

Final Report

LOWER HUNTER & CENTRAL COAST REGIONAL BIODIVERSITY CONSERVATION STRATEGY

Fauna Survey and Mapping Project - Module 1 - Fauna Surveys

Prepared by

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For

**LOWER HUNTER & CENTRAL COAST REGIONAL ENVIRONMENTAL
MANAGEMENT STRATEGY STEERING COMMITTEE**

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EXECUTIVE SUMMARY

This fauna survey constitutes Module 1 of the fauna survey and mapping project for the Lower Hunter and Central Coast Regional Biodiversity Conservation Strategy (LHCCRBSCS), which in turn, is a function of the Lower Hunter and Central Coast Regional Environmental Management Strategy (LHCCREMS). The management of the project is being conducted by the Steering Committee of LHCCREMS on behalf of the participating Councils.

The survey area is large, consisting of seven Local Government Areas (LGA's) within the Central Coast and Hunter Valley, from Gosford in the south to Port Stephens, Maitland and Cessnock in the north.

Site selection was achieved by carrying out a data audit, rationalisation of the 54 map units resulting from the vegetation surveys into 14 broad fauna strata and a gap analysis of the results of the data audit and stratification. Sites were generally selected so that gaps in survey effort for each stratum across all of the study area, evident in the maps produced at the data audit stage, would be filled. The site selection priorities were to; sample each strata; address any spatial bias - each stratum must be sampled across geographic range; sample major strata; sample minor strata; address tenure bias if existing - it was anticipated that the majority of sampling would be focused on private land and achieve the highest number of replicates possible.

Based on the methodology requirements, two types of site were sought, major sites, where all methodologies were employed and opportunistic sites, where call playback, spotlighting and/or bat survey only were carried out. Major site selection was driven by the tree trapping as a quadrat had to be set up and the site visited over a five day period. It was also apparent from the data audit that tree trapping had infrequently been conducted on all but three strata (CSPW, DR and SF) and was not carried out during the CRA surveys or State Forest pre-logging surveys. Over the period 6th March to 13th July, 2001, a total of 119 sites were surveyed, comprising 75 major sites and 44 opportunistic sites. The opportunistic sites consisted of 25 extra nocturnal call playback, spotlighting and bat survey sites and 19 harp trap only sites. The land tenure breakdown for the survey sites was; Private/freehold (54); Council/Crown etc. (44); State Forest (18); NPWS (3). Where possible, site selection was tied to the specific location of the previous LHCCREMS vegetation survey sites. This was to enable more accurate strata identification and most of the land owners had previously been contacted and were aware of the project. A separate survey was carried out for the Green and Golden Bell Frog by Dr Arthur White. A total of seventy two (72) sites were surveyed for this species across the study area.

The final agreed list of target species was the Green and Golden Bell Frog, Squirrel Glider, Yellow-bellied Glider, Koala, Brush-tailed Phascogale, Tiger Quoll, relevant Threatened bat species, large forest owls and diurnal birds as a taxonomic group.

The methodology used was tree trapping, cage trapping, spotlighting, nocturnal call playback, bird census, bat trapping, bat call analysis, hair tube sampling, opportunistic records on and off site. The methodology generally follows that of the CRA surveys (NPWS, 1998). Tree trapping and Koala searches were not, however, carried out during the CRA process. Methodology for tree trapping was therefore, based on previous studies carried out for Squirrel Glider surveys in Wyong and Lake Macquarie LGA's (Austeco Environmental Consultants, 1999) and the Koala survey was based on methodology proposed by the Australian Koala Foundation.

The survey resulted in a total of 237 species being recorded, comprising 41 mammal, 136 bird, 23 reptile and 18 frog species. Nine of these were introduced species. A total of twenty two (22) Threatened species were recorded, including most of the target species.

In conclusion, it is considered that the surveys carried out for Module 1 of this project achieved the targeted aims to varying degrees. It is considered that sufficient information exists for most species to be modelled, however, some species will only be able to be modelled by the presence only method. The survey was carried out across all LGA's and all strata (except Dry Rainforest Gully) were sampled within each LGA that each stratum occurred. Less survey effort was applied to Maitland and Newcastle LGA's, as a result of the lack of extensive areas of habitat. The survey was successful in filling in the gaps in previous survey effort within each stratum and identified in the data audit stage of Module 1 (with the exception of DRG). The sampling of private land was probably not carried out to the anticipated degree, as a result of site selection problems, often out of our control. Not all methodologies were successful in detecting the target species, namely cage trapping, hair tubes and bird census. As a result of the timing of the survey, autumn /winter, the bat and Bell Frog surveys was terminated early, the bird census was unable to record summer visitors and the chance of opportunistic sightings of reptiles was reduced. Further surveys, particularly for bats and the Green and Golden Bell Frog, should be considered so as to cover the sites not sampled for these species during the RBCS surveys.

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1.0 INTRODUCTION

This survey is part of a fauna survey and mapping project for the Lower Hunter and Central Coast Regional Biodiversity Conservation Strategy (LHCCRBCS), which in turn, is a function of the Lower Hunter and Central Coast Regional Environmental Management Strategy (LHCCREMS). The management of the project is being conducted by the Steering Committee of LHCCREMS on behalf of the participating Councils.

The survey area is large, consisting of seven Local Government Areas (LGA's) within the Central Coast and Hunter Valley, from Gosford in the south to Port Stephens, Maitland and Cessnock in the north.

The project consists of three modules;

Module 1: Fauna Surveys

Module 2: Fauna Habitat Modelling for the agreed target group of species and their Conservation Requirements

Module 3: Habitat Distribution Modelling for all Threatened Species (optional)

Ecotone Ecological Consultants was awarded the contract to carry out Module 1 in early February, 2001. A frog expert, Dr Arthur White (Biosphere Environmental Consultants P/L), was sub-consulted to carry out the Green and Golden Bell Frog survey. As the survey for this species did not rely on a stratified site selection process, an independent study was conducted. The findings of this study are only summarised here, with the full report being appended.

The main aim of the survey is to provide adequate information for the habitat modelling component of Module 2 by specifically addressing gaps identified in the data audit part of this study. In order to attain this goal, similar survey methodologies to those used by NPWS in the Comprehensive Regional Assessment (CRA) surveys were implemented so as to target a selected suite of threatened species, listed in the Threatened Species Conservation (TSC) Act, 1995. The list of target species is provided in Section 3.0

In order to aid in survey site selection, the following tasks were required prior to the start of field survey

- **Data Audit** - a literature review of previous fauna survey results within the study area and an appraisal of adequate survey effort and methodology. Note that all of the target species for this study may not have been targeted in the reviewed survey.
- **Stratification** - the map units described in the completed vegetation mapping part of the project needed to be assigned to broad fauna habitat strata.
- **GAP Analysis** - a table combining the strata and previous survey effort was produced so as to identify strata that had been poorly surveyed.
- **Survey Site Selection** - prioritised site selection was implemented from the above data. Details of priorities are given in Section 2.

Once sites were selected, site ownership details and access permission was initially organised by staff of the LHCCRBCS, but was undertaken by Ecotone Ecological Consultants in the latter part of the survey.

The systematic surveys were completed over the period 12/3/01 - 13/7/01 and the survey results entered into an Access database, which was designed to be compatible with the modelling requirements, following advice from the NPWS.

2.0 SITE SELECTION PROCESS

2.1 Strata Selection

The purpose of stratification is to ensure that all types of landscapes relevant to fauna distribution are sampled. Features that are most likely to affect fauna distribution can be combined to form parcels of the landscape which comprise similar environmental characteristics (Nelder, 1995; Margules & Redhead, 1995). Alternatively, surrogates can be used to describe the influencing factors. This study used broad clustering of the REMS regional vegetation mapping (NPWS, 2000) as the basis for stratification, on the rationale that the vegetation present would have a direct relationship with fauna species present. A proportional sampling strategy was used to ensure adequate sampling of each stratum across its distribution.

For this fauna survey, the 54 identified REMS map units (NPWS, 2000) were assigned to the most appropriate of the 14 broad strata shown in Table 1. The map units were grouped according to the descriptions given in the provided Map Unit Profiles (Appendix E of the LHCCREMS vegetation survey). The spread of each stratum across the study area is shown on Figure 1.

Table 1 - Broad Vegetation Strata used for the Fauna Surveys

Code	Fauna Strata Description	REMS Map Units
HVF	Hunter Valley Floor	18 & 19
CMG	Coastal Moist Gully	1, 1a, 11, 20 & 39
CMR	Coastal Moist Ridge	6 & 9
CSP	Coastal Sand Plain	4, 34 & 34a
CSPW	Coastal Sand Plain Woodland	30, 31, 32 & 33
DG	Dry Gully	25
DR	Dry Ridge	15, 16, 17, 21, 22, 23 & 24
DRG	Dry Rainforest Gully	8 & 10
DRH	Dry Ridge Hawkesbury	26, 27, 28, 28a & 29
DRVF	Dry Rainforest Valley Floor	3 & 3a
M	Moist Forest	2, 5, 7 & 12
R	Riparian	13 & 14
SF	Swamp Forest	37, 38, 40, 41 & 43
SW	Swamp Woodland	35, 36, 42 & 44
Unassigned	Treeless heaths, scrubs and swamps	26a, 29a, 32a, 36a, 40a, 42a, 43a, 45, 46 - 54, Qa13

Figure 1 - Distribution of Fauna Habitat Strata.

2.2 Data Audit

A previously conducted fauna audit was provided by LHCCREMS (RBCS & Forest Fauna Surveys, 1997 - Sept. 2000). Additional fauna data, mainly derived from surveys supporting development applications and general fauna surveys was sought for by visiting the participating councils. Some Councils, (Lake Macquarie and Port Stephens), already had past survey data and/or threatened species records on a database making the search for appropriate past surveys easier. Appropriate surveys carried out by Ecotone Ecological Consultants were also included.

Any report containing fauna survey results was reviewed and information on the survey methodology used and threatened species recorded was entered onto a database. Fields recorded were as follows; A - ID tag number; B - the date of the survey; C - location; D - LGA; E - easting; F - northing; G to Z - survey methodology used/ threatened species recorded in paired columns (10 categories similar to this survey, with the addition of ground trapping); AA - the recorder and AB - survey effort rating. Methodologies were recorded as either Yes or No and threatened species were recorded as either No or by an abbreviated code. The survey effort ratings used were;

- 1 - range of methodologies used (6-10), high survey effort,
- 2 - moderate methodologies used (4-6), moderate survey effort,
- 3 - low range of methodologies used (1-3), low survey effort,
- 4 - low range of methodologies used (1-3), high survey effort (targeted species).

Surveys indicating that survey effort was poor or unclear were discarded, except where threatened species were recorded. Most reports prior to 1995 were also discarded, as the survey methodology used prior to this time was usually not compatible with current survey techniques.

A total of 570 entries were originally entered into the database, however, it should be noted that, although probably adequate for the particular study, the methodologies used may have differed from the systematic methods used in this survey. The data obtained from Port Stephens Council was primarily a threatened species database of individual records and it was, therefore, difficult to calculate the survey effort and methodology used. Investigation revealed that there was also some doubling up of the information, so unfortunately, many of the records had to be discarded, pruning the data base down to 453 entries. Some surveys only targeted a single species over a wider area, for instance the North Wyong Squirrel Glider Study (Austeco, 1999). Other areas were subjected to intense survey effort as a result of a controversial development proposal (e. g. Wallarah Peninsula in Wyong LGA). It is acknowledged that the data base used was incomplete, as not all of the potential surveys were identified and reviewed in the short time available for this process.

By adding all the data audit records to supplied CRA and State Forest records it was possible to overlay points on a map of the study area using GIS software (MapInfo Professional). Maps produced were broken down to LGA and survey method(s) so as to avoid the obvious congestion if the data for all methods and the whole study area was used.

2.3 Gap Analysis

The data gathered in Sections 2.1 and 2.2, including CRA and State Forest survey sites, were combined and tabulated so as to show the number of sites within each strata versus the method used (Table 3). It could then be seen which strata had been poorly surveyed for the target species. The level of survey effort for each method varied greatly, particularly for tree trapping, which was not carried out during CRA and State Forest surveys.

It was obvious from the results that Strata HVF, DRG and DRVF had been surveyed by no or few methods and that Strata CSP, DG and CMG were depauperate in either the methods used or survey effort. By comparison, Strata CSPW, DR, DRH and SF had been sampled well by all or most survey methods. Surveys had not been conducted evenly across the study area, with obvious gaps in north western Lake Macquarie and most of Newcastle, Cessnock and Maitland. In the case of Newcastle, Maitland and the vineyard area of Cessnock, this was largely due to lack of habitat as a result of past land clearance.

Some data points fell into the unassigned or cleared category so were deleted from the analysis. Reasons for these unusable records are likely to have been that they fell into map units not included in the strata analysis (e. g. coastal wetland habitats, low heaths and scrubs and mangroves), the AMG was inaccurate, thus placing the record outside vegetated areas or, in the case of older records, the area has since been cleared for developments. The reason for the large number of unassigned records for bat detectors is unclear, but may be the result of surveying along the edge of vegetation or in open areas rather than within the assigned forest strata. This practice is often carried out as a result of apparent increased bat activity in these less cluttered environments.

2.4 Site Selection

Based on the strata, data audit and gap analysis, sites were generally selected so that gaps in survey effort, evident in the maps produced at the data audit stage, would be filled (Table 4). The site selection priorities, with regards to the gap analysis, identified in the brief are as follows;

- Sample each strata,
 - Address any spatial bias - each strata to be sampled across geographic range,
 - Sample major strata,
 - Sample minor strata
 - Address tenure bias if existing - it was anticipated that the majority of sampling would be focused on private land,
 - Achieve the highest replicates possible.

Based on the methodology requirements, two types of site were sought, major sites, where all methodologies were employed and opportunistic sites, where call playback, spotlighting and/or a bat survey only were carried out. Major site selection was driven by the tree trapping as a quadrat had to be set up and the site visited over a five day period. It was also apparent that tree trapping had infrequently been conducted on all but three strata (CSPW, DR and SF) and, as already mentioned, was not carried out during the CRA surveys or State Forest pre-logging surveys. Figure 2 shows the location and spread of the survey sites across the study area. The large areas of unsurveyed land mainly consist of National Park or State Forest. Over the period 6th March to 13th July, 2001, a total of 119 sites were surveyed, comprising 75 major sites and 44 opportunistic sites. The opportunistic sites consisted of 25 extra nocturnal call playback, spotlighting and bat survey and 19 harp trap only sites. The land tenure breakdown for the survey sites was as follows;

Private/freehold	54
Council/Crown etc.	44
State Forest	18
NPWS	3

Where possible, site selections were made in the larger tracts of land within a target area and tied to a LHCCREMS vegetation survey site. This would enable more accurate strata identification and most of the land owners had previously been contacted and were aware of the project.

Table 4 and Figure 3 show the spread of survey effort across the study area, derived from all sources. It shows that the current field surveys succeeded in filling some of the gaps and that the eastern part of the study area has been well surveyed across LGA boundaries, although not all methodologies may have been used. Major gaps are still apparent for the north west of the study area, particularly Maitland and parts of Cessnock, however, naturally vegetated land is highly fragmented and remnants are generally small in these LGA's.

The number of sites completed in each LGA and stratum is shown in the Table 2 below.

Table 2 - Fauna Sites shown by Strata and LGA

Strata Code	Cessnock	Gosford	Lake Macquarie	Maitland	Newcastle	Port Stephens	Wyong	Totals
HVF	4(3)	N/A	0	4	1	0	N/A	9(3)
CMG	0	2(1)	N/A	N/A	N/A	N/A	1(1)	3(2)
CMR	0	3(4)	3	N/A	0	N/A	4(3)	10(7)
CSP	N/A	0	0	N/A	N/A	3(2)	0	3(2)
CSPW	0	N/A	4(5)	N/A	1(1)	2(4)	1	8(10)
DG	0	1	0	N/A	N/A	N/A	1	2
DR	3(4)	1	4(4)	1	1(1)	1(2)	2(1)	13(12)
DRG	0	N/A	N/A	N/A	N/A	N/A	N/A	0
DRH	NP ONLY	3(2)	N/A	N/A	N/A	N/A	1(1)	4(3)
DRVF	0	N/A	N/A	1	N/A	1	N/A	2
M	2	1	0	0	1	3	0	7
R	2(1)	0	2(1)	0	0	1	2(1)	7(3)
SF	N/A	1(1)	0	0	0	1	0(1)	2(2)
SW	2	N/A	1	N/A	0	2	0	5
Totals	13(8)	12(8)	14(11)	6	4(2)	14(8)	12(8)	75(44)

N.B. - Numbers in brackets represent opportunistic site only.

N/A = Stratum not available within the LGA.

Table 3 - Survey Effort for each Fauna Stratification within the Study Area Prior to REMS Surveys

SURVEY TECHNIQUE	FAUNA STRATIFICATION															
	HVF	CMG	CMR	CSP	CSPW	DG	DR	DRG	DRH	DRVF	M	R	SF	SW	Unassigned	Cleared
Owl playback	0	3	19	1	44	21	28	0	24	0	13	2	23	5	1	72
Bat detector	0	1	18	5	81	0	20	0	20	0	15	4	25	7	285	94
Harp traps	0	3	12	0	36	0	10	4	18	0	24	2	13	1	2	21
Spotlighting	0	3	18	1	79	0	42	0	22	0	14	4	22	6	1	102
Tree traps	0	0	2	1	49	0	29	0	2	0	3	4	23	5	1	59
Cage traps	0	0	0	0	26	0	8	0	0	0	0	1	4	2	0	19
Hair-tubes	0	1	12	0	18	0	10	0	15	0	8	1	7	3	0	19
Koala scat search	0	0	0	0	8	6	6	0	31	0	8	1	1	0	1	12
Opportunistic records	0	2	12	1	127	6	43	0	45	1	25	6	31	8	4	123

* Includes CRA and State Forest data

Table 4 - Total Survey Effort for each Fauna Stratification within the Study Area, Including REMS Survey data

SURVEY TECHNIQUE	FAUNA STRATIFICATION															
	HVF	CMG	CMR	CSP	CSPW	DG	DR	DRG	DRH	DRVF	M	R	SF	SW	Unassigned	Cleared
Owl Playback	10	6	35	5	59	23	47	0	29	2	20	10	27	10	1	72
Bat detector	10	4	35	9	96	2	38	0	25	2	22	12	29	12	285	94
Harp traps	7	6	20	2	45	1	30	4	21	2	30	10	15	5	2	21
Spotlighting	10	6	34	5	92	2	60	0	27	2	21	12	26	11	1	102
Tree traps	9	3	12	4	57	2	42	0	6	2	10	11	25	10	1	59
Cage traps	9	3	10	3	34	2	21	0	4	2	7	8	6	7	0	19
Hair-tubes	9	3	22	3	26	2	23	0	19	2	15	8	9	8	0	19
Koala scat searches	9	3	10	3	16	8	19	0	35	2	15	8	3	5	1	12
Opportunistic records	9	3	10	4	135	8	56	0	49	2	32	13	33	13	4	123

Figure 2 - Survey Site Locations.

Figure 3 - Combined Survey Effort within the Study Area

3.0 TARGET SPECIES

The list of threatened species to be targeted by the systematic surveys was generated by LHCCREMS following advice given by NPWS, Sydney Zone and based on the following selection criteria;

- a) Efficacy of survey.
- b) Is the species information rich, so as to allow modelling and management procedures?
- c) Is the species endemic to the area?
- d) A ranking of the vulnerability of the species habitat.
- e) Is the anticipated model type possible?

Some minor modifications to the list were made following discussions with Ecotone. It was considered that all threatened bat species would be targeted by the proposed methodology for this taxonomic group. Diurnal birds were not represented in the surveys, so it was decided to carry out a systematic bird census at each of the major survey sites in conjunction with checking the trap lines. This decision inadvertently resulted in the recording of three species recently added to Schedule 2 of the TSC Act, namely the Brown Treecreeper, Speckled Warbler and Grey-crowned Babbler.

The final agreed list of target species was as follows:

Squirrel Glider *Petaurus norfolcensis*
 Yellow-bellied Glider *Petaurus australis*
 Koala *Phascolarctos cinereus*
 Brush-tailed Phascogale *Phascogale tapoatafa*
 Tiger Quoll *Dasyurus maculatus*
 Large (Common) Bent-wing Bat *Miniopterus schreibersii*
 Little Bent-wing Bat *Miniopterus australis*
 Greater Broad-nosed Bat *Scoteanax rueppellii*
 Eastern False Pipistrelle *Falsistrellus tasmaniensis*
 Southern Myotis *Myotis macropus*
 Large-eared Pied Bat *Chalinolobus dwyeri*
 Eastern Cave Bat *Vespadelus troughtoni*
 Golden-tipped Bat *Kerivoula papuensis*
 East-coast Freetail Bat *Mormopterus norfolkensis*
 Yellow-bellied Sheath-tail-bat *Saccolaimus flaviventris*
 Powerful Owl *Ninox strenua*
 Barking Owl *Ninox connivens*
 Sooty Owl *Tyto tenebricosa*
 Masked Owl *Tyto novaehollandiae*
 Green and Golden Bell Frog *Litoria aurea*
 Diurnal Birds - Taxonomic Group

4.0 SURVEY METHODOLOGY

The methodology used generally follows that of the CRA surveys (NPWS, 1998) carried out on public lands within the study area. This enabled the results of this survey to build on the data generated during the CRA surveys by targeting private land and public land not sampled in the CRA surveys. The results of the systematic surveys could also be used for the habitat modelling part of this and future projects.

Tree trapping and Koala searches were not, however, carried out during the CRA process. Methodology for tree trapping was therefore, based on previous studies carried out for Squirrel Glider surveys in Wyong and Lake Macquarie LGA's (Austeco Environmental Consultants, 1999) and the Koala survey was based on methodology proposed by the Australian Koala Foundation. Table 5 lists the methods used and the species to be targeted by each method and further details are given below. Photographs illustrating some of the methodologies are shown in Plates 1-7.

Text books used for confirmation of species identification are listed in the reference section of this report.

4.1 Tree Trapping

- (Targeting the Squirrel Glider and Brush-tailed Phascogale)

At each of the major survey sites (75), a grid of 10 aluminium folding traps (Elliott Scientific Equipment). Five (5) Type A, (measuring 33cm x 10cm x 9cm) and 5 Type B traps (measuring 46cm x 15cm x 15cm) were set alternately in two parallel lines, with the traps being approximately 50m apart. Traps were usually left in place for four nights and checked each morning. With the aid of a step ladder, each trap was mounted on a platform attached to a selected tree at a height of approximately 3 metres. Traps were positioned so as to avoid the morning sun and were covered with a plastic bag to reduce the risk of exposure to any captured animal. Bedding material, usually dry leaves gathered on site, was also provided. Traps were baited with standard peanut butter and rolled oat mixture and candied honey wrapped in paper towel. The tree trunk above the trap was also sprayed each day with a honey /water mixture via a spray bottle.

4.2 Cage Traps

- (Targeting the Tiger Quoll and Brush-tailed Phascogale)

Three cage traps measuring 80cm x 23cm x 23cm were set at each major site. They were generally positioned at the beginning, centre and end of the tree trap quadrat. Most of the traps used have a door at each end and they were set on animal runways where available. Cages were baited with a peanut butter/fish based cat food sandwich and left open for four nights. Traps were covered with shade cloth and plastic as a protection against inclement weather conditions.

4.3 Hair Tubes

- (Targeting the Tiger Quoll and Brush-tailed Phascogale)

At each of the major sites, a line of ten 90mm hair tubes were set on the ground, 20m apart through the tree trap quadrat. The tubes were baited with a peanut butter/fish based cat food sandwich and left in place for 10 nights. In addition five 40mm tubes were affixed to trees along the survey line so as to target the more arboreal Brush-tailed Phascogale and possibly the Squirrel Glider. These tubes were baited with a peanut butter/honey/rolled oat mixture.

Hair of any visiting mammal was collected on double sided tape and was sent to an expert (Barbara Triggs, Genoa, Victoria), for analysis.

Table 5 - Survey Methodologies

Species	Survey Methods Conducted	Standardised Effort Applied
Squirrel Glider <i>Petaurus norfolcensis</i>	<ol style="list-style-type: none"> 10 Tree mounted Elliott Traps (5 Type A, 5 Type B) in a 5 x 2 grid formation along 200m transect (approx 50m apart) Call Playback Hair tubes 5 x 40mm tree mounted tubes per site Spotlighting 500m transect. 	<ol style="list-style-type: none"> 4 nights 2 observers 30 mins
Koala <i>Phascolarctos cinereus</i>	<ol style="list-style-type: none"> Asterisk method (20 trees) with Scat Searches under the canopy Spotlighting 500m transect Call play back 	<ol style="list-style-type: none"> Search area: Centre tree and nearest 20 trees 2 observers 30 mins
Brush-tailed Phascogale <i>Phascogale tapoatafa</i> <i>Surveyed in conjunction with Tiger Quoll</i>	<ol style="list-style-type: none"> 3 cage traps. 200m transect. Hair tubes 5 x 40mm tree mounted tubes per site 10 90mm Hairy tubes 200m transect (on same transect) 10 Tree mounted Elliott Traps (5 Type A, 5 Type B) in a 5 x 2 grid formation along 200m transect (approx 50m apart) 	<ol style="list-style-type: none"> 4 nights 10 nights
Large Forest Owls (Sooty, Masked, Powerful and Barking) <i>Surveyed in conjunction with YB Gliders</i>	<ol style="list-style-type: none"> Callback Spotlighting 	<ol style="list-style-type: none"> 10 mins listening, ((5 minutes playback, 5 mins listening)) repeated for each species. 10 mins listening and general spotlighting 2 observers 30 mins
Yellow-bellied Glider (YBG) <i>Petaurus australis</i> <i>Surveyed in conjunction with Forest Owls</i>	<ol style="list-style-type: none"> Callback Spotlighting 500m transect 	<ol style="list-style-type: none"> 10 mins listening, ((5 minutes playback, 5 mins listening)) repeated for each species. 10 mins listening and general spotlighting 2 observers 30 mins
Tiger Quoll <i>Dasyurus maculatus</i> <i>Surveyed in conjunction with BT Phascogale</i>	<ol style="list-style-type: none"> 3 cage traps. 200m transect. 10 90mm Hairy tubes 200m transect (on same transect) 	<ol style="list-style-type: none"> 4 nights 10 nights
Green and Golden Bell Frog <i>Litoria aurea</i>	CRA method: day/night searches. Habitat assessment. Water quality parameters	20 historic sites, 12 extant sites, 35 potential sites
Large Bent-wing Bat <i>Miniopterus schreibersii</i> Insectivorous Bats surveyed as one group	<ol style="list-style-type: none"> 1 Harp Trap 'Anabat' Detector Anabat Opportunistic Sites 	<ol style="list-style-type: none"> 2 nights 30 min census Using Delay switch. Length of survey dependent on activity levels
Diurnal Birds Taxonomic Group	Census on each major site along a 200m x 50m transect. Birds outside this area and the allotted time were recorded as opportunistic. Birds were recorded by call or sight, sometimes aided by binoculars.	1 observer x 20 mins

4.4 Spotlighting

- (targeting all species except the micro bats and diurnal birds)

Spotlighting was carried out at each survey site (except harp trap only sites) and, where possible, a transect of 500m was surveyed. The spotlighting transect was conducted on completion of the call playback survey. Two observers, each carrying a 50W spotlight (Lightforce), powered by a 12 volt, 12 amp hour sealed lead acid battery, slowly walked along the transect for at least 30 minutes. The identity, time and location of each sighting was recorded. The location of threatened or interesting species was recorded by the use of a GPS unit where possible.

4.5 Call Playback

- (targeting the large forest owls, Squirrel Glider, Yellow-bellied Glider and Koala).

Pre-recorded calls of the relevant target owl species were played at each of the sites (except harp trap only sites), usually just after dusk. The calls were amplified by the use of a loud hailer. The calls of the Powerful Owl, Sooty Owl, Masked Owl and Barking Owl were played in order, following a 10-15 minute initial listening period. A variety of calls from each species was played for 5 minutes, with a 5 minute listening period following each species call sequence. At the completion of the last call sequence, a further 10 minute listening period was conducted. During and at the end of the survey a 50W spotlight was used to scan nearby vegetation for the presence of owls.

On completion of the owl survey, the calls of the Squirrel Glider, Yellow-bellied Glider and Koala were played for approximately 5 minutes each, followed by a short listening period between each species call sequence.

4.6 Bat (Harp) Trap

- (targeting threatened micro bat species)

A harp trap was erected within or near each survey site up until early June, when the bat survey was abandoned as a result of cold weather conditions. Occasional sites were surveyed after this period where an ideal trap location occurred. Ideal sites were sought along obvious bat flyways and these included roadways and tracks with side and overhanging vegetation and open creek lines. Such sites were not always available and marginal locations were the only option. These sites were sometimes improved by closing off open areas around the trap with vegetation and shade cloth. The harp traps were left in place for at least two nights. Any bats caught were identified, the forearm length and weight recorded and then released or held in a cloth bag until the evening, when they were released after dark. Care was taken not to release bats during the day if predatory birds, such as the Grey Butcherbird, Pied Currawong or Kookaburra, were present.

4.7 Ultrasonic Bat Call Analysis

- (targeting threatened micro bat species)

Bats emit ultrasonic calls as a method of navigating and searching for food. These calls are often at a higher frequency than calls audible to the human ear. In order to make the calls audible, bat detectors convert the call to a lower frequency. During this survey, ultrasonic bat calls were recorded onto audio tape via Anabat bat detectors (Titley Electronics, Ballina, NSW). Two methods of recording were used; a) a systematic 30 minute sample at dusk and b) an opportunistic extended recording period using a delay switch.

Plate 1. 'Elliott' folding trap and tree bracket.

Plate 2. Tree trap showing above ground height.

Plate 3. 'Anabat' bat detector with delay switch.

Plate 4. Hair-tube designed for ground dwelling fauna.

Plate 5. Hair-tube designed for arboreal/scansorial mammals.

Plate 6. Cage trap with waterproof and protective cover.

Plate 7. Harp trap (insectivorous bats) .

The systematic 30 minute sample was carried out at all sites (except harp trap only sites) and consisted of a hand held or static detector recording directly into a tape recorder. At the start of each sample the site location, weather details and a frequency calibration tone were recorded onto the tape.

At most of the major sites and some of the opportunistic sites an automated system using the delay switch was implemented. The equipment is assembled in a box and set at a 45⁰ angle, pointing into a likely fly-way. The delay switch activates the equipment at dusk and following each call, the time and a calibration tone is recorded. The equipment is switched off again at dawn. Using this system there is the potential for all night survey, provided that bat activity is not too high or that there is no interference from insects or electrical sources. The results obtained by this method were treated as opportunistic records as the sample time varied according to bat activity levels and insect/electrical interference and therefore can only be used as presence only records in the modelling process.

Calls obtained are analysed via Anabat 5 software on a computer using zero crossing analysis. A visual call sequence is shown on the screen and by comparing the call frequency and shape with those stored in the reference call library and the operators attained knowledge, the identity of the species can often be assigned to a definite or probable rating. Many calls, however, are poor in quality and/or short in duration and cannot be identified except by an educated guess. These calls are assigned a possible rating and cannot be reliably used for data analysis.

4.8 Koala Search

Two Koala search quadrats were carried out at all the major survey sites, except those in Port Stephens LGA, which has already been previously surveyed. The 'Asterisk' method was used and involved searching for scats under the 20 nearest trees to a central tree, ideally a recognised Koala food tree for the area. A hand rake was used to search under leaf litter for the characteristic scats within a 1m radius of the trunk of each tree. Additional ground inspections were also undertaken under the canopy of larger trees. Tree trunks were inspected for potential Koala scratch marks and the canopy visually searched for actual Koala presence.

4.9 Diurnal Bird Census

- (targeting threatened diurnal bird species)

A diurnal bird census was carried out at each of the major sites. Sample plot counts were carried out by one observer traversing a 200m x 50m site (the tree trap quadrat) for a 20 minute period, usually before 10 a. m. Birds were identified by sight with the aid of binoculars or by their characteristic calls. Birds were recorded onto the proforma as being within or outside the study site. Birds recorded after the 20 minute census were classed as being opportunistic on-site. Weather conditions were recorded with rain and strong winds avoided where possible.

4.10 Green and Golden Bell Frog

Frog survey methods included both day and night surveys and were carried out by Dr Arthur White (Biosphere Environmental Consultants). In the day time, the site was visited and a habitat evaluation sheet was completed. The habitat evaluation sheets that were used were prepared by New South Wales National Parks and Wildlife Service (NPWS 2000) specifically for Green and Golden Bell Frogs surveys.

Also during the day, a brief hand search of shelter sites was carried out to try to locate sheltering frogs. A tadpole survey was conducted. Water bodies were netted using a 4 mm mesh hand net. All tadpoles that were caught were identified and released at the site of capture.

During the night, the sites were revisited. All calling frogs were identified. Play-back recordings of the mating call of Green and Golden Bell Frogs were used to stimulate calling. A spotlight search of the emergent cover was undertaken and frogs were caught by hand, identified and released.

All frog and tadpole handling procedures conformed to the NPWS field survey protocols for frogs. The following data was recorded; Type of site (extant, historic or potential), site location (including AMG), date of visit, weather conditions, habitat assessment, presence of frogs, estimate of Bell frog numbers (based on search effort), presence of calling frogs, presence of tadpoles, other frog species present.

4.11 Opportunistic Sightings/Records

All species encountered on or off survey sites but outside official survey effort were recorded as opportunistic sightings. A grid reference using a GPS was sometimes recorded and failing this a general description of the locality was noted.

4.12 Data Entry (excluding Green and Golden Bell Frog)

Data was entered either into a field notebook or directly onto the proformas supplied for each site. The proforma layout followed those used during the CRA process. A site attribute proforma was completed for each site and this detailed the vegetation, geology and condition of the available habitat and assisted with the assignment of the site to a particular strata.

Prior to being entered into an 'Microsoft Access' database, all data proformas were checked for completeness and errors. Each methodology and/or group of data was entered into separate tables and these were linked by key fields e.g. site code, trap line number, species code etc. The following 19 data tables were created:

- Species list
- Site details
- Diurnal bird census
- Diurnal bird census results
- Elliott and Cage trapping
- Harp trap nights
- Harp trap results
- Nocturnal call playback
- Nocturnal call playback results
- Koala quadrats
- Hair tube lines
- Hair tube results
- Ultrasonic bat call recordings
- Ultrasonic bat call recording results
- Spotlight transects
- Spotlighting results
- On-site opportunistic records
- Off-site opportunistic records
- Observers

5.0 SURVEY LIMITATIONS

5.1 Site Selection

Site selection is the fundamental basis of the structure of the survey in order to achieve the aims of the survey and ideally, should be carried out prior to the commencement of the survey.

Ideally, the data audit, gap analysis and site selection should have been carried out over the winter 2000, thus allowing for entry permission to private lands to be formalised and ground truthing of the vegetation type, remnant size and quality of the habitat available verified prior to the surveys. This would then have allowed the survey to be conducted over spring and summer 2000/2001.

In the case of this survey, the site selection process was not completed prior to the start of the field survey, as a result of the timing of the RBCS project and circumstances beyond our control. There was also the need to proceed with the fieldwork as soon as possible so as to avoid as much of the winter season as possible. Site selection was therefore carried out concurrently with the fieldwork and in many cases ground truthing of the site could not be carried out prior to the survey.

Although most sites were initially chosen to coincide with the vegetation sites for the LHCCRBCS study, many land owners did not respond to requests to survey on their land, reducing the availability of survey sites on private land and within the desired strata.. In addition, some of the landowners who agreed to allow access for the survey had to be discounted as a result of the available habitat remnant being too small, incorrect vegetation strata type and occasionally, land owners changing their mind on allowing entry. This resulted in new sites having to be found at very short notice, often situated on public, rather than private land. Sometimes, not all the six standardised weekly survey sites could be set up.

5.2 Tree Trapping

Few limitations were encountered other than fitting in the trap grid in small vegetation remnants and keeping within the desired strata, particularly linear habitats, such as riparian and dry rainforest valley floor.

The mixing of Type 'A' and 'B' Elliott traps had the potential to affect the capture rate, however, the results showed that the target species were caught in both trap sizes at a similar rate (see results). Larger species, such as the Common Brushtail Possum and Common Ringtail Possum were only caught in the larger 'B' type trap, however, these species were infrequently caught and were not targeted by the methodology.

The timing of the survey resulted in trapping during cold weather, increasing the risk of trap deaths and possible periods of torpor in the target species (Squirrel Glider). Fortunately only one trap death, a Brown Antechinus, occurred during the survey. It was noted that this species was feeding on the honey bait, in fact one animal was observed carrying the bait from a trap during the day. In order to provide more food for Brown Antechinus that were caught on a regular basis, the amount of honey bait was increased and this may have reduced the potential mortality rate.

On two occasions trapping had to be abandoned due to continuous heavy rain. In all, five weeks were lost due to bad weather.

5.3 Cage Traps

The success of cage traps depends on the availability of animal pathways through dense ground cover. Many sites did not provide this combination. The traps used are designed more for the capture of medium sized terrestrial mammals (bandicoots, possums, Long-nosed Potoroo and Tiger Quoll) than small mammal species. Rats and the marsupial *Antechinus* are able to escape, often after devouring the bait. Once set off, the trap is no longer available for the target species. This problem was reduced part way through the survey by enclosing the bait in a plastic bottle suspended from the roof of the cage. Holes were drilled in the bottle so as to allow the smell of the bait to seep out. The treadle on the floor of the cage was also set firmer, so that smaller species were less likely to set off the trap.

5.4 Nocturnal Call Playback

The timing of the survey in autumn/winter probably suited the large forest owl species but was less suited to the other target species, particularly the Koala, as the survey was conducted outside their breeding season. The results of the survey demonstrated this, with the target owl species recorded on a regular basis, whereas, very few records of the target mammal species were obtained by this method.

Although the results of the owl call playback survey were acceptable, it is possible that a single nights census was inadequate at some sites and additional nights survey at each site may have increased the success rate. The excessive use of call playback during the breeding season is, however, not recommended as it may have an adverse effect on breeding success. In addition, the results would have been incompatible with the CRA survey for the purpose of habitat modelling.

As many of the sites were near urban/rural residential areas, traffic noise often reduced the broadcast/listening capabilities and probably affected the results. Proximity to houses resulted in a reduced volume of the call playback and a multitude of barking dogs, thus also reducing the effectiveness of the survey. At one site (WF4CMG), a successful letter drop was conducted prior to the survey thus reducing noise from barking dogs and irate residents.

Weather conditions also play an important role in the success of this technique and strong winds and rain were usually avoided during this survey.

5.5 Spotlight Transects

As the spotlight transects were usually 500m in length, it was sometimes difficult to survey within the nominated strata. For safety reasons, transects were carried out along tracks and roads where available, therefore, transects were usually not in a straight line. Transects carried out through the trap site often looped back to the start so as to attain the 500m length and remain within the desired strata.

Weather conditions, such as wind, rain and bright moonlight are thought to have negative effects on spotlight results. Wet and windy nights were avoided during this survey, however, surveys were conducted on moonlit nights.

The success of the spotlight technique is also dependent on whether the animal is facing the observer, the denseness of the vegetation and the quality of the vegetation, in that suitable food and shelter resources are available. Although only a small percentage of mammals on site are actually detected by this method, it is considered to be the most efficient and effective way of surveying for arboreal mammals but less effective for terrestrial species in dense habitats (Catling, et. al., 1997).

5.6 Bat (Harp) Trapping

The success of harp traps is often dependent on the availability of suitable flyways, usually tracks or roads, through the vegetation. Dense vegetation along the sides and above the trap is a distinct advantage if the trap is to be successful, as the bats are funnelled towards the trap. This is particularly important as it has been demonstrated that only 1:10 bats approaching a trap is actually caught (Lumsden et al, 2000 and Ray Williams pers. obs.).

Weather conditions are likely to affect results, particularly strong wind, rain and cold temperatures. It has also been suggested that moonlight has a negative affect on bat activity but this has yet to be proven. It is likely that changes in behaviour, rather than activity occur on bright moonlit nights. During this survey, wet and windy nights were usually avoided, with traps closed in the event of such weather conditions. The bat survey was terminated in early June as a result of cold overnight temperatures, although traps were occasionally set at sites providing a good sheltered trap site.

5.7 Ultrasonic Call Analysis

Although the innovation of the Anabat ultrasonic call system has been a boon for bat surveys there are some limitations. In particular, a large proportion of the calls obtained are of poor quality and short in duration, making definite identification to a species level impossible. Some species within the same Genera, e.g. *Nyctophilus*, *Vespadelus* and *Mormopterus* and between Genera e.g. *Miniopterus schreibersii* and *Vespadelus darlingtoni*, often cannot be reliably separated by call alone.

The systematic 30 minute census carried out during this survey records the initial bat activity at dusk but does not record the full species diversity using the site. The use of a delay switch coupled to the detector enables a potential all night survey, unless there is high bat activity or insect interference. In general, a higher species diversity is usually recorded when using this method, however, call quality is often reduced. Delay switch units were used for opportunistic records up until early June, when the bat survey was terminated as a result of cold temperatures.

5.8 Bird Census

The bird census was usually carried out before 10.00am so as to coincide with peak activity. At some sites, surveys were limited by traffic/aircraft noise, which affected species identification by call alone. Poor weather conditions, particularly strong wind and rain, were avoided during this survey.

The timing of the survey resulted in an absence of species regarded as summer visitors and therefore, a reduction in species diversity.

5.9 Hair Tubes

Although the use of hair tubes is time efficient and less invasive than trapping, definite identification to a species level is often impossible. This is particularly so for the Squirrel Glider/Sugar Glider, Brushtail Possums, Bandicoots and some Rodents. The target species, Tiger Quoll and Brush-tailed Phascogale, can however, be easily identified.

During this survey problems occurred with a new batch of double-sided tape, in that adhesion to the tube was reduced, resulting in lost tape probably stuck to the visiting animal. Also at some sites,

the tape was eaten, probably by Bush Rats, thus reducing potential results. The smaller tree tubes did not suffer the above problems to the same degree.

5.10 Koala Search

Given the comparatively small search area at each site, Koala feed trees could easily be overlooked, particularly in areas where Koalas are in low numbers. It is also difficult to determine whether observed scratch marks are definitely those made by a Koala, although this is easier when a well used tree is involved. Scratch marks are only obvious on smooth-barked tree species.

Koala scats decompose at different rates, depending on moisture level and the amount of litter cover. Scats would, therefore be expected to remain in dry, well drained habitats over a longer period, possibly well over a year, whereas this may be reduced to a matter of weeks in a moist flooding environment.

5.11 Opportunistic Sightings

Opportunistic records often make up a large proportion of records during a survey, however, it may not be possible to use these records in statistical analysis.

5.12 Green and Golden Bell Frog Survey

The LHCCREMS Bell Frog surveys covered a range of sites across the study area. Many potential habitat areas were investigated, others were not. These surveys should not be regarded as representing the total distribution of the frogs in the area. Several mine sites, quarries and pits had not been investigated before cold weather stopped the surveys. These areas need to be investigated under warmer conditions when detection of the frogs is higher.

Sites of particular interest that were not surveyed included:

- Ellalong Lagoon (near Paxton)
- Pelton Colliery
- Jewells Swamp Sand Mining Area
- Browns Quarry off Wollombi Road at Farley.
- Disused PGH Brickpit at East Maitland (Metford Road)
- Quarry Ponds of Old Buttai Road
- Sand Mine Area at Tomago

6.0 SURVEY RESULTS

A total of seventy-five (75) major survey sites and forty-four (44) opportunistic sites were completed during the survey. All methodologies were employed at the major sites, except for harp trapping later in the survey (after mid June), whereas only nocturnal call playback, spotlighting, bat call recording and/or harp trapping were employed at 25 of the opportunistic sites. Harp traps only were set at 19 opportunistic sites and, allowing for the postponement of the bat survey in June, resulted in a total of 75 harp trap sites being sampled. Nocturnal call playback and 30 minute Anabat recordings were completed at a total of 100 sites and spotlighting at 98 sights (2 sites had to be aborted as a result of rain developing).

The survey resulted in a total of 236 species being recorded, involving 41 mammal, 136 bird, 23 reptile and 17 frog species. Nine of these were introduced species. A full species list is shown in Appendix 1. A total of twenty two (22) Threatened species were recorded, including most of the target species. Exceptions were the Barking Owl, Yellow-bellied Sheath-tail-bat, Eastern Cave Bat, Eastern False Pipistrelle and Golden-tipped Bat. The details of the threatened species recorded are shown in Appendix 2.

6.1 Effectiveness of each Methodology

Tree Trapping

Tree traps were successful in that the target species, the Squirrel Glider and Brush-tailed Phascogale, were recorded by this method. In all, nine (9) species of mammal were recorded. The mixture of Elliott A & B Type traps does not appear to have effected the results as all species, except the larger Brushtail and Ringtail Possums, were captured in both trap sizes. There did appear to be preference for the smaller trap by the Sugar Glider (56A/35B) and Brown Antechinus (142A/66B). The larger traps caught more Bush Rats (1A/9B) and for the Squirrel Glider (5A/6B), Brushtail Phascogale (2A/1B), Yellow-footed Antechinus (3A/2B) and Black Rat (12A/14B) there was no significant preference. However, as a result of the low sample size for the Brushtail Phascogale and Yellow-footed Antechinus, meaningful interpretations for these species cannot be made.

Cage Traps

The cage traps failed to capture any target species and in general, capture success was extremely low (15 captures). A total of 6 species were caught by this method, with an Echidna at site CF1R/HVF being most notable. Most commonly caught was the Common Brushtail Possum (8 captures) followed by the Black Rat and Bush Rat (2 captures each) and single captures of the Common Ringtail Possum, Echidna and Northern Brown Bandicoot. Given the large number of sites with bandicoot activity, it would have been expected that regular captures of bandicoots would have occurred. The choice of bait (peanut butter and fish cat food sandwiches) may have had some effect, although this is considered to be unlikely, as bandicoots have been regularly captured during other Ecotone surveys using the same bait combination. In addition, cage traps were regularly triggered by small mammals, usually rats, which often escaped from the cage. This had the effect of reducing the chance of capturing the target species.

Hair Tubes

The hair tubes failed to detect any of the target species. This was disappointing, as this method has been successful in detecting Tiger Quolls and the Brush-tailed Phascogale during other surveys conducted by this firm. From the 1125 hair tubes set 272 were successful. Many of the hair samples

could not be identified to a species level and only seven (7) species were positively recorded. Most commonly recorded species or Family group were the Brushtail Possums with both Common Brushtail and Mountain Brushtail Possum possible at moist strata. As with the cage traps, it would have been expected that bandicoots would have been recorded regularly, however, only two sites were successful. Problems with a new batch of tape resulted in the loss of tape from some tubes, undoubtedly reducing the number of successful results.

Spotlighting

Overall, spotlighting results were poor with no sightings made on a number of occasions. A total of 318 fauna sightings were made over the 98 spotlighting transects, involving 20 mammal, 6 nocturnal bird, 2 reptile and 13 frog species. Most of the target species were encountered, but not on a regular basis. As was to be expected, of the target species, arboreal mammals were most often recorded by this method, with the Yellow-bellied Glider recorded at 8 sites and Squirrel Glider at 6 sites. The Koala was recorded at 2 sites and the Tiger Quoll and Brush-tailed Phascogale at only 1 site. Owls were infrequently recorded by this method, with the Sooty Owl recorded at 3 sites and the Powerful Owl and Masked Owl at 2 sites. Non-target threatened species recorded were the Wallum Froglet heard at 4 sites and the Grey-headed Flying-fox at 1 site.

Call Playback

The call playback was very successful for the recording of the large forest owls, with three of the four species, the Powerful Owl, Masked Owl and Sooty Owl recorded on several occasions at 41% of the survey sites. Details for each individual owl species are given below.

The calls of the target mammal species were less successful, with only the Yellow-bellied Glider recorded at 10 sites by this method. Most calls were, however, heard during the initial listening period and responses to the Yellow-bellied Glider or Powerful Owl call were infrequent. Most other calls of this species were heard during spotlighting transects. The Squirrel Glider was heard calling on two occasions, both not in response to the call playback. No Koalas responded during the playback, however, three individuals called during the spotlighting at PSF1 R, possibly in response to the call playback.

Harp Traps

Harp traps were set for 177 trap nights and resulted in 233 captures. Although ten (10) bat species were recorded, harp trap results were generally poor, with no captures made at 32 sites and greater than 2 captures at only 24 sites. Most captures were of common species, the Little Forest Bat (59), Lesser Long-eared Bat (40) Gould's Long-eared Bat (39), Eastern Forest Bat (17) and Eastern Horseshoe Bat (14). Four of the target species were captured, but only the Little Bent-wing Bat (21 captures) was caught in any numbers. Further details are given below. The reason for the poor results can be attributed to poor trap site availability and the survey extending into winter, thus reducing overall bat activity.

Ultrasonic Bat Call Analysis

This method resulted in 16 species of bat being recorded over the survey period. Six threatened bat species were identified by this method, however, apart from the Bent-wing Bats, records were few in number. Three additional threatened species, the Greater Broad-nosed Bat, Greater Long-eared Bat and East-coast Freetail Bat, were recorded by this method only. As with the harp traps, the reason for the poor results can be attributed to the survey extending into winter, thus reducing overall bat activity. Identification to a species level was also hampered by many calls being of

poor quality and short duration. A large number of calls were assigned to a low number of common species, particularly the Little Forest Bat and Gould's Wattled Bat.

Bird Census

The systematic bird census resulted in 90 of the 136 bird species encountered during the whole survey being recorded. Most are considered to be common, widespread species, however, four threatened species, the Glossy Black Cockatoo, Brown Treecreeper, Speckled Warbler and Grey-crowned Babbler were recorded. The lack of flowering trees suited to threatened species at most sites limited the chance to record species, such as the Swift Parrot and Regent Honeyeater.

Opportunistic Sightings

As is usual for large-scale surveys, opportunistic sightings on and off site make up a large part of the overall records. A total of 185 species were recorded as on-site and 81 species as off-site opportunistic sightings.

The on-site opportunistic records accounted for 124 of the 136 bird species, 18 of the 22 reptile and 16 of the 18 frog species recorded. Mammals were not as well represented, with 25 of the 41 species recorded on-site. It is pointed out that some species were also recorded by other means (see Appendix 1). The lower number of off-site opportunistic sightings is to be expected as most survey time, other than travel, was spent on the survey sites.

6.2 Target Threatened Species

Note that the threatened species locations shown in the Figures only include the results obtained from the data audit and the fauna survey of this study. Although NPWS Wildlife Atlas records would greatly increase the points on the maps for most species, they would cloud the visual image of the results of this survey. It is, however, expected that all available fauna records will be used in the modelling phase of this project.

Squirrel Glider *Petaurus norfolcensis* (Plate 8)

The Squirrel Glider was recorded at 14 sites with 21 individuals recorded. The species was recorded in all LGA's except Gosford and Newcastle, however, there are known records from these areas. There is an obvious preference towards the drier woodland/forests of the coastal plains (CSP, CSPW & DR) and lower Hunter Valley flats (HVF). Locations are shown in Figure 4.

Yellow-bellied Glider *Petaurus australis* (Plate 10)

This species was recorded on 20 occasions at 14 sites in the Gosford, Wyong, Lake Macquarie and Cessnock LGA's. There was an obvious trend towards the moist forests (CMR & CMG) in the south and west of the study area and also hill slopes and flats (DR & HVF) of the lower Hunter Valley. Locations are shown in Figure 4.

Koala *Phascolarctos cinereus* (Plate 12)

The Koala was not recorded outside Port Stephens LGA. Although not a targeted species in Port Stephens the Koala was recorded at 3 Locations, either by site or scat collection in strata SF, SW & R (see Figure 5). At one site (PSF1 R on 4/4/01), Koalas may have responded to the call playback, as three individuals were heard calling, two from over the other side of the Williams River and the third further downstream from the site. Interestingly, the tree cover on the other side of the river was noted to be very sparse and considered poor Koala habitat.

Figure 4 - Threatened Species Records (i. Gliders)

Figure 5 - Threatened Species Records (ii. Non-flying Mammals)

Brush-tailed Phascogale *Phascogale tapoatafa* (Plate 11)

The Brush-tailed Phascogale was recorded at two sites (MF2 DR & MF3 HVF), both in Maitland LGA (see Figure 5). The animals were trapped and sighted during spotlighting transects and were found in HVF and highly disturbed DR Strata in the north of the LGA.

Tiger Quoll *Dasyurus maculata* (Plate 9)

The Tiger Quoll was only recorded once during the survey, with an individual sighted during spotlighting on the Tomago Sandbeds, Salt Ash in Strata CSPW (Site PSOP6 CSPW, Figure 5).

Threatened Bat Species

Four threatened bat species were positively identified during harp trapping surveys, with another three probably identified via ultrasonic call analysis. Locations are shown in Fig 6a-c.

Large Bent-wing Bat *Miniopterus schreibersii* (Plate 15)

This species was caught at only 3 sites in Gosford and Wyong LGA's, however, ultrasonic calls were identified at 15 sites in 8 strata throughout the study area, except Maitland. Several sites were within the coalfields of Lake Macquarie, Newcastle and Cessnock, suggesting that disused mine workings are being used as roost sites.

Little Bent-wing Bat *Miniopterus australis* (Plate 19)

The Little Bent-wing Bat was trapped at 8 sites and recorded by ultrasonic call at 23 sites, mainly throughout the eastern part of the study area. Several sites were within the coal fields of Lake Macquarie, Newcastle and one possible recording near Cessnock, suggesting that disused mine workings are being used as roost sites. Another colony appears to permanently occupy the area to the south-east of Gosford. The roost site is currently unknown but may be sea caves near McMasters Beach. The records within Port Stephens LGA are within flying distance of a known roost site at Balickera.

Southern Myotis *Myotis macropus* (Plate 18)

This species was only caught at one location (Bow Wow Gorge, CF10 M). Ultrasonic calls were recorded at 2 locations on the Wyong River, namely at Wyong Creek (WF1 R) and Lees Reserve (WOP5 R), Chittaway Point and one location near Mooney Mooney Dam (GF7 M) at Somersby.

Large-eared Pied Bat *Chalinolobus dwyeri* (Plate 17)

This species was caught at 2 locations, one near Killingworth (LMF2 CSPW) and the other near Kulnura (WF9 CMR).

Greater Broad-nosed Bat *Scoteanax rueppellii* (Plate 13)

This species was only recorded by a probable ultrasonic call at one site in the Port Stephens LGA (PSF14 CSP) and a possible call at a site in Cessnock (COP1 DR).

Figure 6a - Threatened Species Records (iii. Bats)

Figure 6b - Threatened Species Records (iii. Bats)

Figure 6c - Threatened Species Records (iii. Bats)

Greater Long-eared Bat *Nyctophilus timoriensis*

A single probable call of this species was recorded in Cessnock LGA near the Kurri Kurri aluminium smelter (CF3 DR). This is an interesting record, as this is regarded a more western species, although it has been recorded on several occasions in the upper Hunter district (CRA surveys and NPWS Wildlife Atlas). The species could not be definitely identified by call alone, however, the lower frequency (34-36kHz) of the recorded call, when compared with those recorded for the other Long-eared Bats (around 40kHz), makes it a probable record.

East-coast Freetail Bat *Mormopterus norfolkensis* (Plate 14)

This species was recorded via ultrasonic calls at 2 locations, although one site (GF3 DRH) in the Gosford LGA was only a possible call. A probable call was recorded near Cessnock Racecourse (CF4 SW).

Large Forest Owls

Powerful Owl *Ninox strenua* (Plate 22)

This species was recorded on 20 occasions at 18 sites across the whole study area (Figure 7). There was no apparent preference for a particular strata, with records occurring in 7 of the 14 strata and in both dry and moist habitats. Most records (17) were obtained via the call playback method.

Masked Owl *Tyto novaehollandiae* (Plate 21)

This species was recorded on 12 occasions at 11 sites within all LGA's, with the exception of Maitland (Figure 7). Although there appears to be a preference for drier open forests, some records for moist forests occurred. This observation may be clouded by the linear nature of these habitats along major creek lines and the fact that the Masked Owls were actually drawn from adjoining open forests by the call playback.

Sooty Owl *Tyto tenebricosa*

This species was recorded on 16 occasions at 12 sites within Gosford, Wyong and Lake Macquarie LGA's, largely in the southern part of the study area (Figure 7). There was an obvious preference for moist forest strata with records in dry vegetation types probably a result of being attracted by the call play back.

Threatened Bird Species

Four additional threatened bird species was recorded, the Glossy Black Cockatoo *Calyptorhynchus lathami*, Grey-crowned Babbler (eastern subspecies) *Pomatostomus temporalis temporalis*, Speckled Warbler *Pyrrholaemus sagittata* and Brown Treecreeper (eastern subspecies) *Climacteris picumnus victoriae* (Figure 8).

The Glossy Black Cockatoo (Plate 20) was recorded at 3 locations, one each in Gosford, Cessnock and Lake Macquarie LGA's. A group of 6 individuals (2 family groups of 3 individuals) were sited at CF7R at the Broken Back Range feeding on Forest Oak fruits. The other records were based on finding the chewed fruits of Forest Oaks during survey work.

Figure 7 - Threatened Species Records (iv. Nocturnal Birds)

The other three species have only recently been added to Schedule 2 of the TSC Act and were confined to the north western part of the study area (Cessnock and Maitland), particularly within the Hunter Valley Floor strata. The Brown Tree Creeper and Speckled Warbler were recorded on two occasions and the Grey-crowned Babbler on four occasions, including a sighting within partially cleared open woodland..

Green and Golden Bell Frog

By the end of the survey, 3 extant sites, 5 no longer used sites and 64 potential sites were visited. Locations are shown in Figure 9.

The extant sites surveyed and where Bell Frogs were recorded were at Site 1 at Sandgate, Site 2 at Kooragang Island and Site 46 North Avoca lagoon.

The 5 disused sites were Site 42 at Hexham Swamp, Site 62 at Raymond Terrace, Site 70 at Ourimbah, Site 71 at Ourimbah Creek and Site 72 at Erina. No Bell Frogs were found at these sites.

The remaining 64 sites are listed in the full Green and Golden Bell Frog report in the Appendix. No Bell Frogs were found at any of these sites.

Figure 8 - Threatened Species Records (v. Diurnal Birds)

Figure 9 - Threatened Species Records (vi. Green and Golden Bell Frog)

7.0 DISCUSSION OF RESULTS

The survey was successful in that several of the aims were achieved;

- Most of the target species were encountered,
- the number of known records across the study area was substantially increased for some species e. g. Squirrel Glider, Yellow-bellied Glider, Bent-wing Bats and Large Forest Owls),
- the survey sites were located across the whole study area, excluding large areas of National Park and State Forest in the south and west,
- apparent gaps in survey effort shown up in the data audit were substantially filled,
- survey effort covered all strata, except dry rainforest gully (DRG) and increased the sample size of each strata in relation to the availability of the strata within the study area, and
- information was gained to aid in the completion of the fauna habitat modelling in Module 2.

The survey did have some failings in that;

- the number of sites on private land was reduced as a result of the limitations mentioned in Section 5.1 of this report, thus the survey relied more on council, crown and State Forest land than was proposed,
- some of the survey methods failed to target the intended species. These were Koala scat searches, cage traps and hair tubes for Tiger Quolls and Brush-tailed Phascogale and bird census for threatened diurnal bird species,
- bat surveys were carried out at an inappropriate time, resulting in harp traps not being set at some sites and generally poor ultrasonic call results. However, as the Large Bent-wing Bat, the main target species, is active throughout the winter, the survey results for this species and the Little Bent-wing Bat indicate that the timing was probably acceptable, and
- there appears to some confusion when assigning a site to some strata as a result of an overlap of indicator species. This is particularly so for HVF/DR and Riparian/ M, DRG, DRVF, CMG, SF and DG as all these strata are often in riparian situations. It may be necessary to re-assign some of the map units prior to the modelling process.

The results of the gap analysis indicated that several of the strata within the study area had been poorly surveyed by systematic methodologies prior to the LHCCRBCS, 2001 surveys. In fact seven out of the 14 strata had less than 10 survey sites for each of the methodologies and five of these (HVF, CSP, DG, DRG and DRVF) have had no or very low survey effort. The recent surveys have enabled an increase in survey effort within strata across the study area and with the exception of the Dry Rainforest Gully, has helped to partially correct the apparent imbalance across strata. The main reasons for the lack of survey in Dry Rainforest Gully were the lack of the mapped stratum actually on site, poor access, occurrence largely restricted to western parts of Cessnock LGA and much of DRG is within National Park or State Forest. The strata covering the most surface area, (CMR, CSPW and DR) have obviously received most survey effort, although some methodologies were limited in application. For example, tree trapping in Coastal Moist Ridge, had been formerly poorly

sampled. Survey effort for this methodology in CMR has risen from 2 to 12 sites as a result of the current field surveys.

The Hunter Valley Floor (HVF) mainly occurs on the flat plains of Cessnock and Maitland LGAs and is highly fragmented with very few large remnants remaining as a result of clearing for agriculture. From the data collected, this strata had not been systematically surveyed prior to these surveys. Thirteen sites have now been surveyed to some degree, with the following target species recorded; Brush-tailed Phascogale, Squirrel Glider, Yellow-bellied Glider, Powerful Owl, Masked Owl and Little Bent-wing Bat. Other threatened micro bat species are also expected to occur in this strata as well as recently determined threatened bird species such as the Brown Treecreeper, Speckled Warbler and Grey-crowned Babbler. There is currently some confusion as to the correct vegetation description for this strata, as some sites mapped as Dry Ridge have been assigned to HVF, based on the topography and altitude of the land. As this strata supports several threatened species and has suffered a large reduction in area, it is considered important that detailed vegetation description and mapping be carried out and some protection measures put in place.

Several of the strata occur as linear habitat along creek and drainage lines (R, M, CMG, DRG, DRVF). The often narrow band of vegetation poses problems with interpreting the results, particularly the fauna modelling. This is particularly so for species recorded by the nocturnal call playback method, as the target species are likely to be drawn from adjacent strata, producing erroneous results. This can also work in reverse, with fauna frequenting the moist gullies drawn to adjacent dry strata.

It is considered that sufficient information has been obtained to carry out the fauna habitat modelling process for most of the target species. However, the method of modelling will probably vary between species. Presence/absence modelling will be suited to the species with a large to moderate number of records, with likely species being the Squirrel Glider, Yellow-bellied Glider, Large Bent-wing Bat, Little Bent-wing Bat, Powerful Owl, Masked Owl and Sooty Owl. The remaining species are likely to be modelled by the presence only method, as insufficient records from systematic survey methods occur. The accuracy of the fauna habitat model for these species may be compromised by inaccuracies in the grid reference of the species record and a lack of ground truthing of the actual strata recorded.

Given the poor timing of the bat survey, it has been suggested that additional survey work be carried out during spring/early summer, 2001. This has particular merit for the western part of the study area, as it was poorly surveyed during the study, a result of the termination of harp trapping in mid June. As significant numbers of additional records cannot be guaranteed if this action is taken, it may be more appropriate to channel available resources into the ground truthing of models produced in Module 2 of the project, provided that sufficient data is available to produce the model.

The results of the Bell Frog survey were disappointing in that no new Bell Frog populations were found. It was apparent that the decline in Bell Frogs that had been experienced elsewhere in New South Wales has been equally dramatic in the Lower Hunter and Central Coast region. Of the 22 historic sites listed in the introduction, only Kooragang Island and Gillieston Heights still contain Bell Frogs (i.e. there has been a 91% loss of sites).

Most of the sites where Bell Frogs are known to occur in the region are not historic sites. Extant Bell Frogs populations occur in sites that appear to have been occupied in recent years. These sites include: North Wyong Industrial Area (1998), North Avoca Lagoon (1995); Davistown (1994), Maitland (1995) and Sandgate (2000).

Not all of the extant sites appear to contain stable populations of Bell Frogs: for example, Bell Frogs have not been found at Davistown since 1998, nor at Maitland since 1997. The status of the Bell Frogs at North Wyong is unknown whereas North Avoca Lagoon, Kooragang Island and Sandgate appear to have permanent populations. North Avoca Lagoon and Kooragang Island populations are subject to ongoing monitoring studies and are well documented. Additional surveys for this species at the locations listed in the appended report could be considered. Habitat noted at Ellalong Lagoon (Cessnock LGA) and Brown's Quarry (Maitland LGA) during the systematic fauna surveys appeared to be suitable for the Green and Golden Bell Frog.

In conclusion, it is considered that the surveys carried out for Module 1 of this project achieved the targeted aims to varying degrees. The main aim of the survey was to provide data for Module 2 of the project, the fauna habitat modelling and conservation requirements of the target threatened species. It is considered that sufficient information exists for most species to be modelled, however, some species will only be able to be modelled by the presence only method. The survey was carried out across all LGA's and all strata (except Dry Rainforest Gully) was sampled within each LGA that the strata occurred. Less survey effort was applied to Maitland and Newcastle LGA's, as a result of the lack of extensive areas of habitat. The survey was successful in filling in the gaps in survey effort within each strata and identified in the data audit stage of Module 1 (with the exception of DRG). The sampling of private land was probably not carried out to the anticipated degree, as a result of site selection problems, often out of our control. Not all methodologies were successful in detecting the target species, namely cage trapping, hair tubes and bird census. Further surveys, particularly for bats and the Green and Golden Bell Frog, could be considered so as to cover the sites not sampled for these species during the RBCS surveys.

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9.0 SURVEY PERSONNEL

Ray Williams, Biol. Tech. Cert. - Project Supervisor, including site selection, field survey, bat call analysis and report preparation.

Dr Arthur White, PhD - Frog specialist carrying out the Green and Golden Bell Frog survey.

Chris Thomson, B. Applied Sc. – Field Survey, including bird census and report preparation (MapInfo)

Graham Turner, B. Applied Sc. – Field Survey, specialising in Bird Census and Call Playback

Tanya Williams – Field Survey including bird census, bat call analysis

Amy Williams, BSc (Hons) – Data entry and field assistant

Sara Evans, B. Env. Sc. – Data audit and field assistant

Imogen Jubb, BSc (Hons) – Field assistant

Anne Williams – Caterer for the survey team, bait and hair tube preparation and field assistant.

Barbara Triggs, 'Dead Finish', c/o PO Genoa, Victoria – Hair tube analysis

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11.0 APPENDICES

Appendix 1. Fauna Species Recorded during the LHCCRBCS Survey, 2001

FAMILY NAME <i>Scientific name</i>	Common Name	Method Recorded								
		T	C	N	S	HT	H	D	ON	OF
MAMMALS										
MONOTREMES										
ORNITHORHYNCHIDAE										
<i>Ornithorhynchus anatinus</i>	Platypus								X	
TACHYGLOSSIDAE										
<i>Tachyglossus aculeatus</i>	Short-beaked Echidna		X						X	
MARSUPIALS										
DASYURIDAE										
<i>Antechinus flavipes</i>	Yellow-footed Antechinus	X							X	
<i>Antechinus stuartii</i>	Brown Antechinus	X			X	X			X	
<i>Dasyurus maculatus</i>	Spotted-tailed Quoll (V)				X					
<i>Phascogale tapoatafa</i>	Brushtail Phascogale (V)	X			X					
<i>Sminthopsis murina</i>	Common Dunnart									X
PERAMELIDAE										
<i>Isoodon macrourus</i>	Northern Brown Bandicoot		X			?				
<i>Perameles nasuta</i>	Long-nosed Bandicoot				X	?			X	X
PHASCOLARCTIDAE										
<i>Phascolarctos cinereus</i>	Koala (V)				X				X	
VOMBATIDAE										
<i>Vombatus ursinus</i>	Common Wombat								X	X
PETAURIDAE										
<i>Petaurus australis</i>	Yellow-bellied Glider (V)			X	X				X	X
<i>Petaurus breviceps</i>	Sugar Glider	X			X	X			X	X
<i>Petaurus norfolcensis</i>	Squirrel Glider (V)	X		X	X				X	X
PSEUDOCHEIRIDAE										
<i>Petauroides volans</i>	Greater Glider				X				X	
<i>Pseudocheirus peregrinus</i>	Common Ringtail Possum	X	X		X				X	X
ACROBATIDAE										
<i>Acrobates pygmaeus</i>	Feathertail Glider				X					
PHALANGERIDAE										
<i>Trichosurus vulpecula</i>	Common Brushtail Possum	X	X		X	?			X	X
<i>Trichosurus caninus</i>	Mountain Brushtail Possum				X	?				
MACROPODIDAE										
<i>Macropus giganteus</i>	Eastern Grey Kangaroo				X				X	X
<i>Macropus rufogriseus</i>	Red-necked Wallaby				X				X	X
<i>Macropus robustus</i>	Common Wallaroo									X
<i>Wallabia bicolor</i>	Swamp Wallaby				X	X			X	X

- continued

FAMILY NAME <i>Scientific name</i>	Common Name	Method used								
		T	C	N	S	HT	H	D	ON	OF
PTEROPODIDAE										
<i>Pteropus poliocephalus</i>	Grey-headed Flying Fox (V)				X				X	
RHINOLOPHIDAE										
<i>Rhinolophus megaphyllus</i>	Eastern Horseshoe Bat						X	X		
MOLLOSSIDAE										
<i>Mormopterus nofolkensis</i>	East Coast Freetail Bat (V)							X		
<i>Tadarida australis</i>	White-striped Freetail-bat				X			X	X	X
<i>Mormopterus</i> sp.1	Little Free-tail Bat							X		
VESPERTILIONIDAE										
<i>Miniopterus australis</i>	Little Bentwing-bat (V)						X	X		
<i>Miniopterus schreibersii</i>	Common Bentwing-bat (V)						X	X		
<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat						X	?		
<i>Nyctophilus timoriensis</i>	Greater Long-eared Bat (V)							X		
<i>Nyctophilus gouldi</i>	Gould's Long-eared Bat						X	?		
<i>Chalinolobus dwyeri</i>	Large Pied Bat (V)						X			
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat							X		
<i>Chalinolobus morio</i>	Chocolate Wattled Bat						X	X		
<i>Scotorepens orion</i>	Eastern Broad-nosed Bat							X		
<i>Myotis macropus</i>	Southern Myotis (V)						X	X		
<i>Scoteanax rueppellii</i>	Greater Broad-nosed Bat (V)							X		
<i>Vespadelus darlingtoni</i>	Large Forest bat							X		
<i>Vespadelus vulturnus</i>	Little Forest Bat						X	X		
<i>Vespadelus pumilus</i>	Eastern Forest Bat						X	X		
MURIDAE										
<i>Mus musculus</i> *	House Mouse						X?			
<i>Hydromys chrysogaster</i>	Water-rat								X	
<i>Rattus lutreolus</i>	Swamp Rat						X			
<i>Rattus rattus</i> *	Black Rat	X	X				X			
<i>Rattus fuscipes</i>	Bush Rat	X	X				X			
CANIDAE										
<i>Canis lupus</i> *	Dingo/Dog						X			
<i>Vulpes vulpes</i> *	Fox								X	
FELIDAE										
<i>Felis catus</i> *	Cat				X				X	
LEPORIDAE										
<i>Lepus capensis</i> *	Brown Hare								X	
<i>Oryctolagus cuniculus</i> *	Rabbit				X				X	
SUIDAE										
<i>Sus scrofa</i> *	Feral Pig								X	
BOVIDAE										
<i>Capra hircus</i> *	Goat								X	

- continued

FAMILY NAME <i>Scientific name</i>	Common Name	Method Recorded		
		S	ON	OF
REPTILES				
GEKKONIDAE				
<i>Oedura robusta</i>	Robust Velvet Gecko	X		
<i>Phyllurus platurus</i>	Southern Leaf-tailed Gecko	X	X	
AGAMIDAE				
<i>Amphibolurus muricatus</i>	Jacky Lizard		X	X
<i>Physignathus lesueurii</i>	Eastern Water Dragon		X	
<i>Pogona barbata</i>	Bearded Dragon			X
VARANIDAE				
<i>Varanus varius</i>	Lace Monitor		X	X
SCINCIDAE				
<i>Anomalopus swansoni?</i>			X?	
<i>Carlia tetradactyla</i>	Southern Rainbow Skink		X	
<i>Carlia vivax</i>	Tussock Rainbow-skink		X	
<i>Cryptoblepharus virgatus</i>	Wall lizard		X	X
<i>Ctenotus robustus</i>	Robust Ctenotus		X	
<i>Ctenotus taeniolatus</i>	Copper-tailed Skink			X
<i>Eulamprus quoyii</i>	Eastern Water Skink		X	
<i>Eulamprus tenuis</i>	Barred-sided Skink		X	
<i>Lampropholis delicata</i>	Dark-flecked Garden Sunskink		X	
<i>Saiphos equalis</i>	Three-toed Skink		X	
TYPHLOPIDAE				
<i>Ramphotyphlops sp.</i>	Blind Snake			X
BOIDAE				
<i>Morelia spilota</i>	Carpet/Diamond Python		X	X
COLUBRIDAE				
<i>Dendrelaphis punctulata</i>	Common Tree Snake		X	
ELAPIDAE				
<i>Cacophis krefftii</i>	Krefftt's Dwarf Snake		X	
<i>Demansia psammophis</i>	Yellow-faced Whip Snake		X	X
<i>Pseudechis porphyriacus</i>	Red-bellied Black Snake		X	X
<i>Rhinoplocephalus nigrescens</i>	Eastern Small-eyed Snake		X	
AMPHIBIANS				
MYOBATRACHIDAE				
<i>Crinia signifera</i>	Common Eastern Froglet	X	X	X
<i>Crinia tinnula</i>	Wallum Froglet (V)	X	X	X
<i>Limnodynastes dumerilii</i>	Eastern Banjo Frog	X	X	X
<i>Limnodynastes ornatus</i>	Ornate Burrowing Frog	X	X	
<i>Limnodynastes peroni</i>	Brown-striped Frog	X	X	X
<i>Limnodynastes tasmaniensis</i>	Spotted Grass Frog	X	X	X
<i>Pseudophryne bibroni</i>	Brown Toadlet		X	
<i>Pseudophryne coriacea</i>	Red-backed Toadlet	X	X	X
<i>Uperoleia fusca</i>	Dusky Toadlet	X	X	
HYLIDAE				
<i>Litoria aurea</i>	Green and Golden Bell Frog	X		
<i>Litoria caerulea</i>	Green Tree Frog		X	
<i>Litoria fallax</i>	Eastern Dwarf Tree Frog	X	X	
<i>Litoria jervisiensis</i>	Jervis Bay Tree Frog	X	X	
<i>Litoria latopalmata</i>	Broad-palmed Frog	X	X	X
<i>Litoria lesueuri</i>	Lesueur's Frog	X		
<i>Litoria peroni</i>	Perons Tree Frog	X	X	
<i>Litoria revelata</i>	Whirring Tree Frog		X	
<i>Litoria verreauxi</i>	Verreaux's Tree Frog	X	X	X

- continued

FAMILY NAME <i>Scientific name</i>	Common Name	Method Recorded			
		B	ON	OF	S/N
BIRDS					
CASUARIIDAE					
<i>Dromaius novaehollandiae</i>	Emu		X		
MEGAPODIIDAE					
<i>Alectura lathami</i>	Australian Brush Turkey		X		
PHASIANIDAE					
<i>Coturnix australis</i>	Brown Quail	X	X	X	
ANATIDAE					
<i>Cygnus atratus</i>	Black Swan		X	X	
<i>Chenonetta jubata</i>	Australian Wood Duck		X	X	X
<i>Anas superciliosa</i>	Pacific Black Duck		X	X	
<i>Anas castanea</i>	Chestnut Teal		X		
PELECANIDAE					
<i>Pelecanus conspicillatus</i>	Australian Pelican			X	
ARDEIDAE					
<i>Egretta novaehollandiae</i>	White-faced Heron		X		
THRESKIORNITHIDAE					
<i>Threskiornis molucca</i>	Australian White Ibis		X	X	
<i>Threskiornis spinicollis</i>	Straw-necked Ibis		X	X	
ACCIPITRIDAE					
<i>Aviceda subcristata</i>	Pacific Baza		X		
<i>Elanus notatus</i>	Black-shouldered Kite			X	
<i>Haliastur sphenurus</i>	Whistling Kite	X			
<i>Haliastur leucogaster</i>	White-bellied Sea-Eagle		X		X
<i>Circus assimilis</i>	Spotted Harrier			X	
<i>Circus approximans</i>	Swamp Harrier		X		
<i>Accipiter fasciatus</i>	Brown Goshawk	X	X	X	
<i>Accipiter novaehollandiae</i>	Grey Goshawk		X	X	
<i>Accipiter cirrocephalus</i>	Collared Sparrowhawk	X	X	X	
<i>Aquila audax</i>	Wedge-tailed Eagle		X		
<i>Hieraaetus morphnoides</i>	Little Eagle		X	X	
FALCONIDAE					
<i>Falco berigora</i>	Brown Falcon		X	X	
<i>Falco longipennis</i>	Australian Hobby		X	X	
<i>Falco cenchroides</i>	Nankeen Kestrel		X		
RALLIDAE					
<i>Gallinula tenebrosa</i>	Dusky Moorhen		X		
<i>Porphyrio porphyrio</i>	Purple Swamphen		X	X	
CHARADRIIDAE					
<i>Vanellus miles</i>	Masked Lapwing		X	X	
COLUMBIDAE					
<i>Columba leucomela</i>	White-headed Pigeon		X		
<i>Streptopelia chinensis*</i>	Spotted Turtle Dove		X		
<i>Macropygia amboinensis</i>	Brown Cuckoo-dove	X	X		
<i>Phaos chalcoptera</i>	Common Bronzewing		X		
<i>Phaps elegans</i>	Brush Bronzewing		X		
<i>Geopelia humeralis</i>	Bar-shouldered Dove	X	X		
<i>Leucosarcia melanoleuca</i>	Wonga Pigeon	X	X		
CACATUIDAE					
<i>Calyptorhynchus lathami</i>	Glossy Black-Cockatoo(V)	X	X	X	
<i>Calyptorhynchus funereus</i>	Yellow-tailed Black Cockatoo	X	X		
<i>Callocephalon fimbriatum</i>	Gang-gang Cockatoo	X	X	X	
<i>Cacatua roseicapilla</i>	Galah	X	X		
<i>Cacatua galerita</i>	Sulphur-crested Cockatoo	X	X		X

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FAMILY NAME <i>Scientific name</i>	Common Name	Method Recorded			
		B	ON	OF	S/N
PSITTACIDAE					
<i>Trichoglossus haematodus</i>	Rainbow Lorikeet	X	X		
<i>Glossopsitta pusilla</i>	Little Lorikeet	X			
<i>Alisterus scapularis</i>	Australian King Parrot	X	X		
<i>Platycercus elegans</i>	Crimson Rosella	X	X		
<i>Platycercus eximius</i>	Eastern Rosella	X	X		
CUCULIDAE					
<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo	X	X	X	
<i>Chalcites lucidus</i>	Shining Bronze-Cuckoo	X	X		
STRIGIDAE					
<i>Ninox novaeseelandiae</i>	Southern Boobook Owl	X	X		X
<i>Ninox strenua</i>	Powerful Owl (V)		X		X
TYTONIDAE					
<i>Tyto tenebricosa</i>	Sooty Owl (V)				X
<i>Tyto novaehollandiae</i>	Masked Owl (V)			X	X
<i>Tyto alba</i>	Barn Owl		X		
PODARGIDAE					
<i>Podargus strigoides</i>	Tawny Frogmouth		X	X	X
AEGOTHELIDAE					
<i>Aegotheles cristatus</i>	Australian Owlet Nightjar	X	X	X	X
CAPRIMULGIDAE					
<i>Eurostopodus mystacalis</i>	White-throated Nightjar		X		
APODIDAE					
<i>Hirundapus caudacutus</i>	White-throated Needletail	X			
ALCEDINIDAE					
<i>Alcedo azurea</i>	Azure Kingfisher		X		
<i>Dacelo novaeguineae</i>	Laughing Kookaburra	X	X		
<i>Todiramphus sanctus</i>	Sacred Kingfisher	X	X		
MEROPIDAE					
<i>Merops ornatus</i>	Rainbow Bee-eater		X		
MENURIDAE					
<i>Menura novaehollandiae</i>	Superb Lyrebird	X	X	X	
CLIMACTERIDAE					
<i>Cormobates leucophaeus</i>	White-throated Treecreeper	X	X	X	
<i>Climacteris erythroptera</i>	Red-browed Treecreeper		X		
<i>Climacteris picumnus</i>	Brown Treecreeper	X	X		
MALURIDAE					
<i>Malurus cyaneus</i>	Superb Fairy-wren	X	X		X
<i>Malurus lamberti</i>	Variegated Fairy-wren	X	X	X	
<i>Stipiturus malachurus</i>	Southern Emu-wren	X	X	X	
PARDALOTIDAE					
<i>Pardalotus punctatus</i>	Spotted Pardalote	X	X	X	
<i>Pardalotus striatus</i>	Striated Pardalote	X	X		
<i>Origma solitaria</i>	Rockwarbler			X	
<i>Sericornis citerogularis</i>	Yellow-throated Scrubwren	X	X		
<i>Sericornis frontalis</i>	White-browed Scrubwren	X	X	X	
<i>Sericornis magnirostris</i>	Large-billed Scrubwren	X	X		
<i>Hylacola pyrrhopygia</i>	Chestnut-rumped Heathwren	X	X		
<i>Chthonicola sagittata</i>	Speckled Warbler	X	X		
<i>Gerygone mouki</i>	Brown Gerygone	X	X		X
<i>Gerygone levigaster</i>	Mangrove Gerygone	X	X	X	
<i>Gerygone olivacea</i>	White-throated Gerygone	X	X	X	
<i>Acanthiza pusilla</i>	Brown Thornbill	X	X		
<i>Acanthiza reguloides</i>	Buff-rumped Thornbill	X	X	X	
<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill	X		X	

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FAMILY NAME <i>Scientific name</i>	Common Name	Method Recorded			
		B	ON	OF	S/N
<i>Acanthiza nana</i>	Yellow Thornbill	X	X		
<i>Acanthiza lineata</i>	Striated Thornbill	X	X		
MELIPHAGIDAE					
<i>Anthochaera carunculata</i>	Red Wattlebird	X	X		
<i>Anthochaera chrysoptera</i>	Little Wattlebird	X	X		
<i>Philemon corniculatus</i>	Noisy Friarbird	X	X		
<i>Philemon citreogularis</i>	Little Friarbird	X			
<i>Entomyzon cyanotis</i>	Blue-faced Honeyeater			X	
<i>Manorina melanocephala</i>	Noisy Miner	X	X		
<i>Manorina melanophrys</i>	Bell Miner	X	X	X	
<i>Meliphaga lewinii</i>	Lewin's Honeyeater	X	X	X	
<i>Lichenostomus chrysops</i>	Yellow-faced Honeyeater	X	X		
<i>Melithreptus brevirostris</i>	Brown-headed Honeyeater	X	X		
<i>Melithreptus lunatus</i>	White-naped Honeyeater	X	X		
<i>Lichenostomus leucotis</i>	White-eared Honeyeater	X	X		
<i>Lichenostomus melanops</i>	Yellow-tufted Honeyeater	X	X	X	
<i>Lichenostomus fuscus</i>	Fuscous Honeyeater	X	X		
<i>Lichmera indistincta</i>	Brown Honeyeater	X			
<i>Phylidonyris novaehollandiae</i>	New Holland Honeyeater	X	X	X	
<i>Phylidonyris nigra</i>	White-cheeked Honeyeater	X	X		
<i>Acanthorhynchus tenuirostris</i>	Eastern Spinebill	X	X		
<i>Myzomela sanguinolenta</i>	Scarlet Honeyeater		X		
PETROICIDAE					
<i>Microeca fascinans</i>	Jacky Winter			X	
<i>Petroica rosea</i>	Rose Robin	X	X	X	
<i>Eopsaltria australis</i>	Eastern Yellow Robin	X	X		
POMATOSTOMIDAE					
<i>Pomatostomus temporalis</i>	Grey-crowned Babbler		X	X	
PSOPHODIDAE					
<i>Psophodes olivaceus</i>	Eastern Whipbird	X	X	X	
<i>Cinclosoma punctatum</i>	Spotted Quail-thrush		X	X	
NEOSITTIDAE					
<i>Daphoenositta chrysoptera</i>	Varied Sittella	X	X		
PACHYCEPHALIDAE					
<i>Falcunculus frontatus</i>	Crested Shrike-tit	X	X		
<i>Pachycephala pectoralis</i>	Golden Whistler	X	X	X	
<i>Pachycephala rufiventris</i>	Rufous Whistler	X	X		
<i>Colluricincla harmonica</i>	Grey Shrike-thrush	X	X	X	
DICRURIDAE					
<i>Monarcha melanopsis</i>	Black-faced Monarch		X		
<i>Grallina cyanoleuca</i>	Magpie-lark	X	X		
<i>Rhipidura fuliginosa</i>	Grey Fantail	X	X	X	
<i>Rhipidura leucophrys</i>	Willie Wagtail				
<i>Rhipidura rufifrons</i>	Rufous Fantail	X	X		
<i>Dicrurus bracteatus</i>	Spangled Drongo		X		
CAMPEPHAGIDAE					
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike	X	X		
<i>Coracina papuensis</i>	White-bellied Cuckoo-shrike	X	X		
<i>Coracina tenuirostris</i>	Cicadabird	X			
ORIOLOIDAE					
<i>Oriolus sagittatus</i>	Olive-backed Oriole	X	X		
ARTAMIDAE					
<i>Artamus cyanopterus</i>	Dusky Woodswallow		X		
<i>Cracticus torquatus</i>	Grey Butcherbird	X	X	X	
<i>Cracticus nigrogularis</i>	Pied Butcherbird		X		
<i>Gymnorhina tibicen</i>	Australian Magpie	X	X		X

Appendix 2. Threatened Species Recorded during the Survey

Common name	Scientific name	Number of individuals / records	Strata type
Southern Myotis	<i>Myotis macropus</i>	1 3 2	CMR M R
Little Bent-wing Bat	<i>Miniopterus australis</i>	7 1 10 15 3 2 3 2	CMR CSP CSPW DR HVF M R SW
Common Bent-wing Bat	<i>Miniopterus schreibersii</i>	3 5 4 3 1 2 1 1	CMG CMR CSPW DR HVF R SF SW
Large Pied Bat	<i>Chalinolobus dwyeri</i>	1 1	CMR CSPW
East Coast Freetail Bat	<i>Mormopterus norfolkensis</i>	1	SW
Greater Broad-nosed Bat	<i>Scoteanax rueppellii</i>	1	CSP
Greater Long-eared Bat	<i>Nyctophilus timoriensis</i>	1	DR
Grey-headed Flying Fox	<i>Pteropus poliocephalus</i>	4	CSPW
Koala	<i>Phascolarctos cinereus</i>	2+ 1 Scats	R SF SW
Brush-tailed Phascogale	<i>Phascogale tapoatafa</i>	1 3	DR HVF
Squirrel Glider	<i>Petaurus norfolcensis</i>	3 10 5 4 1	CSP CSPW DR HVF ?
Tiger Quoll	<i>Dasyurus maculatus</i>	1	CSP

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Appendix 2 - *continued*

Common name	Scientific name	Number of individuals / records	Strata type
Yellow-bellied Glider	<i>Petaurus australis</i>	2	CMG
		17	CMR
		3	DG
		2	DR
		5	HVF
		1	SF
		1	?
Glossy Black-cockatoo	<i>Calyptorhynchus lathami</i>	1+	CSPW
		2+	DR
		4	R
		2	?
Masked Owl	<i>Tyto novaehollandiae</i>	1	CMG
		1	CMR
		4	CSPW
		1	DRH
		2	HVF
		3	M
		1	?
Powerful Owl	<i>Ninox strenua</i>	3	CMR
		1	CSP
		2	CSPW
		3	DR
		6	HVF
		4	M
		1	SF
Sooty Owl	<i>Tyto tenebricosa</i>	1	CMG
		8	CMR
		2	DG
		1	DR
		1	DRH
		2	M
		1	R
Wallum Froglet	<i>Crinia tinnula</i>	16+	CSP
		1	DR
		1	SF
		30+	SW
		10+	?

Appendix 3. Green and Golden Bell Frog Survey

Appendix 4. Plates of Threatened Species Targeted by this Study**Plate 8. Squirrel Glider (*Petaurus norfolcensis*)****Plate 9. Tiger Quoll (*Dasyurus maculatus*)****Plate 10. Yellow-bellied Glider (*Petaurus australis*)****Plate 11. Brush-tailed Phascogale (*Phascogale tapoatafa*)****Plate 12. Koala (*Phascolarctos cinereus*)**

Plate 13. Greater Broad-nosed Bat (*Scoteanax rueppellii*)

Plate 14. East Coast Freetail -bat (*Mormopterus norfolkensis*)

Plate 15. Large Bent-wing Bat (*Miniopterus schreibersii*)

Plate 16. Greater Long-eared Bat (*Nyctophilus timoriensis*)

Plate 17. Large-eared Pied Bat (*Chalinolobus dwyeri*)

Plate 18. Southern Myotis (*Myotis macropus*)

Plate 19. Little Bent-wing Bat (*Miniopterus australis*)

Plate 20. Glossy Black-Cockatoo (*Calyptorhynchus lathami*)

Plate 21. Masked Owl (*Tyto novaehollandiae*)

Plate 22. Powerful Owl (*Ninox strenua*)

Plate 23. Green and Golden Bell Frog (*Litoria aurea*)