resources for native faunal species. Eucalypts throughout the study area provide seed sources for species such as Gang-gang Cockatoos, leaves for folivores such as the Greater Glider and sources of nectar, pollen and insects for a range of birds, arboreal mammals and bats. Red Bloodwood trees provide important sap-feeding resources for gliders.

In the sub-canopy, Acacias provide seed resources for birds including the Gang-gang Cockatoo, and sap resources for gliders. Numerous Black She-oaks provide important seed resources for the Glossy Black-cockatoo, particularly in the east of the study area. Flowering Banksias and a range of shrubs provide nectar and seed resources for mammals and birds.

The forest canopy supports a range of mammalian prey species for owls, and nesting passerines as prey for the Square-tailed Kite. Small terrestrial mammals provide a limited foraging resource for predators such as the Masked Owl, but disturbances to ground layer habitats have reduced these populations over most of the study area.

The disturbed ground layer has reduced foraging and sheltering habitat for small terrestrial mammals, but denser ground and shrub layer vegetation exists in association with drainage lines and scattered lots within the study area. Reduced shrub layer density may have provided additional foraging areas for macropods such as the Eastern Grey Kangaroo, but access to many of these areas is restricted by fencing.

Numerous small dams in the study area provide shelter, foraging and breeding resources for a variety of amphibians, limited foraging resources for birds and water sources for a range of species.

Shelter resources in large trees with hollows are a particularly important component of habitats in the study area as they allow many hollow-dependant species to persist in a modified environment. Most of the tree hollows occur in the eastern half of the study area. These resources are known or likely to provide roost, nest and den sites for a variety of diurnal and nocturnal birds, arboreal mammals and microchiropteran bats.

3.4.2 Fauna Species

Targeted fauna surveys and opportunistic observations during the survey period resulted in the detection of 89 faunal species inhabiting the study area. A total of 29 mammals, 47 birds, five reptiles and eight amphibians were recorded and these are listed in Table 5. Ten threatened species and six introduced species were recorded within or adjacent to the study area.

Table 5: Fauna species identified during this study (*denotes introduced species, bold text denotes threatened species)

CATEGORY	COMMON NAME	SCIENTIFIC NAME	DETECTION METHOD
Mammals	Broad-nosed Bat sp.	<i>Scotorepens sp 1</i>	Echolocation call (probable)
	Brown Antechinus	<i>Antechinus stuartii</i>	Elliott trapping
	Bush Rat	<i>Rattus fuscipes</i>	Elliott trapping
	Black Rat*	<i>Rattus rattus</i>	Direct observation
	Cat*	<i>Felis cattus</i>	Direct observation
	Chocolate Wattled Bat	<i>Chalinolobus morio</i>	Echolocation call (definite)
	Common Brushtail Possum	<i>Trichosurus vulpecula</i>	Direct observation
	Dog *	<i>Canis familiaris *</i>	Direct observation

CATEGORY	COMMON NAME	SCIENTIFIC NAME	DETECTION METHOD
Mammals (cont'd)	East Coast Freetail Bat	<i>Mormopterus norfolkensis</i>	Echolocation call (definite)
	Eastern Broad-nosed Bat	<i>Scotorepens orion</i>	Echolocation call (definite)
	Eastern Grey Kangaroo	<i>Macropus giganteus</i>	Direct observation
	European Rabbit*	<i>Oryctolagus cuniculus</i>	Direct observation
	Goat*	<i>Capra hircus</i>	Direct observation
	Gould's Wattled Bat	<i>Chalinolobus gouldii</i>	Echolocation call (definite)
	Greater Broad Nosed Bat	<i>Scoteanax rueppellii</i>	Echolocation call (definite)
	Greater Glider	<i>Petauroides volans</i>	Direct observation
	Grey-headed Flying Fox	<i>Pteropus poliocephalus</i>	Direct observation
	Horse*	<i>Equus caballus</i>	Direct observation
	House Mouse*	<i>Mus musculus</i>	Elliott trapping
	Long-eared Bat sp.	<i>Nyctophilus sp.</i>	Echolocation call (definite)
	Large Forest Bat	<i>Vespadelus darlingtoni</i>	Echolocation call (definite)
	Little Forest Bat	<i>Vespadelus vulturnus</i>	Echolocation call (definite)
	Long-nosed Bandicoot	<i>Perameles nasuta</i>	Digging sign/call recognition
	Red-necked Wallaby	<i>Macropus rufogriseus</i>	Direct observation
	Sugar Glider	<i>Petaurus breviceps</i>	Direct observation
	Swamp Rat	<i>Rattus lutreolus</i>	Cage trapping
	Swamp Wallaby	<i>Wallabia bicolor</i>	Direct observation
	Yellow-bellied Glider	<i>Petaurus australis</i>	Direct observation
	White-striped Free-tailed Bat	<i>Tadarida australis</i>	Call recognition
Birds	Australian Magpie	<i>Gymnorhina tibicen</i>	Direct observation
	Australian Owlet Nightjar	<i>Aegotheles cristatus</i>	Direct observation
	Australian Raven	<i>Corvus coronoides</i>	Call recognition
	Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>	Direct observation
	Brown Thornbill	<i>Acanthiza pusilla</i>	Direct observation
	Domestic Fowl*	<i>Gallus gallus</i>	Direct observation
	Channel-billed Cuckoo	<i>Scythrops novaehollandiae</i>	Direct observation
	Common Koel	<i>Eudynamys scolopacea</i>	Direct observation
	Crimson Rosella	<i>Platyercus elegans</i>	Direct observation

CATEGORY	COMMON NAME	SCIENTIFIC NAME	DETECTION METHOD
Birds (cont'd)	Dollarbird	<i>Eurystomas orientalis</i>	Direct observation
	Eastern Bristlebird	<i>Dasyornis brachypterus</i>	Direct observation
	Eastern Spinebill	<i>Acanthorhynchus tenuirostris</i>	Direct observation
	Eastern Whipbird	<i>Psophodes olivaceus</i>	Direct observation
	Eastern Yellow Robin	<i>Eopsaltria australis</i>	Direct observation
	Fan-tailed Cuckoo	<i>Cacomantis flabelliformis</i>	Call recognition
	Galah	<i>Cacatua roseicapilla</i>	Direct observation
	Gang-gang Cockatoo	<i>Callocephalon fimbriatum</i>	Direct observation
	Glossy Black-cockatoo	<i>Calyptorhynchus lathami</i>	Direct observation
	Golden Whistler	<i>Pachycephala pectoralis</i>	Direct observation
	Grey Butcherbird	<i>Cracticus torquatus</i>	Direct observation
	Grey Fantail	<i>Rhipidura fuliginosa</i>	Direct observation
	Grey Shrike-Thrush	<i>Colluricincla harmonica</i>	Direct observation
	Laughing Kookaburra	<i>Dacelo novaeguineae</i>	Direct observation
	Leaden Flycatcher	<i>Myiagra rubecula</i>	Direct observation
	Magpie-lark	<i>Grallina cyanoleuca</i>	Direct observation
	Masked Owl	<i>Tyto novaehollandiae</i>	Call recognition
	Musk Lorikeet	<i>Glossopsitta concinna</i>	Direct observation
	Noisy Friarbird	<i>Philemon corniculatus</i>	Direct observation
	Olive-backed Oriole	<i>Oriolus sagittatus</i>	Direct observation
	Pied Currawong	<i>Strepera graculina</i>	Direct observation
	Rainbow Lorikeet	<i>Trichoglossus haematodus</i>	Direct observation
	Red Wattlebird	<i>Anthochaera lunulata</i>	Direct observation
	Red-browed Finch	<i>Neochmia temporalis</i>	Direct observation
	Rufous Whistler	<i>Pachycephala rufiventris</i>	Direct observation
	Scarlet Honeyeater	<i>Myzomela sanguinolenta</i>	Direct observation
	Silvereye	<i>Zosterops lateralis</i>	Direct observation
	Sooty Owl	<i>Tyto tenebricosa</i>	Call recognition
	Southern Boobook	<i>Ninox novaeseelandiae</i>	Call recognition
	Spotted Pardalote	<i>Pardalotus punctatus</i>	Call recognition
	Square-tailed Kite	<i>Lophoictinia isura</i>	Direct observation
	Sulphur-crested Cockatoo	<i>Cacatua galerita</i>	Direct observation

CATEGORY	COMMON NAME	SCIENTIFIC NAME	DETECTION METHOD
Birds (cont'd)	Superb Fairy-wren	<i>Malurus cyaneus</i>	Direct observation
	Variegated Fairy-Wren	<i>Malurus assimilis</i>	Direct observation
	White-browed Scrubwren	<i>Sericornis frontalis</i>	Direct observation
	White-throated Treecreeper	<i>Cormobates leucophaeus</i>	Direct observation
	Yellow-faced Honeyeater	<i>Lichenostomus chrysops</i>	Direct observation
	Yellow-tailed Black-Cockatoo	<i>Calyptorhynchus funereus</i>	Direct observation
Reptiles	Blue Tongue Lizard	<i>Tiliqua scincoides</i>	Direct observation
	Dark-flecked Garden Skink	<i>Lampropholis delicata</i>	Direct observation
	Jacky Lizard	<i>Amphibolurus muricatus</i>	Direct observation
	Lace Monitor	<i>Varanus varius</i>	Direct observation
	Red-bellied Black Snake	<i>Pseudechis porphyriacus</i>	Direct observation
Amphibians	Bibron's Toadlet	<i>Pseudophryne bibronii</i>	Call recognition
	Bleating Tree Frog	<i>Litoria dentata</i>	Call recognition
	Common Eastern Froglet	<i>Crinia signifera</i>	Call recognition
	Haswell's Froglet	<i>Paracrinia haswelli</i>	Call recognition
	Jervis Bay Tree Frog	<i>Litoria jervisiensis</i>	Call recognition
	Peron's Tree Frog	<i>Litoria peronii</i>	Call recognition
	Striped Marsh Frog	<i>Limnodynastes peronii</i>	Call recognition
	Tyler's Tree Frog	<i>Litoria tyleri</i>	Call recognition

4. CONSERVATION SIGNIFICANCE

The *NSW Threatened Species Conservation Act 1995 (TSC Act)* and the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)* provide for the listing of threatened flora and fauna species.

The *EPBC Act* also provides for the listing of migratory species. The *NSW Fisheries Management Act 1994 (FM Act)* provides for the listing of threatened fish species and marine vegetation.

The *TSC Act* classifies threatened flora and fauna species as Endangered (Schedule 1, Part 1), Vulnerable (Schedule 2), or Presumed Extinct (Schedule 1, Part 4). Records of these species may be obtained by searching the Atlas of NSW Wildlife.

The *EPBC Act* classifies threatened flora and fauna species as Extinct, Critically Endangered, Endangered or Vulnerable. An indication of the threatened and migratory species likely to be encountered in a locality may be obtained by using the *EPBC Act* Protected Matters Search Tool.

Both of these databases were searched on 7 December 2005 for records of threatened flora, threatened fauna and migratory species within an area of 10 km x 10 km centred on the study area.

The *FM Act* classifies threatened fish and marine vegetation as Endangered, Vulnerable, or Presumed Extinct. An indication of the species likely to be encountered in a locality may be obtained by reviewing the recommendations for threatened species listed on the schedules of the *FM Act*.

4.1 Threatened Flora

The outcomes of database searches for threatened flora are shown in Table 6 with the status of each species listed as endangered (E) or Vulnerable (V).

The potential for each of these species to occur in the study area and the importance of the habitats are discussed in Table 6 and a decision made regarding the need for further assessment in this report.

Table 6: Threatened flora species recorded or likely to occur in the locality.

THREATENED FLORA SPECIES	STATUS		POTENTIAL TO OCCUR IN THE STUDY AREA AND IMPORTANCE OF HABITAT WITHIN THE STUDY AREA
	TSC Act	EPBC Act	
<i>Caladenia tessellata</i> Tessellated Spider Orchid	E	V	This terrestrial orchid is associated with low open forests with a heathy or sometimes grassy understorey on clay-loam or sandy soils. On the coast leaves appear after autumn rains and flowering is thought to occur between August and November depending on the season (Briggs, J. pers. comm., 2004). In coastal areas it can occur in dense shrubbery and is usually detected only after fire. It is currently known from one population in Braidwood and three populations in Wyong. There are no confirmed recent records of the species in the Shoalhaven, although four plants in bud stage were tentatively identified as the species in the Moona Moona Creek area in spring 2003. Another unconfirmed record for the species exists in the Ulladulla area, from Bangalay forest on poorly-drained clay soils. Targeted surveys of potential habitat within the known flowering period for the species did not detect any individuals within the study area. Given the lack of positive records in the locality and the nature of disturbances to much of the study area, it is considered unlikely that the species would occur there.
<i>Cryptostylis hunteriana</i> Leafless Tongue Orchid	V	V	This terrestrial orchid grows in swamp-heath and open forest on sandy soils in coastal districts and a number of populations are known from the Shoalhaven. Targeted surveys of potential habitat, following confirmation of flowering at known populations near Vincentia, did not detect any individuals. Given that good coverage of the most likely habitat was achieved during the survey, the species is considered unlikely to occur within the study area..
<i>Eucalyptus langleyi</i> Albatross Mallee	V	V	This smooth-barked mallee is restricted to mallee shrubland on poorly drained shallow sand on sandstone in the Nowra area. There is no suitable habitat in the study area. It was not observed during surveys and is not expected to occur there.
<i>Eucalyptus sturgissiana</i> Ettrema Mallee	V		This species is restricted to sandstone plateaus south-west of Nowra and is endemic to the region. Typical habitat does not occur in the study area and the species was not observed during the survey period. It is unlikely to occur there.
<i>Genoplesium baueri</i> Bauer's Midge Orchid	V		This small orchid occurs in forest and woodland and has been recorded locally at Vincentia, Jerrawangala, Callala and Nowra. Targeted surveys of potential habitat during the known flowering period when other populations in the locality were confirmed to be in flower, failed to detect the species. It is considered unlikely to occur within the study area.
<i>Melaleuca biconvexa</i> Biconvex Paperbark	V	V	Present. This paperbark is generally restricted to creeks and poorly drained areas. Two discrete occurrences of this species were found during the survey – a major occurrence was in association with the main drainage line in the southwest of the study area, and a smaller occurrence in association with a minor drainage line on the northern edge of the study area.
<i>Triplarina nowraensis</i> Nowra Heath-myrtle	E	E	This shrub is usually found in heathland along stream channels or on swampy slopes within surrounding eucalypt woodland. There is no typical habitat in the study area and the species was not observed during the survey period. The species is not known from the immediate area and is not expected to occur in the study area.

Note: Habitat requirements for flora species in Table 5 have been sourced from: Bishop (2000), Clarke *et al.* (2003), Harden (1994), NPWS www.npws.nsw.gov.au (accessed 2005) www.threatenedspecies.environment.nsw.gov.au (accessed 2005/2006),

One threatened flora species, *Melaleuca biconvexa*, was recorded in the study area. The locations of this species are shown in Figure 5 (Appendix A). The ecological constraints to the rezoning of the study area posed by this species are discussed in subsequent sections of this report. The study area contains potential habitat for three threatened orchid species (*Calladenia tessellata*, *Cryptostylis hunteriana* and *Genoplesium baueri*), however, these species were not detected during targeted surveys and are thus not considered to pose constraints to the rezoning of the study area.

4.2 Flora of Regional Conservation Significance

The study area includes two plant species of local or regional conservation significance after Mills (1993), (KMA 1993, 1995a & b) and PlantNET (accessed February 2005). These species are discussed below, but neither species is considered to pose any ecological constraints to the rezoning of the study area.

Variable-leaved Goodenia *Goodenia heterophylla* subsp. *eglandulosa* – The species is near its southern known limit within the study area, which is listed as Jervis Bay (Mills 1993, PlantNET accessed February 2005), but the species has also been recorded in the Mollymook – Ulladulla area (KMA 1995a).

Hard-leaved Scribbly Gum *Eucalyptus sclerophylla* - The species is near its southern known limit within the study area, which is listed as Jervis Bay (Mills 1993, PlantNET accessed February 2005), but the species has also been recorded in the Mollymook – Ulladulla area (KMA 1995a) and has been recorded by BES at least as far south as Burrill Lake.

4.3 Threatened Fauna

The outcomes of database searches for threatened fauna and the review of recommendations for threatened species listed on the schedules of the *FM Act* are shown in Table 7 below with the status of each species listed as endangered (E) or Vulnerable (V).

The potential for each of these species to occur in the study area and the importance of the habitats are discussed in Table 7 and a decision made regarding the need for further assessment in this report.

Additional species detected in the study area or that may inhabit the study area have also been included by correlating species habitat requirements with the existing environment.

Marine and oceanic species have been omitted as they would not occur in the study area.

Table 7: Threatened fauna species recorded or likely to occur in the locality.

THREATENED FAUNA SPECIES	STATUS		POTENTIAL TO OCCUR IN THE STUDY AREA AND IMPORTANCE OF HABITATS WITHIN THE STUDY AREA
	TSC Act	EPBC Act	
Mammals			
Brush-tailed Rock-wallaby <i>Petrogale penicillata</i>	E	V	This species is associated with sandstone escarpments preferably with a northerly aspect. No suitable habitat occurs in the study area, and the species was not observed during surveys. No potential habitat exists in close proximity to Jerberra Estate and the species is not known from the Tomerong area. The species is not expected to occur within the study area.
Eastern Bent- wing Bat <i>Miniopterus schreibersii</i>	V	-	This bat predominately uses caves as roosting and breeding sites and forests for foraging. Caves are not present in the study area so breeding habitat is absent, although individuals may use trees and other structures for roosting on occasions. Suitable foraging habitat occurs throughout the study area and is likely to be utilised by the species at least on occasions. The foraging habitat within the study area is of good quality, but would form only a small portion of this species expected foraging area. Targeted surveys did not detect this species within the study area.
Eastern Pygmy Possum <i>Cercartetus nanus</i>	V	-	This species forages for pollen and nectar from a wide variety of nectar-bearing plants, and also eats insects, seeds and fruit. It often nests in tree hollows but may use a range of other shelter sites. Potential habitat exists within the study area, although the extent of understorey vegetation removal has substantially reduced the quality of this habitat. The presence of introduced predators such as cats further reduces the quality of this habitat for this species. It was not detected during targeted Elliott trapping or other surveys, but its presence can sometimes be difficult to determine. While suitable habitat is present in the study area, it is patchily distributed, fragmented and mostly disturbed. The species could possibly occur in the study area but the resources present are not considered to be of particular importance or of quality for the species.
Large-footed Myotis <i>Myotis adversus</i>	V		This bat roosts in caves and tree hollows near watercourses. It typically forages over rivers and streams, which are not found in the study area. A number of dams in the study area may provide some foraging habitat for the species, which could also utilise some tree hollows for roosting. However, targeted surveys did not detect this species and the study area does not represent typical or high quality habitat for the Large-footed Myotis.
Greater Broad- nosed Bat <i>Scoteanax rueppellii</i>	V	-	Present. This bat roosts in tree hollows and forages in forests. This species was confidently detected by echolocation call recording during nocturnal walking transects along the main roads within the study area. Suitable foraging habitat is present throughout the study area, and the distribution of tree hollows generally reflects the suitable roosting habitat for the species. Potential breeding habitat is present in the study area, and is most likely to occur within very large trees bearing cavities. No roosts were observed during stag watching surveys of potential trees.

THREATENED FAUNA SPECIES	STATUS		POTENTIAL TO OCCUR IN THE STUDY AREA AND IMPORTANCE OF HABITATS WITHIN THE STUDY AREA
	TSC Act	EPBC Act	
Grey-headed Flying-fox <i>Pteropus poliocephalus</i>	V	V	Present. The species roosts in permanent camps and forages for nectar in flowering trees and shrubs over vast areas. The species was observed foraging in flowering trees during the survey period, and is likely to do so whenever suitable trees are flowering. While land use within the study area has resulted in the removal of or disturbance to much vegetation, a reasonably intact canopy stratum persists. This foraging habitat is probably similar or lower in quality to most of the extensive areas of forest in the locality available to the species. This species could be expected to occur in the study area whenever appropriate resources are present.
Large-eared Pied Bat <i>Chalinolobus dwyeri</i>	-	V	This bat uses caves as roosting sites and forests for foraging. Caves are not present in the study area although suitable foraging habitat is present. The species could be expected to forage in the study area on occasions, although extensive areas of foraging habitat of similar or greater quality exist within the locality. Targeted surveys did not detect this species.
East Coast Freetail Bat <i>Mormopterus norfolkensis</i>	V	-	Present. This bat roosts in tree hollows and forages in forests. This species was confidently detected by echolocation call recording during nocturnal walking transects along the main roads within the study area. Only one definite echolocation call from this species was recorded on one of three nights. Suitable foraging habitat is present throughout the study area, and the distribution of tree hollows generally reflects the suitable roosting habitat for the species. Potential breeding habitat is present in the study area, and is most likely to occur within very large trees bearing cavities. No roosts were observed during stag-watching surveys of potential trees.
Koala <i>Phascolarctos cinereus</i>	V	-	The study area contains some suitable feed trees for the Koala, but it was not detected during surveys. No recent records for the species exist in the general area and no populations are considered likely to occur nearby. Disturbances and the presence of introduced predators (dogs) further reduce the likelihood of the species occurring within the study area.
Parma Wallaby <i>Macropus parma</i>	V		This generally solitary species lives in both wet and dry forests and occasionally in rainforests within the highland ranges of northern and central NSW. The species is unknown from coastal sites and does not frequent areas associated with human disturbance. The species is active throughout the night but tends to be most active in the hour before dawn and is thus difficult to observe (Ord et al. 1999). Wet forests with thick, shrubby understorey associated with grassy patches are preferred. The study area contains generally unsuitable habitat for this species as it is so disturbed. The species was not detected during surveys and no recent records are known from the locality. It is highly unlikely to occur there.
Squirrel Glider <i>Petaurus norfolcensis</i>	V	-	The species dens in tree hollows and forages in forests where it's preferred feed trees are found. The species appears to be sparsely and patchily distributed on the south coast, and can be difficult to locate. Local records exist from Vincentia and Callala Bay. The study area contains suitable, although disturbed, denning and foraging habitat. The species was not detected during the survey period and is not known to occur in the Tomerong area. It is not considered likely to occur in the study area.

THREATENED FAUNA SPECIES	STATUS		POTENTIAL TO OCCUR IN THE STUDY AREA AND IMPORTANCE OF HABITATS WITHIN THE STUDY AREA
	TSC Act	EPBC Act	
Southern Brown Bandicoot <i>Isodon obesulus</i>	E	E	This species requires thick contiguous undergrowth where the soil is light and sandy. Much of the study area contains unsuitable habitat due to the extent of disturbance to and removal of undergrowth vegetation. Some lots in the northeast of the study area with dense undergrowth offered potential habitat for the species, but targeted surveys did not detect any individuals. This species is sparsely distributed in disjunct populations and is not known to occur in the locality. It is considered unlikely to occur within the study area.
Yellow-bellied Glider <i>Petaurus australis</i>	V	-	Present. The species dens in tree hollows and forages in open forests where it's preferred feed trees are found. At least one family group occupies much of the study area on a regular basis. At least one individual was detected on every survey night. Several den trees and a number of incised sap trees were located. Although disturbed, habitats within the study area retain a reasonably intact canopy stratum containing important foraging tree species such as Spotted Gum, Blue Gum/Bangalay hybrid and Red Bloodwood. Habitats within the study area adjoin other areas of known habitat for the species and function as part of a habitat corridor within a rural landscape.
Birds			
Eastern Bristlebird <i>Dasyornis brachypterus</i>	E	E	Present. The Eastern Bristlebird is a cover-dependent species predominantly of dense heath or similar low-level vegetation. The species was seen and heard in the north-eastern corner of the study area among dense vegetation associated with a tributary of Moona Moona Creek. The species may occasionally venture further into the study area where dense understorey vegetation persists, but primary habitat appears to be limited to dense riparian vegetation in the far north east of the study area.
Gang-gang Cockatoo <i>Callocephalon fimbriatum</i>	V	-	Present. Gang-gang cockatoos live as pairs inhabiting woodlands of south-eastern Australia. The species feeds predominantly on the seeds of eucalypts and acacias. Nest sites are usually within medium sized hollows in living eucalypts. Foraging resources occur throughout the study area and one nest tree was located near the centre of the study area. Three pairs of birds were occupying the study area during the breeding season, but only one pair was found to establish a nesting site. Other nest sites within the study area could be used in subsequent years. The species is expected to be a breeding resident of the study area.
Glossy Black- cockatoo <i>Calyptorhynchus lathami</i>	V	-	Present. This species occurs in forests and woodlands where She-oak feeding resources are prevalent and large tree hollows exist for breeding. A number of confirmed feed-trees and individual Glossy Black-cockatoos were located during the survey. Foraging resources are scattered throughout the site. Nesting by this species was not observed during the survey period, although suitable trees with hollows exist. The species is expected to forage in the study area regularly, and may nest in the study area.
Ground Parrot <i>Pezoporus wallicus</i>	V		This species is usually associated with heathland and sedgeland vegetation, which does not occur in the study area. It is considered extremely unlikely to occur in the study area.

THREATENED FAUNA SPECIES	STATUS		POTENTIAL TO OCCUR IN THE STUDY AREA AND IMPORTANCE OF HABITATS WITHIN THE STUDY AREA
	TSC Act	EPBC Act	
Masked Owl <i>Tyto novaehollandiae</i>	V	-	Present. This species breeds in tree hollows and forages mostly on terrestrial mammals. Suitable foraging habitat occurs throughout the study area and suitable breeding and roosting habitat is present within larger trees within the eastern half of the study area. The disturbances within the study area are likely to have reduced the overall quality of roosting and breeding habitat. These disturbances are likely to have had both beneficial and detrimental effects on foraging habitat. The Masked Owl was detected only from a single call on one night during the survey. No evidence of roosting or breeding by the species was found. The species may forage or roost in tree hollows in the study area on occasions, and although possible, it is less likely to breed there given the extent and type of disturbances.
Powerful Owl <i>Ninox strenua</i>	V	-	Preferred habitat for this species is forest containing large tree hollows for breeding. The Powerful Owl forages primarily on arboreal mammals. Suitable foraging habitat occurs throughout the study area and some trees containing hollows large enough for nest sites are present in the eastern half of the site. Only marginal roosting habitat currently occurs in the study area, and no evidence of roosting was found. The potential of the species to breed in the study area is considered to be low due to the disturbances and lack of good roosting habitat associated with otherwise suitable hollow-bearing trees. The species was not detected during the survey period, but is expected to use the area for foraging at least on occasions.
Regent Honeyeater <i>Xanthomyza phrygia</i>	E	E	This migrant to the region forages in winter-flowering trees such as Spotted Gum, Woollybutt, and Swamp Mahogany. Suitable foraging resources are present within the study area and it is possible that the species will utilise such resources on occasions. Forest communities within the study area represent suitable, but not particularly high quality, habitat for the species relative to the quantity and quality of other potential foraging resources within the region.
Sooty Owl <i>Tyto tenebricosa</i>	V	-	Present. This species is typically associated with closed forests and tall wet open forest, but is known to also occur in a wider range of habitats. While typical habitat does not occur in the study area, potential foraging habitat occurs throughout, and potential roosting and breeding habitat is present in large hollow-bearing trees in the eastern half of the study area. This species was heard calling on 2 occasions shortly after dusk from the southern-central part of the study area. Calls early in the night are indicative of roosting nearby, however no evidence of roosting was detected. It does not appear to be a permanent resident within the study area, but is likely to utilise the study area for foraging and roosting on occasions. Breeding is possible but less likely due to the disturbance and sub-optimal habitat.

THREATENED FAUNA SPECIES	STATUS		POTENTIAL TO OCCUR IN THE STUDY AREA AND IMPORTANCE OF HABITATS WITHIN THE STUDY AREA
	TSC Act	EPBC Act	
Square-tailed Kite <i>Lophoictinia isura</i>	V	-	Present. This summer migrant to the Shoalhaven hunts for passerines in coastal open forests and breeds in mature trees often near waterways. The Square-tailed Kite was observed foraging within the study area on several occasions, but no evidence of nesting was found. Suitable foraging habitat occurs throughout the study area and the species is expected to forage there on a fairly regular basis. The species did not breed within the study area during the survey period (which coincided with the breeding period) and is not considered likely to utilise the area for nesting.
Striated Fieldwren <i>Calamanthus fuliginosus</i>	V	-	This species occurs in coastal heaths, swamp margins, tussocky grasslands and other dense, low vegetation. Some potential habitat occurs on the margins of drainage lines in the northeast and south of the study area, although the species was not detected during surveys. It is not known from the Tomerong area, which does not contain typical habitat for the species. It is not expected to occur in the study area.
Swift Parrot <i>Lathamus discolor</i>	E	E	This migrant to the region forages for nectar in winter-flowering trees such as Spotted Gum and Swamp Mahogany. Suitable foraging resources are present within the study area and it is possible that the species will utilise such resources on occasions. Forest communities within the study area represent suitable, but not particularly high quality, habitat for the species relative to the quantity and quality of other potential foraging resources within the region.
Amphibians			
Giant Burrowing Frog <i>Heleioporus australiacus</i>	V	V	This species may be found in a range of habitats from forest to heath, usually in sandy soils and breeds in ephemeral ponds often underlain with sandstone, or within burrows. The species appears intolerant of clearing and poor water quality. The two main drainage lines within the study area, which are characterised by heathy-swamp vegetation, offer potential habitat for the species, particularly the north-eastern occurrence which is less disturbed and adjoins additional undisturbed riparian areas. A number of constructed dams within the study area provide sub-optimal habitat - the high level of disturbances associated with these dams and surrounding areas greatly reduce the likelihood of the species utilising these resources. No individuals of this species were detected during surveys, although conditions during most of the survey period were too dry for the species to be active. No records of the species are known from the Tomerong area and it is unlikely to occur regularly within the study area, apart from the north-eastern corner.
Littlejohn's Tree Frog <i>Litoria littlejohni</i>	V	V	The species is known mainly from forested environments where it calls mainly in late winter and spring from elevated positions beside ponds and creeks. The species occurs adjacent to slow flowing unpolluted water. It appears to occur at mid to high altitudes. The study area contains marginal to unsuitable habitat for this species given the site's altitude, lack of flowing waterbodies and associated riparian vegetation. It is not known from the Tomerong area and was not detected during the survey period. Given also the disturbances to the landscape, it is considered unlikely that the species occurs in the study area.

THREATENED FAUNA SPECIES	STATUS		POTENTIAL TO OCCUR IN THE STUDY AREA AND IMPORTANCE OF HABITATS WITHIN THE STUDY AREA
	TSC Act	EPBC Act	
Green and Golden Bell Frog <i>Litoria aurea</i>	E	V	This species prefers permanent, unshaded water bodies containing emergent vegetation. The constructed dams within the study area provide sub-optimal habitat at best, as most are shaded by trees or lack emergent vegetation and shelter sites and appear to contain introduced Mosquito Fish, which are known to prey on tadpoles of the Green and Golden Bell Frog. A single record of the species at Tomerong to the west of the study area dates back to 1975. No recent records are known from the area. The species was not detected during the survey period and is considered unlikely to occur in the study area.
Reptiles			
Broad-headed Snake <i>Hoplocephalus bungaroides</i>	E	V	This nocturnal species occurs on the edges of sandstone cliffs where it shelters in crevices and under rocks during the cooler months, and utilises tree hollows for shelter during the hot summer months. There is no suitable habitat within the study area and the species is not expected to occur there.
Rosenberg's Goanna <i>Varanus rosenbergi</i>	V	-	This species occurs in heaths, woodlands and forests and incubates its eggs in termite mounds. It shelters in burrows, hollow logs and rock crevices. The study area provides largely unsuitable habitat given the lack of termite mounds and range of disturbances. The species is not known from coastal areas around Jervis Bay – the closest records to the study area appear to be located approximately 20km to the west. The species was not detected during the survey period and is not expected to occur in the study area.

Note: Habitat requirements for fauna species in Table 6 have been sourced from Blakers et.al. (1984), Churchill (1998), Clout (1989), Cogger (1996), Commonwealth DEH (1999), Commonwealth DEH (2001), Daly and Murphy (1996), Ehmann (1997), McDowell (1996), NSW NPWS (1996), NSW NPWS (1998), NSW NPWS (2000), DEC <http://www.threatenedspecies.environment.nsw.gov.au> (accessed 2006), Strahan (1995), DEH <http://www.deh.gov.au/biodiversity/threatened> (accessed 2006).

Ten threatened fauna species were recorded in or adjacent to the study area during the survey period: the East Coast Freetail Bat; Greater Broad-nosed Bat; Grey-headed Flying-fox; Yellow-bellied Glider; Eastern Bristlebird; Gang-gang Cockatoo; Glossy Black-cockatoo; Masked Owl; Sooty Owl and; Square-tailed Kite (Figure 5, Appendix A). In addition, the threatened Powerful Owl, Eastern Bentwing Bat, Eastern False Pipistrelle and Large-eared Pied Bat are considered likely to forage within the study area on occasions. The ecological constraints to the rezoning of the study area posed by these species are discussed in subsequent sections of this report.

4.4 Migratory Species

The outcome of the database search for migratory species is shown in Table 8 below. The potential for each of these species to occur in the study area is discussed in Table 8 and a decision made regarding the need for further assessment in this report.

Species encountered in marine and wetland environments have been omitted as these habitats do not occur in the study area.

Table 8: Migratory species recorded or likely to occur in the locality.

SPECIES	POTENTIAL TO OCCUR IN THE STUDY AREA AND IMPORTANCE OF HABITATS WITHIN THE STUDY AREA
Black-faced Monarch <i>Monarcha melanopsis</i>	This migratory species is known to breed in damp forest types and forage in rainforest and eucalypt forest. Typical habitat does not occur within or adjacent to the study area. The species was not detected during surveys and is considered unlikely to occur in the study area.
Latham's Snipe <i>Gallinago hardwickii</i>	This migratory species is usually found in a range of vegetated wetlands. The drainage lines within the study area do not offer wetland habitat for this species, and the constructed dams in the study area are generally too small and disturbed to provide potential habitat. The species was not detected during the survey period and is unlikely to occur in the study area.
Orange-bellied Parrot <i>Neophema chrysogaster</i>	This migratory species breeds in the south-west of Tasmania and migrates in autumn to spend the winter on coast of south-eastern South Australia and southern Victoria. Typical winter habitat is saltmarsh and strandline/foredune vegetation communities within 3 km of the coast. Birds forage in low samphire herbland or taller coastal shrubland. Suitable habitat is not present in the study area.
Painted Snipe <i>Rostratula benghalensis</i>	This migratory species is usually found in vegetated, shallow, temporary or infrequently filled wetlands. The drainage lines within the study area do not offer wetland habitat for this species, and the constructed dams in the study area are generally too small and disturbed to provide potential habitat. The species was not detected during the survey period and is unlikely to occur in the study area.
Regent Honeyeater <i>Xanthomyza phrygia</i>	This migrant to the region forages in winter-flowering trees such as Spotted Gum, Woollybutt, and Swamp Mahogany. The study area contains some suitable tree species for foraging. It is possible that the species may forage in the study area from time to time, however the study area forms a very small part of the species migratory foraging range and on its own would not constitute an important resource for this species. The species was not detected during the survey period and is unlikely to occur in the study area regularly, nor be dependent upon it.
Rufous Fantail <i>Rhipidura rufifrons</i>	This species is known to utilise dense understorey in damp forests or beside rivers. Habitat in the study area is generally unsuitable for the species, although small amounts of marginal riparian habitat is present along drainage lines. The species was not observed in the study area during the survey period, and given the marginal habitats present, unlikely to occur regularly in the study area.
Satin Flycatcher <i>Myiagra cyanoleuca</i>	This migratory species inhabits lowland eucalypt forests. It is known to nest in dense gully vegetation. Breeding habitat is not present in the study area, but the species may forage there on occasions. This species was not recorded during the survey period and given the heavy disturbances to much of the sub-canopy and shrub-layer vegetation, is unlikely to frequent the study area or rely on the habitats contained within.
Swift Parrot <i>Lathamus discolor</i>	This migrant to the region forages in winter-flowering trees such as Spotted Gum, Woollybutt, and Swamp Mahogany. The study area contains some suitable tree species for foraging. It is possible that the species may forage in the study area from time to time, however the study area forms a very small part of the species migratory foraging range and on its own would not constitute an important resource for this species. The species was not detected during the survey period and is unlikely to occur in the study area regularly, nor be dependent upon it.

SPECIES	POTENTIAL TO OCCUR IN THE STUDY AREA AND IMPORTANCE OF HABITATS WITHIN THE STUDY AREA
White-bellied Sea-eagle <i>Haliaeetus leucogaster</i>	This migratory species inhabits coastal environments such as islands, reefs, headlands, beaches, bays, estuaries, mangroves, inland swamps, lagoons, rivers and floodplains. Suitable foraging habitat is not preset and study area's distance from substantial water bodies suggest these habitats would not be used for breeding. The species was not detected there during the survey period and is unlikely to occur there.
White-throated Needletail <i>Hirundapus caudacutus</i>	This migratory species is associated with hillsides and is thought to spend all of its time in the air whilst in Australia. The study area is not on a prominent hillside so the species is unlikely to occur there apart from overflying the site. It was not recorded during the survey period.

4.5 Endangered Populations

The *TSC Act* provides for the listing of endangered populations on Schedule 1, Part 2. There are no endangered populations listed on the schedules of the *TSC Act* found in the City of Shoalhaven. No further consideration or assessment is given to endangered populations in this report.

4.6 Endangered Ecological Communities

The *TSC Act* and *EPBC Act* provide for the listing of threatened ecological communities.

One endangered ecological community listed under the *TSC Act*, *Swamp sclerophyll forest on the coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions*, hereafter referred to as *Swamp sclerophyll forest*, occurs in the study area (Figure 5, Appendix A). It is associated with drainage lines and occurs in two discrete areas in the south west and north east of the study area, where Large-fruited Red Mahogany Swamp Forest and Melaleuca-Bangalay Swamp Forest are found.

Both of these vegetation communities show floristic and structural affinities with the *Swamp sclerophyll forest* endangered ecological community, and they both occur in landscape positions typical of swamp forests (NSW Scientific Committee 2005b).

The Large-fruited Red Mahogany Swamp Forest is associated with a shallow drainage line in the far north east of the study area, which is a tributary of the Moona Moona Creek coastal floodplain.

Fieldwork in this community within the study area recorded 12 of the 51 (approximately 24%) characteristic species identified in the final determination for the community (NSW Scientific Committee 2005b), which have a range that includes the study area.

The Large-fruited Red Mahogany Swamp Forest resembles the structural and floristic description of the *Swamp sclerophyll forest* (NSW Scientific Committee 2005b) as:

- it has a canopy dominated by eucalypts associated with coastal floodplain habitats such as Large-fruited Red Mahogany;
- it has a sub-canopy of small trees including Snow in Summer;
- it includes shrubs such as Yellow Tea-tree; and
- it has a groundcover and understorey dominated by sedges, forbs and grasses such as Spiny-headed Mat-rush and Blady Grass.

Whilst the final determination does not list Large-fruited Red Mahogany as a characteristic canopy species, the species is associated with coastal floodplain habitats in the locality. Given the characteristics of the Large-fruited Red Mahogany Swamp Forest within the study area it is considered to be representative of *Swamp sclerophyll forest*.

The Melaleuca-Bangalay Swamp Forest is associated with an upper section of a shallow drainage line in the south western section of the study area, which is a tributary of the Moona Moona Creek coastal floodplain.

Fieldwork in this community within the study area recorded 10 of the 51 (approximately 20%) characteristic species identified in the final determination for the community (NSW Scientific Committee 2005b), which have a range that includes the study area.

The Melaleuca-Bangalay Swamp Forest resembles the structural and floristic description of the *Swamp sclerophyll forest* (NSW Scientific Committee 2005b) as:

- it has a canopy dominated by eucalypts associated with coastal floodplain habitats such as Bangalay;
- it has a sub-canopy of small trees including Snow in Summer;
- it includes shrubs such as Yellow Tea-tree and Sydney Golden Wattle; and
- it has a groundcover and understorey dominated by sedges, ferns, forbs and grasses such as Tall Saw-sedge, the Saw sedge *G. radula*, Common Bracken, Spiny-headed Mat-rush, Blue Flax Lily, Bordered Panic, Basket Grass, Shining Pennywort, Asian Pennywort and Common Maidenhair Fern.

Given the characteristics of the Melaleuca-Bangalay Swamp Forest within the study area it is considered to be representative of *Swamp sclerophyll forest*.

No other vegetation communities within the study area have characteristics associated with endangered or threatened ecological communities listed under the *TSC Act* or *EPBC Act*.

4.7 Koala Habitat

The study area contains scattered individuals of Grey Gum *Eucalyptus punctata* trees, which are koala feed trees listed on Schedule 2 of *NSW State Environmental Planning Policy No 44 – Koala Habitat Protection (SEPP No. 44)*. Grey Gum does not constitute at least 15% of the total number of trees in the upper or lower strata of the tree component over most of the study area, and thus, the study area does not contain potential koala habitat as defined by *SEPP No. 44*.

There is also no evidence of koalas occurring within the locality recently and they were not detected during targeted surveys utilising call playback, spotlighting and diurnal searches for individuals and characteristic scratchings on trees. Koalas would appear unlikely to occur within the study area.

4.8 Habitat Corridor and Connectivity Values

The study area generally lies adjacent to a habitat corridor identified within the Jervis Bay Regional Environmental Plan (Clause 14), apart from the north-eastern corner which constitutes part of the corridor (Figure 6, Appendix A). Otherwise, the identified habitat corridor adjoins the northern boundary of the study area as well as parts of the western and eastern boundaries. The bulk of the study area represents an area excised from the habitat corridor, but currently functions as a (disturbed) habitat corridor in both an east-west and north-south direction for a range of fauna.

The habitat values relating to dispersal and movement functionality for native fauna within the bulk of the study area are mainly limited to the forest canopy and in some areas the sub-canopy, as the disturbances to the shrublayer and groundcover have been extensive. Thus, the value of the study area in general as a habitat corridor mainly benefits mobile arboreal or flying species such as diurnal and nocturnal forest birds, gliding mammals, and bats. However, the north-east and south-west of the study area contain higher conservation values as fauna habitat corridors as these areas play a key role in the continuation of habitat corridors beyond the site.

Three lots in the north-eastern corner of the study area (Lots 98-100 DP 11629 Jerberra Road) are contained within the habitat corridor identified under the Jervis Bay Regional Environmental Plan (Figure 6, Appendix A). These lots are traversed by a tributary of Moona Moona Creek, which retains a dense understorey that is contiguous with vegetated neighbouring land to the east and north. This habitat provides connectivity along the creekline for a range of terrestrial and cover-dependent species, and is known to be used by the threatened Eastern Bristlebird. The riparian portion of this corridor approximates the Large-fruited Red-Mahogany Swamp Forest community and is of high conservation value.

Forest in the south-west of the study area (Figure 6, Appendix A), in association with another tributary of Moona Moona Creek, provides habitat connectivity between privately owned vegetated land to the south of Parnell Road, and vegetated Crown Land to the west of Pine

Forest Road, which contains the habitat corridor identified in the Jervis Bay Regional Environment Plan. This part of the study area currently provides an important component in a relatively intact corridor which links the identified habitat corridor mentioned above, with the disturbed habitat and vegetation corridor to the south (which is identified under Clause 15 of the Jervis Bay Regional Environment Plan) via relatively large areas of forest on privately owned land. While not connecting large areas of protected land, which is a key function of habitat corridors, this corridor would retain important functionality for at least a wide range of bird species, and would enhance the value of the identified corridors which it links.

This corridor provides a vegetated link between Yellow-bellied Glider groups within and adjacent to the study area and several Yellow-bellied Glider groups near Island Point Road, although Yellow-bellied Gliders have not been recorded within the corridor itself. The corridor is known to contain relatively large occurrences of *Melaleuca biconvexa* in areas close to Parnell Road. These locations are close enough to allow insect pollinators to move between plants in the study area and the corridor habitat south of Parnell Road.

5. ECOLOGICAL CONSTRAINTS

5.1 Threatened Flora

The Biconvex Paperbark *Melaleuca biconvexa* was found to occur in two discrete locations within the study area. The main occurrence covers approximately 6.16 ha and is associated with the headwaters of the drainage line in the south-west of the study area. This drainage line flows through more heavily disturbed lands to the south of the study area and eventually joins Moona Moona Creek. This drainage line also contains the Swamp Sclerophyll Forest endangered ecological community, which to a large extent overlaps with the *Melaleuca biconvexa* distribution. A much smaller area of *Melaleuca biconvexa* (approximately 0.25 ha) occurs on the northern boundary of the study area, which is also associated with a drainage line and appears almost entirely limited to Lot 64 Invermay Avenue.

Both occurrences are currently considered viable sub-populations, although a substantial amount of clearing has reduced the distribution and size of both occurrences. All individuals of this species should be retained and there is scope to improve the viability of these sub-populations by allowing regeneration of cleared areas within and adjacent to the current distribution. Both occurrences of *Melaleuca biconvexa* are associated with drainage lines that originate within the study area. The species' association with creeks and swampy areas makes them potentially vulnerable to changes in hydrological regimes and water quality. The species' restricted habitat in the study area and vulnerability to run-on impacts justifies a buffer of 50m to these occurrences, in which further disturbances should be prevented or minimised. The extent of these buffers and permissible land use within these buffers is discussed in subsequent sections of this report.

5.2 Threatened Fauna

The threatened fauna species of the study area may be broadly grouped and prioritised according to the presence and quality of key resources for each species within the study area. The presence of numerous hollow-bearing trees, particularly in the eastern half of the study area, offers known and potential breeding and shelter resources for a number of threatened fauna species, and is one of the key fauna habitats within the study area. The constraints relating to threatened fauna species are discussed below. In this discussion, fauna are grouped according to their reliance on hollow-bearing trees, as most of the threatened fauna species of the study area are reliant upon tree hollows at some stage in their life cycle, and this single resource adds substantially to the threatened fauna and general biodiversity and values of the study area.

The suite of threatened hollow-dependant fauna species of the study area persist in this disturbed environment because of their tolerance to various levels and types of disturbance, their mobility, and their predominate use of canopy and sub-canopy resources. Given these

attributes, it is likely that appropriate management of these habitats could sustain these species and their key resources together with some residential development.

5.2.1 Hollow-dependent threatened fauna

Yellow-bellied Glider

Yellow-bellied Gliders, or evidence of the species, were recorded throughout most of the study area. The home range of one family group appears to be centred within the study area, and parts of the study area may also be used by neighbouring glider groups. Targeted stag-watching surveys revealed a number of den trees used by the species in the eastern half of the study area. Further hollow-bearing trees are also expected to be used by the species within the study area. No evidence of breeding was recorded, although this is expected given the suitability of hollow-bearing trees and presence of key habitat resources. Forty eight trees used by the species for sap-feeding (all Red Bloodwood) were located in the central, northern and south-eastern portions of the study area. Sap trees are generally considered key foraging resources for this species. Other portions of the study area are also likely to be used for foraging and dispersal. Suitable habitat for the species adjoins the study area to the north, east and west. Most forest to the south is highly disturbed and fragmented, but some sections appear to offer suitable foraging habitat and dispersal routes.

In order to maintain viable habitat for this species, key resource trees (known den trees and sap-feeding trees), potential den trees (large hollow-bearing trees) and other trees which provide connectivity and foraging resources, would need to be protected. A 50m vegetated buffer should be applied to known den trees and sap-feeding trees, in which further disturbances should be minimised or managed via appropriate prescriptions. Hollow-bearing trees potentially suitable as den sites for the species, should be retained and buffered by 20m, with similar restrictions on further clearing within this buffer. Some less-prescriptive restrictions would also be required for much of the forested areas within the study area to maintain additional foraging habitat and to maintain connectivity between on-site resources and habitat adjacent to the study area.

Threatened microchiropteran bats

Two threatened hollow-dependent microchiropteran bat species were recorded during targeted surveys: the Greater Broad-nosed Bat and the East Coast Freetail Bat. Both species were detected via the analysis of echolocation calls at various locations and could be expected to forage throughout most of the study area, as suitable foraging habitat is present. Although no roosting sites were located during stag-watching surveys, many larger trees provide suitable breeding resources for these species, and other threatened hollow-roosting microchiropterans such as the Eastern False Pipistrelle. None of these species are expected to be restricted to the study area, as all are likely to forage over large areas, and large areas of suitable foraging habitat are available elsewhere in the locality including Tomerong and Yerriyong State Forests,

Jervis Bay National Park, Woollamia Nature Reserve and extensive tracts of retained forest on privately owned lands.

In order to preserve potential communal roosting and/or breeding sites, most large trees with hollows should be retained and buffered from further canopy disturbance by 20m. Some foraging habitat should ideally be sustained by retaining relatively large patches of intact forest and/or scattered trees throughout the study area.

Cockatoos

The study area contains important habitat for two threatened cockatoo species, the Gang-gang Cockatoo and Glossy Black-cockatoo. A nest of the Gang-gang Cockatoo in a large hollow-bearing tree was located near the centre of the study area. Up to three pairs of Gang-gang Cockatoos were observed in the study area during the breeding season, but only one pair was found to nest within the study area. The nest tree is located close to an un-maintained road and an occupied building, but further disturbances to this nesting site should be avoided in order to maintain the viability of the resource, as the species is likely to show some fidelity to this nest tree and use it on other occasions. Further disturbances within 50m of the nest tree should be avoided or minimised. A secondary consideration is the maintenance of other nesting resources for the species in the study area. Wherever possible, all trees containing medium to large hollows within the study area should be retained and buffered from further disturbances by 20m. Foraging resources for this species, primarily seeds from eucalypts and acacias, occur widely within the study area and surrounding areas. A proportion of the foraging resource within the study area should be sustained by retaining patches of forest containing these resources and/or scattered foraging resources (trees & large acacias) throughout the site.

The Glossy Black-cockatoo was regularly detected during surveys and the study area contains important foraging habitat for this species. A total of 139 Black She-oaks displaying evidence of Glossy Black-cockatoo feeding were located over much of the study area, but were particularly concentrated in the south-east. It is expected that many additional Black She-oaks would also be used for foraging. Evidence of foraging generally corresponds with the distribution of mature Black She-oak trees, so additional foraging trees for the species are likely to occur within the general vicinity of the foraging areas already identified. All She-oak trees used by the species for foraging should be retained and buffered from further disturbances by 20m. This buffer distance would be likely to incorporate other mature She-oaks as potential foraging resources and allow for some recruitment of Black She-oaks as longer term foraging resources.

The Glossy Black-cockatoo was not recorded breeding within the study area despite targeted breeding surveys. In a previous survey within the study area, Burcher (1997) observed a pair of Glossy Black-cockatoos apparently investigating a nesting hollow, but did not record any further evidence of breeding. Many of the hollow-bearing trees provide suitable nesting resources for the species, and it is considered possible that the species may use the study area for nesting in

the future. To maintain this potential nesting resource, most large trees with medium to large hollows should be retained and protected from further disturbance by a 20m buffer.

Large Forest Owls

The study area contains suitable habitat for three threatened forest owl species: the Powerful Owl; Masked Owl; and Sooty Owl. None of these species were recorded breeding within the study area.

The Powerful Owl was not recorded during the survey period, although the study area provides suitable foraging habitat as a range of prey species (arboreal mammals and birds) were recorded. This species is expected to forage within the site on occasions, but the study area does not appear to provide particularly important habitat. Sheltered roosting resources for the species are now marginal because of the disturbances associated with clearing and wildfire. While some tree hollows are suitable as nesting sites for the species, the lack of associated roosting resources and the presence of a range of disturbances, suggests the study area no longer contains suitable nesting habitat. The survey period overlapped with the breeding period of this species and no evidence of breeding was detected. Under these circumstances, a lower-level consideration for this species would be the retention of some prey habitat, primarily for arboreal mammals.

The Masked Owl was detected once during the survey period, adjacent to the north-eastern corner of the study area. Foraging habitat within most of the study area appears to be of lower quality for this species given the high level of understorey clearing, relatively poor trapping rates of potential prey species (terrestrial mammals), and the lack of records of the species within the study area. Many tree hollows within the study area are suitable as roosting and possibly nesting sites, although the amount of human disturbance throughout the study area may render nesting sites marginal or unsuitable. Thus, the species is perhaps most likely to use the study area for roosting on occasions. The fact that no individuals were seen nor dusk calls (indicating a potential roosting site) heard within the study area suggests that the study area comprises potential, although not important, habitat for roosting and possibly foraging and nesting. To maintain the key resource for this species, large trees and stags with hollows, particularly chimney-type hollows, should be retained and buffered from further disturbances by a minimum of 20m.

The Sooty Owl was recorded in the south of the study area on one occasion via several dusk calls, suggesting the presence of a roosting site, almost certainly within a tree hollow. The study area contains many suitable roosting sites within tree hollows for this species. Many hollow-bearing trees also constitute potential nesting resources, although disturbances throughout the study area may now render most potential nesting sites as marginal or unsuitable. Suitable foraging habitat is present for this species, as it utilises a more general foraging technique than the other two large forest owls, and will take terrestrial and arboreal mammals. Arboreal mammals would appear to provide the main prey base for this species within the study area due

to the reasons outlined above. Thus, the key resources within the study area for this species are medium to large tree hollows and arboreal prey species habitat. The majority of large hollow-bearing trees should be retained within a 20m buffer which minimises further disturbances. This would maintain potential roosting and breeding trees and also key sheltering/breeding habitat for prey species. A range of other trees should also be retained in order to provide additional prey habitat and future hollow-bearing trees.

5.2.2 Non-hollow-dependent threatened fauna

Threatened fauna species of the study area which are not hollow-dependent can be further considered in two groups according to their use of habitats within the study area, those which occupy a permanent, constrained but potentially important area of habitat (Eastern Bristlebird), and those which forage widely throughout most of the study area on a seasonal basis, but do not breed or reside permanently within the study area.

Eastern Bristlebird

The Eastern Bristlebird was found to occur in the extreme north-east of the study area, primarily in association with the dense shrub layer of the Large-fruited Red Mahogany Swamp Forest. The Eastern Bristlebird was also detected within this habitat to the northwest and east of the study area. The primary Eastern Bristlebird habitat within the study area occupies only 1.84 ha, but may contain foraging, sheltering and breeding resources. The Eastern Bristlebird is also expected to utilise adjacent areas of Scribbly Gum-Red Bloodwood Woodland to forage. An undisturbed vegetated buffer of 50m should be applied to the Large-fruited Red Mahogany Swamp Forest, which is the primary habitat for the Eastern Bristlebird within the study area.

Square-tailed Kite/Grey-headed Flying-fox

The Square-tailed Kite and Grey-headed Flying-fox both forage in the canopy and sub-canopy throughout the study area on an occasional basis as part of their extensive foraging ranges. Neither species was recorded breeding within the study area. The Square-tailed Kite is a migratory species which occurs in the area mainly over summer. The Grey-headed Flying-fox forages in the study area on nectar from trees and large shrubs when key species are in flower. While it is desirable to maintain as much of the canopy foraging resource as possible, these species are able to utilise foraging resources in disturbed landscapes and have access to extensive areas of foraging resources beyond the study area. The retention of areas of forest or even scattered trees within the study area is likely to maintain some foraging habitat for these species. The preferential retention of summer flowering trees such as Red Bloodwood, is likely to benefit both species, as such trees will maintain important foraging resources for the Grey-headed Flying-fox and maintain an important foraging resource for prey species of the Square-tailed Kite.

Although not detected during the surveys period, two species of threatened, non-hollow-dependant microchiropterans, the Eastern Bentwing Bat and the Large-eared Pied Bat, are also

expected to forage within the study area on occasions. These species also utilise the tree canopy (or gaps within it) for foraging as part of extensive foraging areas. Their prey base of insects would similarly be sustained by the retention of vegetation within the study area, particularly summer flowering trees such as Red Bloodwood.

5.3 Endangered Ecological Communities

The *Swamp sclerophyll forest* endangered ecological community occurs in two discrete locations within the study area. In the north-eastern corner it occurs as Large-fruited Red Mahogany Swamp Forest, within part of what is anticipated to be a larger occurrence associated with this east-flowing drainage line. This occurrence appears to have been subjected to low levels of disturbance. In the south-west of the study area, this endangered ecological community occurs as Melaleuca-Bangalay Swamp Forest in association with an unnamed drainage line which flows to the south of the study area. Parts of this community have been extensively disturbed by clearing.

Both occurrences of the *Swamp sclerophyll forest* endangered ecological community should be retained, and protected by a vegetated buffer of approximately 50m, in which further disturbances should be avoided or minimised. Some areas of the endangered ecological community and buffer should be revegetated. The extent of these buffers and permissible land use within these buffers is discussed in subsequent sections of this report.

5.4 Habitat Corridor and Connectivity

Two types of habitat corridors exist in the study area:

- canopy connectivity mainly for arboreal mammals and birds throughout much of study area, although most importantly in the west and southwest; and
- a relatively small, but important, area of riparian corridor in the north-east corner of the study area.

Generally, the disturbed forest habitat within the study area functions as a corridor for highly mobile species such as birds and some mammals (gliders and bats). It is highly desirable to maintain at least part of this functionality through some areas of the study area. This could be achieved through the retention of habitat for other constraints identified in this report, together with appropriate low intensity development. The most desirable configuration for retention of disturbed corridor components is one which maximises connectivity with adjoining wildlife habitat such as the area in the south-west of the study area (see Figure 6).

Forest in the south-west and west of the study area should be preferentially retained as it currently forms a key component of a relatively intact habitat corridor extending to the south.

Lots 97-100 DP 11629 in the north-east of the study area, which contain part of the habitat corridor identified in the Jervis Bay Regional Environment Plan, should be excluded from any

future development. These four lots generally encompass the creek line, associated riparian vegetation mapped as Large-fruited Red-Mahogany Swamp Forest (comprising the *Swamp sclerophyll forest* endangered ecological community) and an appropriate vegetated buffer to the core riparian corridor. Lot 97 does not form part of the recognised habitat corridor, but contains the same constraints as Lots 98-100 in the northern half and a relatively high number of trees with hollows in the southern half.

5.5 Synthesis of Ecological Constraints

The analysis above has identified a number of different types of ecological constraints to the rezoning of the study area as depicted in Figure 7 (Appendix A) including:

- a) specific resources or key habitat (eg. den trees, feed-trees) known to be used by threatened fauna species;
- b) potential key resources (eg. large trees with hollows) for threatened and non-threatened fauna;
- c) occurrences of threatened flora;
- d) occurrences of an endangered ecological community;
- e) general habitat and corridor areas; and
- f) various vegetated buffers to key habitats.

Ecological Constraint Buffers

The provision of fully vegetated or partially vegetated buffers around key habitats plays an important role in sustaining these resources in the longer term. The various buffer widths and management prescriptions applied to each buffer have been determined by a number of factors including the conservation significance of the resource, the likely impacts and/or threats to the resource, and the specific functions or objectives of the buffer, as set out below:

- A 50m buffer vegetated with canopy trees has been applied to the nest tree of the Gang-gang Cockatoo to minimise further disturbances close to this tree, so that the resource can continue to be used as a nest site in the future. This species is known to retain at least some fidelity to nesting sites over successive breeding seasons. Monitoring the use of this nest tree during subsequent breeding seasons would provide data regarding the tree's importance to the species relative to other large hollow-bearing trees in the general area. No increases in human activity should be permitted within this buffer, including dwellings, other structures and upgrading of the adjacent un-maintained road. This is likely to require the realignment of this road as future increases in residential intensity within the study area will result in higher traffic levels. Maintaining the current level of vegetative disturbance within the buffer for bushfire asset protection purposes is considered acceptable, as long as maintenance of the asset protection zone is undertaken outside of the October to January breeding season.

- A 50m buffer vegetated with canopy trees has been applied to known den trees of the Yellow-bellied Glider, as these resources are crucial shelter sites and potentially breeding sites. Den trees may be used regularly and a number may be required to sustain a family group of gliders. These buffers act to minimise further disturbances in proximity to these resources and ensure that other trees within 50m of known den sites are retained to maintain connectivity to and from den trees. Connectivity for this species also needs to be maintained beyond these buffers. Some asset protect zones may be established and maintained within these buffers, as long as adequate canopy trees and recruitment trees are retained to provide connectivity to adjoining areas of habitat. It is also important to control the intensity of recreational uses within these buffers so that substantial increases of such uses (for example construction of a motorbike track) do not occur.
- A 50m managed buffer vegetated with canopy trees has been applied to Yellow-bellied Glider sap-feeding trees primarily to ensure access for the gliders is maintained to these key resources and that inappropriate development does not render the resource unusable. Retained trees within the buffer are also likely to function as additional (non-sap) foraging resources for the species, potential sap-tree resources and allow recruitment trees for connectivity and foraging. Connectivity for this species also needs to be maintained beyond these buffers. It is considered feasible to permit development including dwellings, other structures, asset protection zones and roads within this buffer, as long as the development does not compromise the key objective of this buffer, which is to enable continued use of these resources by protecting the feed-trees themselves and ensuring adequate canopy trees and recruitment trees are retained to provide long-term connectivity with adjoining areas of habitat. Apart from asset protection zone establishment and maintenance using hand tools only, no development should occur within the drip-line of any feed-tree and no buildings should be constructed within 20m of any feed tree. Development should preferentially be located as far away from feed-trees as possible.
- A 50m undisturbed buffer with all vegetation strata intact has been applied to occurrences of *Swamp sclerophyll forest* and *Melaleuca biconvexa* because of the conservation significance of the endangered ecological community, the restricted habitat of both constraints, and their association with drainage lines, which increases the potential for adverse impacts such as weed invasion and changes to hydrological and nutrient regimes. These buffers will provide for the potential of *Melaleuca biconvexa* and species associated with the *Swamp sclerophyll forest* to expand their current occurrence, which in some areas has been reduced by clearing. Vegetated buffers also provide habitat for the pollinators of key species, enhance the ecological function and composition of the ecological community and the paperbark population, and minimise the potential for edge effects to degrade these core areas. Generally, no development or activities should be permissible within these buffers, which should be revegetated

where current disturbances exist. In particular, the part of Inglewood Crescent west of Glen Street will need to be intensively rehabilitated as it lies within the *Swamp sclerophyll forest*. It may be possible to reduce the width of parts of these buffers to retain the use of existing un-maintained roads which pass through the buffers, specifically along Invermay Avenue and Inglewood Crescent to the east of Glen Street.

- A 50m undisturbed buffer with all vegetation intact has been applied to occurrences of the endangered Eastern Bristlebird and core habitat for this species because of its high conservation significance and requirement for dense shrub layer vegetation. The core habitat buffer for the Eastern Bristlebird overlaps with the 50m undisturbed buffer to the Swamp Sclerophyll Forest endangered ecological community in the north-east of the study area.
- A 20m buffer vegetated with canopy trees has been applied to large trees with hollows, which represent an important fauna resource and potential habitat for a range of threatened fauna, to ensure the root zones of these trees are not damaged, to maintain some connectivity to and from these trees by the Yellow-bellied Glider, and to prevent development occurring at a proximity which is likely to compromise the future use of these resources. The outer protection areas of asset protection zones may be established and maintained within the outer 10m of this buffer if they do not substantially affect the objectives of the buffer.
- A 20m managed buffer has been applied to known Glossy Black-cockatoo feed-trees to ensure that the trees, including root zones, are not inadvertently damaged by future development, and to retain some additional Black She-oaks as potential foraging, recruitment and pollination resources. Asset protection zones may be established and maintained within this buffer if they do not substantially affect the objectives of the buffer. The construction of dwellings and other structures should not be permitted within this buffer. Roads and property access may be permitted within the outer 15m of this buffer. In all cases, other female Black She-oaks within these buffers should be retained wherever possible, at densities appropriate for the associated land uses. Beyond these buffers, Black She-oaks should be retained preferentially throughout the study area where possible.

Ecological Constraint Categories

The categorisation of ecological constraints can assist with the identification of appropriate planning strategies to protect and sustain the integrity of ecological infrastructure in the long-term. This categorisation depends on a combination of factors including the conservation significance of the ecological constraint, its function in the ecological landscape, and the potential for impacts on the constraints arising from future uses in its vicinity.

These ecological constraints have been categorised into high, moderate-high, moderate and low levels in Figure 7 (Appendix A) according to their conservation values relating to the study

area and its landscape context. A brief description of the ecological resources associated with each constraint category is given below.

A high level of constraint was applied to endangered ecological communities, key habitat for endangered species (Eastern Bristlebird), key breeding resources for vulnerable fauna species (Gang-gang Cockatoo nest tree and Yellow-bellied Glider den trees), habitat corridor areas identified in the JBREP, and occurrences of the vulnerable flora species *Melaleuca biconvexa*. Occurrences of *Melaleuca biconvexa* were given the highest constraint category because of the species' limited habitat requirements and association with drainage lines, which make the species vulnerable to a range of disturbances within the catchment area. A high level of constraint has also been applied to buffers around endangered ecological communities, endangered species habitat and *Melaleuca biconvexa*.

A moderate-high level of constraint was applied to buffers of endangered species and communities or their key habitat, key foraging resources for vulnerable species (identified feed-trees of the Yellow-bellied Glider and Glossy Black-cockatoo) and their respective buffers, key local habitat corridor areas and potential breeding and sheltering resources for vulnerable species (large trees with hollows). Large trees with hollows were considered a moderate-high level constraint due to the relatively large number of hollow-dependent threatened fauna species which are known or likely to utilise the area (and thus potentially these trees) and the general biodiversity and habitat value these trees would sustain.

A moderate level of constraint was applied to the remaining native vegetation within the study area because it comprises foraging habitat for a number of vulnerable fauna species (particularly the Yellow-bellied Glider) and provides canopy habitat corridors through the study area for a range of species including threatened species.

A low level of constraint was applied to areas which have been so heavily disturbed that they currently offer little in the way of flora or fauna habitat values.

6. POTENTIAL DEVELOPMENT OPTIONS

Based on the analysis of the ecological constraints identified above, two options have been developed for rezoning of parts of the study area to residential uses. Both options involve the retention of substantial areas of habitat to maintain key biodiversity values and a reduction in the number of developable lots.

In developing these options consideration has also been given to the potential for the new local environmental plan to receive biodiversity certification pursuant to Part 7, Division 5 of the *Threatened Species Conservation Act 1995*, which would simplify the future assessment of development applications in the study area by removing the need to assess individual applications for their impacts on flora and fauna.

It should be noted that Council's preferred development option of one dwelling per existing allotment would remove or disturb most of the vegetation in the study area and is considered inadequate in terms of biodiversity conservation. This option is based on the original subdivision plan of the Estate and is unable to retain adequate areas of habitat to accommodate current ecological constraints or conservation objectives. As the option involves impacts on threatened species, Council would be required to consult with the Director-General of the National Parks and Wildlife Service before preparing a draft local environment plan for the area pursuant to Section 34A of the *Environmental Planning and Assessment Act 1979* and BES is of the opinion that this agency would be unlikely to support such impacts.

This option would be unable to achieve biodiversity certification of the local environment plan pursuant to Part 7, Division 5 of the *Threatened Species Conservation Act 1995*, as a basic tenet of the certification is an overall improvement or maintenance of biodiversity values. While not essential, the benefits of biodiversity certification for a local environment plan include the assumption that development and activities which are consistent with the plan will not significantly affect any threatened species, populations and ecological communities or their habitats.

Council's preferred option is not an option that is recommended in this report. BES is of the opinion that the two potential development options recommended for consideration have the potential to be supported by the Director-General of the National Parks and Wildlife Service and possibly achieve biodiversity certification as discussed below.

Option 1 – Minimum lot size of two hectares throughout the study area.

This option combines rural residential development and habitat retention throughout the study area and involves the amalgamation of existing lots into lots of at least two hectares in size. The minimum lot size is based on the assumption that bushfire asset protection zones of up to 40m will require a disturbance area of approximately one hectare for each new dwelling, so that at

least 50 percent of the vegetation on each minimum two hectare lot will be retained for biodiversity conservation.

Retention of blocks of undisturbed vegetation on each lot will allow for regeneration of all vegetative strata without the need for specific management actions, particularly with respect to the future recruitment of trees and other flora species. Recruitment of trees and other flora species, involving the identification and monitoring of recruitment trees and other vegetation, would have been a problematic ongoing management issue for each allotment if amalgamation and general vegetation retention were not included in this option. Option 1 also requires the retention of some mature trees, some hollow-bearing trees and/or some feed-trees of threatened species within asset protection zones in each lot at densities that accord with asset protection zone specifications.

The final shapes and sizes of such lots will need to take into account the distribution of key constraints and highly disturbed vegetation throughout the study area so that dwellings, associated structures and asset protection zones can be located in areas of least ecological constraint, and habitat of high conservation value within each property can be retained. In preparing a layout for this option, consideration will also need to be given to the distribution of retained vegetation throughout the study area to ensure retained habitat is not isolated and continues to provide connectivity and corridor functionality.

As much as possible, this option should be designed in accordance with the recommended management of ecological constraints outlined elsewhere in this report. However, this approach will necessitate the removal of some key fauna resources and encroachment into the recommended buffers of some other key resources. The areas of endangered ecological communities and threatened plants should not be disturbed for residential purposes, and lot sizes in the proximity of these constraints will need to be substantially larger if these habitats are to be contained within individual properties. In particular, areas of high ecological constraint associated with endangered ecological communities and threatened flora species, (Figures 5 & 7 Appendix A), may need to be retained in single contiguous holdings to avoid the need for boundary fences within these areas.

Existing un-maintained roads which occur within areas of moderate-high level constraint may be upgraded if this does not substantially affect the buffer objectives for these areas.

This approach would also maintain some consistency in the context of lot sizes on adjoining lands, as properties to the south and west of the study area are generally a minimum of two hectares in size.

Overall, this option could be designed to retain the majority of key resources and habitat for threatened species and communities and achieve the minimum requirements for conservation of these species and communities in the long term.

Option 2 – Division of study area into one zone primarily for habitat retention and one zone primarily for residential development.

This option (Figure 8, Appendix A) retains the southern and eastern sides and central portion of the study area primarily for habitat conservation and generally allows the remainder of the study area to be developed for residential purposes more intensively than Option 1.

Option 2 retains most high level constraints within a relatively continuous area which contains the majority of high value habitat in the study area. Very low density residential development (for example up to five dwellings) could be permitted within this zone without substantially affecting conservation values. Such development would need to be situated within areas of least ecological constraint to maintain key threatened species habitat and connectivity. This is likely to require the relocation or removal of existing, unauthorised, substantially-commenced dwellings, as the establishment of asset protection zones around these dwellings is likely to result in substantial impacts to threatened species habitats.

The remainder of the study area, generally the north-west, has overall lower levels of ecological constraints, and would contain the main areas of residential development.

The loss of threatened species habitat and key resources in the north-west resulting from Option 2 is at least partially offset by the greater level of habitat retention in the remainder of the study area. However, this option may be unable to achieve biodiversity certification if the north-western section were intensively developed without at least some regard for key threatened species habitat within this area. In this respect, all occurrences of Swamp sclerophyll forest, *Melaleuca biconvexa* and most of their respective buffers (high level constraints) would need to be excluded from development. Where existing un-maintained roads which are important to this option pass through these buffers, it may be possible to reduce sections of the buffer to accommodate continued use and upgrading of the roads. In this respect, these buffers could be aligned with the edges of Invermay Avenue in the north and the part of Inglewood Crescent east of Glen Street in the south, as shown in Figure 8 (Appendix A). Other existing un-maintained roads which occur within areas of moderate-high level constraint may be upgraded if this does not substantially affect the buffer objectives for these areas.

The north-western section relating to Option 2 also contains known Yellow-bellied Glider habitat including approximately half of the Yellow-bellied Glider sap feeding trees in the study area, and approximately 30 trees with medium to large hollows (approximately 15% of the total number of trees with similar sized hollows). Connectivity to the adjoining habitat corridor in the north and west would be substantially reduced by intensive development of this part of the study area. Hence, Option 2 may be unlikely to meet the minimum requirements for long term conservation of the Yellow-bellied Glider and Gang-gang Cockatoo without the retention of key habitat features for these species.

It may be possible to retain some of these key fauna resources by amalgamating some lots which are affected by moderate-high level constraints (Figure 8, Appendix A), allowing key feed trees or habitat trees to be retained within lots, along with linear sections of vegetation (containing mature trees and recruitment trees) or otherwise appropriately spaced canopy and recruitment trees to maintain connectivity between these resources and adjoining habitat for the Yellow-bellied Glider. Roads would need to be sensitively designed in proximity to key habitat trees and relocated further away from the Gang-gang Cockatoo nest tree to provide an adequate buffer to increased traffic levels.

Other areas in the north-west of the study area could support more intensive residential uses with much smaller lot sizes if necessary, as long as proposed subdivision layouts comply with the bushfire and ecological constraints identified. The final design of this option should be refined in consultation with the Department of Environment and Conservation (DEC) if biodiversity certification is sought.

7. CONCLUSIONS

This report describes the biological environment of land within Jerberra Estate, Tomerong, determines the conservation significance of the flora and fauna species and habitats recorded there, and makes recommendations for maintaining the study area's key biodiversity values.

Ten threatened fauna species and one threatened flora species listed on the schedules of the *NSW Threatened Species Conservation Act 1995* or the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* were detected during the survey period.

One endangered ecological community listed on the schedules of the *NSW Threatened Species Conservation Act 1995*, was detected within the study area. No endangered populations are present within the study area.

The study area does not contain any potential Koala habitat pursuant to *NSW State Environmental Planning Policy No 44 – Koala Habitat Protection*.

It is considered possible to maintain the key biodiversity values of Jerberra Estate while permitting some residential development. This would involve the retention of substantial areas of habitat for conservation purposes and the amalgamation or reconfiguration of lots to allow residential development to occur in conjunction with biodiversity conservation objectives and controls. Two potential options for development have been developed. The final design and prescriptions of either of these options could be refined in conjunction with DEC if biodiversity certification of the Local Environment Plan for the area is sought.

A number of strategies have been recommended to maintain the key biodiversity values of the study area and to inform the rezoning process. These strategies should mitigate the effects on threatened species or their habitats of rezoning parts of the study area for residential purposes, and minimise the impacts of rezoning on the flora and fauna values of the study area in general. It is suggested that the specific recommendations in this report form the basis of biodiversity conservation objectives and controls within any Local Environmental Plan prepared for Jerberra Estate.

8. RECOMMENDATIONS

A number of recommendations to preserve the key biodiversity values of the study area are outlined below.

General

1. Appropriate biodiversity conservation objectives and controls for various proposed zones within study area should be developed and met by any future development. Specific recommendations 4-10 set out below should be used as the basis for establishing these objectives and controls as they set the minimum habitat requirements for sustaining threatened species, populations and ecological communities or their habitats.
2. The future development of the study area should generally accord with Option 1 or Option 2 as described in section 6 of this report.
3. Shoalhaven City Council should consider seeking biodiversity certification for any future local environmental plan over the study area.

Significant vegetation

4. Occurrences of the endangered ecological community *Swamp sclerophyll forest* should be protected from any further disturbances and ideally protected by a 50m buffer of undisturbed vegetation with all strata intact. The 50m buffer on the endangered ecological community in the north-east of the study area also forms a buffer to core Eastern Bristlebird habitat. The buffer could potentially be reduced and aligned with the edge of the part of Inglewood Crescent east of Glen Street to permit continued use of the existing road. No other development or activities should be permissible within these buffers, which should be revegetated where current disturbances exist. In particular, the part of Inglewood Crescent west of Glen Street will need to be intensively rehabilitated as it lies within the *Swamp sclerophyll forest* and an area containing *Melaleuca biconvexa*.
5. Occurrences of the vulnerable *Melaleuca biconvexa* should be protected from any further disturbances and ideally protected by a 50m buffer of undisturbed vegetation with all strata intact. The buffer could potentially be reduced and aligned with the edge of Invermay Avenue to permit continued use of the road. No other development or activities should be permissible within these buffers, which should be revegetated where current disturbances exist.

Fauna and fauna habitat

6. The known nest tree of the Gang-gang Cockatoo should be retained and protected from further disturbance by a 50m buffer vegetated with canopy trees. No increases in human activity should be permitted within this buffer, including dwellings, other structures and upgrading of the adjacent un-maintained road. This is likely to require the realignment of this road as future increases in residential intensity within the study area will result in higher

traffic levels. Maintaining the current level of vegetative disturbance within the buffer for bushfire asset protection purposes is considered acceptable, as long as maintenance of the asset protection zone is undertaken outside of the species' October to January breeding season.

7. The known den trees of the Yellow-bellied Glider should be retained and protected from further disturbance by a 50m buffer vegetated with canopy trees. Some asset protect zones may be established and maintained within these buffers, as long as adequate canopy trees and recruitment trees are retained to provide connectivity to adjoining areas of habitat. It is also important to control the intensity of recreational uses within these buffers so that substantial increases of such uses (for example construction of a motorbike track) do not occur.
8. Large trees with hollows, which act as potential nest, den and roost trees for the Yellow-bellied Glider, threatened cockatoos, large forest owls and microchiropteran bats, should be retained and buffered from further disturbance by 20m of vegetation comprising canopy trees. The outer protection areas of asset protection zones may be established and maintained within the outer 10m of this buffer if they do not substantially affect the objectives of the buffer.
9. Sap-feeding trees incised by the Yellow-bellied Glider should be retained and protected from further disturbances. No dwellings or other structures should be permitted within 20m of any feed-tree. Within a 50m radius of each feed tree, an adequate amount and distribution of mature canopy trees and younger recruitment trees should be retained to enable the continued use of sap-feeding trees by this species and to ensure long-term connectivity with adjacent areas of habitat. Asset protection zones and roads may be established and maintained within the buffer as long as the above buffer objectives are met and heavy machinery is not used within the drip-line of any feed-tree. Development should preferentially be located as far away from feed-trees as possible.
10. Canopy trees should be retained at an appropriate density to allow for movement by the Yellow-bellied Glider to access the resources outlined above and to maintain connectivity to other habitat in the study area.
11. Black She-oak feed-trees used by the Glossy Black-cockatoo should be retained and protected from further disturbances by a 20m managed buffer. No dwellings or other structures should be permitted within this buffer. Where necessary, roads and property access may be permitted within the outer 15m of this buffer. Wherever possible, additional mature and immature female Black She-oaks should be retained within these buffers as additional foraging resources and recruitment trees, at densities appropriate for the associated land use. Asset protection zones may be established and maintained within these buffers as long as the above buffer objectives are met and heavy machinery is not

used within 5m of any feed-tree. Development should preferentially be located as far away from feed-trees as possible.

12. Female Black She-oaks should be preferentially retained and also used within landscaping throughout the study area wherever possible as additional foraging resources for the Glossy Black-cockatoo.
13. Three lots in the north-east of the study area (Lots 98-100 DP 11629) should not be zoned for residential uses as they form part of a habitat corridor pursuant to Clause 14 of the Jervis Bay Regional Environmental Plan and contain important riparian corridor habitat. This riparian habitat also constitutes the endangered ecological community *Swamp sclerophyll forest* and primary habitat for the Eastern Bristlebird.
14. Existing un-maintained roads which occur within areas of moderate to high level constraints may be upgraded to accommodate continued use if the upgrade and subsequent increase in traffic levels do not substantially affect the objectives of the relevant buffer/s.

9. GLOSSARY

AnaBat	A type of electronic bat detector used to convert the usually inaudible echolocation calls of insectivorous bats into audible electronic signals, which can then be recorded and analysed to assist with identifying bat species.
Arboreal	Living in trees.
Biodiversity	Biological diversity – the variety of all living organisms.
Bioregion	A relatively large area defined by broad geophysical features and environmental processes. A relatively large area shares roughly similar climatic, geological and ecological communities. The Shoalhaven forms part of the Sydney Basin Bioregion which stretches from Nelson Bay to almost Batemans Bay and almost out to Mudgee.
Call playback	A fauna survey technique whereby recorded vocalisations or calls of certain species are broadcast via a speaker in an attempt to elicit a response from the target species.
Diurnal	Active by day.
Echolocation call	High frequency sound waves emitted by insectivorous bats in order to navigate and forage. Typically inaudible to the human ear, these calls can be recorded via specific equipment and analysed to identify the species of bat.
Elliott trap	A type of collapsible aluminium box-trap of approximately 30cm x 10cm x 8cm for the live capture of mammals.
Endangered ecological community	An ecological community in immediate danger of becoming extinct and listed as endangered in Part 3 of Schedule 1 of the TSC Act or the EPBC Act.

Endangered species	A plant or animal species in immediate danger of becoming extinct and listed as endangered in Part 1 of Schedule 1 of the TSC Act or the EPBC Act.
Ephemeral	Temporary or impermanent.
Feed-tree	Tree used for feeding by the Glossy Black-cockatoo or Yellow-bellied Glider.
Floristics	Description of plant species within an area or community.
Foraging	Feeding.
Locality	The area within 5km of the study area.
Microchiropteran	Small insectivorous bats, often termed ‘microbats’.
Migratory	An animal species which moves between areas on a regular seasonal basis. Migratory species listed on the EPBC Act are considered to be of national environmental significance.
Nocturnal	Active by night.
Quadrat	An area of 20m x 20m defined to intensively survey vegetation species and structure.
Riparian	Associated with edges of a creek or other water body.
Roost	Shelter site for birds or bats, typically in the canopy of a tree, tree hollow or cave.
Stag-watch	Observation of trees with hollows to determine their use by fauna species, typically undertaken at dusk when nocturnal species are emerging from hollows.
Threatened species	Species considered to be at risk of becoming extinct and listed under the TSC Act or EPBC Act. The listing of threatened species incorporates various categories of risk including vulnerable and endangered species.

Transect	A survey line or path used to dissect or sample habitat for flora and fauna surveys.
Vulnerable species	A plant or animal species at risk of becoming endangered and listed as vulnerable on Schedule 2 of the TSC Act or the EPBC Act.

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APPENDIX A: FIGURES

Figure 2: Study area and locations of flora surveys

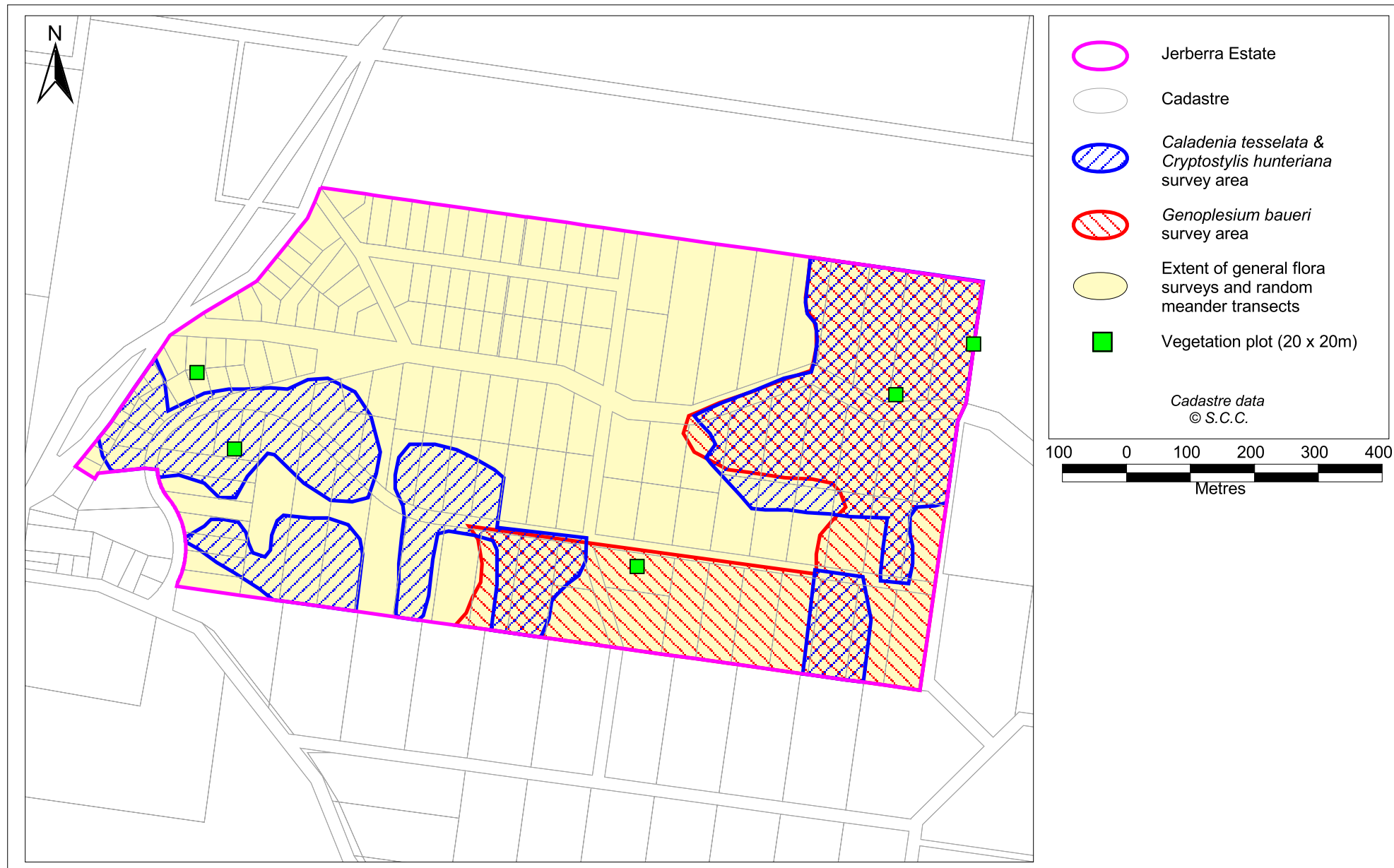


Figure 3: Study area and locations of fauna surveys

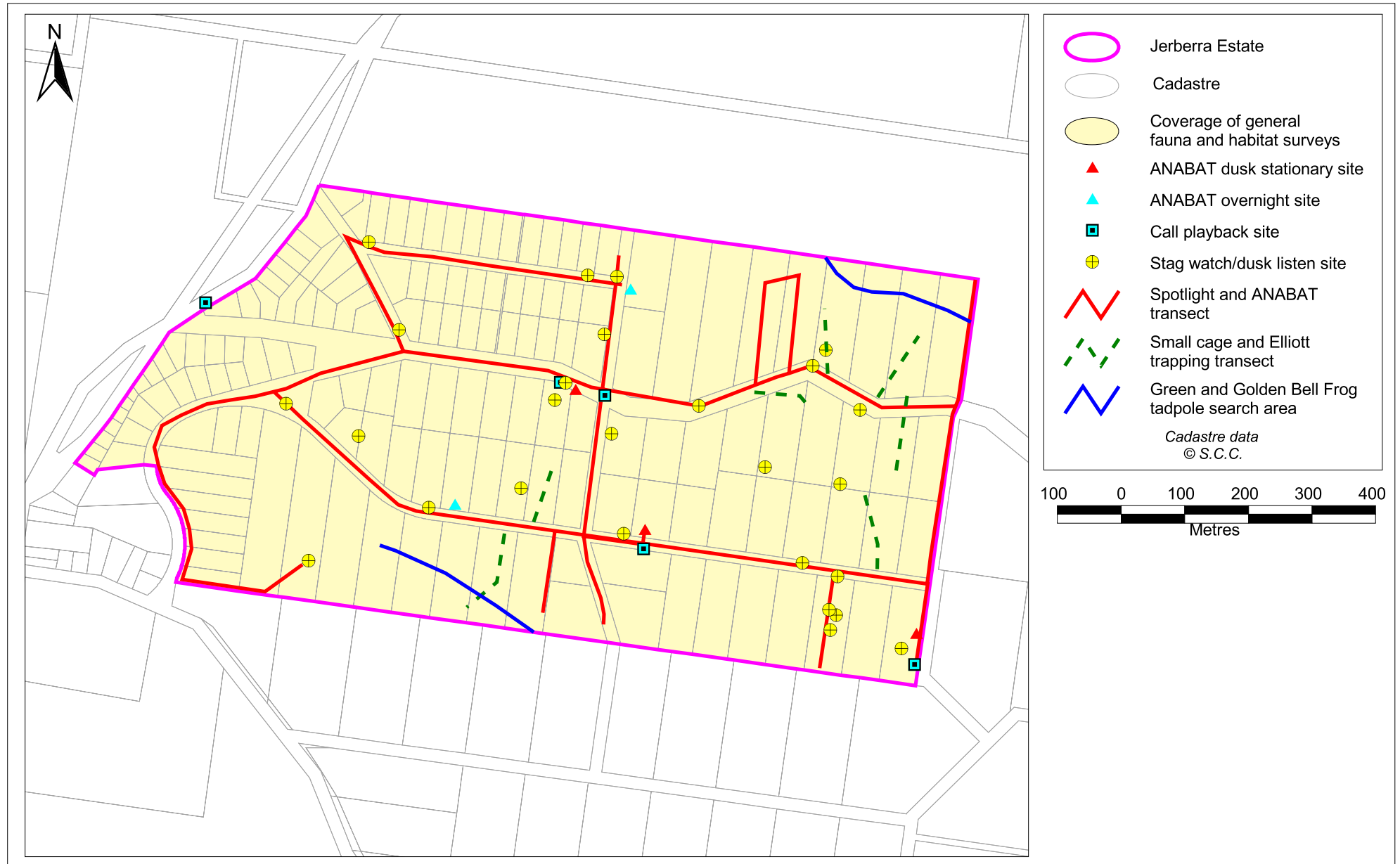
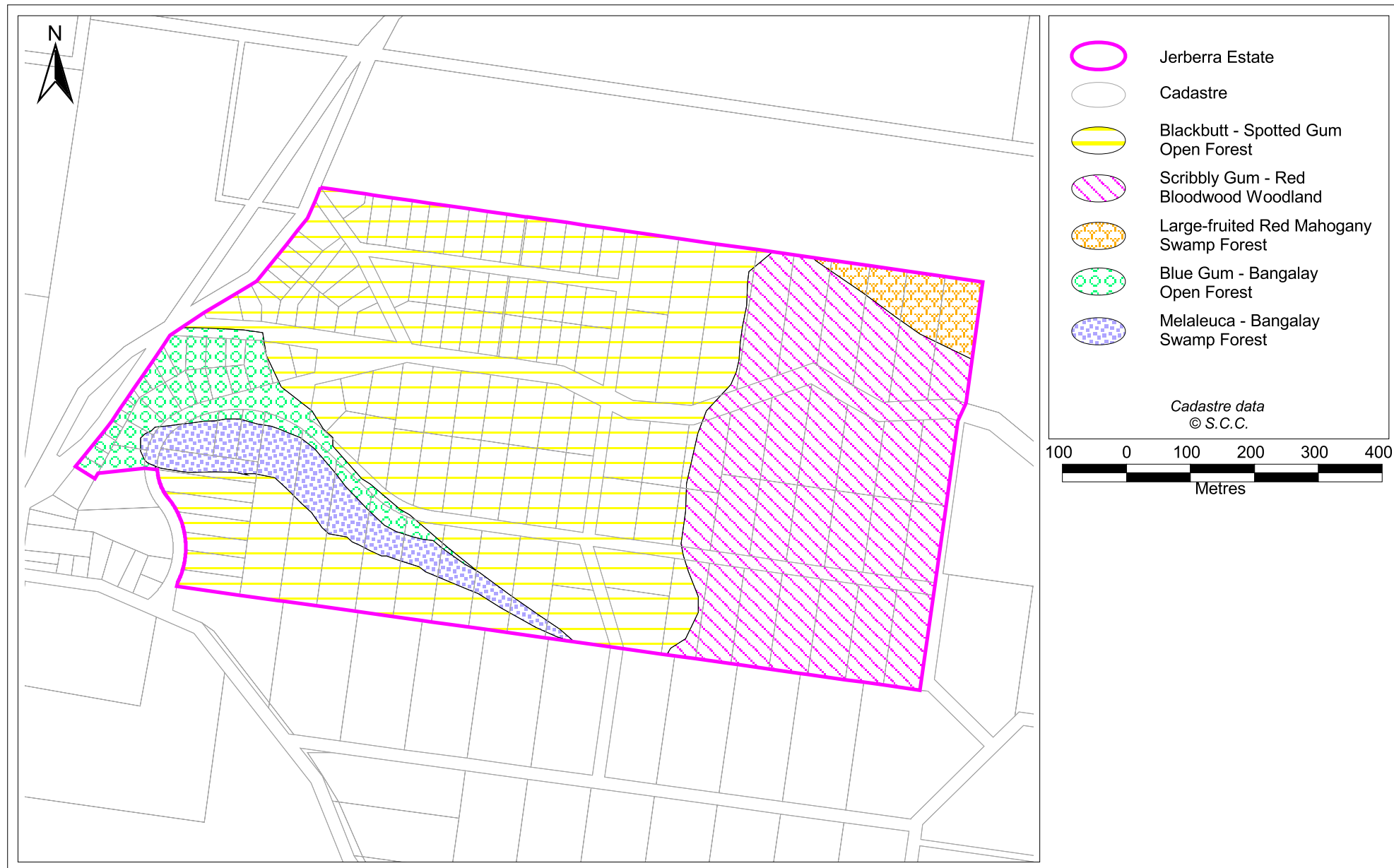


Figure 4: Vegetation of the study area



APPENDIX B:
FINAL DETERMINATION
OF THE
NSW SCIENTIFIC COMMITTEE
FOR THE KEY THREATENING PROCESS

***Invasion of native plant communities by exotic
perennial grasses***

Invasion of native plant communities by exotic perennial grasses - key threatening process declaration

NSW Scientific Committee - final determination

The Scientific Committee, established by the Threatened Species Conservation Act, has made a Final Determination to list the Invasion of native plant communities by exotic perennial grasses as a KEY THREATENING PROCESS in Schedule 3 of the Act. Listing of key threatening processes is provided for by Part 2 of the Act.

The Scientific Committee has found that:

1. A number of exotic perennial grasses including *Cenchrus ciliaris* (Buffel Grass), *Hyparrhenia hirta* (Coolatai Grass), *Eragrostis curvula* (African Lovegrass), *Nassella neesiana* (Chilean Needlegrass) and *Nassella trichotoma* (Serrated Tussock) invade and may dominate native plant communities competing with, and displacing, many native species. Some other perennial grasses (in alphabetical order) that invade smaller areas of native plant communities include *Agrostis capillaris* (Browntop Bent), *Andropogon virginicus* (Whisky Grass), *Chloris gayana* (Rhodes Grass), *Cortaderia* spp. (Pampas Grasses), *Ehrharta erecta* (Panic Veldgrass), *Melinis minutiflora* (Molasses Grass), *Panicum repens* (Torpedo Grass), *Paspalum urvillei* (Vasey Grass), *Pennisetum clandestinum* (Kikuyu), *Phalaris aquatica* (Phalaris), *Setaria sphacelata* (South African Pigeon Grass), *Sporobolus fertilis* (Giant Parramatta Grass), *Sporobolus natalensis* (Giant Rats Tail Grass) and *Urochloa mutica* (Para Grass). Other exotic perennial grasses not specified may, or have the potential to, adversely affect native plant communities and native species.
2. Exotic perennial grasses have been both deliberately and accidentally introduced to New South Wales. *Hyparrhenia hirta* and forms of *Eragrostis curvula* were introduced for soil stabilisation while species such as *Cenchrus ciliaris* and *Phalaris aquatica* have been introduced for pasture. These species as well as accidentally introduced *Nassella neesiana* and *Nassella trichotoma* have spread to become dominant species in some native grasslands and woodlands.
3. The characteristics of vigorous growth, prolific seed production and effective seed dispersal enable many exotic perennial grasses to compete strongly with, or in some places displace, native vegetation. Exotic perennial grasses may also change the fuel load in plant communities. The changed structure and fire regimes of the habitat is likely to adversely impact on both native vertebrate and invertebrate fauna.
4. Dense monocultures of perennial grasses that develop after invasion threaten local vegetation at all sites that are affected. This may result in local and regional declines of many native species and communities, possibly to the extent that they become endangered. Many of the perennial exotic grasses establish following disturbances such as overgrazing, road works and management of roadside areas. Spread of these grasses is often aided by slashing, weed control, forestry and mining operations, movement or addition of fertilisers and nutrients, changes to drainage and fire regimes. Some species, such as *Hyparrhenia hirta*, *Sporobolus fertilis*, *Sporobolus natalensis*, *Nassella neesiana*, *Nassella trichotoma*, and forms of *Eragrostis curvula*, are also considered a problem in pastures. These

grasses are not favoured grazing species and selective grazing results in a rapid increase in numbers of these less palatable grasses.

5. Invasion of native plant communities by exotic perennial grasses is an identified threat to a number of communities listed in Schedule 1 of the Threatened Species Conservation Act including, but not restricted to:

White Box, Yellow Box, Blakely's Red Gum Woodland
McKie's Stringybark/Blackbutt Open Forest in the Nandewar and New
England Tableland Bioregions
Howell Shrublands in the Northern Tablelands and Nandewar Bioregions
Cumberland Plain Woodland

These grasses are also an identified threat to a number of plant species listed in Schedule 1 and Schedule 2 of the Threatened Species Conservation Act, including:

Calystegia affinis
Desmodium camplocaulon
Dichanthium setosum
Digitaria porrecta
Eucalyptus mckieana
Goodenia macbarronii
Polygala linariifolia
Rutidosia heterogama
Thesium australe

Many terrestrial orchid species listed in Schedule 1 and Schedule 2 of the Threatened Species Conservation Act are also threatened by exotic perennial grasses.

A number of bird, reptile and invertebrate species listed on Schedule 1 and Schedule 2, and dependent on plants that are being displaced by exotic perennial grasses are also likely to be threatened. Examples of some listed bird species are:

<i>Chthonicola sagittata</i>	Speckled Warbler
<i>Emblema guttata</i>	Diamond Firetail
<i>Melanodryas cucullata</i>	Hooded Robin
<i>Pomatostomus temporalis</i>	Grey-Crowned Babbler

6. In view of above the Scientific Committee is of the opinion that the Invasion of native plant communities by exotic perennial grasses adversely affects two or more threatened species, populations or ecological communities.

Associate Professor Paul Adam
Chairperson
Scientific Committee

Proposed Gazettal date: 12/09/03
Exhibition period: 12/09/03 – 24/10/03