FINAL REPORT

Threatened Biodiversity Survey and Assessment
Verons Estate, Sussex Inlet

Prepared for
Shoalhaven City Council

July 2011

CONTENTS

List of Tables

List of Appendices

Appendix A: Figures

Acknowledgements

This Threatened Biodiversity Assessment Report was prepared under contract by Bushfire and Environmental Services Pty Ltd, now Eco Logical Australia, 8/128 Island Point Road, St Georges Basin, NSW 2540, PO Box 106. The consulting team included David Coombes (Senior Ecologist) and Ryan Smithers (Senior Ecologist). Mapping and analysis was undertaken by Steve Edwards (GIS Project Officer) and Patrick Grady (GIS Project Officer). Assistance with field surveys was provided by Rob Kielly, Peter Izzard, Terry Turner, Kirsten Vine and Owen Dredge.

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:

Eco Logical Australia, 2011. Final Report, Threatened Biodiversity Survey and Assessment – Rezoning Investigations; Verons Estate, Sussex Inlet, City of Shoalhaven. Report prepared for Shoalhaven City Council.

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Acronyms

APZ	Asset Protection Zone
DECCW	Department of Environment, Climate Change and Water
DP	Deposited Plan
EPBC Act	Environment Protection and Biodiversity Conservation Act, 1999
FM Act	Fisheries Management Act, 1994
GIS	Geographic Information System
GPS	Global Positioning System
OEH	Office of Environment and Heritage
PFC	Projected Foliage Cover
ROTAP	Rare or Threatened Australian Plants
SEPP	State Environmental Planning Policy
SISS	Sussex Inlet Settlement Strategy
SLEP	Shoalhaven Local Environmental Plan, 1985
TSC Act	Threatened Species Conservation Act, 1995

EXECUTIVE SUMMARY

This report has described the biological environment of land comprising Verons Estates, Sussex Inlet, with particular focus on threatened biodiversity values. The overall aim of the study was to identify species, communities and habitats of high conservation value, 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 June 2007 and May 2011. The project was delayed from mid 2010 to early 2011, when Council was considering its approach to State Government advice on Swan Lake. Flora and fauna surveys resulted in the detection of 158 flora species and 114 fauna species in the study area.

The study area supports a mosaic of sedgelands, woodlands, and open forest containing six vegetation communities: Scribbly Gum – Bloodwood Forest; Scribbly Gum – Bloodwood Woodland/Open Woodland; Peppermint – Blackbutt Forest; Peppermint – Bloodwood Forest; Sandstone Sedgeland; and Woollybutt – Paperbark Forest.

The vegetation communities of the study area were not considered to constitute endangered ecological communities listed under the *NSW Threatened Species Conservation Act 1995* or the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999.*

Eleven threatened fauna species were recorded in or near the study area during the survey period: the Eastern Freetail Bat *Mormopterus norfolkensis,* Eastern Bentwing Bat *Miniopterus schreibersii,* Eastern False Pipistrelle *Falistrellus tasmaniensis***,** Eastern Pygmy-possum *Cercartetus nanus***,** Gang-gang Cockatoo *Callocephalon fimbriatum;* Glossy Black-cockatoo *Calyptorhynchus lathami,* Grey-headed Flying-fox *Pteropus poliocephalus,* Masked Owl *Tyto novaehollandiae,* Powerful Owl *Ninox strenua,* Square-tailed Kite *Lophoictinia isura* and Yellow-bellied Glider *Petaurus australis.*

All of these threatened fauna species are listed as Vulnerable on Schedule 2 of the *NSW Threatened Species Conservation Act 1995*. The Grey-headed Flying-fox is also listed as Vulnerable on the Schedules of the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999.*

Two threatened flora species were recorded in the study area. The Leafless Tongue Orchid *Cryptostylis hunteriana* is listed as Vulnerable under both the *NSW Threatened Species Conservation Act 1995* and the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999.* The orchid *Pterostylis ventricosa* has recently been listed as Critically Endangered under the *Threatened Species Conservation Act 1995.*

One migratory species listed on the schedules of the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* was recorded within the study area, the Rufous Fantail *Rhipidura rufifrons.*

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

The study area currently has good habitat connectivity with the adjoining Conjola National Park to the west and south, and disturbed habitat linkages with larger areas of vegetation to the north. Riparian habitats in the study area are also connected to water bodies and wetland habitats of high conservation value. The protection of habitat for threatened species, maintenance of habitat connectivity and riparian/water quality are key considerations for maintaining ecological integrity with future development of the study area.

In order to maintain the long-term viability of threatened species habitat and general biodiversity in the study area, key habitat linkages need to be retained, managed and in some areas rehabilitated or re-established. Priority species for connectivity include less mobile, resident threatened fauna (Yellow-bellied Glider and Eastern Pygmy-possum) and habitat for the orchids *Cryptostylis hunteriana* and *Pterostylis ventricosa.* Maintaining connectivity with Conjola National Park should also be given a high priority.

Maintaining the key biodiversity values within the subject land whilst allowing one dwelling per lot outside of the Swan Lake catchment appears to be achievable, provided that development is located in specific areas of least ecological constraint and that substantial and strategic areas of habitat are retained, rehabilitated and managed for conservation purposes. Recommendations are provided to assist in this regard.

A range of planning strategies and development controls, coupled with education and enforcement strategies would be necessary to achieve biodiversity outcomes. Consideration should be given to seeking biocertification of any future local environmental plan over the subject land.

1. INTRODUCTION

1.1 Background

This report has been commissioned by Shoalhaven City Council, to investigate threatened biodiversity values associated with the Verons Estate, Sussex Inlet, and to identify areas of conservation significance that should be protected in conjunction with further development of the Estate. This report is the outcome of field surveys and desktop analyses undertaken by Bushfire and Environmental Services (BES) (now Eco Logical Australia) between July 2007 and May 2011.

The Verons Estate subdivision was registered in 1920, comprising Lots 1-32 DP 9897. Each lot is approximately 8ha in size. The Estate is currently zoned Rural 1(d) under the Shoalhaven Local Environment Plan 1985 (SLEP), apart from two lots in the south western corner which are partially zoned Environmental Protection 7 (a) (Ecology). Current zoning generally does not permit the establishment of dwellings of individual lots.

A moratorium on the rezoning of rural land at Sussex Inlet was implemented by the NSW Government in 1994, pending completion of a broader development strategy or plan for the area. The recently finalised Sussex Inlet Settlement Strategy (SISS), which provides a broad framework for the future growth and development of the area, has allowed the rezoning moratorium to be lifted. The SISS states that a maximum of one dwelling per Lot in Verons Estate will be considered.

On 19 April 2011 Council resolved to exclude lots 20-32 from proposed development due to requirements for protecting water quality in Swan Lake. As a result, Council is investigating rezoning land in Verons Estate to potentially allow up to one dwelling per lot on lots 1 to 19.

1.2 The Study Area and Locality

The study area for the purposes of this report is the whole of Verons Estate, as shown in Figure 1 (Appendix A).

The study area is located at Sussex Inlet, approximately 4 km west of Sussex Inlet township. The study area contains approximately 270 ha of partially cleared bushland containing forest, woodland, and sedgeland communities. The Estate is generally bounded to the:

- north and north east by semi-cleared private land, consisting the rural-zoned Millallen Farmlets, which front Sussex Inlet Road;
- south east by largely undeveloped rural-zoned land; and
- west and south by Conjola National Park.

The study area is currently zoned Rural 1(d) (General Rural) apart from approximately 7.5ha within the south western corner (parts of Lots 24 and 25) which is zoned Environmental Protection 7 (a)

(Ecology) under the SLEP. Lots 20 to 32, which are within the Swan Lake catchment in the west of the Estates, are also identified as “land of ecological sensitivity” in the SLEP.

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.

1.3 Aim and Objectives

The aim of this study was to investigate and assess the conservation values of Verons Estate to inform the rezoning process currently being undertaken by Council.

The objectives of this study were to:

a) identify and describe the 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) undertake appropriate targeted surveys for threatened or otherwise significant biota;

d) identify and map vegetation and habitat important for the survival of threatened species and communities and the maintenance of biodiversity;

e) determine whether the study area provides potential or core Koala habitat pursuant to *NSW State Environmental Planning Policy No. 44 – Koala Habitat Protection*;

f) identify any ecological constraints to, and opportunities for development; and

g) provide recommendations to protect any significant biodiversity values.

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.

2.2 Flora Survey Methods

General botanical surveys were conducted in the study area on 18-19 June, 27-28 July and 5-6 September 2007 to identify communities and characteristic species as described below. The general flora survey effort totalled 36 person-hours.

Community Identification and Floristic Audit

The Random Meander technique documented by Cropper (1993) was used across the study site to document the flora species present, including those of conservation significance, and the location and extent of vegetation communities.

A vegetation survey sheet was completed for each vegetation community. The vegetation was surveyed at all levels present: the canopy (trees), middle canopy (trees), understorey (shrubs), and groundcover plants (plants less then one metre in height). An abundance score was assigned to each species recorded. Dominant species and the projected foliage cover of each stratum were recorded at locations that typified the vegetation communities present in the study area. A general description of the vegetation was then prepared based on structural characteristics and dominant canopy species in accordance with Walker and Hopkins (1990) and Specht (1970). These techniques were used to classify and name the vegetation communities in the study area.

The boundaries of vegetation communities were marked onto a plan of the site using a combination of GPS field data, aerial photography, landscape position, geology, soils and existing vegetation maps and field survey.

The vegetation communities recorded in the study area were compared with the Final Determinations of the NSW Scientific Committee to ascertain whether the communities were components of listed threatened ecological communities.

Targeted Flora Surveys

Specific searches for Bauer's Midge Orchid *Genoplesium baueri*, East Lynne Midge Orchid *G. vernale,* Leafless Tongue Orchid *Cryptostylis hunteriana*, Pretty Beard Orchid *Calochilus pulchellus*, Tessellated Spider Orchid *Caladenia tessellata, Pterostylis ventricosa* and Tangled Bedstraw *Galium australe* were conducted by a team of experienced surveyors systematically walking along parallel transects approximately 10-20m apart, targeting areas of suitable or potential habitat (Figure 2, Appendix A). A more intensive search was undertaken in the vicinity of any individuals of target species found. Surveys were undertaken during each species known flowering period, verified where possible at known local populations. Specific dates and survey efforts are detailed in Table 1.

A variation to the above methodology was required for the Eastern Underground Orchid *Rhizanthella slateri* because the species is almost completely subterranean and may prefer locations around the base of tree species such as Scribbly Gum *Eucalyptus sclerophylla*. Transects through potential habitat approximately 100m apart were followed, and the leaf-litter around the bases of trees within 5m either side of the transect was carefully raked back to a distance of up to 2m from the base of the

tree while searching for evidence of flowers and stems. Surveys for this species were undertaken in early November 2008.

All individuals or clusters of target species located during the survey period were marked nearby with coloured flagging tape and the location was recorded using Garmin Gecko 301 Global Positioning System.

Targeted searches for the Biconvex Paperbark *Melaleuca biconvexa* and Magenta Lilly Pilly *Syzygium paniculatum* were conducted using a combination of random meander and systematic searches through areas of suitable habitat. The most suitable habitat for these species within the study area was considered primarily to occur close to drainage lines and searches focused on these areas, although other habitat was also searched at lower intensities during other surveys.

Limitations

The floristic audit undertaken recorded as many species as possible and provides a comprehensive but not definitive species list. More species would probably be recorded during a longer survey over various seasons.

The techniques used in this investigation are considered appropriate and adequate to gather the data necessary to identify the flora species and vegetation communities found in the study area. With surveys for *Pterostylis ventricosa*, a positive identification of the species was not always possible due to poor flower condition (e.g. withered flowers) or the presence of similar leaf rosettes without flowers. Given the conservation significance of the species, a conservative approach was taken and the presence of the species was assumed in the above situations.

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 781.25 person-hours, as documented in Table 1.

Table 1: Flora survey effort employed over the study area

DATE	METHOD	EFFORT	TARGET SPECIES
18 June – 6 September 2007	Vegetation plots, random meander, community identification	36 person hours	All species
12-20 December 2007	Parallel transect search	141.75 person hours	*Cryptostylis hunteriana*

DATE	METHOD	EFFORT	TARGET SPECIES
21-29 February 2008	Parallel transect search	109 person hours	*Genoplesium baueri*
13-30 May, 2-5 June 2008, 9-10 May 2011	Parallel transect search	206 person hours	*Pterostylis ventricosa*
24-26, 29 September 2008	Parallel transect search	126 person hours	*Caladenia tessellata*
4, 5, 7, 10 November 2008	Parallel transect search & leaf raking for *R. slateri*	64 person hours	*Rhizanthella slateri, Calochilus pulchellus*
24-28 November, 2-5 December 2008	Parallel transect search	98.5 person hours	*Galium australe, Genoplesium vernale*
TOTAL FLORA SURVEY EFFORT		**781.25 person hours**	

2.3 Fauna Survey Methods

Habitat Analysis

Field investigations for fauna habitats were conducted in the study area between May 2007 and August 2007 for a total of 119.5 person-hours. 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 and defining areas for targeted surveys. 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.

Diurnal searches were conducted throughout the study area, 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. Searches targeted trees containing medium to large sized hollows, feed-trees of the Glossy Black-cockatoo and Yellow-bellied Glider, roost sites of large forest owls, nests of raptors, mammal diggings, scratchings and scats. The locations of key habitat features, fauna species of conservation significance, or evidence of such species, were recorded with a Garmin Gecko 301 Global Positioning System or Personal Digital Assistant XDA O2 linked to a bluetooth EMTAC S3 BTGPS Global Positioning System.

Stagwatching surveys and nesting assessments for hollow-dependant fauna

A range of modified stagwatching surveys were used to assess breeding or sheltering use of tree hollows by threatened fauna during the survey period. Species specifically targeted by these techniques included the Yellow-bellied Glider, Squirrel Glider, microchiropteran bats, Gang-gang

Cockatoo, Glossy Black-cockatoo, Powerful Owl and Masked Owl. For species which use hollows only for breeding, such as the Gang-gang Cockatoo, Glossy Black-cockatoo and Powerful Owl, targeted surveys were undertaken only within the known nesting periods. Gliders, hollow-roosting microchiropterans and the Masked Owl may use tree hollows at any time of the year, so were targeted during all nocturnal stagwatching surveys, at various times of the year.

Trees were initially assessed for suitability and prioritised for stag watching using characteristics such as tree species and height, the size and type of hollows, evidence of usage and surrounding habitats. Nocturnal observation sessions (for owls, gliders and bats) generally commenced at sunset on each survey night and continued for another one to one and a half hours. During this period hollows were observed with the aid of binoculars and spotlights where necessary.

Diurnal nesting assessments for the Gang-gang Cockatoo and Glossy Black-cockatoo were undertaken using a combination of listening for calls and stagwatching of potential nest trees. These surveys were commenced one to two hours prior to dusk during the relevant breeding periods. 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 in the late afternoon. Generally, multiple observers simultaneously monitored different groups of trees throughout the study area to ensure adequate coverage of all suitable habitat in the study area. The surveys became more focused on particular areas if the behaviour of the cockatoos indicated a possible nest or roost site. This work was supplemented by opportunistic monitoring at various times of the day, when surveys for other species were being conducted.

Call playback surveys for nocturnal mammals and birds

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 areas of appropriate habitat in the study area. Calls were generally broadcast intermittently for a period of up to five minutes each, followed by a listening period of 15 minutes. Post-playback listening periods generally extended into subsequent spotlighting surveys for a further half to one hour. Pre-playback listening surveys were generally undertaken during stagwatching surveys which involved a listening period of between one and two hours after sunset.

Nocturnal spotlighting surveys

Spotlighting surveys using a Narva Colt 55 W hand-held spotlight with Faunatech battery pack were undertaken along tracks and transects through habitats likely to support threatened nocturnal fauna species at various times throughout the survey period. Binoculars were used to aid in the identification of species where necessary. Species targeted with this technique included the Koala, Yellow-bellied Glider, Squirrel Glider, Eastern Pygmy-possum, large forest owls and ground dwelling mammals such as the Spotted-tailed Quoll, Southern Brown Bandicoot, Long-nosed Potoroo and amphibians including Giant Burrowing Frog. Spotlighting was undertaken while actively listening for vocalisations of nocturnal threatened fauna species. In general, each spotlighting session commenced at least 30 minutes after sunset and was undertaken for 0.5 to 1.5 hours.

Microchiropteran echolocation call recording surveys

Echolocation recording surveys were used to target microchiropteran bats in the study area over two nights in March 2008. Four AnaBat II bat detectors linked to ZCAIM digital data recorders were used in various habitats along walking transects and at stationary overnight positions to record microchiropteran echolocation calls. Walking AnaBat transects were undertaken in all broad habitat types along roads and open areas from approximately sunset for a further one hour.

Eight overnight (stationary) echolocation recording survey sites sampled all broad habitat types in the study area over two nights. Within each broad habitat type, overnight Anabat surveys targeted resources such as creeks or obvious flyways. Echolocation recording surveys were undertaken and analysed by Lesryk Environmental Consultants. Only those species identified to a 'confident' or 'probable' level were included in this report.

Microchiropteran trapping surveys

Four harp traps were used to target microchiropteran bats in the study area over two nights in March 2008, yielding a total of 8 trap nights. Harp traps were positioned across tracks or creeks to sample areas of higher bat activity. Shade cloth was erected to the sides of traps where necessary to direct bats into the trap. Captured bats were retrieved early in the morning and identified, then placed into cloth bags and released that night. Harp trapping was undertaken by Lersyk Environmental Consultants.

Terrestrial mammal trapping and hair funnel surveys

Trapping surveys for terrestrial mammals were undertaken over eight nights during March and April 2008. A range of trapping techniques were employed to target threatened mammals including the Eastern Pygmy-possum, White-footed Dunnart, Southern Brown Bandicoot, Long-nosed Potoroo and Spotted-tail Quoll. Trap sites were stratified by broad vegetation type and placed in areas of suitable habitat for target species.

A total of 50 type-A Elliott traps and 50 small cage (or bandicoot) traps were set over two periods of four consecutive nights, yielding a trapping effort of 400 trap-nights each. Traps were laid on the ground at 10-20 m intervals and were baited with a mixture of peanut butter, honey and rolled oats.

Ten large cage traps were set within appropriate habitat in the study area for the same period as above, yielding a trapping effort of 80 trap-nights. Traps were positioned at least 50-100m apart at either ends of the Elliott and small cage transects above. Large cage traps were baited with chicken pieces to attract carnivores, primarily the Spotted-tailed Quoll and potentially the Heath Monitor.

A total of 16 pitfall traps were set to sample the range of habitat types in the study area for four consecutive nights in April 2008, yielding a trapping effort of 64 trap-nights. Each trap site contained four pits approximately 15m apart, connected by drift fencing in a 'Y' configuration. Buckets approximately 50cm deep and 30cm wide were used for pit traps. Each bucket contained holes in the bottom to facilitate draining and floating material (usually bark) in case of heavy rainfall. Other material such as leaves provided shelter from sunlight and predators. Builder's damp course (30cm high) was used for drift fencing.

All traps were checked each morning soon after sunrise. Captured animals were identified and then released at the trap site.

Forty Faunatech hair funnels were set on the ground or on trunks of flowering or hollow trees in all habitat types across the study area for fifteen consecutive nights from 4-18 April 2008, yielding a total hair funnel effort of 600 trap-nights. Hair funnels were baited with a mixture of peanut butter, honey and rolled oats. Any hair-funnel wafers with obvious hairs attached were sent to Ms. Barbara Triggs of Mallacoota, Victoria for analysis.

Targeted Amphibian Surveys

A range of techniques were used to survey for the Giant Burrowing Frog and Green and Golden Bell Frog during the survey period. Spotlighting was undertaken for frogs in areas of potential breeding or foraging habitat in selected ponds and ephemeral creeks during general spotlighting surveys and during targeted spotlighting following heavy rainfall. Diurnal searches for tadpoles were also undertaken at various times throughout the survey period. Call playback surveys were undertaken in potential habitats of better quality, consisting of up to five minutes of call playback and between 15 and 30 minutes of listening for a response. Call playback for these species was undertaken with other call playback surveys and separately during targeted surveys following heavy rainfall.

Opportunistic nocturnal searches for these species were also made by vehicle, driving slowly along tracks within the study area, particularly after any rainfall. Opportunistic listening for calls of these species was undertaken throughout the survey period, particularly after any rainfall and in association with riparian areas and dams.

Diurnal Bird Surveys

Targeted surveys for diurnal bird species of conservation significance were undertaken in various habitats at various times during the survey period. Each survey combined a number of target species and habitats, including riparian areas for the Eastern Bristlebird, Australasian Bittern, Black Bittern, Latham's Snipe, Black-faced Monarch, Rufous Fantail, Satin Flycatcher and roosting sites of large forest owls; winter-flowering trees for the Regent Honeyeater and Swift Parrot; open grassy areas for the Turquoise Parrot; and general forest areas for evidence of nesting or other habitat use by the Square-tailed Kite, Osprey and White-bellied Sea-eagle.

Diurnal bird surveys utilised visual (aided by binoculars) and aural methods of detection, while actively searching or monitoring targeted habitats. Opportunistic surveys for diurnal birds were also undertaken at other time of the survey period during other flora and fauna surveys.

Limitations

The results of fauna surveys can be optimised by conducting repeat investigations over a long period to compensate for the effect of unfavourable weather, seasonal changes and climatic variation. In general, the longer the survey or the higher the number of repeat surveys, the more species will be detected and more detail will be gained in relation to the abundance, distribution and habitat use of

the fauna. Wherever possible, surveys were conducted using a range of methods best suited for detecting target species, at optimum times during appropriate conditions.

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. The fauna detected in current survey work are a comprehensive guide to the native fauna present, but are not necessarily a definitive list of the species occurring in the study area. Nevertheless, given the habitats present, the techniques used in this investigation are considered adequate to gather the data necessary to identify species 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 during the survey period

DATE	SURVEY TYPE	TEMPERATURE	WIND	CLOUD	MOON	RAIN
11-12 March 2008	Nocturnal	21-23^{o}C	Nil	8/8	N/A	Nil
13 March 2008	Nocturnal	20 – 17^{o}C	Nil	Nil	2/4	Nil
27 March 2008	Nocturnal	17- 16^{o}C	Nil	3/5	Nil	Nil
31 March – 4 April 2008	Trapping	14 - 23^{o}C	N/A	N/A	N/A	Nil
7 April – 11 April 2008	Trapping	13 - 22^{o}C	N/A	N/A	N/A	Nil
4-18 April 2008	Hair Funnels	13 - 23^{o}C	N/A	N/A	N/A	Nil
01 May 2008	Diurnal	18^{o}C	Nil	7/8	N/A	Nil
01 May 2008	Nocturnal	17^{o}C	Nil – Light	7/8	1/4	Nil
27 May 2008	Diurnal	19^{o}C – 17^{o}C	Nil	1/8	N/A	Nil
	Nocturnal	17^{o}C – 15^{oC}	Nil	1/8	N/A	Nil
15 July 2008	Nocturnal	17^{o}C – 14^{o}C	Nil	8/8	N/A	Nil
17 July 2008	Nocturnal	13.5^{o}C – 8.4^{o}C	Light N/W	Nil	1/4	Nil
01 September 2008	Nocturnal	17^{o}C – 12^{o}C	Light S/W	Nil	Nil	Nil
05 November 2008	Diurnal	22^{o}C – 19^{o}C	Light	2/8	N/A	Nil
10 November 2008	Diurnal	23^{o}C – 20^{o}C	Light E	Nil	N/A	Nil

DATE	SURVEY TYPE	TEMPERATURE	WIND	CLOUD	MOON	RAIN
24 November 2008	Diurnal	24°C – 19°C	Nil	4/8	N/A	Nil
15 December 2008	Nocturnal	17°C	Nil	7/8	0/4	Nil
21 January 2009	Nocturnal	23°C – 25°C	Light NE	8/8	0/4	Showers
09 February 2009	Nocturnal	22°C	Light SE	4/4	0/4	Nil-light

Survey Effort

The fauna survey effort involved a total of 174.75 person-hours, 400 Elliott (type A) trap nights, 400 small cage trap nights, 80 large cage trap nights, 64 pitfall trap nights, 600 hair funnel trap-nights, 8 harp trap nights and 80 hours of AnaBat echolocation call recording as documented in Table 3.

Table 3: Fauna survey effort employed over the study area

DATE	METHOD	EFFORT	TARGET SPECIES
22-30 May 2007	Habitat assessment	112 person hours	N/A
11-12 March 2008	Harp Trapping	8 trap nights	Microchiropteran bats
	Anabat echolocation recording	80 recording hours	Microchiropteran bats
13 March 2008	Stagwatch	1 person hour	Nocturnal birds and mammals
	Spotlight	3.5 person hours	Nocturnal fauna
	Call Playback	1.5 person hours	Green and Golden Bell Frog, Giant Burrowing Frog, Yellow-bellied Glider, Squirrel Glider, Koala, Powerful Owl, Masked Owl, Barking Owl
25 March 08	Habitat assessment	7.5 person hours	N/A
27 March 08	Nesting Assessment	1 person hour	Glossy Black-cockatoo
	Stagwatch	1 person hour	Nocturnal birds and mammals
	Spotlight	1.5 person hours	Nocturnal fauna
31 March – 4 April 2008	Elliott trapping	200 trap nights	Eastern Pygmy-possum, White-footed Dunnart
	Small cage trapping	200 trap nights	Long-nosed Potoroo, Southern Brown Bandicoot
	Large cage trapping	40 trap nights	Spotted-tailed Quoll
	Pitfall trapping	32 trap nights	Eastern Pygmy-possum, White-footed Dunnart, Giant Burrowing Frog
7 April – 11 April 2008	Elliott trapping	200 trap nights	Eastern Pygmy-possum, White-footed Dunnart

DATE	METHOD	EFFORT	TARGET SPECIES
7 April – 11 April 2008	Small cage trapping	200 trap nights	Long-nosed Potoroo, Southern Brown Bandicoot
	Large cage trapping	40 trap nights	Spotted-tailed Quoll
	Pitfall trapping	32 trap nights	Eastern Pygmy-possum, White-footed Dunnart, Giant Burrowing Frog
4-18 April 2008	Hair Funnels	600 trap nights	Eastern Pygmy-possum, White-footed Dunnart, Long-nosed Potoroo, Southern Brown Bandicoot
01 May 2008	Nesting Assessment	1.5 person hours	Glossy Black-cockatoo
	Stagwatch	1.25 person hours	Nocturnal birds and mammals
	Call Playback	1 person hour	Yellow-bellied Glider, Squirrel Glider, Powerful Owl, Sooty Owl, Masked Owl
27 May 2008	Nest assessment & roost search	5.5 person hours	Powerful Owl
	Nest Assessment	3.5 person hours	Glossy Black-cockatoo
	Stagwatch	1 person hour	Nocturnal birds and mammals
15 July 2008	Nesting Assessment	1.5 person hours	Glossy Black-cockatoo
	Stagwatch	1 person hour	Nocturnal birds and mammals
	Spotlight	0.5 person hours	Nocturnal fauna
17 July 2008	Nesting Assessment	1.5 person hours	Glossy Black-cockatoo
	Stagwatch	1 person hour	Nocturnal birds and mammals
	Spotlight	0.5 person hours	Nocturnal fauna
1 September 2008	Nesting Assessment	1 person hour	Powerful Owl
	Stagwatch	1 person hour	Nocturnal birds and mammals
	Call Playback	0.5 person hours	Yellow-bellied Glider, Sugar Glider, Koala, Powerful Owl, Masked Owl
	Spotlight	1 person hour	Nocturnal fauna
05 November 2008	Nesting Assessment	2.5 person hours	Gang-gang Cockatoo
10 November 2008	Nesting Assessment	5 person hours	Gang-gang Cockatoo
24 November 2008	Nesting Assessment	8 person hours	Gang-gang Cockatoo
15 December 2008	Stagwatch	0.5 person hours	Nocturnal birds and mammals
	Call Playback	1.5 person hours	Yellow-bellied Glider, Masked Owl
	Spotlight	0.5 person hours	Nocturnal fauna
21 January 2009	Call Playback	1.5 person hours	Masked Owl, Green and Golden Bell Frog, Giant Burrowing Frog

DATE	METHOD	EFFORT	TARGET SPECIES
9 February 2009	Call Playback	3 person hours	Yellow-bellied Glider, Masked Owl
TOTAL FAUNA SURVEY EFFORT		**174.75 person hours, 1552 trap nights, 80 AnaBat echolocation recording hours.**	

3. THE EXISTING ENVIRONMENT

3.1 Topography, Geology, and Soils

The study area lies at an altitude between approximately 10 and 40 metres Australian Height Datum and comprises gentle slopes around a central ridgeline. Two main ephemeral drainage lines occur in the north east and south western sections. The north east of the study area lies within the catchment of Badgee Lagoon to the east, while the south western half of the study area drains to Swan Lake in the south.

Soils in the study area vary from course sand to loam and clay. The study area appears to be underlain by Quaternary alluviums in association with the main drainage lines and Permian deposits of conglomerate, sandstone and silty sandstone from the Conjola Formation and/or Wandrawandian Siltstone elsewhere (Ulladulla 1:250,000 Geological Series Sheet S1 56-13).

3.2 Disturbances

Substantial clearing and under scrubbing of vegetation has occurred over large parts of the study area for grazing and the construction of fences, dwellings, sheds and related purposes. Associated disturbances have included pasture improvement, introduced plantings, the construction of a number of dams and firewood collection. Clearing has also occurred across the south of the study area for an electricity easement.

A number of unformed and unmaintained roads dissect the study area, generally in accordance with cadastral road easements, property boundaries and the electricity easement. Some sections of these roads have been formally constructed by Council and other sections have been informally augmented by introduced road base and drain pipes at creek crossings as they are regularly used. A number of informal vehicle tracks exist elsewhere through the study area.

Most of the native vegetation in the study area is also recovering from a major wildfire, which occurred in 2000/2001.

3.3 Flora

Despite the disturbances, most of the study area is covered with native vegetation. The quality and condition of this vegetation is variable dependent on the degree and intensity of recent human impact. Several lots shown little evidence of recent human disturbances, whilst others have been mostly cleared and pasture improved. Some lots have been partially cleared or slashed and under-scrubbed, however the native groundcovers still predominate and the recovery potential is high. There are also clearings for roadways, powerlines and tracks evident throughout the study area. These unformed roadways have been subject to erosion and sedimentation. Despite the range of anthropocentric disturbances, the majority of the estate still supports relatively undisturbed native vegetation although the vegetation across the majority of the study area is recovering from a high intensity wildfire in 2001.

The study area supports a mosaic of sedgelands, open woodlands, woodland and open forest usually characterised by a heathy understorey. With reference to the vegetation community descriptions of the SCC vegetation mapping for the LGA (Kevin Mills & Associates (KMA) (1999)), the study area supports six vegetation communities; Scribbly Gum – Bloodwood Forest (SCL-GMF), Scribbly Gum – Bloodwood Woodland/Open Woodland (SCL-GUM), Peppermint – Blackbutt Forest (PIP-PIL), Peppermint – Bloodwood Forest (PIP-GUM), Sandstone Sedgeland (SST-STG), and Woollybutt – Paperbark Forest (LON-MEL) (Figure 4, Appendix A).

The relationship of the vegetation communities within the study area to relevant regional vegetation datasets is identified in Table 4. Table 4 also identifies the proportion of the known distribution of these vegetation communities that is within the study area, with reference to the mapping of KMA (1999). However, it should be noted that considerably different results would be obtained by using other more recently developed regional datasets, such as Tindall *et al.* (2004) and Tozer *et al*. (2006), which tend to combine many of the communities identified by KMA (1999). Using these datasets it is apparent that the vegetation communities within the study area are all relatively widespread and well-conserved vegetation communities.

Table 4: Vegetation communities within the study area as described by relevant regional vegetation datasets

KMA[1]	SCIVI[2]	CMA[3]	EEC	Area in SA (ha)	% known dist.[4]
SCL-GMF	Shoalhaven Sandstone Forest	Shoalhaven Sandstone Forest	No	123	7
SCL-GUM	Shoalhaven Sandstone Forest / Morton Mallee-Heath	Shoalhaven Sandstone Forest / Morton Mallee-Heath	No	65	0.58
PIP-PIL	Currambene-Batemans Lowlands Forest / Southern Turpentine Forest	Currambene-Batemans Lowlands Forest / Southern	No	7	1.2
PIP-GUM	Shoalhaven Sandstone Forest	Morton_Mogo Dry Forest / Shoalhaven Sandstone Forest	No	53	0.15
SST-STG	Booderee Heath Swamp / Coastal Sand Swamp Forest	Booderee Heath Swamp / Coastal Sand Swamp Forest	No	19	0.64
LON-MEL	Booderee Heath Swamp / Coastal Sand Swamp Forest	Booderee Heath Swamp / Coastal Sand Swamp Forest	No	2	0.31

[1] KMA(1999). [2] Tozer et. al. 2006. [3] After the vegetation communities identified in the Biometric Tool for the Southern Rivers CMA. [4] Distribution within the Shoalhaven LGA after KMA (1999).

3.3.1 Scribbly Gum – Bloodwood Forest (SCL-GMF)

This community is widespread within the study area usually occurring on the higher parts of the landscape and on clayey soils. The canopy is dominated by Hard-leaved Scribbly Gum *Eucalyptus*

sclerophylla and Red Bloodwood *Corymbia gummifera*, but also includes Silvertop Ash *Eucalyptus seiberi*, Yertchuck *Eucalyptus consideniana*, White Stringybark *Eucalyptus globoidea* and Thin-leaved Stringybark *Eucalyptus eugenioides.* The community is either an open forest or a woodland within the study area to a height of 10-15 m and Projected Foliage Cover (PFC) of approximately 20-30%. There is generally a patchy sparse sub-canopy of Saw Banksia *Banksia serrata* and Black She-oak *Allocasuarina littoralis* to a height of 6-10 m.

The dense understorey comprises a diverse range of heathy species the most common of which are Hairpin Banksia *Banksia spinulosa* var. *spinulosa*, Turpentine *Syncarpia glomulifera* subsp. *glomulifera*, Myrtles Wattle *Acacia myrtifolia*, Needlebush *Hakea sericea*, Yellow Tea-tree *Leptospermum polygalifolium* subsp. *polygalifolium*, and Hoary Guinea Flower *Hibbertia obtusifolia*. Other common understorey species include Soft Geebung *Persoonia mollis* subsp. *caleyi,* Broad-leaved Hakea *Hakea dactyloides*, Heath Wattle *Acacia brownii*, Handsome Flat-pea *Platylobium formosum*, Broad Leaf Geebung *Persoonia levis*, Flaky-barked Tea-tree *Leptospermum trinervium,* Sunshine Wattle *Acacia terminalis*, Golden Glory Pea *Gompholobium latifolium*, Stalked Conesticks *Petrophile pedunculata*, Spiny Bossiaea *Bossiaea obcordata*, Sydney Golden Wattle *Acacia longifolia* and *Conospermum ericifolium*. The understorey is generally to a height of approximately 1-3 m with PFC of approximately 30-40%.

The groundcover includes a diverse range of heathy native grasses, shrubs, forbs, and sedges to a height of up to 1 m and PFC of up to approximately 30-70%. The most common groundcovers include Wiry Panic *Entolasia stricta*, Heathy Mirbelia *Mirbelia rubiifolia,* Curl Wig *Caustis flexuosa*, Lesser Flannel Flower *Actinotus minor*, Rock Xanthosia *Xanthosia tridentata*, Wallum Heath *Epacris pulchella*, Dwarf Blue Trumpet *Brunoniella pumilio,* Drumsticks *Isopogon anemonifolius*, Slender Stackhousia *Stackhousia viminea*, *Sphaerolobium vimineum*, *Hybanthus vernonii* subsp. *vernonii, Xanthorrhoea concava,* Halo Bush-pea *Pultenaea linophylla,* Variable Bossiaea *Bossiaea heterophylla,* Holly Lomatia *Lomatia ilicifolia,* Germander Raspwort *Gonocarpus teucrioides, Dampiera stricta,* Kangaroo Grass *Themeda australis*, Oat Spear Grass *Anisopogon avenaceus*, *Baumea acuta*, Common Bracken *Pteridium esculentum*, Screw Fern *Lindsaea linearis*, *Poranthera ericifolia*, Variable Sword-sedge *Lepidosperma laterale,* Pale Mat-rush *Lomandra glauca,* Blue Flax-lily *Dianella caerulea,* Silky Purple Flag *Patersonia sericea,* Threeawn Speargrass *Aristida vagans,* the Wallaby Grass *Austrodanthonia tenuior,* and the sedge *Ptilothrix deusta*.

Creepers and climbers include Twining Pea *Hardenbergia violacea* and Apple Berry *Billardiera scandens*. The lady's finger orchids Caladenia spp. and a sun orchid *Thelmytria* sp. were also reasonably abundant in the groundcover.

3.3.2 Scribbly Gum – Bloodwood Woodland/Open Woodland (SCL-GUM)

This community is very closely related to the SCL-GMF community and they grade into each other throughout the study area with the SCL-GUM community occurring in those areas where soils are poorer or soil drainage is more impeded. The community is floristically very similar to the SCL-GMF community however canopy species are generally restricted to Hard-leaved Scribbly Gum and Red Bloodwood, with Red Bloodwood often occurring as a mallee. The most notable difference between

the communities is structural with the SCL-GUM being much more open and generally occurring as an open woodland with the canopy to a height 8-14 m with PFC of 5-15%. The other strata are also very similar structurally and floristically as the SCL-GMF community with the understorey generally being slightly more open. Broad-leaved Hakea *Hakea dactyloides* and Dagger Hakea *Hakea teretifolia* are more common than in the SCL-GMF and Coral Heath *Epacris microphylla*, Drumsticks *Isopogon anemonifolius*, Oat Spear Grass *Anisopogon avenaceus,* Fish Bones *Lomandra obliqua* and the sedges *Leptocarpus tenax* and *Ptilothrix deusta* are more common in the groundcover.

3.3.3 Peppermint – Blackbutt Forest (PIP-PIL)

This community occurs generally on the margins of the study area in lower parts of the landscape on the edges of shallow gullies as described by KMA (1998). The canopy is dominated by Blackbutt *Eucalyptus pilularis*, Sydney Peppermint *Eucalyptus piperita* and Red Bloodwood to a height of 25 m with PFC of 20-30%. There is usually a sparse sub-canopy of Turpentine to a height of 10-20 m with PFC of less than 5%.

The understorey is usually in the early stages of recovery post the intense wildfires of 2001 and as a result is very dense with PFC of up to 50% and to a height of 1-2.5 m. The dominant understorey species are Sunshine Wattle, Turpentine, Sydney Golden Wattle, Soft Geebung, Hoary Guinea Flower, Hairpin Banksia, Needlebush, Stalked Conesticks, Large-leaf Bush-pea *Pultenaea daphnoides*, Heath Wattle and Handsome Flat-pea *Platylobium formosum*.

The groundcover is typically fairly sparse given the density of the understorey with PFC of approximately 20%. Dominant groundcovers include Wiry Panic, Common Bracken, Twining Pea, Apple Berry, Rock Xanthosia, Variable Sword-sedge, Curl Wig *Caustis flexuosa*, Dwarf Blue Trumpet *Brunoniella pumilio,* Blady Grass, Halo Bush-pea *Pultenaea linophylla,* Blue Flax-lily *Dianella caerulea,* Holly Lomatia*, Lomandra cylindrica*, Many-flowered Mat-rush *Lomandra multiflora*, and Spiny-headed Mat-rush *Lomandra longifolia*.

3.3.4 Peppermint – Bloodwood Forest (PIP-GUM)

This community occurs in between the SCL-GMF and SCL-GUM communities and the PIP-PIL. The community generally occurs in higher parts of the study area and contrary to the description in KMA (1999) occurs on the clayey soils which predominate throughout the study area. The community shares many of the species characteristic of adjacent communities but is characterised by the absence or very low abundance of both Blackbutt and Hard-leaved Scribbly Gum and the predominance of Sydney Peppermint. Other canopy species include Red Bloodwood, Silvertop Ash, White Stringybark and Thin-leaved Stringybark. The canopy is typically to a height of 15 m with PFC of 25%.

There is generally no sub-canopy however the understorey is typically quite dense and tall from 1-4 m with PFC of approximately 40%. Typical understorey species include a broad mix of the species associated with the SCL-GMF, SCL-GUM, and PIP-PIL communities. Additional understorey species include *Gahnia radula* and Straight Wattle *Acacia stricta*. Similarly, the groundcover includes a broad mix of the species associated with the SCL-GMF, SCL-GUM, and PIP-PIL communities.

3.3.5 Sandstone Sedgeland (SST-STG)

This community occurs in the broad swampy drainage lines in the north-eastern and south-western extremities of the study area. The community is characterised by a dense but patchy shrubland to a height of 1-3 m and PFC of approximately 40%, dominated by Yellow Tea-tree and Dagger Hakea, and in the north-east Narrow-leaved Bottlebrush *Callistemon linearis*, and in the south-west Swamp Wattle *Acacia elongata*. Other common shrubs include Golden Spray *Viminaria juncea*, Thyme Honey-myrtle *Melaleuca thymifolia*, Hairpin Banksia, Heath-leaved Banksia *Banksia ericifolia*, Swamp Paperbark *Melaleuca ericifolia*, Soft Geebung, *Sphaerolobium vimineum*, Halo Bush-pea *Pultenaea linophylla, Conospermum ericifolium,* Flaky-barked Tea-tree, Prickly Tea-tree *Leptospermum juniperinum*, Sydney Golden Wattle, Needlebush, Broad-leaved Hakea and Black She-oak. The community often includes occasional individuals of or fringed by a patchy cover of small trees such as Flax-leaved Paperbark *Melaleuca linariifolia* or eucalypts such as Hard-leaved Scribbly Gum.

The groundcover is dominated by sedges and rushes including *Baumea acuta*, Jointed Twig-rush *Baumea articulata*, *Leptocarpus tenax*, *Cyathochaeta diandra*, *Ptilothrix deusta, Baloskion gracile, Schoenus brevifolius* and Common Reed *Phragmites australis*. Other abundant groundcovers include River Rose *Bauera rubioides,* Wiry Panic, Blunt-leaf Heath *Epacris obtusifolia*, Swamp Selaginella *Selaginella uliginosa*, *Almaleea paludosa*, *Dillwynia floribunda*, Pink Swamp Heath *Sprengelia incarnata*, Coral Heath, Blue Dampiera, Erect Guinea-flower *Hibbertia riparia*, Dwarf Blue Trumpet, *Darwinia leptantha*, Germander Raspwort and Creeping Raspwort *Gonocarpus micranthus*.

The community shows some affinities with the Teatree Shrubland (LEP-MEL) of KMA (1999), particularly the abundance in places of Yellow Teatree, and the presence of shrubs such as Swamp Wattle and Golden Spray.

3.3.6 Woollybutt – Paperbark Forest (LON-MEL)

This community is restricted to the swampy broad drainage line in the north-western extremity of the study area. This is the sole location where Woollybutt *Eucalyptus longifolia* was observed within the study area, however it was generally observed as occasional rather stunted small trees making the community an open woodland rather than a forest. Otherwise the floristics of the community appears to be similar to the Sandstone Sedgeland that occurs in the other broad drainage lines within the study area.

3.3.7 Flora Species

A total of 158 flora species were identified during the flora surveys (Table 5). Two threatened orchid species, the Leafless Tongue Orchid *Cryptostylis hunteriana* and *Pterostylis ventricosa,* were recorded at a number of locations.

Table 5: Flora species identified in the study area

(* denotes introduced species, bold denotes threatened species listed under the *TSC Act* or *EPBC Act*).

SCIENTIFICE NAME	COMMON NAME	SCL-GMF	SCL-GUM	PIP-PIL	PIP-GUM	SST-STG	LON-MEL
Acacia brownei	Prickly Moses	✓	✓	✓			
Acacia elongata	Swamp Wattle					✓	✓
Acacia longifolia	Sydney Golden Wattle	✓	✓	✓	✓	✓	✓
Acacia myrtifolia	Myrtles Wattle	✓	✓		✓		
Acacia stricta	Hop Wattle	✓	✓		✓	✓	✓
Acacia suaveolens	Sweet Wattle	✓	✓				
Acacia terminalis	Sunshine Wattle	✓	✓	✓		✓	✓
Acacia ulicifolia	Prickly Moses	✓	✓		✓	✓	✓
Actinotus minor	Flannel Flower	✓	✓				
Acianthus sp.	A gnat orchid	✓	✓	✓	✓		
Allocasuarina littoralis	Black She-oak	✓	✓			✓	✓
Almaleea paludosa	-					✓	✓
*Andropogon virginicus**	Whiskey Grass	✓	✓				
Anisopogon avenaceus	Oats Speargrass	✓	✓			✓	✓
Aristada vagans	Three-awned Spear-grass	✓	✓				
Austrodanthonia tenuior	Wallaby Grass	✓	✓				
Austrostipa pubescens	Tall Speargrass	✓	✓				
Baloskion gracile	-					✓	✓
Banksia ericifolia	Heath-leaved Banksia	✓	✓			✓	✓
Banksia serrata	Saw Banksia	✓	✓			✓	✓
Banksia spinulosa var. *spinulosa*	Hairpin Banksia	✓	✓	✓	✓	✓	✓
Baumea acuta	A sedge	✓	✓			✓	✓
Baumea articulata	-					✓	✓
Baurea rubioides	Dog Rose					✓	✓
Billardiera scandens	Hairy Apple Berry	✓		✓	✓	✓	✓
Bossiaea heterophylla	Variable Bossiaea	✓	✓		✓	✓	✓
Bossiaea obcordata	Spiny Bossiaea	✓	✓		✓		
Brunoniella pumilio	Dwarf Blue Trumpet	✓	✓	✓	✓	✓	✓
Burchardia umbellata	Milkmaids					✓	✓
Caladenia spp.	lady's finger orchids	✓	✓				
Callistemon linearis	Narrow-leaved Bottlebrush					✓	✓
Cassytha glabella	Slender Devil's Twine	✓					
Caustis flexuosa	A sedge	✓	✓		✓	✓	✓
Chorizandra cymbaria	A sedge					✓	✓

SCIENTIFICE NAME	COMMON NAME	SCL-GMF	SCL-GUM	PIP-PIL	PIP-GUM	SST-STG	LON-MEL
Comesperma ericinum	Matchheads	✓				✓	✓
Conospermum longifolium	Long Leafed Smoke Bush	✓	✓				
Corymbia gummifera	Red Bloodwood	✓	✓	✓	✓	✓	✓
Cryptostylis hunteriana	**Leafless Tongue Orchid**	✓	✓		✓		
Cryptostylis subulata	Large Tongue Orchid	✓	✓		✓		
Cyathochaeta diandra	-					✓	✓
Dampiera stricta	Blue Dampiera	✓				✓	✓
Darwinia leptantha	-					✓	✓
Daviesia ulicifolia	Gorse Bitter Pea	✓	✓				
Deyeuxia decipiens	Reed Bent Grass	✓	✓				
Dianella caerula var. *producta*	Paroo Lily	✓	✓	✓		✓	✓
Dichelachne rara	-	✓	✓				
Dillwynia floribunda	Flowery Parrot-pea					✓	✓
Drosera spatulata	A sundew	✓	✓			✓	✓
Empodisma minus	Spreading Rope Rush					✓	✓
Entolasia marginata	Bordered Panic					✓	✓
Entolasia stricta	Wiry Panic	✓	✓	✓	✓	✓	✓
Epacris obtusifolia	Blunt-leaf Heath					✓	✓
Epacris microphylla	Coral Heath	✓	✓			✓	✓
Epacris pulchella	NSW Coral Heath	✓	✓	✓	✓	✓	✓
Eragrostis leptostachya	Paddock Lovegrass	✓	✓			✓	✓
Eucalyptus botryoides	Bangalay	✓					
Eucalyptus consideniana	Yertchuck	✓			✓		
Eucalyptus eugenioides	Thin-leaved Stringybark				✓		
Eucalyptus globoidea	White Stringybark	✓	✓			✓	✓
Eucalyptus longifolia	Woollybutt						✓
Eucalyptus pilularis	Blackbutt			✓			
Eucalyptus piperita	Sydney Peppermint			✓	✓		
Eucalyptus sclerophylla	Hard-leaf Scribbly Gum	✓	✓			✓	✓
Eucalyptus seiberi	Silvertop Ash	✓	✓		✓	✓	✓
Gahnia radula	A saw-sedge			✓	✓		
Gahnia sieberana	Red-fruited Saw-sedge	✓	✓			✓	✓
Glycine clandestina	Love Creeper	✓	✓	✓	✓		
Gompholobium latifolium	Broad-leaf Wedge-pea	✓	✓		✓		
Gompholobium pinnatum	A wedge-pea	✓	✓				
Gonocarpus micranthus	Creeping Raspwort					✓	✓
Gonocarpus teucrioides	Germander Raspwort	✓	✓		✓	✓	✓

SCIENTIFICE NAME	COMMON NAME	SCL-GMF	SCL-GUM	PIP-PIL	PIP-GUM	SST-STG	LON-MEL
Goodenia bellidifolia	Daisy-leaved Goodenia	✓	✓			✓	✓
Goodenia paniculata	Swamp Goodenia					✓	✓
Grevillea linearifolia	White Spider					✓	✓
Haemadorum corymbosum	Bloodroot					✓	✓
Hakea dactyloides	Broad-leaved Hakea	✓	✓			✓	✓
Hakea sericea	Bushy Needlebush	✓	✓	✓	✓	✓	✓
Hakea teretifolia	Dagger Hakea		✓			✓	✓
Hardenbergia violacea	Twining Pea	✓		✓	✓		
Hibbertia aspera	Rough Guinea Flower			✓	✓		
Hibbertia obtusifolia	Grey Guinea-flower	✓		✓			
Hibbertia riparia	A guinea-flower		✓			✓	✓
Hovea linearis	Narrow-leaf Hovea	✓			✓		
Hybanthus vernonii subsp. *vernonii*	-		✓				
Hydrocotyle peduncularis	A pennywort					✓	✓
Hypericum gramineum	St. Johns Wort			✓	✓		
Hypericum japonicum	-					✓	✓
Imperata cylindrica	Blady Grass			✓	✓	✓	✓
Isopogon anethifolius	Drumsticks	✓	✓				
Juncus usitatis	Common Rush	✓	✓			✓	✓
Kennedia rubicunda	Dusky Coral Pea			✓			
Kunzea ambigua	White Tickbush	✓	✓				
Kunzea capitata	Pink Kunzea		✓				
Lagenifera stipitata	Blue Bottle-daisy	✓	✓	✓	✓	✓	✓
Lambertia formosa	Mountain Devil	✓	✓				
Lepidosperma laterale	Variable Sword-sedge	✓	✓	✓	✓	✓	✓
Leptocarpus tenax	Leptocarpus tenax		✓			✓	✓
Leptomeria acida	Native Currant	✓					
Leptospermum juniperinum	Prickly Tea-tree	✓	✓			✓	✓
Leptospermum polygalifolium subsp. *polygalifolium*	Yellow Tea-tree	✓	✓	✓		✓	✓
Leptospermum trinervium	Flaky-barked Tea-tree	✓	✓			✓	✓
Leucopogon lanceolatus	Lance-leaf Beard-heath			✓			
Lindsaea linearis	Screw Fern	✓	✓				
Lindsaea microphylla	Lacy Wedge Fern	✓	✓				
Lomandra gracilis	A mat-rush			✓			
Lomandra longifolia	Spiny-headed Mat-rush	✓	✓	✓		✓	✓
Lomandra multiflora	Many-flowered Mat-rush			✓	✓		

SCIENTIFICE NAME	COMMON NAME	SCL-GMF	SCL-GUM	PIP-PIL	PIP-GUM	SST-STG	LON-MEL
Lomandra obliqua	Fish Bones	✓	✓				
Lomatia ilicifolia	Holly Lomatia	✓	✓	✓	✓		
Melaleuca ericifolia	Swamp Paperbark					✓	
Melaleuca linariifolia	Narrow-leaved Paperbark	✓	✓			✓	✓
Melaleuca thymifolia	A tea-tree					✓	✓
Micrantheum ericoides	-					✓	✓
Microlaena stipoides var. *stipoides*	Weeping Meadow Grass	✓	✓				
Mirbelia rubiifolia	Heath Mirbelia	✓	✓			✓	✓
Opercularia diphylla	-	✓	✓		✓	✓	✓
Panicum simile	Two Colour Panic	✓	✓		✓		
Paspalidium distans	-	✓	✓				
Patersonia glabrata	Leafy Purple Flag	✓	✓			✓	✓
Patersonia sericea	Silky Purple Flag	✓	✓				
*Pennisetum clandestinum**	Kikuyu	✓	✓				
Persoonia levis	Broad-leaf Geebung	✓	✓	✓	✓	✓	✓
Persoonia linearis	Narrow-leaved Geebung	✓	✓	✓	✓		
Persoonia mollis subsp. *caleyi*	Soft Geebung	✓	✓	✓	✓	✓	✓
Petrophile pedunculata	Conesticks	✓		✓	✓		
Phragmites australis	Common Reed					✓	
Pimelea linifolia	Slender Rice-flower	✓	✓	✓	✓	✓	✓
Platylobium formosum	Handsome Flat-pea	✓	✓	✓	✓		
Platysace lanceolata	Carrot Tops	✓					
Podolobium ilicifolium	Native Holly			✓	✓	✓	✓
Poranthera ericifolia	-	✓					
Pteridium esculentum	Bracken	✓	✓	✓	✓	✓	✓
Pterostylis nutans	Nodding Greenhood	✓			✓		
Pterostylis parviflora	Tiny Greenhood	✓			✓		
Pterostylis ventricosa	**An orchid**	✓			✓		
Ptilothrix deusta	A sedge	✓	✓			✓	✓
Pultenaea daphnoides	Broad-leaved Bush Pea			✓	✓		
Pultenaea linophylla	Halo Bush Pea	✓	✓	✓	✓	✓	✓
Pultenaea villosa	Hairy Bush-pea				✓		
Rhytidosporum procumbens	-	✓	✓				
Schoenus brevifolius	A bog-rush					✓	✓
Selaginella uliginosa	Swamp Selaginella					✓	✓
*Setaria gracilis**	Slender Pigeon Grass	✓	✓				

SCIENTIFICE NAME	COMMON NAME	SCL-GMF	SCL-GUM	PIP-PIL	PIP-GUM	SST-STG	LON-MEL
Smilax glyciphylla	Native Sarsaparilla			✓			
Sowerbaea juncea	Vanilla Plant					✓	✓
Sphaerolobium vimineum	-	✓	✓			✓	✓
Sprengelia incarnata	Pink Swamp Heath					✓	✓
Stackhousia viminea	-	✓	✓				
Syncarpia glomulifera subsp. *glomulifera*	Turpentine	✓	✓	✓	✓		
Thelymitra sp.	A sun orchid	✓	✓				
Themeda australis	Kangaroo Grass	✓	✓		✓	✓	✓
Viminaria juncea	Golden Spray	✓	✓			✓	✓
Viola hederacea	Native Violet				✓		
Viola sieberana	Tiny Violet					✓	✓
Xanthorrhoea concava	-	✓		✓	✓		
Xanthosia tridentata	Rock Xanthosia	✓	✓	✓	✓		
Xylomelum pyriform	Woody Pear	✓	✓				

3.4. Fauna

3.4.1 Fauna Habitats

A number of broad fauna habitats are present in the study area, ranging from riparian sedgeland/shrubland to mature forest. Additionally, the study area provides specific fauna resources including a large number of trees with visible hollows, stands of Black She-oak, winter-flowering and high nectar-producing trees and shrubs, sap-trees, ephemeral creeks and farm dams. The more important or these resources are shown in Figure 5 (Appendix A).

A key fauna resource of the study area is the large number of trees with visible hollows, which provide shelter and breeding sites for a wide range of bird, mammal and possibly frog and reptile species. A total of 1434 trees containing medium to large visible hollows were recorded during habitat surveys, although this is likely to be an underestimate of the number of trees with hollows in the study area. The total number of trees containing visible hollows within the study area is substantially higher, as trees containing only small hollows were not recorded during the survey.

Threatened species likely to utilise these resources in the study area for sheltering or breeding include the Yellow-bellied Glider, Eastern Pygmy-possum and possibly Masked Owl. Hollows are also important for sustaining populations of birds and possums, which provide a prey base for the threatened Powerful Owl.

The seed cones of Black She-oak trees provide an almost exclusive food source for the Glossy Black-cockatoo, and these trees are scattered throughout much of the forest and woodland

communities, although only 14 Black She-oak trees were found to be used by Glossy Black-cockatoos for foraging during initial habitat surveys. The actual number of Black She-oak trees used for foraging is likely to be higher, but the study area does not appear to provide a particularly important foraging area for this species. Canopy and sub-canopy seed sources for the threatened Gang-gang Cockatoo and other birds occur widely throughout the forests and woodlands of the study area.

Important nectar sources for birds and mammals, including the threatened Swift Parrot, Yellow-bellied Glider, Eastern Pygmy-possum and Grey-headed Flying-fox, are present in the form of eucalypts and larger banksias within forest and woodland areas. Large numbers of Red Bloodwood trees within forest and woodland provide important summer nectar and pollen resources for birds, possums, gliders and Grey-headed Flying-foxes, and provide a food source for prey species of microchiropteran bats and the Square-tailed Kite. Red Bloodwood provides the main sap resource for gliders throughout the study area, including the threatened Yellow-bellied Glider. Eighteen bloodwood trees were found to be incised by the Yellow-bellied Glider.

The density of the lower level vegetative stratum varies greatly throughout the study area due mainly to the mosaic of vegetation disturbances, with less intensively disturbed areas of forest, woodland and sedgeland providing habitat for a range of smaller terrestrial mammals, reptiles, birds and amphibians. Less disturbed areas of forest and woodland contain a relatively high number of hollow logs, fallen timber and other debris on the ground, providing habitat for a range of smaller vertebrates and invertebrates.

Amphibian habitats are present in the form of ephemeral drainage lines, poorly drained swampy areas and constructed dams. Approximately 40 dams exist in the study area, and were the primary habitats used by the relatively diverse frog population. These aquatic habitats also provide limited resources for waterbirds and some reptiles, birds and mammals.

The fauna habitats in the study area are well connected to larger areas of similar habitats in the adjacent Conjola National Park and other bushland to the west, south and south east (Figure 6, Appendix A). Connectivity with habitats to the north and north east is very fragmented by substantially cleared smaller rural properties.

3.4.2 Fauna Species

Targeted fauna surveys and opportunistic observations during the survey period resulted in the detection of 114 faunal species in or adjacent to the study area. A total of 31 mammals, 68 birds, four reptiles and 11 amphibians have been recorded in the study area and these are listed in Table 6.

The results of the survey indicate a relatively high faunal species richness and diversity, reflecting the range and quality of habitats present. Eleven threatened fauna species were recoded during the survey period, consisting of six threatened mammals and five threatened

birds. Eight introduced species have been recorded in the study area, generally in association with areas of higher disturbance.

Table 6: Fauna species recorded in the study area

(* denotes introduced species, bold denotes threatened species listed under the *TSC Act* or *EPBC Act*).

CATEGORY	COMMON NAME	SCIENTIFIC NAME	DETECTION METHOD
Mammals	Agile Antechinus	*Antechinus agilis*	Elliott trapping
	Bush Rat	*Rattus fuscipes*	Elliott/cage trapping
	Cat *	*Felis domesticus* *	Direct Observation
	Chocolate Wattled Bat	*Chalinolobus morio*	Harp Trapping
	Common Brushtail Possum	*Trichosurus vulpecula*	Direct observation
	Common Ringtail Possum	*Pseudocheirus peregrinus*	Direct observation
	Cow *	*Bos Taurus* *	Direct observation
	Dog *	*Canis familiaris* *	Direct observation
	Eastern Bentwing Bat	***Miniopterus schreibersii***	Echolocation recording
	Eastern False Pipistrelle	***Falistrellus tasmaniensis***	Echolocation recording (probable identification)
	Eastern Freetail-bat	***Mormopterus norfolkensis***	Harp Trapping
	Eastern Grey Kangaroo	*Macropus giganteus*	Direct observation
	Eastern Pygmy-possum	***Cercartetus nanus***	Pitfall trapping
	European Rabbit *	*Oryctolagus cuniculus* *	Direct observation
	Freetail Bat	*Mormopterus planiceps (Species 2)*	Echolocation recording
	Goat *	*Capra hircus* *	Direct observation
	Gould's Wattled Bat	*Chalinolobus gouldii*	Harp Trapping
	Gould's Longeared Bat	*Nyctophilus gouldi*	Harp Trapping
	Grey-headed Flying-fox	***Pteropus poliocephalus***	Direct observation
	Horse *	*Equus caballus* *	Direct observation
	Lesser Long-eared Bat	*Nyctophilus geoffroyi*	Harp Trapping
	Large Forest Bat	*Vespadelus darlingtoni*	Echolocation recording
	Little Forest Bat	*Vespadelus vulturnus*	Harp Trapping
	Long-nosed Bandicoot	*Perameles nasuta*	Cage trapping
	Red-necked Wallaby	*Macropus rufogriseus*	Direct observation

CATEGORY	COMMON NAME	SCIENTIFIC NAME	DETECTION METHOD
	Red Fox*	*Vulpes vulpes* *	Direct observation
	Sugar Glider	*Petaurus breviceps*	Direct observation
	Swamp Rat	*Rattus lutreolus*	Elliott/cage trapping
	Swamp Wallaby	*Wallabia bicolor*	Direct observation
	Yellow-bellied Glider	***Petaurus australis***	Direct observation
	White-striped Free-tailed Bat	*Tadarida australis*	Echolocation recording
Birds	Australian King Parrot	*Alisterus scapularis*	Direct observation
	Australian Magpie	*Gymnorhina tibicen*	Direct observation
	Australian Owlet-nightjar	*Aegotheles cristatus*	Call recognition
	Australian Raven	*Corvus coronoides*	Call recognition
	Black-faced Cuckoo-shrike	*Coracina novaehollandiae*	Direct observation
	Black Swan	*Cygnus atratus*	Direct observation
	Brown Goshawk	*Accipiter fasciatus*	Direct observation
	Brown Thornbill	*Acanthiza pusilla*	Direct observation
	Channel-billed Cuckoo	*Scythrops novaehollandiae*	Direct observation
	Common Bronzewing	*Phaps chalcoptera*	Direct observation
	Common Koel	*Eudynamys scolopacea*	Call recognition
	Crimson Rosella	*Platycercus elegans*	Direct observation
	Dollarbird	*Eurystomas orientalis*	Direct observation
	Eastern Rosella	*Platycercus eximius*	Direct observation
	Eastern Spinebill	*Acanthorhynchus tenuirostris*	Direct observation
	Eastern Whipbird	*Psophodes olivaceus*	Direct observation
	Eastern Yellow Robin	*Eopsaltria australis*	Direct observation
	Fan-tailed Cuckoo	*Cacomantis flabelliformis*	Call recognition
	Galah	*Cacatua roseicapillus*	Direct observation
	Gang-gang Cockatoo	***Callocephalon fimbriatum***	Direct observation
	Glossy Black-cockatoo	***Calyptorhynchus lathami***	Direct observation
	Golden Whistler	*Pachycephala pectoralis*	Direct observation
	Grey Butcherbird	*Cracticus torquatus*	Direct observation
	Grey Fantail	*Rhipidura fuliginosa*	Direct observation
	Grey Shrike-Thrush	*Colluricincla harmonica*	Direct observation

CATEGORY	COMMON NAME	SCIENTIFIC NAME	DETECTION METHOD
	King Parrot	*Alisterus scapularis*	Direct observation
	Laughing Kookaburra	*Dacelo novaeguineae*	Direct observation
	Magpie-lark	*Grallina cyanoleuca*	Direct observation
	Mallard Duck*	*Anas platyrhynchos**	Direct observation
	Masked Lapwing	*Vanellus miles*	Direct observation
	Masked Owl	***Tyto novaehollandiae***	Call recognition
	Musk Lorikeet	*Glossopsitta concinna*	Direct observation
	New Holland Honeyeater	*Phylidonyris novaehollandiae*	Direct observation
	Noisy Friarbird	*Philemon corniculatus*	Direct observation
	Olive-backed Oriole	*Oriolus sagittatus*	Direct observation
	Pacific Black Duck	*Anas superciliosa*	Direct observation
	Pallid Cuckoo	*Cuculus pallidus*	Direct observation
	Peaceful Dove	*Geopelia placida*	Call recognition
	Pied Currawong	*Strepera graculina*	Direct observation
	Powerful Owl	***Ninox strenua***	Call recognition
	Rainbow Lorikeet	*Trichoglossus haematodus*	Direct observation
	Red Wattlebird	*Anthochaera lunulata*	Direct observation
	Red-browed Finch	*Neochmia temporalis*	Direct observation
	Rufous Fantail	*Rhipidura rufifrons*	Direct observation
	Sacred Kingfisher	*Todiramphus sanctus*	Direct observation
	Scarlet Honeyeater	*Myzomela sanguinolenta*	Direct observation
	Silvereye	*Zosterops lateralis*	Direct observation
	Southern Boobook	*Ninox novaeseelandiae*	Call recognition
	Spotted Pardalote	*Pardalotus punctatus*	Call recognition
	Square-tailed Kite	***Lophoictinia isura***	Direct observation
	Striated Thornbill	*Acanthiza lineata*	Direct observation
	Sulphur-crested Cockatoo	*Cacatua galerita*	Direct observation
	Superb Fairy-wren	*Malurus cyaneus*	Direct observation
	Tawny Frogmouth	*Podargus strigoides*	Direct observation
	Weebill	*Smicrornis brevirostris*	Direct observation
	Wedge-tailed Eagle	*Aquila audax*	Direct observation
	White-bellied Sea Eagle	*Haliaeetus leucogaster*	Direct observation

CATEGORY	COMMON NAME	SCIENTIFIC NAME	DETECTION METHOD
	White-browed Scrubwren	*Sericornis frontalis*	Direct observation
	White-eared Honeyeater	*Lichenostomus leucotis*	Direct observation
	White-faced Heron	*Ardea novaehollandiae*	Direct observation
	White-naped Honeyeater	*Melithreptus brevirostris*	Call recognition
	White-throated Nightjar	*Eurostopodus mystacalis*	Call recognition
	White-throated Treecreeper	*Cormobates leucophaeus*	Direct observation
	Willie Wagtail	*Rhipidura leucophrys*	Direct observation
	Wood Duck	*Chenonetta jubata*	Direct observation
	Yellow-faced Honeyeater	*Lichenostomus chrysops*	Direct observation
	Yellow-tailed Black-cockatoo	*Calyptorhynchus funereus*	Direct observation
	Yellow Thornbill	*Acanthiza nana*	Direct observation
Reptiles	Dark-flecked Garden Skink	*Lampropholis delicata*	Direct observation
	Diamond Python	*Morelia spilota spilota*	Direct observation
	Red-bellied Black Snake	*Pseudechis porphyriacus*	Direct observation
	Jacky Lizard	*Amphibolurus muricatus*	Direct observation
Amphibians	Bibron's Toadlet	*Pseudophryne bibronii*	Call recognition
	Bleating Tree Frog	*Litoria dentata*	Call recognition
	Brown-striped Frog	*Limnodynastes peronii*	Direct observation
	Common Eastern Froglet	*Crinia signifera*	Direct observation
	Eastern Banjo Frog	*Limnodynastes dumerilli*	Call recognition
	Eastern Dwarf Tree Frog	*Litoria fallax*	Call recognition
	Freycinet's Frog	*Litoria freycineti*	Call recognition
	Haswell's Froglet	*Paracrinia haswelli*	Call recognition
	Peron's Tree Frog	*Litoria peronii*	Call recognition
	Verreaux's Tree Frog	*Litoria verreauxii*	Call recognition
	Toadlet	*Uperoleia sp.*	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 *EBPC Act* Protected Matters Search Tool.

Both of these databases were searched on 23 May 2007 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 7, with the status of each species listed as Vulnerable (V), Endangered (E) or Critically Endangered (CE).

The potential for each of these species to occur in the study area and the importance of the habitats are discussed in Table 7.

Table 7: 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	
Caladenia tessellata Tessellated Spider Orchid	E	V	Unlikely. This terrestrial orchid is associated with low open forests with a heathy or sometimes grassy understorey on clay-loam or sandy soils. 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, One tentative record of the species exists in the Moona Moona Creek area at Huskisson and another record exists in the Ulladulla area, from Bangalay forest on poorly-drained clay soils. Given the limited understanding of the species habitat preferences it would appear that the study area provides extensive areas of potential habitat for the species. However, targeted surveys did not record any individuals. Given also the lack of positive records in the locality, it is probably unlikely that the species would occur in the study area.
Calochilus pulchellus Pretty Beard Orchid	E		Unlikely. The species is known only from very small populations occurring in the Vincentia, Booderee and Little Forest Plateau areas. Habitat preferences appear to be associated with a heathy groundcover, sometimes with scattered trees, including Hard-leaved Scribbly Gum. The study area provides some limited areas of potential habitat for this species, however the species was not recorded during targeted surveys during the known flowering season and appears unlikely to occur there.
Cryptostylis hunteriana Leafless Tongue Orchid	V	V	Present. This terrestrial orchid grows in swamp-heath and open forest and woodland on sandy and clayey soils in coastal districts and a number of populations are known from the Shoalhaven. This species was found to be relatively widespread in the study area, although occurring at very low densities. This orchid is also known to occur at low densities elsewhere in the Sussex Inlet area, although larger populations are known from Jervis Bay to the north and Dolphin Point in the south.
Galium australe Tangled Bedstraw	E	-	Unlikely. In the Shoalhaven, this perennial herb is known from Lake Windemere in Booderee National Park, Lake Yarrunga near Kangaroo Valley, Conjola National Park and Swan Lake near Swan Haven. The species has been recorded in moist gullies of tall forest, *Eucalyptus tereticornis* forest, coastal Banksia shrubland, and *Allocasuarina nana* heathland. The like most members of the genus, the species is cryptic and can be difficult to locate, however no Galium individuals were detected within the study area and it is probably unlikely that the species occurs in the study area given the habitats present.
Genoplesium baueri Bauer's Midge Orchid	V	-	Unlikely. This small terrestrial orchid occurs in forest and woodland, sometimes in moss garden on sandstone and has been recorded locally at Tabourie, Vincentia, Callala and Nowra, apparently associated with Scribbly Gum, Red Bloodwood and Black She-oak. The study area provides extensive areas of potentially suitable habitat for the species, although no individuals were recorded during targeted surveys in the known flowering season, suggesting the species is unlikely to occur there. Not known from the Sussex Inlet area.

THREATENED FLORA SPECIES	STATUS		POTENTIAL TO OCCUR IN THE STUDY AREA AND IMPORTANCE OF HABITAT WITHIN THE STUDY AREA
	TSC Act	EPBC Act	
Hibbertia sp. no. 'Menai'	E	-	Unlikely. This recently described species is similar to the common *Hibbertia riparia* and until recently was considered part of the *Hibbertia riparia* complex. Herbarium specimens show the species occurring in the Shoalhaven, to the west and south-west of Nowra. A specimen of *Hibbertia riparia* collected from the study area was sent to the Royal Botanic Gardens for identification and was concluded to be *Hibbertia riparia* and not *Hibbertia sp. no. 'Menai'*. The species is not known from the locality and is considered unlikely to occur in the study area.
Melaleuca biconvexa Biconvex Paperbark	V	V	Unlikely. This paperbark is generally restricted to creeks and poorly drained areas and in the Shoalhaven is restricted to the Jervis Bay area. The study area provides some potential habitat for the species in the drainage lines and swampy areas, however it was not detected there despite targeted searches, and it is considered unlikely that it occurs in the study area.
Prasophyllum affine Jervis Bay Leek Orchid	E	E	Unlikely. This orchid occurs on clayey soils overlain by sand in heathland and sedgeland at Vincentia and Currarong. Potential or marginal habitat occurs within the poorly drained parts of the study area however it was not recorded during targeted surveys within the known flowering period.
Pterostylis ventricosa	CE	-	Present. This recently described terrestrial orchid is currently known only from a few locations around the St. George's Basin and Conjola areas where it grows in open areas within eucalypt forest with a heathy understorey and also disturbed sites such as road verges and powerline easements. *Pterostylis ventricosa* was recorded from a number of locations in the study area. Up to 114 individuals were recorded, and a further 502 similar *Pterostylis* leaf rosettes (without flowering stems) are also possibly *P. ventricosa.* In the study area the species was recorded in Peppermint-Bloodwood Forest and Scribbly Gum-Bloodwood Forest, but potential habitat occurs over much of the site.
Rhizanthella slateri Eastern underground Orchid	V	-	Unlikely. This orchid occurs almost entirely underground, although flowering heads may protrude up to 2cm above the ground. The species is very cryptic and difficult to detect, and is known from fewer than 10 locations in New South Wales. The species has been recorded from near Vincentia, in Scribbly Gum Woodland. The study area provides extensive areas of potentially suitable habitat for the species, although targeted surveys did not detect any individuals. While the species and its habitat associations are poorly understood, it is probably unlikely to occur in the study area. The species has not been recorded in the Sussex Inlet area.
Syzygium paniculatum Magenta Lilly Pilly	V	V	Highly unlikely. This shrub or small tree with flaky bark is usually found in subtropical and littoral rainforests on sandy soils or sheltered gullies, especially near watercourses. The study area does not provide suitable habitat for the species and it is considered highly unlikely that it occurs within the study area. It was not recorded during the survey period.
Thesium australe Austral Toad-flax	V	V	Unlikely. This species is associated with native grasslands and is a hemi-parasite of Kangaroo Grass *Themeda australis*, which occurs in very low densities within the study area. As Kangaroo Grass only occurs sporadically throughout the study area, it is considered unlikely that the species would occur there. It was not recorded during the survey period.

THREATENED FLORA SPECIES	STATUS		POTENTIAL TO OCCUR IN THE STUDY AREA AND IMPORTANCE OF HABITAT WITHIN THE STUDY AREA
	TSC Act	EPBC Act	
Wilsonia backhousei Wilsonia	V	V	Highly unlikely. This mat-forming perennial herb occurs on the landward margins of salt-marshes and more rarely on sea cliffs. There is no suitable habitat in the study area and the species was not observed during surveys. It is not expected to occur in the study area.

Two threatened flora species, the Leafless Tongue Orchid *Cryptostylis hunteriana* and *Pterostylis ventricosa,* were recorded in the study area. The constraints posed by these species are discussed in Section 5. Consideration of targeted survey results, habitats present and records of threatened flora in the wider area suggests that other threatened flora species are unlikely to occur in the study area.

4.2 Other Flora of Conservation Significance

Several flora species that are close to the limit of their geographic distribution may occur in the study area, but these are expected to be relatively well represented and protected in the adjoining conservation reserves, which contain similar habitats to those of the study area. Further development of the study area is not expected to advesly affect these species.

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 *TSC* and *EPBC Act* are shown in Table 8 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 within the study area to these species are discussed in Table 8.

Additional threatened species recorded 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 aquatic species have been omitted as they would not occur in the study area.

Table 8: 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			
East Coast Freetail Bat *Mormopterus norfolkensis*	V		Likely. This bat roosts in tree hollows and forages in forests. This species is known to occur in the locality but was not recorded during the survey period. Suitable foraging habitat is present throughout the study area, and the distribution of large trees with hollows generally reflects potential roosting habitat for the species. The species is likely to forage in the study area at least on occasions.
Eastern Bent-wing Bat *Miniopterus schreibersii oceanensis*	V		Present. This bat predominately uses caves as roosting and breeding sites and forested areas for foraging. Caves are not present in the study area so breeding habitat is absent, although good quality foraging habitat occurs over much of the study area. The species is known from the locality, was recorded during the survey period and is likely to forage throughout the study area.
Eastern Cave Bat *Vespadelus troughtoni*	V		Unlikely. This species generally roosts in caves and forages in forest and woodland. The study area provides suitable foraging habitat but no important roosting resources. Few records of this species exist in the Shoalhaven and its status in the areas is unclear, although it does not appear to occur regularly in the area. Could potentially occur in the study area but unlikely to do so regularly.
Eastern Chestnut Mouse *Pseudomys gracilicaudatus*	V		Unlikely. The southernmost distribution of this species is thought to be the Jervis Bay area, where it has been recorded in low numbers. Preferred habitat in the region is dense vegetation such as heathlands and swamps, particularly where the understorey is regenerating after fire. The sedgelands and associated riparian habitats in the study area may provide small areas of habitat for the species, however it was not recorded during the survey period. The species is not known from the Sussex Inlet area and is unlikely to occur in the study area.
Eastern False Pipistrelle *Falsistrellus tasmaniensis*	V		Present. This bat generally roosts in tree hollows and forages in forests. It is known to occur in the locality and was recorded during the survey period. Suitable foraging, sheltering and breeding habitat is present in the study area and the species is likely to at least forage in the area on a regular basis. The species may potentially roost in the study area.
Eastern Pygmy-possum *Cercartetus nanus*	V		Present. 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. One individual was trapped towards the south of the study area. The species is likely to occur more widely in the study area and is known to occur elsewhere in the locality.
Greater Broad-nosed Bat *Scoteanax rueppellii*	V		Probable. This bat generally roosts in tree hollows and forages in forests for insects. The species was not recorded during the survey period, but is known from the locality and likely to occur in the study area given the suitability of habitat present.

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 *Pteropus poliocephalus*	V	V	Present. The species roosts in permanent or semi-permanent camps and forages for nectar, pollen and fruit in flowering or fruiting trees over vast areas. Roosting habitat is not present, but the species was recorded during the survey period and is expected to forage throughout the study area. Suitable foraging resources are widespread in the study area.
Large-eared Pied Bat *Chalinolobus dwyeri*	V	V	Possible. 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 was not recorded in the study area and does not appear to be regularly detected south of Nowra. The species could conceivably forage in the area on occasions, but is unlikely to occur in the study area regularly.
Large-footed Myotis *Myotis adversus*	V		Possible. This bat roosts in caves, tree hollows ad dense foliage near watercourses. It typically forages for insects or small fish over rivers, streams and ponds and is known to occur in the locality but was not recorded during the survey period. Foraging habitat for this species in the study area appears to be relatively poor, although possible roosting and breeding habitat is present within larger trees containing hollows. The species is not likely to frequent the study area but could occur there on occasions.
Koala *Phascolarctos cinereus*	V		Possible. This species was not recorded in the study area and is not regularly detected in the locality, although has apparently been recorded towards the south of Conjola National Park. The study area contains some suitable feed trees for the Koala and it could potentially occur there on rare occasions. This species is not likely to regularly occur in the study area, which does not provide high quality habitats.
Long-nosed Potoroo *Potorous tridactylus*	V	V	Possible. This species requires dense and relatively contiguous undergrowth often on sandy loam soils, and forages on underground fungi, invertebrates and tubers. The species was not recorded in the study area, but has been recorded locally near Tomerong and the northern side of Conjola Lake. Parts of the study area contain potential habitat and the species could possibly occur there, but the species does not appear to frequent the area.
Southern Brown Bandicoot *Isoodon obesulus*	E	E	Possible. This species occurs in a range of habitats from heath to forest where it forages on underground fungi and invertebrates. Parts of the study area contain suitable habitat for the species, although it was not recorded during surveys. Locally the species has been recorded from Conjola National Park approximately 10km south west of the study area. The species could potentially occur in the study area, but appears unlikely to frequent the area.
Spotted-tailed Quoll *Dasyurus maculatus*	V	E	Possible. This species occurs in a wide range of habitats and dens in fallen logs, tree hollows and rock crevices. It forages on a range of mammals, birds and insects over a large home range. The species was not recorded during the survey period, but has been recorded locally near the highway to the west of the study area. Suitable (although not particularly good quality) habitat exists within less disturbed vegetation in the study area and the species could possibly occur there on occasions, but does not appear to frequent 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	
Squirrel Glider *Petaurus norfolcensis*	V	-	Unlikely. The species dens in tree hollows and forages in forests and woodlands where it's preferred feed trees are found. The species can be difficult to locate and appears to be sparsely and patchily distributed on the south coast. It has been recorded from several locations in the Jervis Bay area and to the south of Ulladulla. The species was not recorded during the survey period and has not been recorded in the locality. The Squirrel Glider is unlikely to occur in the study area, although given the cryptic nature of the species and the suitability of habitat in parts of the study area and surrounding landscape, its occurrence can not be confidently discounted.
White-footed Dunnart *Sminthopsis leucopus*	V	-	Unlikely. This species inhabits a range of environments including grassland, heath and forest, and in NSW apparently prefers vegetation with a more open understorey. The species is not known from the immediate area, but has been recently recorded at Jervis Bay and Dolphin Point. Potentially suitable habitat occurs over parts of the study area, however the species was not recorded during targeted surveys and appears unlikely to occur in the study area.
Yellow-bellied Glider *Petaurus australis*	V	-	Present. This species dens in tree hollows and forages in open forests where it's preferred feed trees are found. This species was found over much of the study area, which contains suitable denning and foraging habitat. Numerous records of the species exist in the locality.
Yellow-bellied Sheathtail Bat *Saccolaimus flaviventris*	V	-	Unlikely. This species generally roosts in tree hollows and buildings and forages for insects in a wide variety of habitats from forests to treeless areas. The study area provides potential roosting and foraging habitat. This species does not appear to be regularly recorded in the Shoalhaven and was not recorded during the survey period. The species is unlikely to occur in the study area.
Birds			
Barking Owl *Ninox connivens*	V	-	Unlikely. This species relies on hollow trees for nesting and a range of mammals and birds for foraging. Records of this species in the locality are scarce and may not represent resident individuals or indicate permanent territories. Some suitable foraging, roosting and nesting habitat occurs in the study area, but the species was not recorded during targeted surveys. The species is unlikely to occur in the study area on a regular basis.
Black Bittern *Ixobrychus flavicollis*	V	-	Unlikely. This species is usually found in wetlands, soaks and along densely vegetated creeks. The study area contains small areas of marginal habitat where the species could potentially occur on occasions, although no typical or otherwise important habitat for the species.
Eastern Bristlebird *Dasyornis brachypterus*	E	E	Unlikely. The Eastern Bristlebird is a cover-dependent species predominantly of dense heath or similar low-level vegetation. Most of the study area does not provide typical habitat for this species, although the riparian areas and heathy woodland vegetation may provide small areas of marginal habitat. The species is not known from the Sussex Inlet area and was not recorded during the survey period. The species is not expected 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	
Gang-gang Cockatoo *Callocephalon fimbriatum*	V	-	Present. Gang-gang cockatoos are hollow-dependent inhabitants of forest and woodlands of south-eastern Australia. The species feeds predominantly on the seeds of eucalypts and acacias. The study area contains suitable foraging and nesting resources for the species and it is known from the locality. The species was heard calling from beyond the study area, but is expected to forage in the study area as seed resources are widespread. While suitable nesting trees exist in the study area, no evidence of nesting was found during the survey period.
Glossy Black-cockatoo *Calyptorhynchus lathami*	V	-	Present. This species occurs in forests and woodlands where She-oak feeding resources are prevalent and large tree hollows exist for breeding. Foraging resources occur in the study area and evidence of feeding by the species was found at 14 of these trees. The study area does not appear to be a particularly important foraging area. The presence of numerous large trees with hollows indicates that nesting sites may occur in the study area, however no evidence of nesting was recorded during the survey period.
Ground Parrot *Pezoporus wallicus*	V	-	Unlikely. This cover-dependent species is usually associated with low heathland and sedgeland vegetation. Most of the study area does not provide suitable habitat for this species, although some small areas of marginal habitat exist in association with drainage lines and other poorly drained areas. The species was not recorded during the survey period and is not known from the Sussex Inlet area. Given the largely unsuitable habitat in the study area, it is unlikely to occur there.
Masked Owl *Tyto novaehollandiae*	V	-	Present. This species breeds and may roost in tree hollows and forages mostly on smaller terrestrial mammals. Suitable foraging, roosting and nesting habitat occurs throughout much of the study area. This species was recorded in the study area and is likely to forage there on a regular basis. No evidence of roosting or nesting was observed, although this is possible given the number and quality of hollow-bearing trees present.
Olive Whistler *Pachycephala olivacea*	V	-	Unlikely. This species is usually associated with moist tall forests at higher elevations but may move to lower elevations during the winter months. Breeding generally occurs during spring and summer at higher altitudes within habitats providing both a thick understorey and moderate canopy. The species has been infrequently recorded in coastal areas in the Shoalhaven, and was not recorded in the study area. Habitats in the study area are not typical of the species and it would appear unlikely to occur there.
Orange-bellied Parrot *Neophema chrysogaster*	E	E	Unlikely. This non-breeding winter migrant to the region forages mainly on seeds and fruits of sedges, saltmarsh plants and shrubs close to the coast, but may occur in other near-coastal habitats including highly modified areas. The study area generally provides unsuitable habitat for the species in terms of vegetation and distance from the coast. Riparian shrubland, sedges and modified pastures could provide some marginal foraging resources, although the species was not recorded during the survey period and is 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	
Osprey *Pandion haliaetus*	V	-	Unlikely. This species builds nests on cliff tops or in large dead trees close to water and hunts for fish in open water such as rivers, lakes and the ocean. It has been recorded at Jervis Bay. The study area does not contain important resources for this species, which was not recorded during surveys and is unlikely to occur there.
Powerful Owl *Ninox strenua*	V	-	Present. Preferred habitat for this species is forest containing large tree hollows for breeding. The Powerful Owl forages primarily on arboreal mammals. The species was recorded during the survey period and is likely to forage throughout the study area. While many large tree hollows occur in the study area, sheltered roosting and nesting sites were scarce and no evidence of roosting or nesting was found. Unlikely to roost regularly or nest in the study area.
Regent Honeyeater *Xanthomyza phrygia*	E	E	Unlikely. This migrant to the region forages on a wide range of trees and mistletoes and on the south coast stands of trees such as Spotted Gum and Swamp Mahogany appear to be favoured. Preferred foraging resources are not prevalent within the study area, suggesting that the site would not constitute important habitat for this species. The species was not recorded during the survey period, but has been recorded in the Conjola National Park area.
Sooty Owl *Tyto tenebricosa*	V	-	Unlikely. This species is typically associated with closed forest and tall wet open forest, but is known to also occur in a wider range of habitats. The species was not recorded during surveys, but has been recorded in the vicinity of Conjola National Park. The study area provides suitable foraging habitat but not typical roosting or breeding habitat. The species could potentially occur in the study area on occasions, but is unlikely to given the lack of favourable habitat there and in adjoining areas.
Square-tailed Kite *Lophoictinia isura*	V	-	Present. This summer migrant to the Shoalhaven hunts for passerines in coastal open forests and nests in large trees, often near waterways. Suitable foraging habitat occurs over most of the study area, which the species uses as part of a much larger home range. Two Square-tailed Kites were observed in the study area on several occasions, although no evidence of nesting was found.
Striated Fieldwren *Calamanthus fuliginosus*	V	-	Unlikely. This species occurs in coastal heaths, swamp margins, tussocky grasslands and other dense, low vegetation. The study area generally contains marginal habitat for this species, which was not recorded during the survey period. Unlikely to occur in the study area.
Swift Parrot *Lathamus discolor*	E	E	Possible. This non-breeding migrant to the region forages for nectar in flowering trees such as Spotted Gum, Swamp Mahogany and Red Bloodwood. Suitable Red Bloodwood foraging resources are present within the study area and it is possible that the species will utilise such resources on occasions. Not recorded in the survey period.

THREATENED FAUNA SPECIES	STATUS		POTENTIAL TO OCCUR IN THE STUDY AREA AND IMPORTANCE OF HABITATS WITHIN THE STUDY AREA
	TSC Act	EPBC Act	
Turquoise Parrot *Neophema pulchella*	V	-	Possible. This species favours open woodland habitats and generally feeds on seeds from grasses, herbs and shrubs. It nests in hollow trees or logs, which may be close to the ground. The species was not recorded during the survey period and is not regularly recorded in the locality, although has been recorded nearby in Conjola National Park. Potential foraging and breeding habitat exist in the study area. The disturbances to vegetation within the study area may have increased the area of potential foraging habitat for the species, although it is considered unlikely to frequent the study area.
Amphibians			
Giant Burrowing Frog *Heleioporus australiacus*	V	V	Possible. This species may be found in a range of habitats from forest to heath, usually in sandy soils and breeds in creeks and ephemeral ponds often underlain with sandstone, or within burrows. The species appears intolerant of clearing and poor water quality. Potential habitat in the study area is mainly associated with the ephemeral riparian area in the south west. The species was not recorded in the study area and is not known from surrounding areas. The study area does not appear to support important habitat or a large population of the species, although it could conceivably occur there.
Green and Golden Bell Frog *Litoria aurea*	E	V	Possible. This species prefers unshaded water bodies containing emergent vegetation. The species is known to breed at the Sussex Inlet sewage treatment plant, located approximately 1.5 km to the south east of the study area. Dispersing individuals could conceivably reach the study area, where some riparian vegetation and a few of the farm dams provide small areas of suitable habitat. The most suitable habitats were targeted during surveys, but the species was not recorded in the study area. The study area does not provide important habitat for this species. Given the limited habitat available, the species is probably unlikely to occur in the study area.
Littlejohn's Tree Frog *Litoria littlejohni*	V	V	Unlikely. 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 creeks. It appears to occur at mid to high altitudes and is not known from the locality. The species was not recorded during the survey period and is not expected to occur in the study area.
Reptiles			
Broad-headed Snake *Hoplocephalus bungaroides*	E	V	Unlikely. 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 in the study area. It is not known from the locality and is not expected 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	
Rosenberg's Goanna *Varanus rosenbergi*	V	-	Unlikely. 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 does not appear to have many termite mounds, which are a critical resource for this species. The species is not known from coastal areas in the Shoalhaven and is not expected to occur in the study area.
Insects			
Giant Dragonfly *Petalura gigantea*	E	-	Unlikely. This dragonfly occurs in permanent swamps and bogs and is detectable from about November to early February when adults forage on flying insects among vegetation adjacent to swamps. All of the creeks or swampy areas in the study area ephemeral, although the study area is linked to larger swampy areas. The species was not recorded during the survey period. Given the marginal habitat in the study area and lack of records in the locality, the species appears unlikely to occur there.

The threatened Eastern Bentwing-bat, Eastern False Pipistrelle, Eastern Freetail-bat, Eastern Pygmy-possum, Grey-headed Flying-fox, Yellow-bellied Glider, Gang-gang Cockatoo, Glossy Black-cockatoo, Masked Owl, Powerful Owl and Square-tailed Kite were recorded in or near the study area during the survey period. The Eastern Pygmy-possum and Yellow-bellied Glider appear to inhabit parts of the study area on a permanent basis, and are expected to breed in the study area. Other threatened fauna recorded are likely to utilise the study area for foraging (possibly on a regular basis) and possibly sheltering, but no evidence of breeding sites was found during the survey period. The ecological constraints to development posed by these species are discussed further in Section 5.

4.4 Migratory Species

The outcome of the *EPBC Act* database search for migratory species is shown in Table 9 below. The potential for each of these species to occur in the study area and the importance of habitats in the study area is discussed in Table 9.

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

Table 9: 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 *Monarcha melanopsis*	Possible. This species is known to breed in damp forest types and forage in rainforest and eucalypt forest. The Black-faced Monarch could occur in the study area on occasions, although the study area does not contain typical or important habitat for this species.
Latham's Snipe *Gallinago hardwickii*	Possible. This species is found in a range of vegetated wetlands. The species does not breed in Australia, but riparian vegetation and some dams within the study area provide small areas of pestilential shelter and foraging habitat. Unlikely to frequent the study area.
Orange-bellied Parrot *Neophema chrysogaster*	Unlikely. This non-breeding winter migrant to the region forages mainly on seeds and fruits of sedges, saltmarsh plants and shrubs close to the coast, but may occur in other near-coastal habitats including highly modified areas. The study area generally provides unsuitable habitat for the species in terms of vegetation and distance from the coast. Riparian shrubland, sedges and modified pastures could provide some marginal foraging resources, although the species was not recorded during the survey period and is unlikely to occur in the study area.
Painted Snipe *Rostratula benghalensis*	Unlikely. This species is usually found in vegetated, shallow, temporary or infrequently filled wetlands. The larger drainage lines and some dams in the study area provide small areas of marginal habitat during wetter periods, however, given the species' rarity in the region and lack of records in the Shoalhaven, it is considered unlikely to occur in the study area.
Regent Honeyeater *Xanthomyza phrygia*	Unlikely. This migrant to the region forages on a wide range of trees and mistletoes and on the coast stands of trees such as Spotted Gum and Swamp Mahogany appear to be favoured. Preferred foraging resources are not prevalent within the study area, suggesting that the site would not constitute important habitat for this species. Has been recorded in the Conjola National Park area although was not recorded during the survey period. Unlikely to occur in the study area.
Rufous Fantail *Rhipidura rufifrons*	Present. This species often occurs in dense understorey in damp forests or beside rivers. This species was recorded close to the drainage line in the north of the study area and possible habitat occurs in other dense understorey habitats, particularly in association with riparian vegetation. Typical or good quality habitat for this species is absent over most of the study area, and while the species may occur there, the study area does not provide important or substantial habitat for the species.
Satin Flycatcher *Myiagra cyanoleuca*	Possible. This species inhabits lowland eucalypt forests and is known to nest in dense gully vegetation. Habitats in the study area are generally unsuitable for breeding. While the species could forage in the study area on occasions, the habitats present are unlikely to be important for this species.
Swift Parrot *Lathamus discolor*	Possible. This non-breeding migrant to the region forages for nectar in flowering trees such as Spotted Gum, Swamp Mahogany and Red Bloodwood. Suitable foraging resources are present within the study area and it is possible that the species will utilise such resources on occasions.
White-bellied Sea-eagle *Haliaeetus leucogaster*	Unlikely. This species inhabits primarily coastal environments but may occur inland in association with rivers, lagoons and floodplains, where it forages for fish and nests in tall trees. This species occurs in the locality although is unlikely to occur in the study area given the lack of foraging habitat and unlikely nesting resources. No evidence of nesting

SPECIES	POTENTIAL TO OCCUR IN THE STUDY AREA AND IMPORTANCE OF HABITATS WITHIN THE STUDY AREA
	was observed during habitat surveys and trees within the study area do not appear to provide high quality nesting resources for this species.
White-throated Needletail *Hirundapus caudacutus*	Possible. This insectivorous species spends most of its time in the air, but is known to roost on cliffs or trunks of trees. It is likely to fly over the study area from time to time and could potentially roost there on occasions, but the study area does not contain any habitats of importance for this species.

The Rufous Fantail was recorded during the survey period and several other migratory species listed in Table 9 could occur in the study area on occasions, although habitats in the study area are not of particular importance to any of these species. The ecological constraints posed by migratory fauna species and their habitats are discussed in Section 5.

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 is given to endangered populations in this report.

4.6 Endangered Ecological Communities

The *TSC Act* and *EPBC Act* provide for the listing of endangered ecological communities. Those vegetation communities associated with the swampy drainage lines in the study area, the Sandstone Sedgeland (SST-STG) and Woollybutt – Paperbark Forest (LON-MEL), are not considered to comprise endangered ecological communities. Whilst these drainage lines are;

- associated with the coastal floodplains of Swan Lake and Badgee Lagoon;
- include Melaleuca species, including *Melaleuca ericifolia* in the eastern extremities of the study area; and
- in a few areas, support individuals of eucalypts characteristic of the community such as Woollybutt and Bangalay *Eucalyptus botryoides;*

they are not considered to comprise the 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), listed on the *TSC Act* as they do not, in any locations, have any of the features identified in point six of the final determination (NSW Scientific Committee 2004) as a distinguishing the community from other EEC on coastal floodplains such as;

- a relatively dense canopy dominated by Swamp Mahogany or Bangalay;
- the occasional presence of rainforest elements as scattered trees or understorey plants; or

- groundcovers characterised by a prominent cover of large sedges and ferns.

Similarly they do not include areas of fernland, tall reedland or sedgeland fringing treeless floodplain lagoons or wetlands with semi-permanent standing water, such as those that are identified in point one of the final determination as being included within the Swamp Sclerophyll Forest.

The Sandstone Sedgeland (SST-STG) and Woollybutt – Paperbark Forest (LON-MEL) are more typical of the Coastal Heath Swamps than the Coastal Swamp Forests or Coastal Floodplain Wetlands of Keith (2004). These latter two communities are associated with the Swamp Sclerophyll Forest. The Woollybutt – Paperbark Forest may represent a transitional community between the Coastal Heath Swamps and the Coastal Swamp Forests and Coastal Floodplain Wetlands which occur further downstream along these drainage lines to the east and south of the study area where there is greater influence of the associated coastal water bodies. However, the presence of Woollybutt does not, in our opinion, outweigh the absence of some of the key characteristics of the Swamp Sclerophyll Forest as identified above and in the final determination.

A few immature individuals of Bangalay were observed in the extreme south-west of the study area in the lower parts of the broad swampy area that occurs there, however these individuals occur in association with an area that appears to have previously been subject to active gully erosion and where there has been relatively recent substantial disturbance to the substrate. Despite the presence of Bangalay the vegetation in this area was dominated by species not associated with the Swamp Sclerophyll Forest.

The vegetation communities associated with the swampy drainage lines in the study area do not comprise the Freshwater Wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions, listed on the *TSC Act,* as this community is dominated by herbaceous plants with few woody species.

The vegetation within the study area does not correlate with any other EECs listed on either the *TSC Act* or *EPBC Act*. Tindall *et al*. (2004) map an area of South Coast Grassy Woodland in the western parts of the study area. This community is associated with the Lowland Grassy Woodland in the South east Corner Bioregion, which has been recently listed on the *TSC Act*. However no evidence of the South Coast Grassy Woodland was observed within the study area.

4.7 Koala Habitat

The study area does not appear to contain any koala feed tree species listed on Schedule 2 of *NSW State Environmental Planning Policy No 44 – Koala Habitat Protection* (*SEPP No. 44*). Thus, the study area does not contain potential koala habitat as defined by *SEPP No. 44* and no further provisions of *SEPP No. 44* apply to the study area.

4.8 Habitat Corridor and Connectivity Values

Maintenance of habitat corridors and connectivity is important to maintain biodiversity within the study area and surrounding lands.

The study area has very good connectivity with habitats to the south and west, due to the limited clearing of this section of the study area and the relatively undisturbed interface with the adjacent Conjola National Park. Some good habitat connectivity also exists to the east with larger, vegetated rural properties, although this value is limited by extensive clearing of vegetation within the eastern side of the study area.

Habitat connectivity is most limited to the north, where much of the adjoining land has been cleared or heavily disturbed by smaller rural holdings and Sussex Inlet Road. However, disturbed habitat linkages do exist to the north through a few less disturbed rural properties. This is most apparent to the north east, due to the vegetated lots in the north eastern corner of the study area and relatively short distance to several largely vegetated rural lots which are contiguous with extensive areas of intact vegetation on the southern side of St. Georges Basin. All connectivity to the north and north east is limited by the presence of Sussex Inlet Road and a number of partially cleared rural properties with associated fencing, domestic animals and other disturbances. Thus, connectivity to the north and north east is most functional for highly mobile species such as birds, bats and possibly gliders, while substantially compromised for terrestrial and less mobile fauna.

Habitat connectivity within the study area is provided by retained vegetation, although limited by broad clearing, road and electricity easements, and fencing of most property boundaries. Elements of this connectivity should be maintained with future development and could be enhanced by strategic revegetation of some currently disturbed areas. Habitat connectivity within and beyond the study area is particularly important for the resident threatened species Eastern Pygmy-possum and Yellow-bellied Glider.

The study area drains to Badgee Lagoon in the east and Swan Lake in the south and provides riparian habitat connectivity to these areas, including associated SEPP 14 Wetlands and endangered ecological communities. Development of the study area should ensure that water quality and riparian habitat integrity are not compromised. This should involve the restriction of development and further clearing around the main riparian areas of the estate, and the provision and maintenance of substantial vegetated buffers.

The range of habitat connections within and beyond the study area is shown in Figure 6 (Appendix A).

5. ECOLOGICAL CONSTRAINTS

5.1 Threatened Flora

Leafless Tongue Orchid *Cryptostylis hunteriana*

A total of 21 Leafless Tongue Orchids *Cryptostylis hunteriana* were recorded in the study area (Figure 7, Appendix A). The species was found to be widespread in the study area, although occurring at very low densities in association with Scribbly Gum, Red Bloodwood and Sydney Peppermint dominated vegetation communities. Individuals were often found along slashed tracks or road verges, which contrasted markedly with the dense understorey regeneration over much of the study area. It is likely the population size revealed by the survey has been substantially underestimated, largely due to the difficulty of detecting individual orchids in a dense understorey and a subdued flowering rate because of the densely regenerating vegetation.

Individuals of the species in the study area should be retained, along with additional suitable habitat that connects these individuals with the adjoining national park. The retention of suitable habitat and appropriate linkages within the study area will ensure that additional individuals of the population are protected, along with habitat for the pollinating wasp species to maintain the transfer of genetic material within and beyond the study area. An indicative 50m buffer has been applied to these orchids (Figure 10, Appendix A), which is likely to contain undetected individuals. It is likely that the retention of additional habitat and linkages for this species can be provided in conjunction with retained habitat for other ecological constraints. With appropriate habitat retention and management together with development controls, it is expected that the species can be adequately protected within the study area in conjunction with limited residential development.

Pterostylis ventricosa

Up to 114 *Pterostylis ventricosa* individuals were recorded in the study area. A further 502 similar *Pterostylis* leaf rosettes were recorded but could not be identified to species level due to the absence or poor condition of flowers. For the purpose of this assessment and due to the high conservation value of the speices, these unidentified *Pterostylis* plants are considered potential *P. ventricosa* individuals (Figure 7, Appendix A). *Pterostylis ventricosa* was recorded in Scribbly Gum, Red Bloodwood and Sydney Peppermint dominated communities, with the majority of individuals associated with vegetative clearing along forest edges or more open areas within denser forest.

An indicative 50m buffer has been applied to all known and potential individuals (Figure 10, Appendix A) to allow for the retention of suitable habitat for undetected individuals and pollinators (which are largely unknown at this time). The 50m buffers around individuals should

be linked to areas of similar adjacent habitat to be retained and also connected to similar habitat in the adjacent national park, which is also likely to contain the species.

Suitable habitat for *Pterostylis ventricosa* in the study area at lest partially overlaps with that of *Cryptostylis hunteriana*, and it is likely that the species can be adequately protected within the study area in conjunction with limited further development, provided that habitat can be appropriately retained and managed.

5.2 Threatened Fauna

5.2.1 Mammals

Yellow-bellied Glider

Yellow-bellied Gliders were recorded over much of the study area containing large trees, including heavily disturbed lots. The only habitats in the study area that are not suitable for the species are cleared treeless paddocks, low riparian vegetation and areas of low, open and disturbed woodland in the south west.

The study area supports at least one resident group of gliders, which were regularly recorded in the central and south-eastern portions of the site (Figure 7, Appendix A). It is possible that other glider groups from adjacent areas also use habitats in the study area, as there is good habitat connectivity to the west, south and southeast, and evidence of the species in these areas. The species was also recorded in the north and east of the study area, where connectivity beyond the site is possible, although limited by clearing and unsuitable vegetation. Eighteen sap-feeding trees (Red Bloodwoods) were recorded in the study area, although this is likely to be an underestimate of this resource. The species is expected to use many of the larger hollow-bearing trees in the study area for denning. No specific use of hollows was recorded during the survey period; although a number of dusk calls by the species were heard from within the study area, indicating the presence of nearby den trees.

Important habitat in the study area for the Yellow-bellied Glider includes larger trees with hollows, known and potential sap-feeding trees, areas of forest containing other foraging resources, and areas of forest providing connectivity to suitable habitat within and beyond the study area (Figure 8, Appendix A). In this case, important foraging and connecting habitat includes some larger trees in otherwise heavily cleared lots. In order to protect key habitat for the Yellow-bellied Glider, an indicative 20m buffer has been applied to both sap-feeding trees and all trees containing medium and/or large hollows, which may provide denning resources (Figure 10, Appendix A).

Yellow-bellied Glider groups require relatively large areas of habitat to ensure a continual supply of seasonally varying foraging resources. Further development in the study area should avoid areas of high quality glider habitat, should avoid the removal of large areas of suitable glider

habitat, should avoid the removal of key foraging and potential denning resources, and should avoid the removal of corridors or linking habitat (which may be present as individual trees within cleared land). The retention and strategic revegetation of habitat linkages (Figure 6, Appendix A) is important for this species.

Eastern Pygmy-possum

A single Eastern Pygmy-possum was recorded via pitfall trapping in the south of the study area (Figure 7, Appendix A) and is expected to occupy a relatively permanent home range within the study area given the quality of habitat and small home range of this species, which is generally less than 1 ha (DECC 2005)..Suitable habitat for the species occurs over much of the study area in woodland and forest where the understorey vegetation is intact. The species is likely to occur more widely in the study area, although survey results suggest it does not occur at high densities. Vegetation recovering from fire and/or clearing, particularly in the west of the study area, may currently provide lower quality habitat for the species. The quality of this habitat for the Eastern Pygmy-possum is expected to increase over time.

Good quality known and potential Eastern Pygmy-possum habitat (Figure 9, Appendix A) should be retained within the study area in useful configurations that provide robust connectivity with the adjacent national park. An indicative 50m buffer has been placed around the Eastern Pygmy-possum record in the south of the study area (Figure 10, Appendix A). Habitat retention should build on this area and consider current and future habitat quality and habitat connectivity. Due to the difficulty in detecting individuals of this species, and hence determining the actual area of occupancy, more detailed surveys may be necessary if development is proposed in habitat regarded as good quality for the species.

Microchiropterans

Eastern False Pipistrelle, East Coast Freetail Bat, Eastern Bentwing-bat

The East Coast Freetail and Eastern Bentwing-bat were found to occur widely in the study area from echolocation recording and harp trapping. The Eastern False Pipistrelle was recorded at one site near the north east of the study area, but is also expected to occur more widely. All of these species are fairly regularly recorded from forested areas in the region.

Each species generally forages for insects in or around forested environments over a very large home range and suitable foraging habitat occurs throughout the majority of the study area.

The East Coast Freetail-bat and Eastern False Pipistrelle may roost and breed in tree hollows, which are widespread in the study area. While no evidence of tree hollow use was found during the survey period, it is possible given the suitability of resources present.

A number of other threatened microchiropteran species are known from nearby areas and could potentially occur in the study area on occasions, including the Greater Broad-nosed Bat and

Large-footed Myotis. Suitable foraging and roosting resources exist in the study area for these species, particularly the Greater Broad-nosed Bat.

An indicative buffer of 20m has been applied to hollow-bearing trees in the study area in recognition of their potential use by hollow-dependant microchiropterans and other threatened fauna and importance to biodiversity in general. Strategic revegetation of some currently cleared or degraded areas would enhance habitat for microchiropterans over the long term.

Retaining substantial amounts of forest and woodland vegetation for threatened microchiropterans (and other species) through the study area, linked to adjoining vegetated areas, should protect important resources for these species and continue to facilitate their movement through the landscape. In particular, removal of hollow-bearing trees should be minimised.

Grey-headed Flying-fox

The Grey-headed Flying-fox was recorded foraging and flying within the study area on a number of occasions during the warmer months, and it is known to forage widely throughout the locality. No important roosting sites were recorded or are expected to occur within the study area. The study area contains a range of eucalypt and banksia foraging resources for this species. It is desirable to maintain at least some of these foraging resources, particularly in the form of larger undisturbed areas containing large, mature trees, but even the retention of a number of isolated larger trees will still provide usable foraging resources for the species. Recommended habitat retention for other threatened species is likely to retain adequate foraging resources for the Grey-headed Flying-fox.

5.2.2 Birds

Gang-gang Cockatoo

The Gang-gang Cockatoo was only recorded beyond the study area to the west, although is known to be relatively common in the general area and likely to forage within the study area on occasions. No evidence of nesting activity was recorded during targeted surveys within the breeding season. While the study area contains suitable foraging and nesting habitat, these resources are widespread and common in the region. The study area does not contain any specific constraints to development posed by this species, although it is recommended that a substantial proportion of forest and woodland vegetation is retained in the study area to provide future foraging and potentially nesting resources. This is likely to be achieved by the retention of habitat for other threatened biodiversity.

Glossy Black-cockatoo

The Glossy Black-cockatoo was observed in the study area on several occasions and evidence of foraging was found at 14 Black She-oaks trees, mostly in the north of the study area. While this number is likely to be an underestimate of the actual feed trees used by the species, the

study area does not currently appear to provide a particularly important foraging area for the species. This is partly attributable to the impact of the large wildfire several years ago, which killed many of the Black She-oak feeding resources.

Feed trees are selected by the Glossy Black-cockatoo for their particular qualities and important trees are reused over time. All known feed trees should be retained within surrounding vegetation. An indicative 20m buffer has been applied to known feed trees (Figure 10, Appendix A). Other Black She-oak stands or vegetation containing high densities of Black She-oak trees should also be retained as potential or future foraging areas.

No evidence of Glossy Black-cockatoo nesting was observed during the survey period, so specific nesting sites do not pose constraints to further development. However, many suitable hollow-bearing trees are present in throughout the study area and could be utilised by the species in the future, as well as being important resources to maintain biodiversity in general. Therefore it is recommended that a substantial component of the hollow-bearing tree resource in the study area is retained. An indicative 20m buffer has been applied to all trees with medium to large hollows.

Powerful Owl

The Powerful Owl was recorded in the study area on one occasion when an individual responded to call playback and subsequently entered the study area from the national park to the south. Most, if not all, of the study area appears to constitute part of a Powerful Owl home range. The Powerful Owl is likely to forage in the study area on occasions, given the presence of suitable prey species, although no roosting or breeding activity was recorded. Potential roosting or breeding sites were sparsely distributed, and the study area does not appear to contain any important or good quality roosting or breeding resources.

Maintenance of good quality foraging habitat in the study area is the primary constraint relating to the Powerful Owl. Better foraging habitat is generally associated with forest communities and largely coincides with Yellow-bellied Glider habitat. Many prey species of the Powerful Owl are dependant on hollow-bearing trees, which should be retained as much as possible. An indicative 20m buffer has been applied to hollow-bearing trees in the study area to reflect their importance to threatened fauna and biodiversity in general. Maintaining habitat connectivity with the adjacent national park should also be a primary consideration for the maintenance of Powerful Owl foraging habitat in the study area.

Masked Owl

The Masked Owl was recorded in the south west and towards the north east of the study area, within woodland and disturbed forest habitats. A very strong response to call playback survey suggests that the species may regularly utilise at least parts of the study area. The species is expected to forage over much of the study area given the suitability of vegetation structure and presence of a range of terrestrial prey species.

While no evidence of roosting or breeding was recorded in the survey period, the study area contains numerous hollow-bearing trees suitable for roosting and potentially breeding. The species could conceivably utilise larger trees with hollows in the study area for roosting, but appears less likely to breed in the study area.

With much of the study area likely to be used by the Masked Owl for foraging and possibly roosting, the retention of substantial areas of habitat is recommended. The species may utilise semi-cleared areas and forest edges for foraging and may roost in large hollow-bearing trees in heavily cleared paddocks, so the species is able to utilise a semi-cleared landscape better than many other forest birds. The retention of blocks of intact habitat is still recommended to maintain roosting and foraging resources, and this is likely to largely coincide with habitat retention requirements for other threatened species.

Square-tailed Kite

A pair of Square-tailed Kites was observed foraging on several occasions in the north west and south of the study area. The species is expected to regularly forage throughout the study area during the warmer months of the year, as part of a much larger foraging area. No nests were observed in the study area during systematic searches and the species is considered unlikely to breed in the study area.

The retention of some foraging habitat is recommended, and this is likely to be achieved through retention of habitat for other environmental constraints. As long as substantial areas of forest and woodland are retained within the study area, no further habitat retention measures are considered necessary for this species.

5.2.3 Amphibians

While no threatened frogs were recorded during the survey period, it is possible that the Giant Burrowing Frog may occur within riparian habitats, particularly less disturbed riparian habitat in the south west of the study area. The retention and buffering of riparian habitats in the study area, as recommended elsewhere in this report, together with robust controls on water quality, should also adequately protect any potentially important Giant Burrowing Frog habitat. The potential for the Green and Golden Bell Frog to occur in the study area is somewhat lower, although can not be completely dismissed given the proximity of a breeding population and presence of possible habitat (albeit of lower quality). The retention of riparian habitats as indicated above, together with the retention of most farm dams, would generally maintain habitat for the Green and Golden Bell Frog.

5.3 Migratory Species

One migratory species, the Rufous Fantail, was recorded in the north east of the study area and it is expected to occur more widely in riparian or denser forest habitats. Similarly, the Black-faced Monarch may forage in the forested areas on occasions and conceivably the Satin

Flycatcher, Swift Parrot, Regent Honeyeater and Latham's Snipe could also occur in appropriate habitat on occasions. Apart from the Rufous Fantail, no migratory species are expected to breed in the study area and the habitats present do not contain important foraging or sheltering resources.

Adequate habitat retention for the Rufous Fantail and most other EPBC Act listed migratory species likely to occur in the study area would be achieved by the recommended protection of riparian areas and other habitat for threatened biota. Larger farm dams could conceivably be used for short periods by Latham's Snipe, and the retention of these dams may benefit this species and other birds, mammals and amphibians.

5.4 Endangered Ecological Communities

No endangered ecological communities listed on the TSC Act or EPBC Act occur in or immediately adjacent to the study area. However, several endangered ecological communities listed on the TSC Act and associated with riparian areas are known or likely to occur on the fringes of Badgee Lagoon and Swan Lake and along parts of the creeks flowing from the study area to these water bodies. Endangered ecological communities do not pose any direct constraints to development of the study area, as long as water quality and riparian habitats are not degraded.

5.5 Habitat Corridor and Connectivity

In order to maintain the long term viability of threatened species habitat and general biodiversity in the study area, key habitat linkages need to be retained, managed and in some areas rehabilitated or re-established. Various types of habitat connections are shown in Figure 6 (Appendix A) including areas that could be revegetated to enhance connectivity (lots 20-32 will be excluded from rezoning to allow development).

The revegetation and management of corridors needs to ensure that the requirements of target species are catered for along with requirements general biodiversity. Priority species for habitat connectivity enhancement include less mobile, resident threatened fauna (Yellow-bellied Glider and Eastern Pygmy-possum) and habitat for threatened flora (*Cryptostylis hunteriana* and *Pterostylis ventricosa)* and their pollinators.

The maintenance of habitat linkages should also consider the distribution of particular resources such as hollow-bearing trees and feed-trees, prey habitat for threatened owls (Powerful Owl and Masked Owl) and overall connectivity to Conjola National Park.

The interface with the adjoining national park is the most important habitat linkage supporting threatened biodiversity within the study area. This linkage should be enhanced to maximise the integrity of retained habitats within the study area. At the same time this interface should be managed to ensure that biological and other values within adjoining areas of the national park

are not degraded by activities related to further development in the study area. An indicative 20m buffer has been applied at the national park interface, in which activities such as inappropriate clearing, construction, stockpiling of materials and planting of non-native species, should be restricted to minimise the risk of adverse edge effects to the national park.

Maintaining the condition of riparian vegetation and water quality is particularly important for downstream habitats, including SEPP 14 Wetlands, coastal lakes, endangered ecological communities and Conjola National Park. An indicative 50m vegetated buffer has been applied to all riparian vegetation in the study area to ensure that the impacts to riparian vegetation are minimised. Council's resolution on 19 April 2011 to exclude lots 20-32 from proposed development should assist in this regard.

5.6 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 10 (Appendix A) including:

a) key habitat or specific resources (e.g. feed-trees) known to be used by threatened fauna species;

b) potential key resources (e.g. trees with hollows) for threatened and non-threatened fauna;

c) habitat for threatened or otherwise significant flora;

d) foraging habitat for threatened fauna;

e) habitat linkages and connectivity;

f) riparian vegetation; and

g) various vegetated buffers to key habitats.

Ecological Constraint Buffers

The provision of fully vegetated or partially vegetated buffers around specific habitats or resources can play 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 has been applied to known and potential occurrences of *Pterostylis ventricosa,* to reflect the species current status as Critically Endangered. Further development within these buffers should be avoided, as they are likely to contain and protect additional individuals and maintain habitat for pollinators. Maintaining connectivity between these buffers is also important for genetic exchange (pollinator movement) and protection of undetected individuals in the population, as suitable

habitat appears to extend beyond the 50m buffers. Specifically managed Asset Protection Zones (APZs) may be permissible within these buffers where legal clearing already exists.

- A 50m buffer has been applied to occurrences of *Cryptostylis hunteriana* in the study area in recognition of their state and federal 'vulnerable' status. These buffers are likely to encompass other undetected individuals and pollinator habitat. The scattered occurrence of this species in the study area will require the retention of additional areas of suitable habitat (beyond the buffers) to link individuals in the study area to each other and the adjacent national park. Specifically managed Asset Protection Zones may be permissible within these buffers where legal clearing already exists.
- Buffers of at least 50m have been applied to riparian vegetation (Sandstone Sedgeland and Woollybutt - Paperbark Forest) in the north east, south west and north west of the study area, in recognition of their restricted habitats, ecological processes, sensitivity to disturbances and association with downstream areas of endangered ecological communities, SEPP 14 Wetlands and coastal lakes. A substantially larger buffer may be required, particularly on riparian vegetation in the relatively undisturbed Swan Lake catchment, if water quality is to be maintained at current levels.
- A 20m vegetated buffer has been applied to large trees with hollows, which represent an important fauna resource and potential habitat for a range of threatened fauna. These buffers ensure the root zones of these trees are not damaged; maintain some connectivity to and from these trees for the Yellow-bellied Glider and Eastern Pygmy-possum; and prevent development occurring at a proximity which is likely to compromise the future use of these resources. Development should preferentially be located as far away from hollow-bearing trees as possible.
- A 20m vegetated buffer has been applied to Yellow-bellied Glider sap-feeding trees to ensure access for the gliders is maintained to these resources and that inappropriate development does not render the resource unusable. The buffers are likely to contain additional foraging resources, trees providing connectivity with other habitat, and recruitment trees for future connectivity and foraging. Connectivity for this species also needs to be maintained beyond these buffers, between areas of suitable habitat within and beyond the study area. Development should preferentially be located as far away from feed-trees as possible, but APZs may be maintained within the buffers if legal clearing of vegetation has been undertaken there and the objectives of the buffers are not compromised.
- A 20m vegetated 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 could be established and

maintained within this buffer if legal clearing has already occurred and the objectives of the buffers are not substantially affected. The construction of dwellings and other structures should not be permitted within this buffer. Other female (cone-bearing) 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 11 (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 riparian vegetation in recognition of its ecological function and significance of downstream vegetation and habitats. Both catchments in the study area drain into sensitive coastal lakes, SEPP 14 wetlands and associated endangered ecological communities. In the south west of the study area, the Swan Lake catchment also drains directly into Conjola National Park.

A high level of constraint was applied to individuals and buffers of the orchids *Cryptostylis hunteriana* and *Pterostylis ventricosa* (known and potential records) for several reasons. The life cycle of these terrestrial orchids is such that the full extent of populations are not readily apparent until multiple surveys have been undertaken and the buffers to orchids are likely to contain and provide habitat for undetected individuals and pollinators. Otherwise, these orchids have been given a high level of constraint because of the current lack of information regarding their distribution and abundance beyond the study area.

A high level of constraint was also applied to the 50m buffer surrounding the single Eastern Pygmy-possum record towards the south of the study area in recognition of the scarcity of other records in the locality; the small home range (generally less than 1 ha) occupied by individuals; and the sensitivity of the species to many types of disturbances. The Eastern Pygmy-possum is susceptible to predation by introduced species, due to its size and tendency to utilise lower stratum habitat. The species often forages and sometimes shelters in shrub layer vegetation and may regularly move along the ground between resources. This makes the species potentially susceptible to other habitat disturbances associated with rural residential areas such

as inappropriate fire regimes, removal of dead timber for firewood (loss of nest sites), under scrubbing of vegetation (for asset protection, grazing etc.) and fragmentation of habitat.

A moderate-high level of constraint was applied to key foraging resources for vulnerable species (identified feed-trees of the Yellow-bellied Glider and Glossy Black-cockatoo) and their respective buffers; known or likely habitat for the resident threatened fauna species Yellow-bellied Glider and Eastern Pygmy-possum; riparian vegetation buffers, and potential breeding and sheltering resources for vulnerable species (large trees with hollows and associated buffers). Large trees with hollows were considered a moderate-high level constraint due to the 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 support.

A moderate level of constraint was applied to the remaining native vegetation within the study area because it comprises possible foraging habitat for the resident species Yellow-bellied Glider and Eastern Pygmy-possum, foraging habitat for a number of other vulnerable fauna species (including the Grey-headed Flying-fox, East Coast Freetail Bat, Eastern Bentwing Bat, Eastern False Pipistrelle, Gang-gang Cockatoo, Masked Owl, Powerful Owl and Square-tailed Kite) and habitat for non-threatened flora and fauna species. The 20m buffer to Conjola National Park and recommended revegetation areas were also given a moderate level of constraint.

A low level of constraint was applied to areas that have been so heavily disturbed that they currently offer little in the way of flora or fauna habitat values and do not form part of any buffers, habitat corridors or recommended regeneration areas described above.

While the buffer sizes and categories discussed above should be used as a guide to maintaining threatened biodiversity values, compromises may be necessary to achieve a balance between biodiversity and development.

6. CONCLUSIONS

This report describes the biological environment of Verons Estate, Sussex Inlet and specifically investigates the presence and conservation significance of threatened biodiversity and makes recommendations for maintaining the Estate's key biodiversity values in respect of the proposed one dwelling per lot on lots 1-19.

These biodiversity values included eleven 'vulnerable' threatened fauna and one 'vulnerable' threatened flora species, listed on the schedules of the *NSW Threatened Species Conservation Act 1995*. The threatened flora species and one of the threatened fauna species recorded in the study area are also listed as 'vulnerable' on the schedules of the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999.* One migratory species listed under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* and a newly described orchid species nominated as critically endangered under the TSC Act were recorded in various location 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*.

Much of the Estate contains areas of known or likely threatened species habitat and relatively high numbers of resources such as hollow-bearing trees that are important for general biodiversity. Habitat connectivity and water quality issues within and beyond the Estate are important considerations, which need to be managed appropriately by limiting the extent of clearing and other disturbances.

Maintaining the key biodiversity values of the Estate in conjunction with further development at a maximum of one dwelling entitlement per lot on lots 1-19 appears to be achievable, provided that development is restricted to specific areas of least ecological constraint and substantial areas of habitat are retained, rehabilitated and managed for conservation purposes. The cumulative impacts of allowing a dwelling and associated disturbance on each lot is reduced by Council's resolution to exclude rezoning to allow development on lots 20-32, however could still potentially adversely affect values such as threatened species habitat and riparian habitat integrity. In particular, significant off-site biodiversity values including endangered ecological communities and wetlands associated with coastal lake ecosystems are at risk of inappropriate development within Verons Estate.

A number of other strategies have been recommended below to maintain the key biodiversity values of the Estate 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.

Achieving long-term habitat retention on rural land can be difficult, but is considered achievable given the size of allotments in Verons Estate, and provided a range of appropriate planning and development controls are in place, coupled with education and enforcement strategies.

7. RECOMMENDATIONS

A number of recommendations to preserve the key biodiversity values of Verons Estate are outlined below.

General

1. Appropriate biodiversity conservation objectives and controls for various proposed zones within the study area should be developed for any future development. The recommendations 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. 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 and if no feasible alterative route exists.
3. The entire Estate drains into sensitive coastal lakes, wetlands and endangered ecological communities, so protection of water quality and riparian areas is a primary consideration in any future development.
4. The Estate contains a number of threatened or significant species and habitats that are generally well connected with the adjacent national park. The maintenance of threatened species and habitat connectivity is a primary consideration in any future development.
5. The impacts of future development should be minimised by locting dwellings in defined areas of least ecological constraint to allow for the retention and protection of significant habitat. On more heavily constrained lots, the development footprint of future dwellings should be restricted by constructing dwellings to an appropriate standard to minimise APZ size and by locating effluent disposal areas and other related disturbances within APZs where possible.
6. Shoalhaven City Council should consider seeking biodiversity certification for any future local environmental plan over the study area. If a biodiversity certified LEP is not prepared, appropriate survey and assessment should be undertaken for flora, fauna and habitats, with reference to Figure 10, prior to the approval of any development application.

Significant vegetation

7. Occurrences of riparian vegetation (Sandstone Sedgeland and Woollybutt-Paperbark Forest) should be protected from any further disturbances by a minimum 50m buffer of

undisturbed vegetation. No other development or activities should be permissible within these buffers. Buffers should be revegetated where current disturbances exist.

8. The occurrences of the vulnerable orchid species *Cryptostylis hunteriana*, should be retained and ideally protected by a 50m buffer, which would encompass primary habitat and probably undetected individuals. Additional areas of suitable habitat should be retained between buffers and connected to suitable habitat in Conjola National Park. No further development should be permitted in these buffers, although specifically managed Asset Protection Zones may be permissible where legal clearing has already occurred.

9. All occurrences of the critically endangered species *Pterostylis ventricosa* should be retained and adjacent habitat protected from further disturbances by a minimum 50m buffer. Additional areas of suitable habitat should be retained between buffers and connected to suitable habitat in Conjola National Park. Management strategies, such as not disturbing known habitat during the period of flowering and above ground growth, should be implemented immediately to ensure that the survival of existing individuals is not compromised. Additional surveys of potential habitat in surrounding lands are recommended to better understand the distribution and habitat preferences of the species. Management strategies should be reviewed as additional information on the ecology or conservation status of this species becomes available.

Fauna and fauna habitat

10. Larger trees with hollows, which act as potential shelter and/or breeding habitat for threatened fauna (including the Yellow-bellied Glider, Eastern Pygmy-possum, threatened cockatoos, Masked Owl and bats), and non-threatened fauna, should be retained and buffered from further disturbance by at least 20m of intact vegetation.

11. Sap-feeding trees incised by the Yellow-bellied Glider should be retained and protected from further disturbances by a vegetated buffer of 20m. Other trees should be retained at an appropriate density to maintain connectivity to these resources for the gliders. Substantial areas of intact forest habitat in the vicinity of these feed-trees will need to be retained as additional habitat for the Yellow-bellied Glider.

12. Over most of the study area, canopy trees should be retained at an appropriate density to allow for movement by the Yellow-bellied Glider to access the resources outlined above, to provide additional foraging resources and to maintain connectivity to other habitat in and adjacent to the study area.

13. Intact forest and woodland surrounding the Eastern Pygmy-possum record should be retained to the greatest extent possible. Habitat to the south and south west of this record (at a minimum the western half of Lot 9) should be retained as a habitat corridor to Conjola National Park.

14. Areas providing habitat connectivity for flora and fauna species (as indicated on Figure 6, Appendix A) should not be fragmented or otherwise degraded by future residential development. Habitat connectivity in the study area should be maintained and enhanced by appropriate management, development controls and rehabilitation where required.

15. Disturbances should be minimised at the interface with Conjola National Park, riparian areas and undeveloped land to the south east. A 20m buffer to the national park should be managed to maintain and improve habitat connectivity and reduce edge effects by prohibiting unnecessary clearing, construction, storage/stockpiling of material and planting of non-indigenous species.

16. Revegetation of degraded areas (as indicated on Figure 6, Appendix A) should be specifically designed to enhance habitat and connectivity for relevant threatened species, resources or communities, such as Yellow-bellied Glider, Eastern Pygmy-possum, Leafless Tongue Orchid, buffers to feed-trees, hollow-bearing trees or riparian vegetation. General revegetation of degraded areas in the study area should include the use of foraging resources for the Yellow-bellied Glider, Eastern Pygmy-possum and Glossy Black-cockatoo.

17. Black She-oak feed-trees used by the Glossy Black-cockatoo should be retained and protected from further disturbances by a 20m vegetated buffer.

18. Female (cone-bearing) Black She-oaks should be preferentially retained throughout the study area wherever possible as additional foraging resources for the Glossy Black-cockatoo.

19. Most of the farm dams should be retained where possible, given their habitat value to a range of fauna species.

Implementation

20. The above recommendations should be included in appropriate planning and development controls for the subject land and underpinned by education and enforcement strategies.

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APPENDIX A: FIGURES

Figure 1: Location of Verons Estate, Sussex Inlet

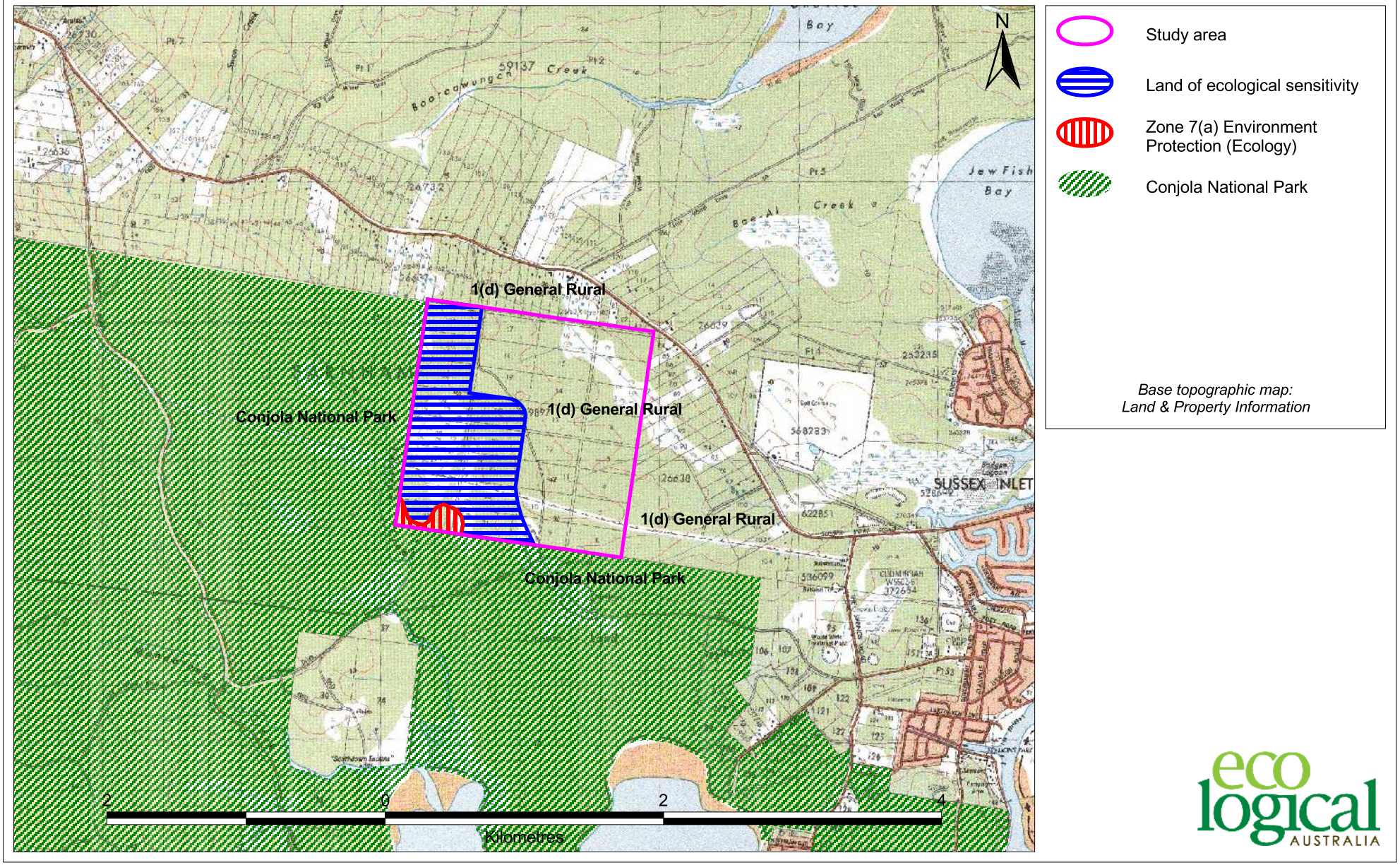
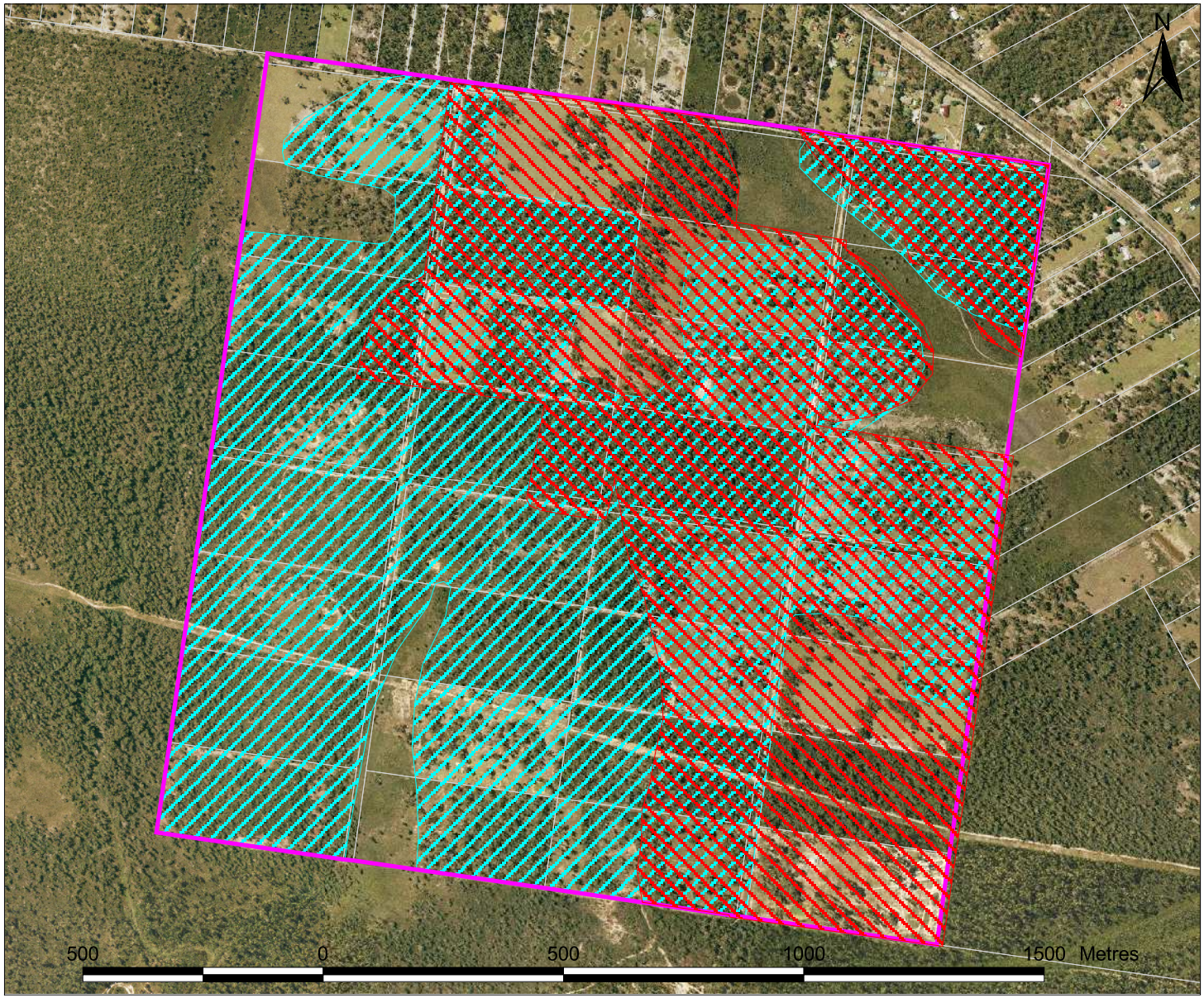


Figure 2a: Locations of flora surveys *(Rizanthella slateri , Calochilus pulchellus & Pterostylis ventricosa)*



Study area

Rizanthella slateri and Calochilus pulchellus targeted survey area

Pterostylis ventricosa targeted survey area

Base air photos: Shoalhaven City Council

Figure 2b: Locations of flora surveys *(Cryptostylis hunteriana, Genoplesium baueri, Genoplesium vernale & Galium australe)* and vegetation quadrats

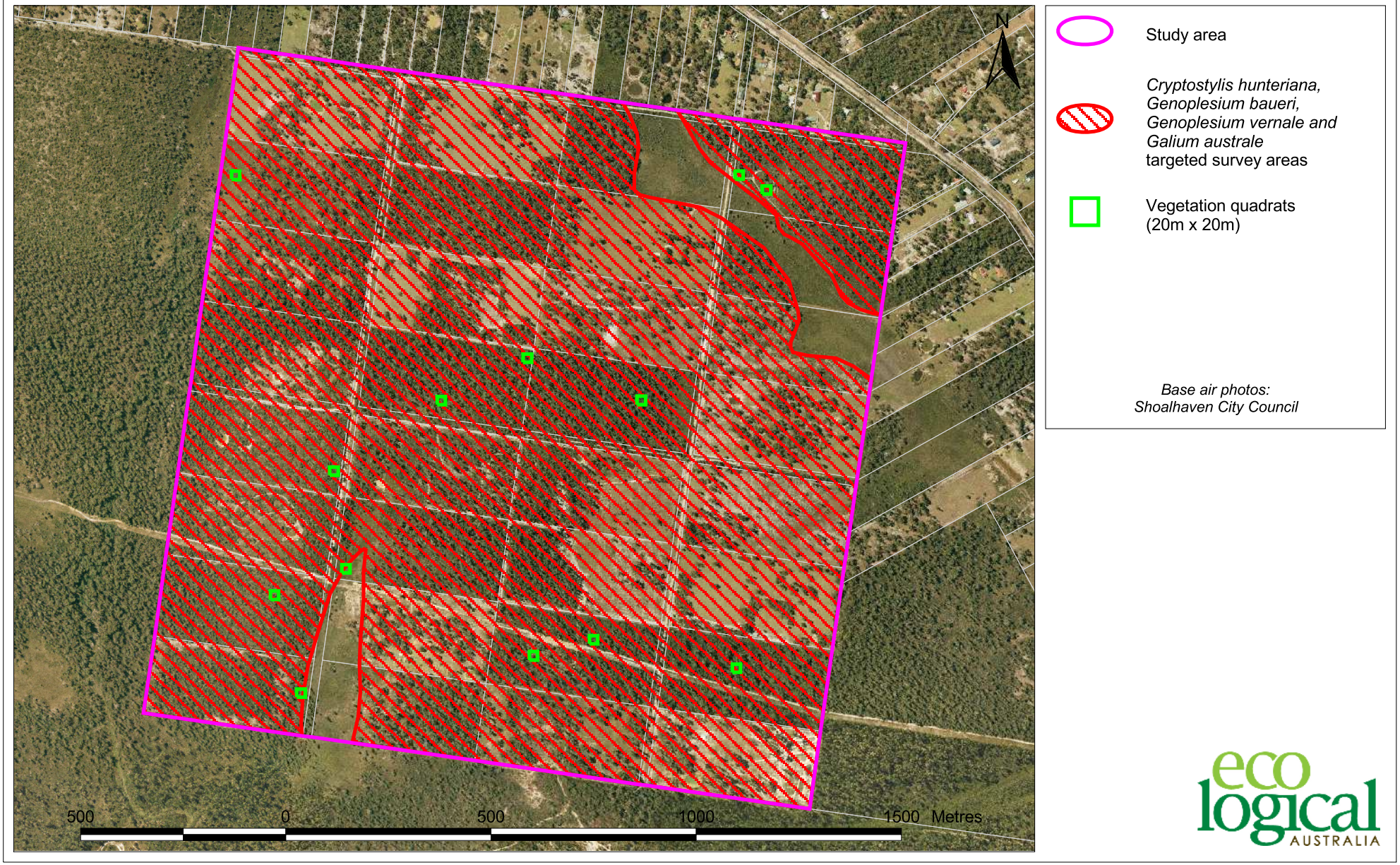


Figure 3a: Locations of fauna surveys (mammals)

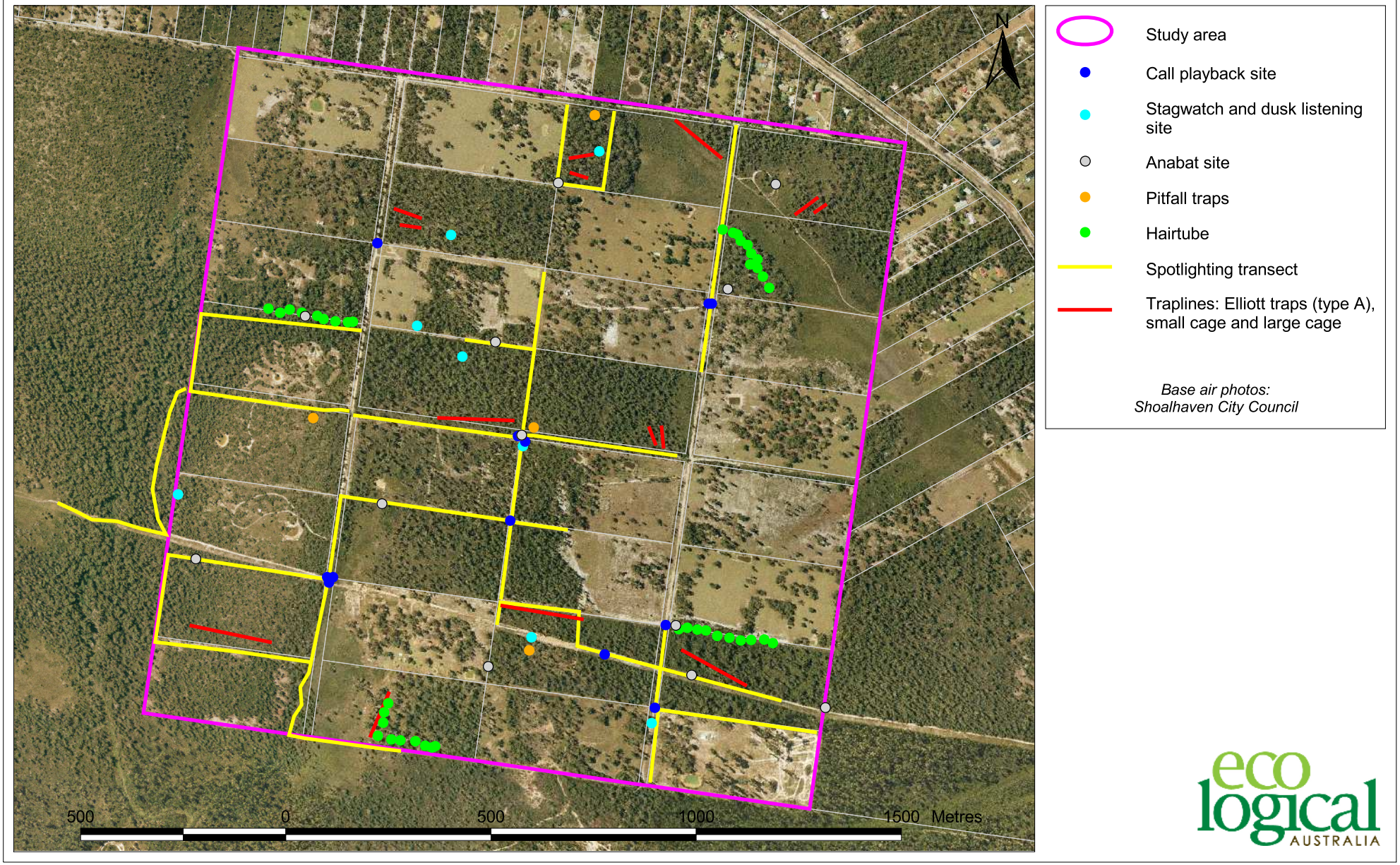


Figure 3b: Locations of fauna surveys (birds)

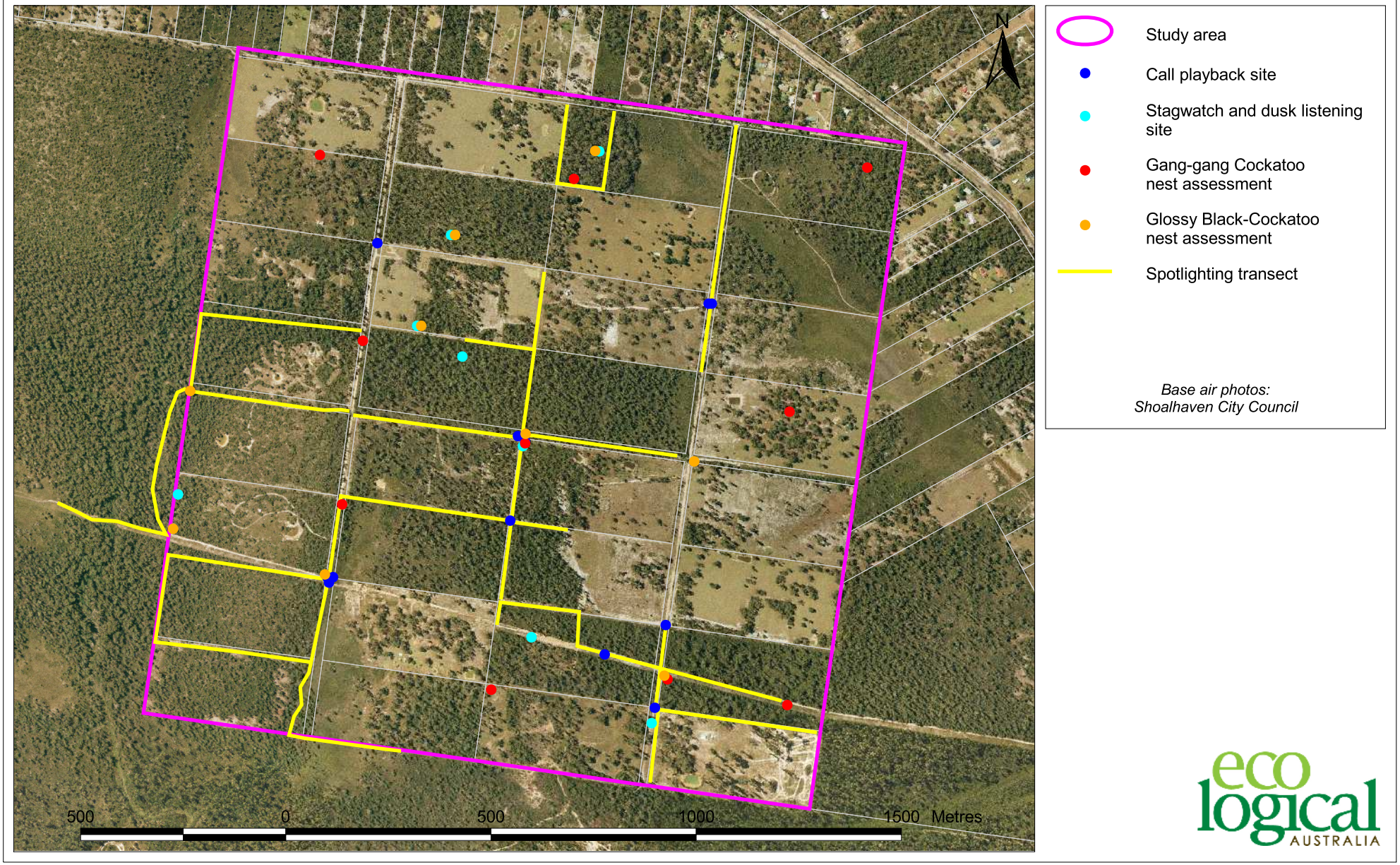


Figure 3c: Locations of fauna surveys (frogs)

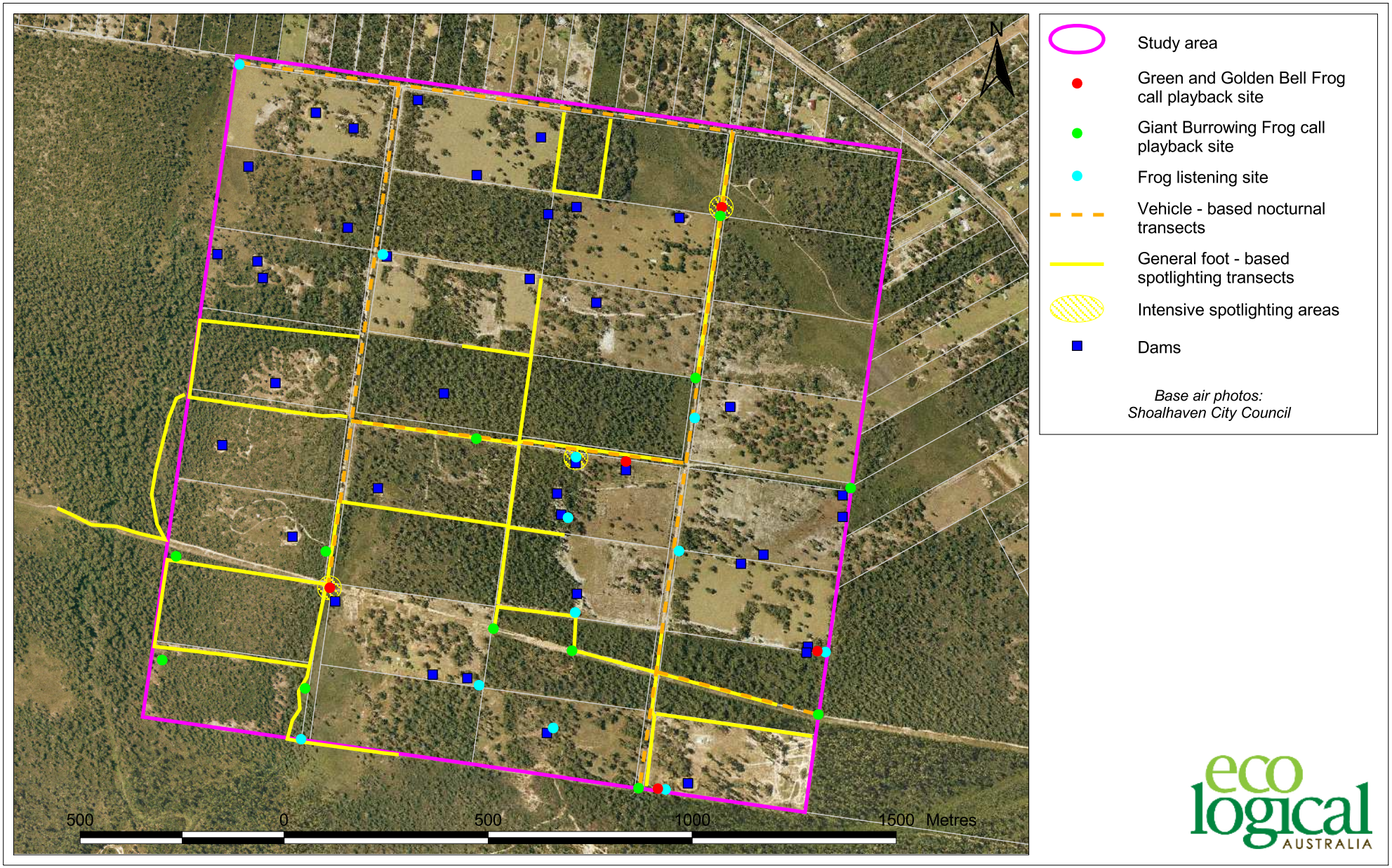


Figure 4: Vegetation communities

Figure 9: Eastern Pygmy-possum habitat

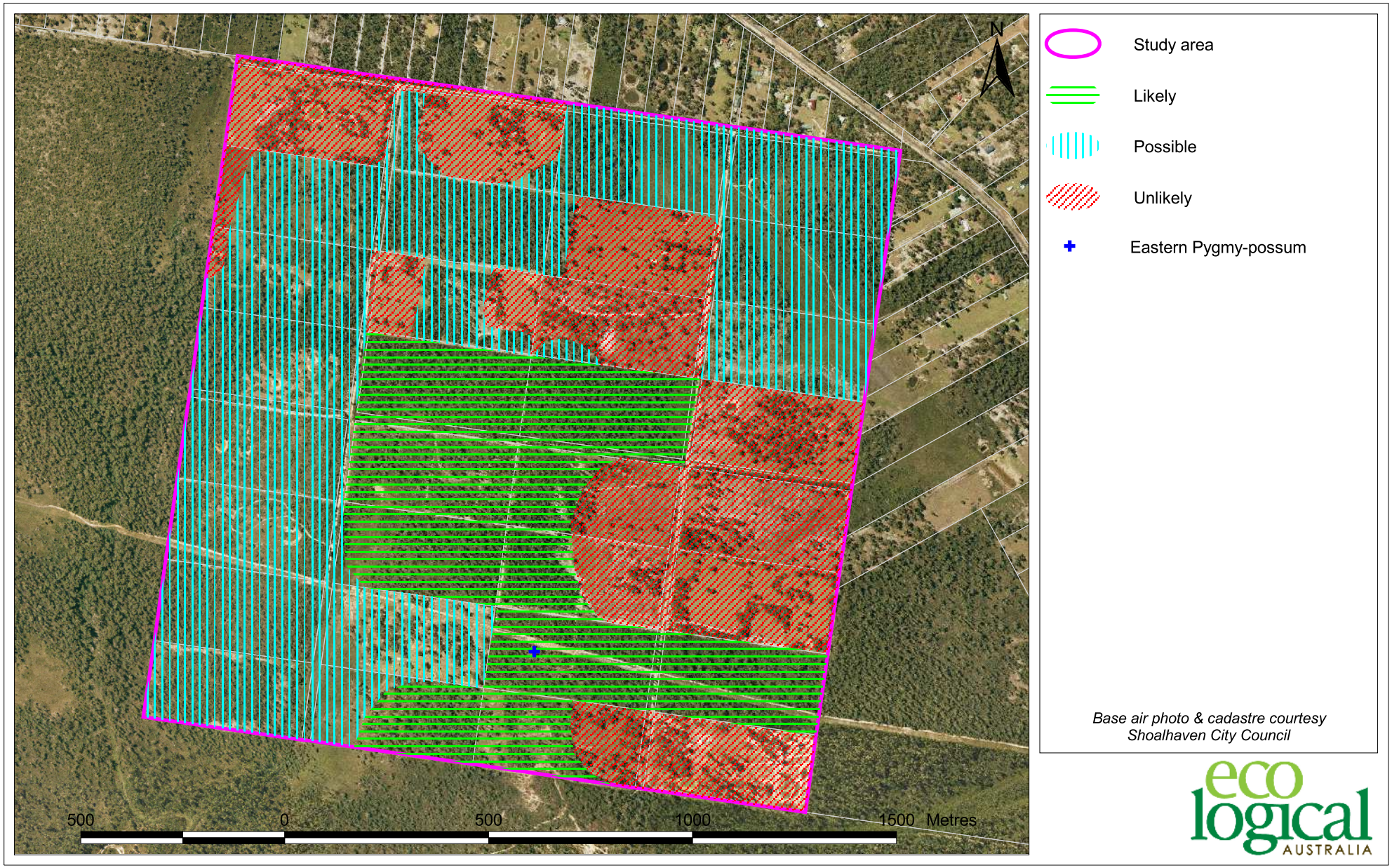


Figure 11: Ecological constraint categories