PROPOSED BADGINGARRA WIND FARM
FLORA AND FAUNA ASSESSMENT

WorleyParsons Services Pty Ltd

BRETT LANE & ASSOCIATES PTY LTD
Ecological Research & Management
P O Box 592
North Carlton, Vic. 3054
Ph. (03) 9387 5008
Fax. (03) 9387 6115

February 2008

Report No. 7044 (1.9)

CONTENTS

1. EXECUTIVE SUMMARY 1
2. INTRODUCTION 3
3. SITE DESCRIPTION 5
4. VEGETATION ASSESSMENT 6
4.1. Existing information 6
4.2. Field methodology 6
4.2.1. Limitations 8
4.3. Flora and native vegetation of the site 8
4.3.1. Flora 8
4.3.2. Vegetation types 8
4.3.3. Vegetation quality 10
4.3.4. Declared rare and priority flora 13
5. FAUNA ASSESSMENT 16
5.1. Existing information 16
5.1.1. Fauna 16
5.1.2. Threatened species 16
5.2. Field methodology 16
5.2.1. Limitations 17
5.3. Fauna 18
5.3.1. Fauna habitat 18
5.3.2. Fauna species 20
6. BIRD UTILISATION SURVEY 24
6.1. Methods 24
6.1.1. Fixed-point bird count method 24
6.1.2. Location of survey points 25
6.1.3. Incidental observations 25
6.2. Limitations 25
6.3. Results of the bird utilisation survey 27
6.3.1. Representativeness of the survey 27

6.3.2. Bird observations 28
6.3.3. Species 35
7. CARNABY'S BLACK-COCKATOO 36
7.1. Existing information 36
7.2. Background information 36
7.2.1. Species description and status 36
7.2.2. Distribution 37
7.2.3. Habitat 38
7.2.4. Breeding 38
7.2.5. Movements 38
7.2.6. Feeding and foraging 39
7.3. Field methodology 40
7.3.1. Limitations 40
7.4. Results 41
7.4.1. Carnaby's Black-Cockatoo at the proposed Badgingarra wind farm site 41
7.4.2. Behavior and movements of the Carnaby's Black-Cockatoo in relation to the existing wind farm 43
8. CONSERVATION SIGNIFICANCE OF SPECIES OBSERVED 46
8.1. Criteria for conservation significance 46
8.1.1. Botanical conservation significance criteria 46
8.1.2. Fauna conservation significance criteria 46
8.2. Botanical conservation significance of the site 47
8.3. Fauna conservation significance of the site 47
9. IMPLICATIONS OF THE SURVEY FINDINGS 48
9.1. Potential impacts on native flora and vegetation 48
9.2. Potential impacts of wind farms on birds 49
9.2.1. Mortality caused by wind turbines 49
9.2.2. Australian studies 51
9.2.3. Indirect habitat disturbance 51
9.2.4. Direct habitat disturbance 52
9.3. Impacts of the proposed Badgingarra Wind Farm on fauna 53

9.3.1. Impacts on Birds 53
9.3.2. Impacts on the Carnaby's Black-Cockatoo 54
9.3.3. Impacts on Other Vertebrate Fauna 67
9.4. Legislative implications 68
9.5. Conclusions 68
10. REFERENCES 70

LIST OF TABLES

Table 1: Vegetation Quality and likelihood of occurrence of threatened species..... 12
Table 2: Definitions of declared rare and priority flora 13
Table 3: Threatened EPBC Act-listed flora species that could potentially occur at the proposed Badgingarra Wind Farm 14
Table 4: Threatened vertebrate fauna species predicted to occur at the proposed Badgingarra Wind Farm site (excludes fish). 20
Table 5: Times of day when bird utilization survey points* were counted during each survey day (T1 to T18 refers to count period) 24
Table 6: Summary of numbers of individual birds and their height distribution seen on impact points at the proposed Badgingarra Wind Farm site. 31
Table 7: Summary of numbers of individual birds and their height distribution seen on the reference survey points at the proposed Badgingarra Wind Farm site. A, B, and C as in Table 8. 33
Table 8: The number of birds counted at each of the survey points at Badgingarra Wind Farm 34
Table 9: Species flying at rotor swept area height (RSA height) during bird utilisation surveys at the Badgingarra Wind Farm site 35
Table 10: The number and species of raptors counted at the survey points at Badgingarra Wind Farm. 35
Table 11: Carnaby's Black-Cockatoo sightings at the proposed Badgingarra Wind Farm 41
Table 12: The rate of Carnaby's Cockatoos seen / hr / 1000 ha of habitat. 44
Table 13: Summary of bird mortality estimates for wind farms in Europe and North America (Sources: Erickson *et al* 2001; Percival 2003; NWCC 2004). 50
Table 14: Studies of the possible effects that wind farms impose on birds (after Percival 2003). 52

Table 15: Area and percentage of habitat on the site affected by 65 x 2 MW turbines in the north and north east of the site.....57

Table 16: Area and percentage of habitat on the site affected by 43 x 2 MW turbines in the north and north east of the site.....57

Table 17: Area and percentage of habitat on the site affected by 65 x 2 MW turbines in the north and south of the site.....58

Table 18: Area and percentage of habitat on the site affected by 41 x 3 MW turbines in the north and south of the site.....58

Table 19: Area of regional habitat subject to disturbance effect (65 x 2 MW turbines in north and north-east of site.....60

Table 20: Area of regional habitat subject to disturbance effect (43 x 3 MW turbines in north and north-east of site.....60

Table 21: Area of regional habitat subject to disturbance effect (65 x 2 MW turbines in north and south of site.....60

Table 22: Area of regional habitat subject to disturbance effect (43 x 3 MW turbines in north and south of site.....61

Table 23: Areas of Carnaby's Black-Cockatoo habitat on the proposed Badgingarra Wind Farm site exposed to estimated deterrence effect from turbines (three cases, 65 turbine 'worst case' option).....67

LIST OF FIGURES

Figure 1: Native Vegetation at the proposed Badgingarra Wind Farm site.....11

Figure 2: Map of the proposed Badgingarra Wind Farm site showing the location of the bird utilisation survey points.....26

Figure 3: The cumulative number of species of birds recorded during consecutive counts at the observation points on the proposed Badgingarra Wind Farm site.....27

Figure 4: Carnaby's Black Cockatoo in the southern part of the proposed Badgingarra Wind Farm site, near the existing Emu Downs Wind Farm.....37

Figure 5: Potential habitat for the Carnaby's Black-Cockatoo at the proposed Badgingarra Wind Farm site.....42

Figure 6: The number of Carnaby's Black-Cockatoos recorded in each habitat type at the proposed Badgingarra Wind Farm site.....43

Figure 7: Records of Carnaby's Cockatoo during the current investigation at the existing Emu Downs Wind Farm and surrounding areas.....45

Figure 8: Map showing the areas of Carnaby's Black-Cockatoo habitat exposed to the disturbance effect of turbines (65 2 MW turbines in north and north east of site). 63

Figure 9: Map showing the areas of Carnaby's Black-Cockatoo habitat exposed to the disturbance effect of turbines (43 3 MW turbines in north and north east of site). 64

Figure 10: Map showing the areas of Carnaby's Black-Cockatoo habitat exposed to the disturbance effect of turbines (65 2 MW turbines in north and south of site). 65

Figure 11: Map showing the areas of Carnaby's Black-Cockatoo habitat exposed to the disturbance effect of turbines (41 3 MW turbines in north and south of site). 66

LIST OF APPENDICES

Appendix 1: Incidental list of flora species recorded at the proposed Badgingarra Wind Farm site.

Appendix 2: List of fauna that could potentially occur at the proposed Badgingarra Wind Farm site.

Appendix 3: Results of Anabat® surveys

Appendix 4: Report of Johnstone and Johnstone on status and movements in the Badgingarra region of the Carnaby's Black-Cockatoo.

Appendix 5: GIS Analysis of regional vegetation by the Western Australian Department of Agriculture.

1. EXECUTIVE SUMMARY

A flora and fauna assessment, bird utilisation survey and a targeted Carnaby's Black-Cockatoo investigation have been undertaken at the proposed Badgingarra Wind Farm site to enable a level one and two bird risk assessment of the project, and an assessment of potential flora and fauna impacts. This approach is consistent with the interim risk assessment standards for birds and wind farms issued by the Australian Wind Energy Association (AusWEA 2005).

The conclusions from this investigation are summarised below.

- The proposed wind farm site supports predominantly exotic pasture grasses. Some sections of the site support Kwongan heathland and grassy woodland communities, particularly along some of the ridges and steep slopes. The proposed turbine locations mostly avoid these areas. Given the predominance of cleared country, it is considered feasible to locate access tracks underground power cables and the sub station in a way that avoids any requirement to remove native vegetation. The possible exception is if turbines are located on a vegetated ridge in the southern part of the site, south of the Badgingarra National Park. Here, several specimens of Lesuer's Hakea (an EPBC Act listed threatened species) were found. The area occupied by this species is small and avoiding impacts on them is considered feasible through careful micro-siting of turbines, tracks and underground power cables.
- The site is a largely altered agricultural landscape supporting a low diversity of predominantly opportunistic and adaptable native bird species and potentially one introduced bird species. The site supports species and relative abundances of birds comparable with similar farmland settings elsewhere in Western Australia. The site supports few birds of prey and waterbirds; groups considered vulnerable to collision with operating wind turbines. Studies of wind farms in many parts of the world indicate that the rate of bird collision is between 0.04 and 4 birds per turbine per year. Rates of between 1 and 4 birds per turbine per year have been observed at Australian wind farms. The proposed Badgingarra Wind Farm had fewer birds flying at rotor swept area height than comparable wind farms in South Australia and Victoria. Therefore, collision rates would be expected to be at the lower end of the range of collision rates observed in Australia (i.e. closer to one than four birds per turbine per year).
- The collision risk to other birds from the proposed Badgingarra Wind Farm is considered to be low due to the low utilisation rates of birds compared with elsewhere. At wind farm sites elsewhere in southern Australia where surveys have recorded higher bird utilisation rates before commissioning, collision rates have generally been less than two birds per turbine per year. This is at the lower end of results for wind farms overseas (see Section 9.2). At the proposed Badgingarra Wind Farm, the rate of bird collision is likely to be less than this and involve common farmland species of negligible conservation significance.

- The site lies within the territory of one or two pair of Wedge-tailed Eagles. Significant impacts on this species are not anticipated from the wind farm due to the low level of eagle usage.
- The Carnaby's Black-Cockatoo, a nationally endangered species, was the only threatened bird species observed on or near the wind farm site and it is expected to occur regularly in the area. Further investigations were undertaken and it was concluded that the cockatoo avoids turbines and that the probability of regular collision with wind turbines is very low. A disturbance effect was observed associated with the existing Emu Downs Wind Farm. The distance over which this effect was observed was up to 500 meters. Within the proposed Badgingarra Wind Farm site and within 500m from the outer turbines, between 400 and 1,400 hectares of potential roosting and foraging habitat may be excluded from use by the cockatoo. If turbines are located in the southern part of the site, movements between the Badgingarra National Park and roosting sites within the wind farm site to the east may be disrupted and birds foraging in the national park may need to find alternative roosts to the west (where suitable roosting habitat is available). The areas of habitat potentially affected by the project represent a very small proportion of the hundreds of thousands of hectares of potential habitat available in the region through which the species moves in the non-breeding season to the northern Swan Coastal Plain. Therefore, the risk from the project to the population is considered to be low. A referral under the EPBC Act is being submitted to the Commonwealth.
- A preliminary investigation of bats indicated that no threatened species occur in the region. The results of an exploratory Anabat® ultrasonic bat detection survey at two positions on the wind farm site are presented in Appendix 3.
- No threatened mammals, reptiles or frogs were recorded on the site and those present were common species and none are expected to regularly occur at the study site.

In conclusion, the effects on flora and fauna of the proposed wind farm are not expected to be of significant conservation concern. Applicable legislation and policies related to biodiversity conservation can be met, subject to careful consideration to positions of turbines and access tracks to avoid the removal of native vegetation and fauna habitat.

2. INTRODUCTION

Brett Lane and Associates Pty Ltd was initially engaged by Enthalpy Pty Ltd to undertake a flora and fauna assessment and bird utilisation survey (level one risk assessment) at its proposed Badgingarra Wind Farm site located about 30 km north - east of Cervantes, to the north of the existing Emu Downs Wind Farm site, in Western Australia. The proposed wind farm site is a combination of seven rural holdings used mainly for cattle and sheep grazing, with limited areas of remnant indigenous vegetation. Up to 65 wind turbines are proposed to be constructed, together with associated access tracks, underground power cabling, a small transmission connection and a substation.

The wind farm will comprise either 65 2 MW (REPower MM82 or similar) wind turbines (hub height 80m, blade length 41m), or 43 3MW (Vestas V90 or similar) wind turbines (hub height 80m, blade length 45m) They are proposed to be located to the north of the Badgingarra – Cervantes Road, on ridges and knolls with an elevation of greater than 200m. Four turbines in the western part of the site lie on knolls with elevations between 170 and 200m. Turbine spacing within groups ranges between 500m and 1000m.

In this assessment, particular attention was paid to the areas where turbines are proposed to be located. The vegetation and habitat characteristics of these areas were assessed. In addition, areas of remnant vegetation and habitat were mapped and characterised as an aid to site layout planning, with a view to ensuring any area supporting remnant vegetation or habitat is avoided.

This report assesses the impacts that the wind farm may have on species and communities listed under applicable legislation and policies, including:

- the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- the state *Conservation and Land Management Act 1984* (CLM Act);
- the state *Conservation and Land Management Regulation 2002;*
- the state *Wildlife Conservation Act 1950* (WC Act)*;* and
- the state *Wildlife Conservation Regulations 1979.*

The likelihood and presence of any indigenous flora and fauna on the site was ascertained on the basis of a review of existing information. In addition, a site inspection was undertaken to ground truth existing information and to ascertain the suitability of any habitats on the site for rare or threatened flora and fauna species. This enabled the likelihood of occurrence of matters listed under state and Commonwealth legislation and regulations to be determined.

Consistent with the Level One bird risk assessment standards of the Australian Wind Energy Association (AusWEA 2005, 2006), a seven-day detailed bird utilisation survey was undertaken, focussing on the wind turbine layout on the hilltops and elevated areas across the properties, and on a number of reference points in similar landscape settings nearby.

Finally, due to the presence of the nationally endangered Carnaby's Cockatoo at the proposed wind farm site, further investigations were implemented to satisfy the requirements of an AusWEA level two bird risk assessment. This study aimed to determine the risk, if any, the wind farm may pose to this species.

Although initially engaged by Enthalpy Pty Ltd (Study Manager for the Pre-feasibility Study of the Badgingarra Wind Farm), Brett Lane & Associates Pty Ltd were directly engaged by Worley Parsons Services Pty Ltd (the Environmental Manager for the Pre-feasibility Study of the Badgingarra Wind Farm) during the later stages of this work.

This report summarises the results of the investigations and it is divided into the sections described below.

Section 3 briefly describes the proposed wind farm site;

Section 4 presents the methodology and results of the flora assessment;

Section 5 presents the methodology and results of the fauna assessment;

Section 6 presents the results of the bird utilisation survey;

Section 7 discusses the Carnaby's Cockatoo in more detail;

Section 8 discusses the significance of the proposed wind farm site for flora and fauna; and

Section 9 considers the implications of the survey findings.

This investigation was undertaken by a team comprising:

- Don Williams, Botanist;
- Khalid Al-Dabbagh, Ornithologist;
- Curtis Doughty, Ecologist;
- Brett Lane, Principal Consultant;
- Mr Ron Johnstone, Western Australia Museum; and
- Mr Phil Goulding, Western Australia Department of Agriculture.

3. SITE DESCRIPTION

The proposed Badgingarra Wind Farm site is located between Perth and Geraldton in Western Australia, approximately 30 km north - east of Cervantes. The proposed wind farm site is approximately 22,720 hectares in extent and includes up to seven farming properties, which are primarily used for grazing purposes. Up to 65 wind turbines are proposed to be constructed at the site, depending on the type and size of the turbines that are selected by the proponents.

The proposed wind farm site is situated in an area of low hills with a number of ridges and valleys. The ridges are between 190 m and 315 m in elevation. On some of the slopes and high ridges, there are areas of exposed laterite.

Kwongan Heathland was once the dominant vegetation type across the site but since European settlement, much of this has been cleared and converted to sown pasture for sheep and cattle grazing. Along some of the ridges, areas of native vegetation remain, particularly where exposed laterite has prevented cultivation. Remnant Kwongan heathland is also present along most of the roadsides throughout the site.

The proposed wind farm site today consists of cleared land, dominated by introduced pasture and weed species with scattered remnant trees, moderate-sized patches (up to 10+ ha) of remnant Kwongan heathland, and a small number of remnant native woodland areas. Remnant heathlands make up the majority of native vegetation across the site and usually occur along ridges, or on steep slopes and roadsides. Remnant native trees are scattered across the site. There are areas of planted vegetation along fence lines, roads and farm tracks, as well as planted forage crops, predominantly Tree Lucern.

The study area has some wetland areas that consist of drainage lines, farm dams and soaks, and swampy areas. Drainage lines lead into farm dams used for watering stock. These dams are highly disturbed, their edges having been trampled by stock and they lack fringing vegetation. In times of high rainfall the study area has areas of boggy swamps, which are vegetated with heathland species characteristic of wetter settings. Waterbirds may use these areas when they hold water.

The site lies in the Geraldton Sandplains Bioregion. The area is under the jurisdiction of the Cervantes office of the WA Department of Environment and Conservation. The local planning authority is the Shire of Dandaragan.

4. VEGETATION ASSESSMENT

4.1. Existing information

Existing information on flora and vegetation used in this investigation is described below.

The likelihood of suitable habitat on the site for nationally threatened flora species was obtained through the EPBC Act – Protected Matters Search Tool (DEWR 2007). The search area was generated using a 20 km buffer from the centre point of coordinates: latitude 33°29'00" longitude 115°18'20". In addition to this, the likelihood of occurrence of any species listed as threatened under state legislation was also assessed.

4.2. Field methodology

The vegetation assessment was conducted from 16th to 26th March 2007. During this assessment, the site was inspected in detail on foot. Incidental records of flora species were made based on random intuitive sampling methods. Plant species surveys concentrated on the turbine sites, while all remnant vegetation on the site was subject to an overview assessment aimed at determining vegetation quality and the likelihood of occurrence of threatened species (see below).

All areas of remnant native vegetation on the site were visited and assessed for their type, quality and likelihood of supporting threatened plant species and communities.

Vegetation types are described in Section 4.3.2. The quality of vegetation was assessed based on the criteria detailed below.

The following Vegetation Quality Assessment criteria are generally applicable to treed vegetation communities but key quality indicators can also be applied to shrub or treeless communities. The degree of structural intactness, diversity and the extent of weed invasion are the three most important vegetation quality indicators.

High quality – the vegetation is representative of pre-European condition having either escaped disturbance or largely recovered from historical disturbance events. Depending on vegetation type, but as a general guide, the following attributes are typical:

- Overstorey / grass tussock layer intact - senescent, mature, juvenile and regenerating canopy species present;
- Middle and understorey layers (in treed communities) intact and species present are indicative of community description;
- Ground flora / herb layers intact and indicative of community description;
- Presence of introduced species is minimal or negligible; and
- Fallen wood and other habitat components present.

Moderate quality – the vegetation exhibits signs of disturbance or decline associated with past or current land use or the use of surrounding land. Depending on vegetation type but as a general guide the following attributes are typical:

- Canopy / grass tussocks largely intact with some signs of decline - senescent and mature trees present with some juvenile and regenerating canopy species;
- Middle and understorey layers (in treed communities) largely intact however some decline in structural diversity and distribution present, most species indicative of community description are present;
- Ground flora / herb layers reduced in extent and diversity with only some species indicative of community description remaining. Decline resultant of a combination of physical, mechanical or competitive removal associated with grazing, development or weed invasion;
- Presence of introduced species is obvious and potential for further invasion is moderate to high; and
- Fallen wood and other habitat components present but in decline.

Poor quality – the vegetation is in a state of decline with a disruption of basic ecological processes obvious and the potential for recovery low. Depending on vegetation type but as a general guide the following attributes are typical:

- Canopy / tussock layer highly fragmented or in serious decline - senescent and mature trees present with few or no regenerating canopy species;
- Middle and understorey layers (in treed communities) absent or surviving in isolated patches, most species indicative of community description are absent;
- Ground flora/herb layers absent or replaced with introduced species, some isolated patches present. Few species indicative of community description remaining. Decline resultant from total physical, mechanical or competitive removal or alteration associated with grazing, development or weed invasion;
- Presence of introduced species is extensive and potential for further invasion is very high; and
- Fallen wood and other habitat components largely absent or unlikely to be of value given decline in other ecological attributes.

The likelihood of occurrence of threatened plant species was judged based on a combination of vegetation type (using information on preferred habitats of potential threatened species in the area), and the quality and degree of degradation of patches of native vegetation.

4.2.1. Limitations

Flora surveys usually fail to record all species present for various reasons, including the seasonal absence of some species and short survey duration. Rare or cryptic species are often missed in short surveys.

The flora assessment conducted during March 2007 comprised an inspection of all parts of the site to ascertain where remnant native vegetation and trees occurred on the proposed wind farm site. Surveying was carried out at the beginning of autumn, when most summer flowering grasses (indigenous and exotic species) contained sufficient flowering and/or fruiting material for positive identification to species level. Spring flowering specimens that no longer held fruiting material required for identification may not have been detected or identified to species level. The proponents propose to avoid the removal of most native vegetation on the site, so this limitation can easily be overcome through pre-construction surveys of the two areas where vegetation may be affected to inform micro-siting to avoid significant flora species populations.

Domestic stock grazing on the site has removed much of the plant material required for species identification and may have resulted in some species not being detected. In addition, the late stage of the growing season and the effects of a significant drought meant that deciduous species such as orchids could not be detected during this assessment.

The effects of the drought may have further reduced plant growth and reproduction, thereby further limiting the detection of some species. Overall, the timing of the botanical survey was considered sufficient to detect native vegetation communities present or likely to be present within the study area, gauge their quality and their suitability for threatened plant species known from the wider region.

4.3. Flora and native vegetation of the site

This section describes the plant species and vegetation of the proposed wind farm site. Vegetation quality is also considered, along with the likelihood of occurrence of threatened plant species.

4.3.1. Flora

A list of flora recorded at the proposed wind farm site is provided in Appendix 1. A total of 57 species were recorded during the flora survey conducted in March 2007, including 52 (91%) indigenous and six (9%) exotic species.

4.3.2. Vegetation types

Remnant native vegetation on the site comprised two types: Kwongan heathland and grassy woodland. Scattered eucalypts occurred in some low lying areas but no trees were found along the ridges.

Kwongan Heathland

Native vegetation on some of the ridges included intact Kwongan Heathland or a degraded, grazed version of it. Most ridges however lacked remnant indigenous vegetation.

Prior to agricultural development, the majority of the site would have supported Kwongan Heathland. Kwongan Heathland is a high diversity vegetation type that thrives in low fertility sandy soils on dunes in the Geraldton Sandplains Bioregion.

Kwongan heathland was the most extensive indigenous vegetation type across the site. This heathland had a high diversity of species, including *Banksia sphaerocarpa, Dryandra stenoprion, Grevillia amplexicaulis, Hakea trifurcate* and *Xanthorrhoea preisii.*

There were linear strips of Kwongan Heathland along the roadsides throughout the site that had a very high flora diversity. Nearby principal roads in the region are listed as 'flora roads' in local maps, indicating a high value as wildflower viewing areas. Roadsides within the site were of equivalent value.

Grassy Woodland

Areas of grassy eucalypt woodland occurred across the site that were typically dominated by Marri (*Eucalyptus calophylla*) and had an exotic grass understorey (see Figure 1).

Areas of grassy woodland were dominated either by eucalypt or banksia. The dominant overstorey species in these woodlands were: River Red Gum (*Eucalyptus camaldulensis*), Marri (*Eucalyptus calophylla*) or Blackbutt (*Eucalyptus patens*). The eucalypt woodlands had a grassy understorey dominated by exotic species. The banksia woodland areas were not as accessible to domestic stock and some shrubs persisted in these areas.

Most of the remnant treed patches occurred in lower parts of the site. Many of these areas were not fenced and a prolonged history of grazing by stock, together with fertiliser application and leaching on surrounding slopes, has eliminated much of the original understorey and ground cover.

Exotic (Introduced) Vegetation

The majority of the site had been cleared and sown to pasture, resulting in infestations of exotic, weed species. This vegetation included exotic grasslands, hedges planted for stock forage, and landscape and windbreak plantings. Exotic species observed included Cape Weed (*Arctotheca calendula*), Stinkwort (*Dittrichia graveolens*), Patterson's Curse (*Echium plantagineum*), Barley Grass (*Hordeum geniculatum*), Lupin (*Lupinus cosentinii*) and Subterranean Clover (*Trifolium subterraneum*). Planted tree species were used across the site for wind breaks, stock shelter and around farm houses. No-indigenous eucalypts and exotic pine species were the most common trees planted at the site.

4.3.3. Vegetation quality

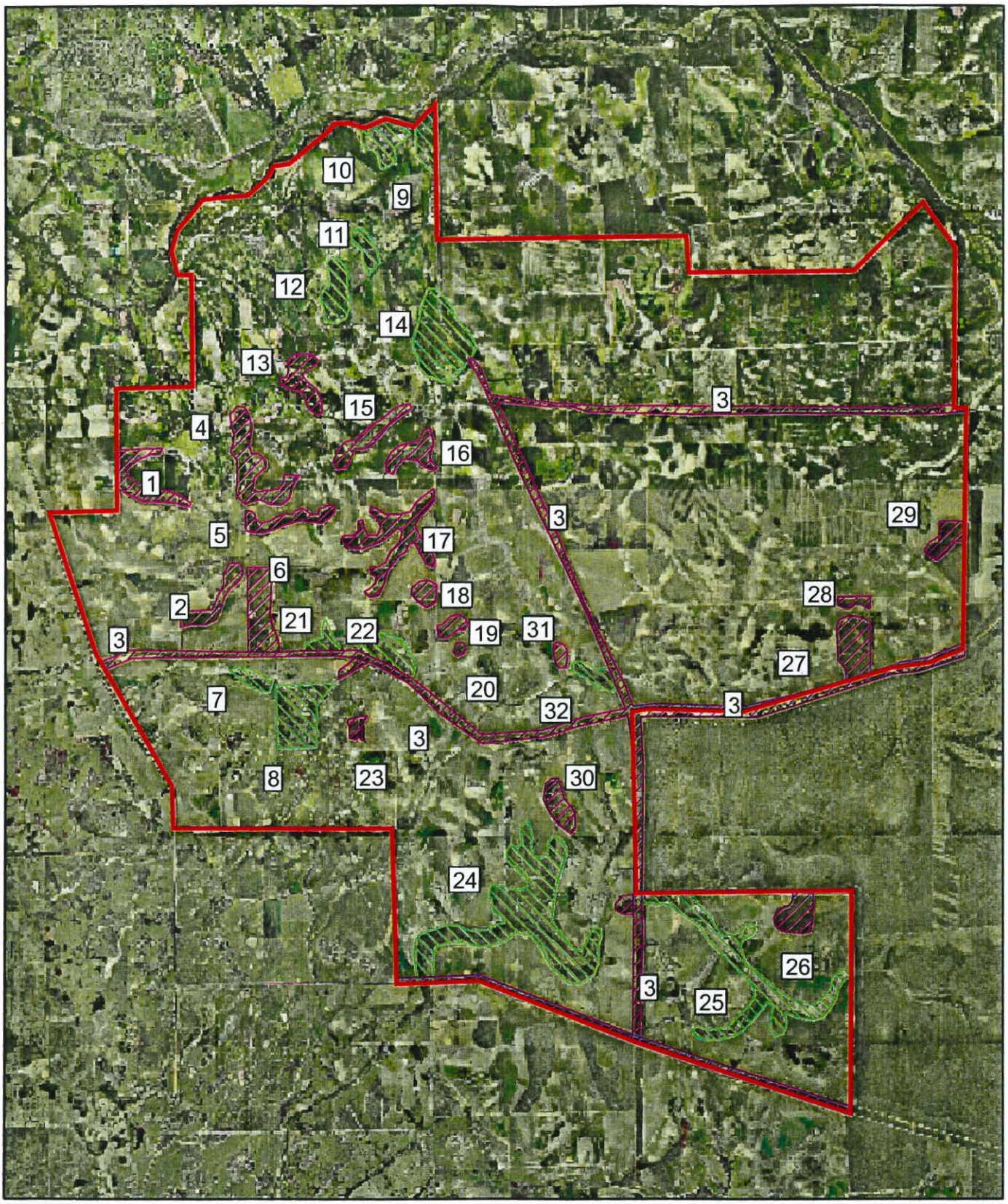
Table 1 shows the quality of each remnant of native vegetation recorded on the site. It should be read in conjunction with Figure 1, in which each vegetation remnant has a designated number. The table also provides an indication of the likelihood of threatened plant species occurring in each vegetation remnant.

Most areas of remnant indigenous vegetation on the site were of poor quality and had a low likelihood of supporting threatened plant species. Some remnants were of moderate or high quality (see Table 1) and these are discussed below.

Vegetation remnants 4 and 5 are moderate quality Kwongan heathland, with a moderate likelihood of supporting threatened plant species. Vegetation remnants 8 and 24 are moderate quality grassy woodland, with a low likelihood of supporting threatened plant species, due to past grazing.

The roadside reserves throughout the study site have a high diversity of flora, are free from grazing pressures and therefore have a high likelihood of supporting threatened flora species. The roadside reserves are referred to as remnant three in Figure 1 and Table 1. Some areas of degradation occur along the road reserves as a consequence of earth moving and vegetation clearing activities but overall these linear remnants are considered to be of high quality.

Native Vegetation



Legend

- Woodland
- Kwongan Heathland
- Study Area

0 1,000 2,000 4,000 6,000 8,000 Metres

Badgingarra Wind Farm		
Figure 1: Native Vegetation		
Client: Enthalpy Pty Ltd		
Project No.: 7044	Date: 13/06/2007	Created by: I. Mau / C. Doughty

BL&A Brett Lane & Associates Pty. Ltd. Ecological Research & Management

Experience Knowledge Solutions

505 Nicholson Street PO Box 592, Carlton North VIC 3054 Australia

ph (03) 9387 5008 | fax (03) 9387 6115

blane@ecologicalresearch.com.au

www.ecologicalresearch.com.au

Table 1: Vegetation Quality and likelihood of occurrence of threatened species.

Vegetation Number	Vegetation Type	Vegetation Quality	Likelihood of occurrence of threatened species
1	Kwongan	Poor	Low
2	Kwongan	Moderate	Low
3	Kwongan	High	High
4	Kwongan	Moderate	Moderate
5	Kwongan	Moderate	Moderate
6	Kwongan	High	High
7	Woodland	Poor	Low
8	Woodland	Moderate	Low
9	Woodland	Poor	Low
10	Woodland	Poor	Low
11	Woodland	Poor	Low
12	Woodland	Poor	Low
13	Kwongan	Poor	Low
14	Woodland	Poor	Low
15	Kwongan	Poor	Low
16	Kwongan	Poor	Low
17	Kwongan	Poor	Low
18	Kwongan	Poor	Low
19	Kwongan	Poor	Low
20	Kwongan	Poor	Low
21	Woodland	Poor	Low
22	Woodland	Poor	Low
23	Kwongan	Poor	Low
24	Woodland	Moderate	Low
25	Woodland	Poor	Low
26	Kwongan	High	High
27	Kwongan	Poor	Low
28	Kwongan	Poor	Low
29	Kwongan	High	High
30	Kwongan	Poor	Low
31	Kwongan	Poor	Low
32	Woodland	Poor	Low

High quality Kwongan heathland occurred in remnants 6 and 26. Remnant 6 (see Figure 1) had a high diversity of flora species, was comparatively extensive and was continuous with a vegetated roadside reserve.

4.3.4. *Declared rare and priority flora*

Declared Rare and Priority Flora (DRPF) are plant taxa that are rare, threatened or have reduced populations. Definitions of DRPF are shown in Table 2. Recorded DRPF are discussed below.

Table 2: Definitions of declared rare and priority flora

Category	Definition
Declared Rare	Taxa which have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction, or otherwise in need of special protection
Priority 1	Taxa which are known from one or a few (generally <5) populations which are under threat
Priority 2	Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat
Priority 3	Taxa which are known from several populations, and the taxa are not believed to be under immediate threat
Priority 4	Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors

Source: Atkins (2006).

Two DRPF were recorded at the study site; Meisn (*Davesia epiphyllum*), a priority 3 species, and *Loxocarya gigas*, a priority 2 species. Meisn was recorded frequently throughout the Kwongan Heathland vegetation type at the study site and along road reserves. *Loxocarya gigas* was found in its thousands at remnant number 26 (Figure 1) on the study site.

One species Lesueur Hakea (*Hakea megalosperma*), listed as vulnerable under the EPBC Act, was recorded on the site at vegetation site number 26 (see Figure 1). Several plants were confirmed to occur at this site. This is the southern limit of their range.

Table 3 below lists the plant species listed in the EPBC Act Protected Matters Search Tool from the search region as either occurring or for which habitat may occur. Their likelihood of occurrence at the study site is also given, based on habitat suitability. Lesueur Hakea is the only EPBC Act listed threatened species confirmed to occur at the site.

Table 3: Threatened EPBC Act-listed flora species that could potentially occur at the proposed Badgingarra Wind Farm.

Scientific Name	Common Name	Status	Habitat Preference	Likelihood of occurrence
Andersonia gracilis	Slender Andersonia	Endangered	Sand	Low
Anigozanthos viridis subsp. *Terraspectans*	Dwarf Green Kangaroo Paw	Vulnerable	Sand	Low at study site, moderate on roadside reserves
Dryandra serratuloides subsp. *Perissa*	Northern Serrate Dryandra	Vulnerable	Low dense heath and also in low open woodland	Low, too far west
Dryandra serratuloides subsp. *Serratuloides*	Southern Serrate Dryandra	Vulnerable	Low dense heath and also in low open woodland	Low, too far west
Eucalyptus absita	Badgingarra Box	Endangered	White lateritic sand	Low
Eucalyptus balanites	Cadda Road Mallee, Cadda Mallee	Endangered	Sandy heathland, only occurs in Badgingarra National Park	Low
Eucalyptus johnsoniana	Johnson's Mallee	Vulnerable	Duplex sand	Low
Eucalyptus lateritica	Laterite Mallee	Vulnerable	White or grey sand with gravel. Lateritic breakaways & mesas	Low, too far south
Eucalyptus leprophloia	Scaly Butt Mallee, Scaly-butt Mallee	Endangered	Black sand	Low, too far south
Eucalyptus pruiniramis	Midlands Gum, Jingymia Gum	Endangered	Skeletal soils over sandstone or laterite. Rocky hillslopes	Low, too far west
Eucalyptus suberea	Cork Mallee, Mount Lesueur Mallee	Vulnerable	Grey sand. Near or on lateritic breakaways	None
Grevillea curviloba subsp. *Incurva*	Narrow curved-leaf Grevillea	Endangered	Sand, sandy loam	Low

Scientific Name	Common Name	Status	Habitat Preference	Likelihood of occurrence
Grevillea humifusa	Spreading Grevillea	Endangered	Gravelly loam over laterite	Low
Hakea megalosperma	Lesueur Hakea	Vulnerable	Low heath in grey sand and lateritic gravel or laterite boulders on hilltops and ridges	High
Macarthuria keigheryi	Keighery's Macarthuria	Endangered	White or grey sand	Low
Paracaleana dixonii Hopper & A.P.Brown ms.		Endangered	Sand	Low at study site, moderate on road reserves
Patersonia spirafolia	Spiral-leaved Patersonia	Endangered	Sand, gravel	Low at study site, moderate on road reserves
Ptychosema pusillum	Dwarf Pea	Vulnerable	Sandy rises	Low at study site, moderate on road reserves
Spirogardnera rubescens	Spiral Bush	Endangered	Clay gravel – Wondoo	Low
Thelymitra stellata	Star Sun-orchid	Endangered	Low heath and scrub in Jarrah and Wandoo woodland, and in low heath on lateritic hill tops	Low at study site, moderate on road reserves or in ungrazed areas

5. FAUNA ASSESSMENT

5.1. Existing information

Existing information on fauna referred to in this investigation is described below.

5.1.1. Fauna

A list of the fauna species recorded in the area was obtained from the following sources:

- Storr-Johnstone bird data bank;
- Birds Australia Atlas of Australian Birds; and the
- Western Australian Museum mammal database.

Literature reviews on reptile and frog species that occur in the region were done with the aid of Wilson and Swan (2003), Cogger (2000) and the 'Frogs of Australia' website (ARC 2007).

5.1.2. Threatened species

The likelihood of occurrence on the site of nationally threatened fauna species was obtained through the EPBC Act – Protected Matters Search Tool (DEWR 2007). The search area comprised a 20 km buffer from the centre point of the site, or coordinates: latitude 33°29'00"S longitude 115°18'20"E. In addition to this, the likelihood of occurrence of any species listed as threatened under state legislation was also assessed.

5.2. Field methodology

The fauna field survey was carried out from 16th to 23rd March 2007, simultaneously with the bird utilization survey (see Section 6). Weather conditions were mild to warm with no rain and were considered to be suitable for detecting the majority of the fauna species likely to occur on the site. The entire site was walked and inspected by four wheel drive and on foot.

A number of techniques were used to detect fauna species inhabiting the study area. These included:

- Incidental searches for mammal scats, tracks and signs (e.g. diggings, signs of feeding and nests/burrows);
- Three nights (16th to 18th April 2007) of Anabat® ultrasonic bat detector surveying on the site;
- Turning over logs and large stones for reptiles, frogs and mammals; and
- Bird observations during the day.

Spotlighting for arboreal mammals and nocturnal birds, pitfall trapping and mammal trapping was not undertaken. As most works are proposed to be confined to already-cleared areas used for cropping and grazing, no significant impacts on remnant indigenous fauna habitats are anticipated. In

the two areas where vegetation may require removal, a detailed assessment of fauna habitat will be undertaken before construction to inform micro-siting to avoid or minimise potential impacts.

Fauna habitat types were characterised on the site and are described in Section 5.3.1. The quality of fauna habitat was assessed based on the criteria detailed below. These criteria have been modified to suit particular vegetation types, such as treeless environments, as necessary. Three quality categories were used, as described below:

High: Fauna habitat components are usually all present (i.e. vegetation intact, old-growth trees and fallen timber) and habitat linkages to other remnant ecosystems in the landscape are intact;

Moderate: Some fauna habitat components are often missing (i.e. vegetation disturbed, old-growth trees, fallen timber), although linkages with other remnant habitats in the landscape are usually intact;

Low: Many fauna habitat elements in low quality remnants have been lost, including old-growth trees (eg. due to past timber harvesting) and fallen timber, and tree canopies are often highly fragmented. Remnants may be severely weed-invaded and possess few native structural and floristic components. Habitat linkages with other remnant ecosystems in the landscape have usually been removed by extensive past clearing.

5.2.1. Limitations

Fauna field surveys usually fail to record all species present for various reasons, including the seasonal absence of some species and short survey duration. Rare or cryptic species are often missed in short surveys.

The fauna assessment was undertaken in March during mostly clear skies and hot weather conditions. Diurnal conditions were suitable for detecting species likely to occur on the site.

As works are proposed to be confined mostly to already cleared areas used for cropping and grazing, no significant impacts on remnant indigenous fauna habitats are anticipated, so detailed field studies of unaffected habitats were not considered warranted at the time of the survey. In the two areas where vegetation may require removal, a detailed assessment of fauna habitat will be undertaken before construction to inform micro-siting to avoid or minimise potential impacts.

Wherever appropriate, a precautionary approach has been adopted in the discussion of implications. That is, where insufficient evidence is available on the occurrence or likelihood of occurrence of a species, it is assumed that it could be in an area of habitat, if suitable, and the implications under legislation and policy are considered accordingly.

5.3. Fauna

5.3.1. Fauna habitat

The study area consisted of paddocks used for sheep and cattle grazing, and cropping. The majority of the area is dominated by exotic vegetation, including pasture grasses, with remnant, mature scattered eucalypt trees and patches of heathland scattered across the site, particularly on some rocky slopes and ridges. The fauna habitats identified on the site are described below.

Kwongan Heathland

This habitat type made up the majority of remnant native vegetation on the site. Large patches of remnant heathland occurred along ridges, steep slopes and roadsides (see Figure 1). These areas had a high diversity of flora and fauna. The high abundance of plants provides good food and shelter for fauna. Some of the dominant plant species in this habitat type include *Dryandra stenoprion, Hakea auriculata, Petrophile linearis, Lambertia multiflora* (Chitick) and *Xanthorrhoea* spp.

Although not all patches are connected, they do provide stepping-stones with cover from predators for fauna to move across the landscape. Roadside vegetation in particular provides habitat links throughout the site and to the large remnant heathland area in Badgingarra National Park at the eastern and south eastern edge of the site. This habitat type is considered to be of high quality for fauna, as it is comparatively intact in many cases.

Heathy Woodland

At the centre of the site there were patches of remnant heathland with an overstorey of banksia and sheoak species, and a species-rich heathland understorey. These areas had a high diversity in plant species and habitat structure, providing good food and shelter for fauna. Many lizard burrows were observed in these areas and high numbers of small bush-birds were observed here.

There was connectivity to other heathy woodland areas and also to Kwongan Heathland areas, similar in plant species composition. A combination of good connectivity, high structural and plant diversity, and low levels of disturbance, made this habitat type of high quality for native fauna.

Grassy Woodland

There were two types of grassy woodland habitats on the study site: one dominated by eucalypts and the other by banksias. Both had an exotic grass understorey. The eucalypt grassy woodland was dominated by River Red Gum (*Eucalyptus camalduensis*) and Marri (*Eucalyptus calophylla*) and lacked a middle-storey. The banksia grassy woodland was dominated by Slender Banksia (*Banksia attenuata)* and had a middle-storey of shrubs. As a consequence of grazing, plant diversity in these areas was low. These areas had a lot of leaf litter and fallen logs due to a recent storm.

These habitats are an important food and shelter resource for native fauna and providing hollows, seeds and nectar. These habitat types were limited in extent on the site due to land clearing and current grazing practices. Habitat linkages occur via the heathland corridors. This habitat type is considered to be moderate quality fauna habitat.

Wetlands

Wetland habitat comprised three different types: drainage lines, farm dams and swampy marshland. A severe storm had swept through the region two weeks prior to the field investigation, eroding slopes and depositing debris in these areas.

The **drainage lines** were usually unvegetated in their upper sections and were prone to soil erosion. The lower sections of the drainage lines in some areas were vegetated with *Melaleuca preissiana* and River Red Gum. These areas were highly modified and of low quality habitat for fauna.

Farm dams made up the majority of the wetland habitats throughout the site. These areas were generally located at the end of drainage lines and were used to water stock. The dam edges were generally trampled by stock and no vegetation grew there. The farm dams provided habitat for small numbers of waterfowl and the Black-fronted Dotterel. Overall the farm dams were low quality fauna habitat.

There were a small number of **swampy marshland** areas in low-lying parts of the site. They were generally well vegetated. Some of the dominant overstorey species include melaleuca and River Red Gum. There was a high diversity of understorey species; some of the dominant species included sedges (*Juncus* sp.), Bullrush (*Typha* sp.) and weed species. These areas provide good resources for fauna species; frogs and waterbirds were using these areas at the time of the field investigation. This habitat type is considered to be of high quality.

Planted Trees

Non-indigenous trees have been planted on parts of the site as windbreaks, feed for stock and for aesthetic reasons. These included eucalypts and pines. Some trees have been planted in hedges and rows in paddocks that are slashed and used as feed for cattle. These habitat types were generally utilised by common farmland fauna, particularly birds, and are of low to moderate habitat quality.

Exotic Pasture

This habitat type made up the majority of the study site and comprised exotic pasture grasses (e.g. Barley Grass) and weed species (e.g. Patterson's Curse). Some scattered remnant trees occurred in these areas. Due to grazing and drought conditions, most of the paddocks were bare. Surface rocks have been collected from these areas with some exposed embedded rocks along bare ridgelines and on steep slopes. This habitat type is considered to be low quality habitat for fauna.

5.3.2. Fauna species

Based on the field assessment and the review of existing information, the site is known or likely to support 143 species of fauna, including 16 species of mammals (3 introduced), 105 species of birds (1 introduced), 15 species of reptile and seven species of frog. These species are listed with their scientific names in Appendix 2, which also records those found during the field assessment and bird utilisation survey (see Section 6).

The fauna databases and the EPBC Act Protected Matters Search Tool contained a total of seven threatened or listed species of vertebrate fauna, including one species of mammal, six species of birds but no reptile or frog species. These are listed in Table 4.

Table 4: Threatened vertebrate fauna species predicted to occur at the proposed Badgingarra Wind Farm site (excludes fish).

Common Name	Scientific Name	EPBC	WATSSC	WC
Birds				
Carnaby's Cockatoo	*Calyptorhynchus latirostris*	E	E	L
Cattle Egret	*Ardea ibis*	M		
Fork-tailed Swift	*Apus pacificus*	M		
Great Egret	*Ardea alba*	M		
Rainbow Bee-eater	*Merops ornatus*	M		
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	M		
Mammals				
Western Quoll	*Dasyrus geoffroii*	V	V	L

Notes: EPBC – Status under EPBC Act; WATSSC – Status from WA Threatened Species Scientific Committee (2003); WC –Wildlife Conservation Act (WC Act).
E – Endangered; M – Migratory species (EPBC Act); V – Vulnerable; L – Listed as threatened under WC Act.

Mammals

A total of 16 species of mammal occurs or is likely to occur on the site based on the Western Australian Museum mammal database records and the site assessment. This total includes three introduced species. During the field assessment, five species were recorded. The native Western Grey Kangaroo and Short-beaked Echidna and all three introduced species were observed (Appendix 2).

In addition, a total of five common bat species were recorded during the Anabat® surveys: Chocolate Wattled Bat (*Chalinolobus morio*), an unidentified Long-eared Bat (*Nyctophilus* sp.), Southern Forest Bat (*Vespedalus regulus*), Freetail Bat (*Mormopterus* sp. 4) and White-striped Freetail Bat (*Tadarida australis*). A detailed report on the results of this survey can be found in Appendix 3.

The presence of the heathlands on site provides good opportunities for food and shelter for native fauna. The eucalypts on the site may provide daytime roosts for bat species.

The EPBC Act Protected Matters Search Tool predicted, based on habitat preference, the possible presence of one species of threatened mammal on the proposed wind farm site: the Western Quoll.

The **Western Quoll** is considered to be nationally vulnerable, listed as vulnerable in Western Australia (WATSSC 2003) and as threatened under the WC Act. This species prefers jarrah forests, dry woodlands and mallee shrubland (Menkorst and Knight 2001). The woodland habitat at the study site is small and isolated from other preferred habitats of the Western Quoll. Due to the lack of extensive suitable habitat it is considered unlikely that this species would regularly occur at the study site.

Birds

A total of 105 species of birds occurs or is likely to occur on the site based on the Birds Australia and Storr-Johnstone database records. During the current assessment and bird utilisation survey, 61 species were seen on the site (Appendix 2).

The EPBC Act Protected Matters Search Tool predicted the presence of the Carnaby's Cockatoo, and five migratory species on the site.

The **Carnaby's Cockatoo** has been previously recorded from the area and was listed as potentially occurring in the EPBC Act search tool. This species is considered to be nationally endangered, is listed as endangered in Western Australia (WATSSC 2003) and as threatened under the WC Act. It is also listed as endangered in the Action Plan for Australian Birds (Garnett and Crowley 2000) and a Recovery Plan (Cale 2003) has been prepared for this species.

This cockatoo prefers remnant native woodlands dominated by eucalypts and often occurs in surrounding sand plains in shrubland or Kwongan Heathland, dominated by hakea, dryandra, banksia and grevillea. It can also occur in pine plantations, Marri, Karri or Jarrah forests, she-oak woodlands or mallee country (Higgins 1999).

This species was recorded in significant numbers at the study site during the current investigation. It was observed utilising all habitat types from woodlands and heathlands to exotic pasture. It is considered that this species occurs regularly at the study site during the non-breeding months (January to July). A Level Two risk assessment for this species was undertaken, involving targeted field studies of its use of the site and surrounding region. The results of this assessment are presented separately in Section 7 of this report.

Two **egret** species were identified as having potential habitat at the site or in surrounding areas from the EPBC Protected Matters Search Tool. The Cattle Egret and Great Egret are listed under the EPBC Act as migratory species and both are listed on international treaties, including the *Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment* (JAMBA) and the *Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their*

Environment (CAMBA). There are no records of Cattle Egret from the search area. There are records of the Great Egret from the region in both the Storr-Johnstone databank and the Atlas of Australian Birds.

The **Cattle Egret** occurs in tropical and temperate grasslands and terrestrial wetlands. They regularly forage away from water on low-lying grasslands, improved pastures and croplands (Marchant and Higgins 1990). Although there is potential habitat for this species at the site, due to the lack of records it is considered highly unlikely that this species would occur regularly.

The **Great Egret** occurs in terrestrial wetlands, estuaries and moist grasslands. It prefers permanent water bodies on floodplains, shallow areas of deep permanent lakes, semi-permanent swamps with tall emergent vegetation and herb-dominated seasonal swamps with abundant aquatic flora (Marchant and Higgins 1990). This species was not recorded during the current investigation but potential habitat occurs on the study site. This species potentially occurs in wetland habitats on the site, particularly in the swampy marshlands at the study site.

The **White-bellied Sea-Eagle** is listed as a migratory species under the EPBC Act. There are no records on or near the site from the Storr-Johnstone or Birds Australia databases. The nearest records are along the coat near Cervantes and Jurien Bay. This species prefers maritime habitats, large terrestrial wetlands and coastal rivers of tropical and temperate Australia and it disperses inland only along large rivers and inland wetlands (Marchant and Higgins 1993). There are no large lakes, reservoirs or rivers at the site so habitats here are considered unsuitable for it to occur regularly.

The **Fork-tailed Swift** is listed as a migratory species under the EPBC Act and is listed under the CAMBA treaty. There are no records of the region from the Storr-Johnstone databank or the Atlas of Australian Birds. This species is almost exclusively aerial, has been recorded up to at least 300 m above ground level (Talbot and Talbot 1989). It occurs throughout Asia and Australia. In Australia, it occurs mostly over inland plains but sometimes over foothills or in coastal areas (Higgins 1999). This species may pass over the site from time to time but it is considered unlikely to occur regularly at the study site.

The **Rainbow Bee-eater** is listed as migratory under the EPBC Act and included on the *Convention on the Conservation of Migratory species and Wild animals* (Bonn Convention). There are records of the Rainbow Bee-eater in the surrounding region. It frequents open or lightly timbered areas. It occurs in a variety of habitats including dry, open sclerophyll forests, open woodlands and shrublands, including mallee, Spinifex tussock grasslands with scattered trees, riverine areas and partly cleared land such as farmland (Higgins 1999). This species was not recorded during the current investigation and individuals may have migrated north before the field investigation was undertaken. There is potential habitat for this species to occur on the site and it may occur here between September and February each year.

Reptiles

A total of 15 species of reptiles occurs or is likely to occur on the site based on the literature review and the habitat assessment. During the field assessment only two species was recorded (Stumpy-tailed Lizard and Western Heath Dragon). Skink species were also observed but were not identified to species level.

No threatened reptile species have been recorded from the search region and none are expected to occur at the study site.

Frogs

A total of seven species of frogs occurs or is likely to occur on the site, based on the literature review and the habitat assessment. During the field assessment two species of frog were heard calling in the swampy marsh habitat. One of the frogs was identified as the Western Banjo Frog (*Limnodynastes dorsalis*). Frogs may occur in wetland habitats throughout the site.

There are no records of threatened frog species from the region and none are considered to occur regularly at the study site.

6. BIRD UTILISATION SURVEY

This section describes the methods used in the bird utilisation survey and presents the results.

6.1. Methods

6.1.1. Fixed-point bird count method

The current survey was undertaken over seven days in autumn, between 17th and 23rd of March 2007.

The fixed-point bird count method has been adopted as the standard technique for the study of bird use of wind farm sites (Australian Wind Energy Association 2005, 2006; US Fish and Wildlife Services 2003; Langston and Pullan 2002). The method involved an observer stationed at a survey point for 15 minutes. During this period, all birds observed within 200 metres were recorded. Species, number, distance from the point and flight height were documented, with flight height being classified as below, at or above rotor swept area heights (RSA height). RSA height lies at heights between 35 and 125 metres above the ground for the largest turbines under consideration for the wind farm.

During the surveys, ten points on the site and two off the site (see Figure 2) were counted seven times during the survey. Points were counted at different times of the day to allow for time-of-day differences in bird movements and activity. Table 5 indicates when each point was counted on each survey day. This schedule ensured that all points were visited equally at all times of day.

Table 5: Times of day when bird utilization survey points* were counted during each survey day (T1 to T18 refers to count period).

Days	8:00	8:30	9:00	9:30	10:00	10:30	11:00	11:30	12:00
1	1	2	3	4	5	6	7	8	9
2	7	8	9	10	R1	R2	1	2	3
3	2	3	4	5	6	7	8	9	10
4	8	9	10	R1	R2	1	2	3	4
5	3	4	5	6	7	8	9	10	R1
6	9	10	R1	R2	1	2	3	4	5
7	4	5	6	7	8	9	10	R1	R2
Days	**13:00**	**13:30**	**14:00**	**14:30**	**15:00**	**15:30**	**16:00**	**16:30**	**17:00**
1	10	R1	R2	1	2	3	4	5	6
2	4	5	6	7	8	9	10	R1	R2
3	R1	R2	1	2	3	4	5	6	7
4	5	6	7	8	9	10	R1	R2	1
5	R2	1	2	3	4	5	6	7	8
6	6	7	8	9	10	R1	R2	1	2
7	1	2	3						

*** See Figure 2 for location of survey points.**

A total of 12 fixed survey sites (points) were established. Ten of these were considered to be "impact" points and they were located on the proposed wind farm site where turbines are proposed to be constructed. Two were considered to be "reference" points and they were located in similar landscapes, outside the boundaries of the proposed wind farm site and were accessible via public roads. Most of the impact points were established on elevated ground, either on top of or on the sides of knolls and ridges, allowing a clear view of all surrounding areas for at least 200m.

6.1.2. Location of survey points

Figure 2 shows the location of the bird utilisation survey points.

The two reference points were located greater than 1 km away from proposed turbine locations. The sites for the reference points were the nearest possible sites on a public road that had a broadly similar landscape and survey area visibility to the impact points. It was practically difficult to find exactly the same conditions. One of the reference points was on a hilltop, and in this respect accurately resembled the impact points. The other was along a farm track in generally agricultural land but included two linear strips of roadside vegetation.

6.1.3. Incidental observations

In addition to the observations during formalised fixed-point counts, incidental observations of birds were also made while moving about the site. Emphasis was placed on observing raptors and waterbirds that are found on parts of the site not covered during the fixed-point counts, or those passing through the site. Notes were also made on bush birds observed in remnant vegetation while travelling between observation points. Among raptors, particular attention was given to Wedge-tailed Eagle use of the site.

6.2. Limitations

This bird utilisation survey was undertaken in early autumn 2007. At this time of year many bird species were in the area, including resident and summer migratory birds that have not yet left the area.

Although a summer bird utilisation survey has not been undertaken, the lack of suitable habitats on the site for most migratory bird species makes it unlikely that these species occur here.

For these reasons, the utilisation rates and species abundances recorded during the current survey are considered to be representative of the site and a reasonable basis for a level one bird risk assessment for the proposed Badgingarra Wind Farm.

Bird Utilisation Survey

Legend

- Survey Point
- Reference Point
- Study Area

0 1,000 2,000 4,000 6,000 8,000 Metres

Badgingarra Wind Farm		
Figure 2: Bird Utilisation Survey		
Client: Enthalpy Pty Ltd		
Project No.: 7044	Date: 13/06/2007	Created by: I. Mau / C. Doughty

BL&A Brett Lane & Associates Pty. Ltd.
Ecological Research & Management
Experience Knowledge Solutions
605 Nicholson Street
PO Box 592 Carlton North
Vic 3054 Australia
ph (03) 9387 5008 | fax (03) 9387 6115
blane@ecologicalresearch.com.au
www.ecologicalresearch.com.au

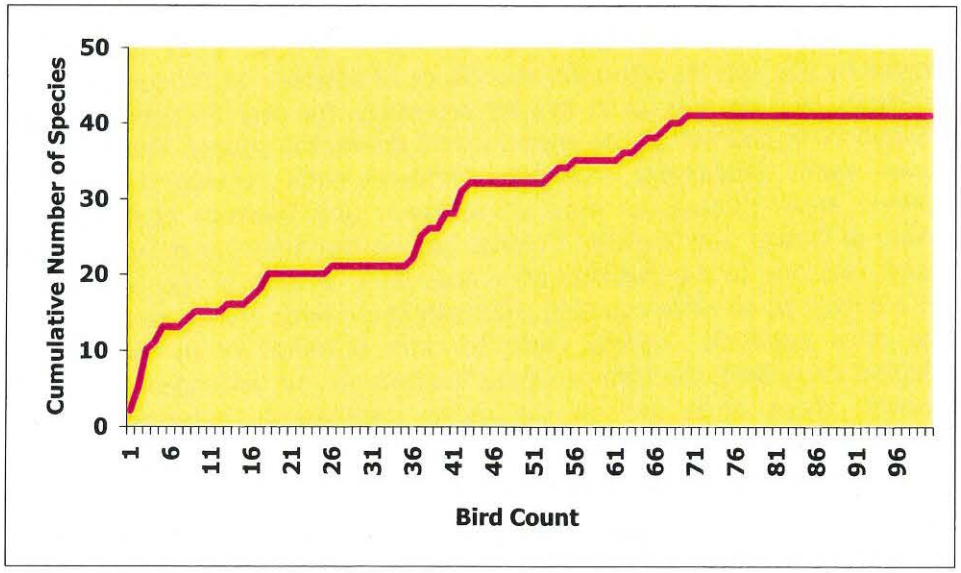
6.3. Results of the bird utilisation survey

This section of the report presents the bird utilisation survey results.

6.3.1. Representativeness of the survey

The cumulative number of species observed from the consecutive fixed-point bird counts conducted at the impact points during the survey has been plotted (see Figure 3). This revealed that the number of new species observed almost levelled off after about 40 counts (out of 100 counts), after which the occasional new species was found. Over 90% of species were found after less than 60% of the surveys. This suggests strongly that the sites collectively provided a representative picture of the diversity of bird species flying over the wind farm site during the period of the survey. Species recorded incidental to the fixed point counts either have very low utilisation rates or do not occur regularly on those parts of the wind farm site on which wind generators will be placed.

Figure 3: The cumulative number of species of birds recorded during consecutive counts at the observation points on the proposed Badgingarra Wind Farm site.



The adequacy of using 15 minutes as an interval to record the presence of birds during bird utilisation surveys was investigated in an earlier study at another wind farm site (Brett Lane and Associates, unpubl. data). This showed that 82 to 100 percent (average 88 percent) of species actually seen in one hour of surveying were seen in the initial 15 minutes of observation. Based on this result, the period of 15 minutes used in the formal bird utilisation surveys generated representative data on the bird species in the area during the survey. The results presented in Figure 3 also suggest strongly that the 15-minute count interval was adequate.

6.3.2. Bird observations

A total of 39 species of birds was seen at the impact points and 24 at the reference points. In addition, another 22 species of birds were seen incidentally while moving between points, bringing the total number of bird species at the site to 61. The additional incidental birds were mainly small bush-birds seen mainly in roadside vegetation or small heathland and woodland remnants on the site. Consideration of other birds likely to occur on the site is provided in the preceding section of this report.

Table 6 presents a list of the species observed during the bird utilisation survey and the numbers in which they were seen at each point and in each height zone. The most abundant species at the impact points were:

- Australian Pipit;
- Raven spp. (including both Australian Raven and Little Crow);
- Galah;
- Western Corella;
- White-fronted Chat; and
- Australian Magpie.

The Australian Pipit was the most abundant species (135 individuals), followed by five species with total abundance of between 113 to just under 60 individuals. The six species in this list accounted for over 55 percent of the individual birds counted at the impact points during the survey. The abundant species were, predictably, common farmland birds, known to occur in farmland areas throughout most of southern and Western Australia. The ranking of Galahs and Western Corellas among the first four most abundant species was due to the passage of a large flock of each of the two species over a survey point while counting. Normally these birds are found foraging in large open paddocks, usually close to farm buildings or in the flat low paddocks away from the hilltops where the turbines are proposed to be built. However, these birds are on the move continuously between foraging grounds and may occasionally pass though turbine sites. The Galahs were recorded from three points and the corellas from two points.

The next five abundant species were mainly small bushland birds recorded from the points where some heathland formed part of the count area. Their abundance ranged between 29 and 54 individuals per observation point, and together with the first group of abundant birds, they formed more than 75 percent of all birds observed during the formal bird counts.

The ranked abundance by species was almost the same at the ten observations points, with Richard's Pipit and ravens being the most common resident farmland bird at all points (see Table 6). On the impact points, species richness was similar between the 10 observation points. There was a tendency for species richness to be slightly higher at observation point 4, where the point included a row of planted eucalypts along a fence-line and a small remnant of heathland vegetation. In general however, this result

indicates that bird species use of those parts of the site where turbines are proposed to be built is comparatively uniform.

At the reference points, the first five common species formed more than 75 percent of all birds seen on the reference points. The first five most abundant birds were a mixture of heathland and common farmland birds (Table 7). The first most common species, the White-cheeked Honeyeater was a very common bird among the roadside heathland vegetation, and since both reference sites included such habitat in their counting areas, the honeyeater featured often, and formed more than 43 percent of all birds seen at the reference sites. The other common bird was the Emu. This large bird was regularly seen grazing around reference point one probably because the point was on the borders of the Badgingarra National Park, where good numbers of Emu occur. The other common birds at the reference sites were farmland birds, namely magpies and the ravens, similar to the impact points.

Table 8 shows the distribution of bird numbers among the survey points. The total number of birds counted at the impact points varied between a minimum of 45 birds at point eight to a maximum of 260 birds at point four, with an average total of 96 birds per point (total of 10 replicate counts). Nearly a quarter of the birds were concentrated at point four.

Table 9 shows the numbers of individual birds of each species observed flying at rotor swept area (RSA) height. During the survey, 43 individuals of nine species were observed flying at RSA height at the impact points, or about 4.3 percent of the total number of birds counted during the seven day survey.

The most abundant species observed flying at RSA height were:

- Welcome swallow;
- Wedge-tailed Eagle;
- Western Corella; and
- Black-faced Woodswallow.

The first two species accounted for over 37 percent of individual birds observed at RSA height and the four species together accounted for more than 65 percent. Two to four individuals each of the remaining five species were observed at RSA heights. The two most abundant bird species flying at RSA height were again common farmland birds. The swallows usually move and forage in flocks and occasionally ascend to RSA heights while foraging. The presence of the Wedge-tailed Eagle was more uniform among the observation points and was seen at seven out of the ten observation points. The significance of the eagle observations will be discussed below in more detail. The appearance of the other two species, namely the corella and the woodswallow, at RSA heights was expected since both birds are known to fly at such heights while foraging or travelling between foraging habitats.

The remaining five species of birds that flew at RSA height were common farmland species. Ravens, shelducks and magpies occasionally fly high, particularly when moving between foraging areas; the kestrel usually flies and

hovers at RSA heights when searching for prey and the martins are also known to fly at RSA heights sometimes when foraging.

The presence of birds at RSA heights at each of the ten impact points varied between 4.7 and 18.6 percent of the birds seen at the points. In common with the total number of birds at the observation points, there were no particular patterns of distribution of birds at RSA heights among the impact points. Points located in open paddocks usually attracted the larger farmland birds, such as magpies and ravens; both of which are known to fly at RSA heights when moving between foraging and roosting areas, particularly early in the morning and late in the evenings.

Birds of Prey (Raptors)

Few birds of prey were observed on the site. During the formal bird counts at the impact points, four species were seen. In addition, two more species were seen, one incidentally while moving between points (Collared Sparrowhawk) and the other on the reference points only (Black-shouldered Kite). The number of raptors was low in relation to the total number of birds recorded during the survey (Table 10). Raptors formed 2.3 percent of all individuals counted at the impact points and 28 percent of birds seen at RSA height.

The Nankeen Kestrel was the most abundant species of raptor utilizing the wind farm site. The kestrel was seen on 12 occasions, four of which were at RSA height. The Wedge-tailed Eagle was seen on 11 occasions, eight of which were at, two above and one below RSA height.

Raptors in general prefer open, cleared land for foraging coupled with rising hills and ridges, especially when partially treed to provide nesting habitat and shelter. The proposed wind farm site provided such habitat for raptors.

Wedge-tailed Eagles, which are birds of concern as they are prone to colliding with wind turbines, were seen utilizing the site during the seven-day survey. The eagles were seen over most of the site and were not concentrated at any particular point. Most of them were seen as single birds soaring or drifting over the site. Once a pair was seen over point four. This might indicate that the wind farm site is part of a foraging territory of one or probably two pairs of eagles. No nests or suitable nesting area was seen on the site. The utilization rate of the eagles at the site is not dissimilar from that at a number of operating wind farm sites in south eastern Australia (Brett Lane & Associates Pty Ltd, unpublished data), where no significant level of eagle collisions have occurred.

Table 6: Summary of numbers of individual birds and their height distribution seen on impact points at the proposed Badgingarra Wind Farm site.

	P1			P2			P3			P4			P5			P6			P7			P8			P9			P10			Total				%
Species	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**A**	**B**	**C**	**Total**	**Tot**
Richard's Pipit	9	0	0	4	0	0	2	0	0	0	0	0	20	0	0	23	0	0	58	0	0	13	0	0	6	0	0	0	0	0	135	0	0	135	13.4
Raven spp.	18	0	0	48	2	0	4	0	0	21	2	0	5	0	0	2	0	0	3	0	0	5	0	0	3	0	0	4	0	0	113	4	0	117	11.6
Galah	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	90	0	0	2	0	0	110	0	0	110	10.9
Western Corella	0	0	0	0	0	0	0	0	0	90	4	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	92	6	0	98	9.7
White-fronted Chat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	0	0	8	0	0	43	0	0	63	0	0	63	6.3
Australian Magpie	12	3	0	5	0	0	4	0	0	15	0	0	2	0	0	7	0	0	0	0	0	0	0	0	0	0	0	14	0	0	59	3	0	62	6.2
White-winged Fairywren	0	0	0	11	0	0	12	0	0	8	0	0	0	0	0	5	0	0	8	0	0	0	0	0	10	0	0	0	0	0	54	0	0	54	5.4
Welcome Swallow	5	6	0	0	0	0	4	2	0	11	0	0	5	0	0	2	0	0	0	0	0	2	0	0	2	0	0	4	0	0	35	8	0	43	4.3
White-cheeked Honeyeater	0	0	0	0	0	0	17	0	0	16	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	36	0	0	36	3.6
Silvereye	0	0	0	0	0	0	7	0	0	22	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	33	0	0	33	3.3
Yellow-rumped Thornbill	4	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	29	0	0	29	2.9
Tawny-crowned Honeyeater	0	0	0	1	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	26	0	0	26	2.6
Magpie-lark	2	0	0	0	0	0	4	0	0	5	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0	5	0	0	19	0	0	19	1.9
White-backed Swallow	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	17	0	0	0	0	0	19	0	0	19	1.9
Banded Lapwing	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	15	1.5
Stubble Quail	0	0	0	5	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0	15	0	0	15	1.5
Tree Martin	4	2	0	0	0	0	6	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12	2	0	14	1.4
Black-faced Woodswallow	6	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	7	6	0	13	1.3
Nankeen Kestrel	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	3	0	0	1	2	0	0	0	0	2	0	0	1	0	0	8	4	0	12	1.2
Willie Wagtail	2	0	0	2	0	0	0	0	0	4	0	0	1	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	12	0	0	12	1.2
Wedge-tailed Eagle	1	1	0	0	1	0	0	0	0	0	2	0	0	1	2	0	1	0	0	0	0	0	0	0	0	1	0	0	1	0	1	8	2	11	1.1
Crested Pigeon	0	0	0	0	0	0	2	0	0	4	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	10	1.0
Emu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	5	0	0	0	0	0	9	0	0	9	0.9
Brown-headed Honeyeater	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	8	0.8
Rufous Fieldwren	0	0	0	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	6	0	0	6	0.6

Species	P1			P2			P3			P4			P5			P6			P7			P8			P9			P10			Total				% Tot
	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	Total	
Southern Emu-wren	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	6	0.6
Australian Ringneck Parrot	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	4	0.4
Australian Shelduck	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	4	0.4
Short-billed Black-Cockatoo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	4	0.4
Laughing Kookaburra	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3	0.3
Western Gerygone	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3	0.3
Pied Butcherbird	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	2	0.2
Red Wattlebird	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0.2
Red-capped Robin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2	0	0	2	0.2
Singing Honeyeater	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0.2
Spiny-cheeked Honeyeater	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0.2
Australian Hobby	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0.1
Shy Heathwren	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0.1
Spotted Harrier	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	1	0.1
Black-faced Cuckoo-Shrike	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Black-shouldered Kite	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Blue-breasted Fairywren	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Inland Thornbill	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Rufous Whistler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Total	64	14	0	85	5	0	92	2	0	260	8	0	44	3	2	68	3	0	78	2	0	45	4	0	150	1	0	75	1	0	961	43	2	1006	100.0

Notes: (A) below (0–35 m), (B) at (35–125), and (C) above (>125) rotor swept area height.

Table 7: Summary of numbers of individual birds and their height distribution seen on the reference survey points at the proposed Badgingarra Wind Farm site. A, B, and C as in Table 8.

Species	R1			R2			Total				%
	A	B	C	A	B	C	A	B	C	Total	Total
White-cheeked Honeyeater	26	0	0	104	0	0	130	0	0	130	43.5
Emu	41	0	0	0	0	0	41	0	0	41	13.7
Raven spp.	26	2	0	5	1	0	31	3	0	34	11.4
Australian Magpie	8	0	0	8	0	0	16	0	0	16	5.4
Blue-breasted Fairywren	0	0	0	10	0	0	10	0	0	10	3.3
White-winged Fairywren	5	0	0	2	0	0	7	0	0	7	2.3
Banded Lapwing	0	0	0	6	0	0	6	0	0	6	2.0
Magpie-lark	2	0	0	4	0	0	6	0	0	6	2.0
Richard's Pipit	3	0	0	3	0	0	6	0	0	6	2.0
Welcome Swallow	0	0	0	6	0	0	6	0	0	6	2.0
Silvereye	3	0	0	2	0	0	5	0	0	5	1.7
Yellow-rumped Thornbill	0	0	0	5	0	0	5	0	0	5	1.7
Crested Pigeon	0	0	0	4	0	0	4	0	0	4	1.3
Galah	4	0	0	0	0	0	4	0	0	4	1.3
Tawny-crowned Honeyeater	0	0	0	4	0	0	4	0	0	4	1.3
Black-faced Woodswallow	0	0	0	3	0	0	3	0	0	3	1.0
Australian Ringneck Parrot	2	0	0	0	0	0	2	0	0	2	0.7
Black-shouldered Kite	0	0	0	2	0	0	2	0	0	2	0.7
White-fronted Chat	0	0	0	2	0	0	2	0	0	2	0.7
Willie Wagtail	0	0	0	2	0	0	2	0	0	2	0.7
Black-faced Cuckoo-Shrike	0	0	0	1	0	0	1	0	0	1	0.3
Nankeen Kestrel	0	0	0	1	0	0	1	0	0	1	0.3
Rufous Whistler	0	0	0	1	0	0	1	0	0	1	0.3
Shy Heathwren	0	0	0	1	0	0	1	0	0	1	0.3
Total	**120**	**2**	**0**	**176**	**1**	**0**	**296**	**3**	**0**	**299**	100.0

Table 8: The number of birds counted at each of the survey points at Badgingarra Wind Farm.

Observation Points	Number of Birds at			Total	% Of Total Birds	% At RSA Height	% RSA Birds of Total Birds
	A	B	C				
Impact Points							
P 1	64	14	0	78	7.8	21.9	1.4
P 2	85	5	0	90	8.9	5.9	0.5
P 3	92	2	0	94	9.3	2.2	0.2
P 4	260	8	0	268	26.6	3.1	0.8
P 5	44	3	2	49	4.9	6.8	0.3
P 6	68	3	0	71	7.1	4.4	0.3
P 7	78	2	0	80	8.0	2.6	0.2
P 8	45	4	0	49	4.9	8.9	0.4
P 9	150	1	0	151	15.0	0.7	0.1
P10	75	1	0	76	7.6	1.3	0.1
Total	961	43	2	1006	100.0	4.5	4.3
Reference Points							
R 1	120	2	0	122	40.8	1.7	0.7
R 2	176	1	0	177	59.2	0.6	0.3
Total	296	3	0	299	100.0	1.0	1.0

Notes: (A) below (0–35 m), (B) at (35–125), and (C) above (>125) rotor swept area height.

Table 9: Species flying at rotor swept area height (RSA height) during bird utilisation surveys at the Badgingarra Wind Farm site.

	Impact Observation Points														
6.3.3. Species	**P1**	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**	**Birds at RSA Height**	**Birds at All Heights**	**% RSA Birds**	**% of Total RSA Birds**	**% RSA Birds of Birds At all Heights**
Welcome Swallow	6	0	2	0	0	0	0	0	0	0	8	43	18.6	18.6	0.8
Wedge-tailed Eagle	1	1	0	2	1	1	0	0	1	1	8	11	18.6	72.7	0.8
Western Corella	0	0	0	4	2	0	0	0	0	0	6	98	14.0	6.1	0.6
Black-faced Woodswallow	2	0	0	0	0	0	0	4	0	0	6	13	14.0	46.2	0.6
Raven spp.	0	2	0	2	0	0	0	0	0	0	4	117	9.3	3.4	0.4
Nankeen Kestrel	0	2	0	0	0	0	2	0	0	0	4	12	9.3	33.3	0.4
Australian Magpie	3	0	0	0	0	0	0	0	0	0	3	62	7.0	4.8	0.3
Tree Martin	2	0	0	0	0	0	0	0	0	0	2	14	4.7	14.3	0.2
Australian Shelduck	0	0	0	0	0	2	0	0	0	0	2	4	4.7	50.0	0.2
Total	14	5	2	8	3	3	2	4	1	1	43	1006*	100.0	4.3	4.3

* Total is for all birds

Table 10: The number and species of raptors counted at the survey points at Badgingarra Wind Farm.

	Total of all Impact observation points				
Species of Raptor	**A**	**B**	**C**	**Total**	**% All birds**
Nankeen Kestrel	8	4	0	12	1.2
Wedge-tailed Eagle	1	8	2	11	1.1
Australian Hobby	1	0	0	1	0.1
Spotted Harrier	1	0	0	1	0.1
Total	11	12	2	25	

Notes: (A) below (0–35 m), (B) at (35–125), and (C) above (>125) rotor swept area height.

7. CARNABY'S BLACK-COCKATOO

This section discusses the Carnaby's Black-Cockatoo investigation at the site and outlines any risks associated with the construction and operation of the proposed Badgingarra Wind Farm.

7.1. Existing information

Existing information on the status and habitat of the Carnaby's Cockatoo was obtained from the following sources:

- Carnaby's Black-Cockatoo Recovery Plan (Cale 2003);
- Carnaby's Black-Cockatoo Action Plan (Garnett and Crowley 2000);
- Carnaby's Black-Cockatoo Fact Sheet (Threatened Species Network); and
- Various journal articles written by D.A Saunders.

In addition, a review of information in the Western Australian Museum historical database was commissioned by Mr Ron Johnstone, Curator at the Western Australia Museum. Mr Johnstone's report is attached as Appendix 4 and referred to in this section.

To place the habitat on the proposed wind farm site in wider context, the Western Australian Department of Agriculture native vegetation unit was commissioned to prepare a GIS analysis of the area of vegetation types that support abundant food sources for the Carnaby's Black-Cockatoo within 100 km of the proposed wind farm site. The results of this analysis are presented in Appendix 5 and referred to in this section.

7.2. Background information

7.2.1. Species description and status

The Carnaby's Black-Cockatoo is listed as nationally endangered under the EPBC Act, as endangered in Western Australia (WATSSC 2003) and as threatened under the WC Act. It is also listed as endangered in the Action Plan for Australian Birds (Garnett and Crowley 2000). The Department of Environment and Conservation (DEC) has prepared a recovery plan for Carnaby's Cockatoo and a Recovery Team also has been established. Birds Australia has coordinated the Carnaby's Black-Cockatoo Recovery Project since 2001. Johnstone (see Appendix 4) has estimated the population at 40,000 individuals.

This large black cockatoo grows to 56 cm in length, has a large bill and erect crest. It has white ear-coverts and white panels in the tail (Higgins 1999). In males, the bill is black and the eye-ring red. Females differ from males in having a light grey bill, grey eye-ring and a more distinctive cheek patch (Cale 2003). Figure 4 shows a photograph of the bird near the existing, nearby Emu Downs Wind Farm.

Figure 4: Carnaby's Black Cockatoo in the southern part of the proposed Badgingarra Wind Farm site, near the existing Emu Downs Wind Farm.

7.2.2. Distribution

Carnaby's Black-Cockatoo is endemic to the south-west of Western Australia, extending from the Murchison River to Esperance, and inland to Coorow, Kellerberrin and Lake Cronin (Saunders 1974, Saunders & Ingram 1995, Johnstone & Storr 1998). The range of this cockatoo has declined by a third between the 1970's and 1990's (Saunders & Ingram 1995) and has been pushed further south and further west due to land clearing for agricultural purposes.

Within 100 km of the proposed Badgingarra Wind Farm, the review by Johnstone (see Appendix 4) indicated that the birds that breed inland and to the north of the proposed wind farm site move between February and early May to the northern Swan Coastal Plan, between Laneclin and Perth, where they forage in the pine plantations and Kwongan heathlands of this region. They return to their breeding grounds between late July and early September. At these times, several hundred can be observed in the Badgingarra region.

In March and April 2007, surveys as part of the impact assessment for this wind farm indicated that these numbers were present in the vicinity of and on the proposed wind farm site (see later in this section).

7.2.3. Habitat

The preferred habitat of the Carnaby's Black-Cockatoo is uncleared and remnant native woodlands dominated by eucalyptus, particularly Wandoo and Salmon Gum. It often utilises surrounding sand plains with shrubland or Kwongan Heathland, dominated by *Hakea, Dryandra, Banksia* and *Grevillia* (Higgins 1999).

A close association between feeding areas and woodland nesting habitat is important to the breeding success of the cockatoo (Saunders 1977, 1986; Saunders & Ingram 1987). Seasonally, the species moves to higher-rainfall coastal areas that feature areas of feeding habitat, such as heath, *Banksia* woodland and/or *Pinus* plantations, accessible water and trees around watercourses that provide shade in summer (Saunders 1980).

For the purposes of the regional GIS analysis by the Western Australia Department of Agriculture, Appendix 5 lists the vegetation types that were deemed to have a good foraging resource of proteaceous shrubs, the seeds of which are the preferred food of Carnaby's Black Cockatoo. Of 95 types mapped in the region, 89 were considered suitable, comprising the majority of the area of remaining native vegetation within the region investigated.

7.2.4. Breeding

The Carnaby's Black-Cockatoo breeds from July to November in woodlands in the wheatbelt region of south western Australia. It requires large hollows in live or dead standing trees for nesting purposes. It primarily nests in the smooth-barked Salmon Gum or Wandoo but are also known to nest in Red Morrell (*Eucalyptus longicornis*), York Gum (*E. loxophleba*), Tuart (*E. gomphocephala*), Flooded Gum (*E. rudis*), Gimlet (*E. salubris*), Swamp Yate (*E. occidentalis*) and Marri (*Eucalyptus calophylla*) (Saunders 1980, 1982; Storr 1991, Johnstone & Storr 1998). It has been found nesting on private property, road and railway reserves, crown land and conservation reserves (Cale 2003).

Birds from the coastal sand plains region north of Perth (including the proposed wind farm site) are known to breed at Coomallo Creek, Middle Hill River and near Cataby (Saunders 1982, Higgins 1999). Sub-populations breeding at these sites would account for the majority of cockatoos utilising the proposed wind farm site. At Coomallo Creek birds usually forage within 1.4 km of the nest (Saunders 1980). The Coomallo Creek breeding area is approximately 25 km north-east of the site.

7.2.5. Movements

Carnaby's Black-Cockatoo are gregarious birds that congregate in large feeding flocks during the non-breeding season. During the breeding season they appear in pairs or small flocks.

After fledging, generally between January and July, the young move with their parents to their non-breeding areas where other family groups join

them. The cockatoos congregate in large flocks that wander in search of food. In the Coomallo Creek area, cockatoos forage locally in heathland within 50 km of their breeding area (Saunders 1980). They concentrate along watercourses in the drier times and forage more widely after rain (April, May). Birds from other breeding populations may congregate with the Coomallo Creek sub-population during the non-breeding season.

The Carnaby's Black-Cockatoo returns to its original breeding place year after year (Saunders 1977).

The species is known to move to regular roosting sites at night and generally does not move about the landscape after dark (Higgins 1999).

In the vicinity of Badgingarra, records compiled by Johnstone and Johnstone in Appendix 4, provided a basis for their conclusion, repeated below:

> *"Judging from our data bank all birds from the Three Springs, Carnamah, Coorow, Badgingarra and Moora regions completely vacate their breeding sites by the end of February and aggregate into large flocks in the Kwongan heaths and pine plantations on the northern Swan Coastal Plain. Occasionally a flock of 60 – 100 birds remains in the Badgingarra National Park area into March – April. The reverse migration occurs in July – August (sometimes later) as birds return back to their breeding sites."*

7.2.6. Feeding and foraging

The Carnaby's Black-Cockatoo prefers seeds of proteaceous plants, introduced pines and wild geranium *Erodium*. It is also known to feed on nectar, flowers and insect larvae (Higgins 1999). It also consumes seeds from species of *Banksia*, *Dryandra*, *Hakea*, *Grevillea*, *Allocasuarina* and *Eucalyptus* (Saunders 1974, 1980). The seeds of introduced plant species are consumed, particularly pines *Pinus* spp., Storksbill *Erodium* sp. and Wild Radish *Raphanus raphanistrum* (Saunders 1980).

The species has been observed taking nectar from the flowers of *Dryandra* species (De Rebeira & De Rebeira 1977, Storr 1991, Johnstone & Storr 1998), *Lambertia inermis* (Storr 1991), *Callistemon viminalis* (Mawson 1995), *Banksia grandis* and *Eucalyptus* spp. (Johnstone & Storr 1998). The cockatoos are known to feed on insects hidden in the flowers or fruits of *Banksia* species, such as the larvae of a wood-boring moth *Arthrophora* sp. (Tortricidae) found in *Banksia tricuspis* (Van Leeuwen & Lamont 1996) and the weevil *Alphitopis nivea* from *Banksia attenuata* fruits (Scott & Black 1981). They also are known to feed on the larvae of moths from the family Pyralidae found in flowers of *Dryandra* aff. *circioides* (Saunders 1980).

A list of food plants was provided by Johnstone and Johnstone (see Appendix 4). This indicated the predominance of the seeds, buds and nectar of proteaceous shrubs in the diet of the species.

7.3. Field methodology

Survey's were undertaken at the proposed Badgingarra Wind Farm site and the surrounding region from 16th to 23rd March and from 16th to 19th April 2007. All Carnaby's Black-Cockatoo sightings within the proposed wind farm site were recorded and marked with a hand held global positioning system (GPS). The numbers of birds observed and the habitat they were utilising were recorded.

Potential habitat of the Carnaby's Black-Cockatoo at the proposed Badgingarra Wind Farm site was described and mapped.

At Stanwell's Toora Wind Farm in southern Victoria (Brett Lane & Associates Pty Ltd 2004) the closely related Yellow-tailed Black Cockatoo (*Calyptorhynchus funereus*) avoids wind turbines. Yellow-tailed Black Cockatoos were recorded in pre development bird utilisation surveys of the site but not during the post development surveys at the same points. To test the hypothesis that the Carnaby's Black-Cockatoo avoids turbines a Level Two investigation was undertaken around the existing Emu Downs Wind Farm from 16th to 19th April 2007.

The existing Emu Downs Wind Farm site was considered a suitable location to test this hypothesis as it had similar habitat characteristics to the proposed Badgingarra Wind Farm site. A roaming survey was undertaken, dividing the survey area into three survey zones. The survey zones were as follows: between existing turbines, less than one km from the nearest existing turbine and between one and six km from the nearest turbine.

An equal amount of time was spent searching the two survey zones away from the existing turbines and a considerable amount of time was spent surveying among the existing turbines. Time of day differences were allowed for by having short duration surveys and altering the time of day each zone was surveyed.

All Carnaby's Black-Cockatoo sightings were recorded and locations marked using a handheld GPS. Any flight paths observed by these birds were recorded on a map.

7.3.1. Limitations

The current investigation was conducted during March and April 2007. Carnaby's Black-Cockatoo flock during the non-breeding season at this time of year. The survey area was situated in the cockatoo's non-breeding feeding grounds and was therefore the appropriate time of the year to conduct the investigation.

The weather conditions during the current investigation were considered appropriate for detecting Carnaby's Black-Cockatoo. Effort was taken to perform an unbiased survey by ensuring a spatially uniform search effort and allowing for time of day differences.

There was limited access to the east of the site due to large areas of land being private property. Cockatoos may have been missed in these areas.

7.4. Results

This sub-section presents the results of the level two risk assessment for the Carnaby's Black-Cockatoo at the proposed Badgingarra Wind Farm site. The usage of the proposed wind farm site is considered first, followed by usage in relation to the existing Emu Downs Wind Farm.

7.4.1. Carnaby's Black-Cockatoo at the proposed Badgingarra wind farm site

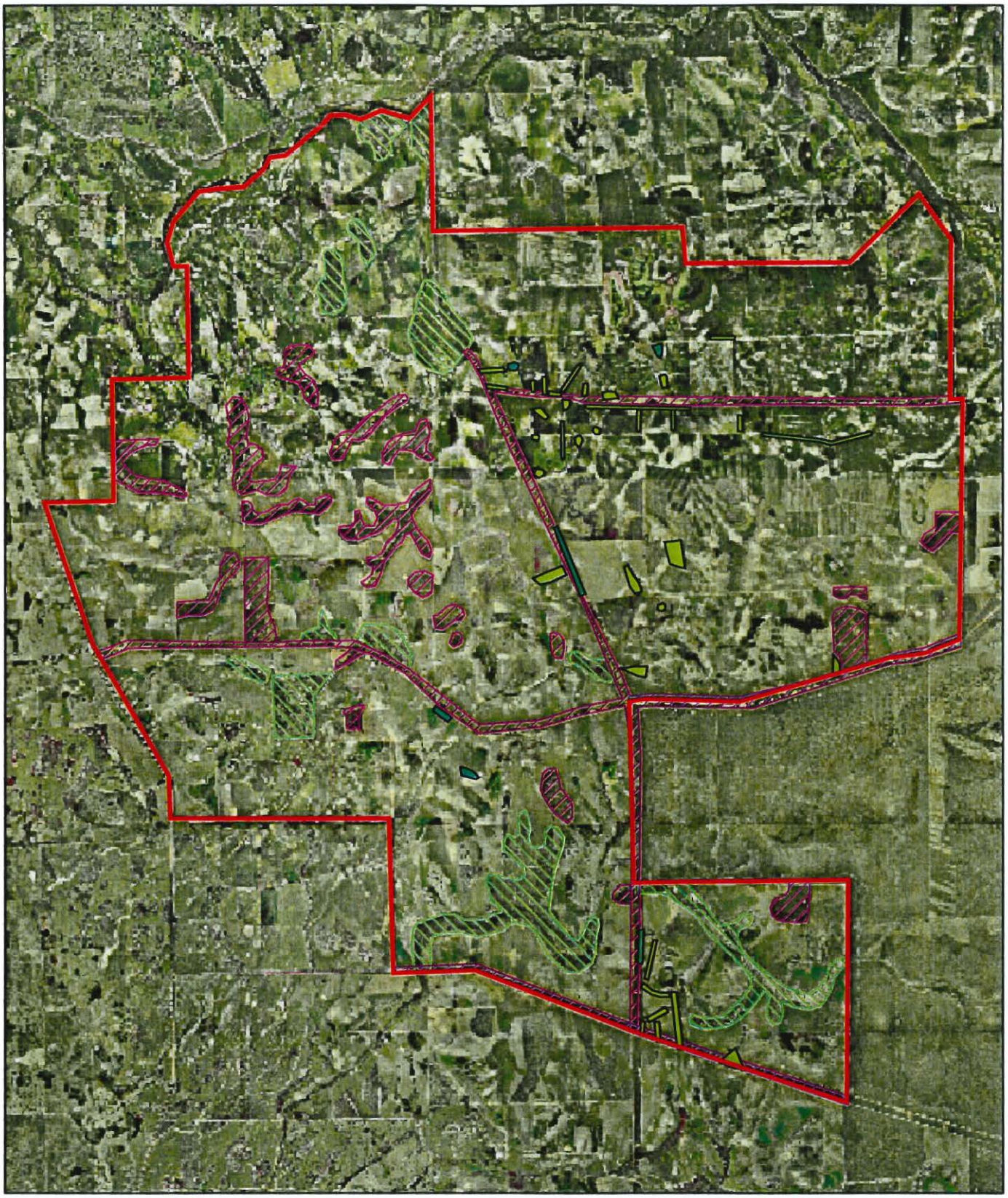
Potential habitat for the Carnaby's Black-Cockatoo at the proposed Badgingarra Wind Farm site consists of Heathland, Woodland and Planted non-indigenous trees. These habitat types have been described above (see Section 5.3.2). Figure 4 shows the potential habitat for the species at the proposed wind farm site.

During the current investigation, cockatoo sightings at the site were recorded. All sightings at the proposed wind farm site are presented in Table 11.

Table 11: Carnaby's Black-Cockatoo sightings at the proposed Badgingarra Wind Farm

Date	Population size	Habitat	Behavior
16/03/2007	16	Woodland (Marri)	Flying
17/03/2007	80	Woodland (Marri)	Resting
	44	Exotic pasture	Feeding
	88	Heathland	Feeding
	16	Planted Trees (Pine)	Flying to
	48	Planted Trees (Eucalypt)	Flying from
18/03/2007	28	Woodland (Marri)	Resting
	34	Exotic Pasture	Feeding
	30	Woodland (Banksia)	Feeding
	36	Woodland (Marri)	Feeding
20/03/2007	7	Heathland	Feeding
	18	Planted Trees (Pine)	Resting
21/03/2007	4	Planted Trees (Eucalypt)	Flying from
22/03/2007	20	Flying across farmland towards Marri Woodland	Flying to
23/03/2007	15	Woodland (Marri)	Feeding
17/04/2007	88	Planted Trees (Eucalypt)	Resting
18/04/2007	200	Heathland	Feeding
	6	Heathland	Feeding
19/04/2007	1	Planted Eucalypts	Flying

Potential Habitat for the Carnaby's Cockatoo



Legend

- Woodland
- Kwongan Heathland
- Planted Eucalypts
- Planted Pines
- Study Area

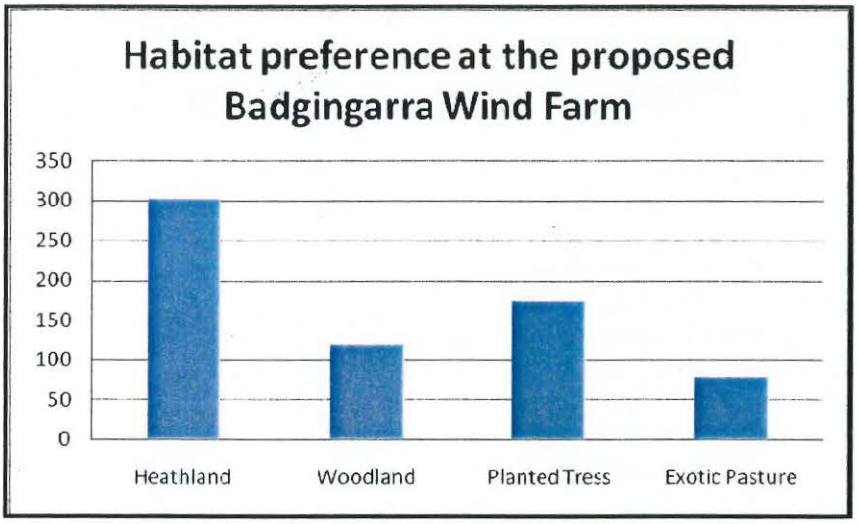
0 1,000 2,000 4,000 6,000 8,000 Metres

Badgingarra Wind Farm		
Figure 5: Potential Habitat for the Carnaby's Cockatoo		
Client: Enthalpy Pty Ltd		
Project No.: 7044	Date: 13/06/2007	Created by: I. Mau / C. Doughty

BL&A Brett Lane & Associates Pty. Ltd.
Ecological Research & Management
Experience Knowledge Solutions
605 Nicholson Street PO Box 592 Carlton North Vic 3054 Australia
ph (03) 9387 5006 | fax (03) 9387 6115
blane@ecologicalresearch.com.au
www.ecologicalresearch.com.au

The total number of cockatoos recorded in each habitat type is presented in Figure 5. The species occurred mostly in the Heathland, Woodland and Planted Tree habitats at the site. The majority of the sightings were from the heathland habitat, usually along the roadside reserves. Planted non-indigenous trees had a high number of records, mostly from eucalypts but also from pine trees. The cockatoos were observed utilising woodland areas for feeding and resting.

Figure 6: The number of Carnaby's Black-Cockatoos recorded in each habitat type at the proposed Badgingarra Wind Farm site



7.4.2. Behavior and movements of the Carnaby's Black-Cockatoo in relation to the existing wind farm

A roaming, targeted survey was undertaken near the existing Emu Downs Wind Farm. This was the first season that the species would have been in the region since wind farm operations began at Emu Downs, so may not reflect long-term avoidance patterns.

Three survey zones were predetermined and all Carnaby's Black-Cockatoo observed within 6 km of the nearest turbine were recorded. The cockatoo numbers and distance from the nearest turbine are presented in Figure 6.

A total of seven hours was spent during the roaming survey in each of the two survey zones outside the existing wind farm: <1 km and 1 - 6 km from the nearest turbine. Four hours and twenty minutes were spent searching between turbines at the Emu Downs Wind Farm to detect any movements between turbines within the existing wind farm (see Figure 7).

During this survey, the cockatoos were observed as follows:

- One bird was observed within the Emu Downs Wind Farm;
- 62 birds were observed within 1 km of the Emu Downs Wind Farm turbines; and

- 353 birds were observed between 1 and 6 km of the Emu Downs Wind Farm turbines.

As the total area of habitat in each survey zone varied, and there were differences in the survey effort between the three zones, a more realistic comparison between the zones was obtained by determining the number of cockatoos observed per search hour per 1000 hectares (ha) of habitat for each zone (i.e. normalising for availability of habitat and survey effort). These results are presented in Table 12.

Table 12: The rate of Carnaby's Cockatoos seen / hr / 1000 ha of habitat.

Zone	Number of birds seen	Hours spent in the field	Amount of suitable habitat (ha)	Rate
Within the turbines	1	4.3	645	**0.360555**
< 1 km from nearest turbine	62	7	244	**36.29977**
1 - 6 km from nearest turbine	353	7	10156	**4.965397**

The number of cockatoos observed per hour per 1000 hectares of suitable habitat is considerably higher in the survey zone '< 1 km from nearest turbine' than in the other zones. This is partly due to the smaller area of suitable habitat located in this zone (244 ha), with most of the habitat being along the roadside, and the presence of a large flock of 60 cockatoos observed flying over the roadside heathland vegetation in this zone.

Only one individual was observed flying 'within the turbines'. This accounts for the low rate of 0.4 cockatoos / search hour / 1000 ha within the existing wind farm. This low rate indicates that cockatoos avoided the area among the existing turbines.

In the larger survey zone, '1 – 6 km from nearest turbine', a rate of 5 cockatoos / search hr / 1000 ha was obtained. This survey zone had a large and extensive habitat that was made up of Badgingarra National Park and other conservation reserves. A high number of cockatoos was observed utilising this zone. Cockatoos were observed feeding in the heathlands on public land, including roadside reserves, national parks and conservation reserves. Cockatoos were also seen feeding and resting in planted trees on private property.

The position of cockatoo observations and of observed flight paths were recorded and are mapped in Figure 7. The majority of flight paths recorded around the existing Emu Downs Wind Farm site were above the Kwongan Heathland habitat type. It is worth considering that the availability of food can vary from year to year and in future years, habitat usage may differ from that observed.

During all investigations in the region, no cockatoos were observed flying higher than 10 metres above the ground. That is, all flights occurred below RSA heights.

Records of Carnaby's Cockatoo

Legend

- Carnaby's Cockatoo Records
- Carnaby's Cockatoo Flight Paths
- Survey Zone between Turbines
- Survey Zone < 1 km from nearest Turbine
- Survey Zone 1 - 6 km from nearest Turbine

0 1,000 2,000 4,000 6,000 8,000 Metres

Badgingarra Wind Farm		
Figure 7: Records of Carnaby's Cockatoo		
Client: Enthalpy Pty Ltd		
Project No.: 7044	Date: 13/06/2007	Created by: I. Mau / C. Doughty

BL&A Brett Lane & Associates Pty. Ltd. Ecological Research & Management
Experience Knowledge Solutions
605 Nicholson Street PO Box 592, Carlton North VIC 3054 Australia
ph (03) 9387 5008 | fax (03) 9387 6115
blane@ecologicalresearch.com.au
www.ecologicalresearch.com.au

8. CONSERVATION SIGNIFICANCE OF SPECIES OBSERVED

This section of the report provides an assessment of the conservation significance of the proposed wind farm site for flora and fauna. The criteria for determining conservation significance are first described, followed by assessment of the conservation significance of the site for flora then fauna.

8.1. Criteria for conservation significance

8.1.1. Botanical conservation significance criteria

The following criteria for botanical conservation significance have been used.

National botanical significance applies to an area when it supports one or more of the following attributes:

- A population of at least one nationally threatened plant species listed on the schedules to the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999.*
- A nationally threatened ecological community listed on the schedules of the *Environment Protection and Biodiversity Conservation Act 1999.*

State botanical significance applies to an area when it supports one or more of the following attributes:

- A population of at least one plant species declared rare or priority flora in Western Australia.
- An ecological community considered threatened in Western Australia

Regional botanical significance applies to an area that supports one or more of the following attributes:

- Supports a population of one or more regionally depleted species defined in a valid regional assessment of biodiversity (e.g. Regional Native Vegetation Plan, or Comprehensive Regional Assessment documents).
- An ecological vegetation class that is declared rare or priority in a particular bioregion.

Local botanical significance applies to all remnant native vegetation that does not meet the above criteria. In many parts of south western Western Australia, native vegetation has been so depleted by past clearing and disturbance that all remaining vegetation must be considered to be of at least local conservation significance.

8.1.2. Fauna conservation significance criteria

The following criteria for fauna conservation significance have been used.

National fauna conservation significance applies to an area that supports one or more of the attributes described below.

- A population of one or more species listed as nationally threatened by Maxwell *et al.* (1996), Lee (1995), Duncan *et al.* (1999), Garnett and

Crowley (2000), Cogger *et al.* (1995), Tyler (1997) or Wager and Jackson (1993), or listed on the *Environment Protection and Biodiversity Conservation Act 1999*, and/or

- A nationally threatened ecological community listed on the schedules of the *Environment Protection and Biodiversity Conservation Act 1999*.

State fauna conservation significance applies to an area when it supports one or more of the following attributes.

- A population of at least one fauna species threatened in Western Australia, and listed by DEC or on the schedules to the Western Australian *Wildlife Conservation Act 1950*.

Local fauna conservation significance applies to all 'other' native fauna that do not meet the above criteria.

As it is not always possible to confirm the presence of some fauna species, due to seasonal or behavioural difficulties in detection, the foregoing significance levels can be qualified by the word "**potential**" where habitat attributes are considered suitable for a species of a particular level of conservation significance.

8.2. Botanical conservation significance of the site

Two DRPF were recorded at the study site; Meisn (*Davesia epiphyllum*), a priority 3 species, and *Loxocarya gigas*, a priority 2 species. Mesin was recorded frequently throughout the Kwongan Heathland vegetation type at the study site and along road reserves. *Loxocarya gigas* was found in its thousands at remnant number 26 (Figure 1) on the study site.

One species Lesueur Hakea (*Hakea megalsperma*) is listed as vulnerable under the EPBC Act was recorded at vegetation number 26 (Figure 1) at the study site. Several plants were confirmed to occur at this section. This is the southern limit of their range.

Therefore the areas of Kwongan Heathland on the site are considered to be of **state** conservation significance for native flora. Remnant 26 is considered to be of **national** botanical conservation significance.

8.3. Fauna conservation significance of the site

One fauna species of national significance was observed on the proposed wind farm site during the current investigations. The nationally endangered Carnaby's Black-Cockatoo was recorded in significant numbers on the proposed Badgingarra Wind Farm site across all habitat types. Section 7 of this report provides more details.

The Carnaby's Black-Cockatoo inhabits the proposed Badgingarra Wind Farm site due to the close location to breeding sites and presence of preferred habitat type and food resources. The woodland and heathland areas at the study site are therefore considered to be of **national** conservation significance for native fauna. The implications of this are discussed further in Section 9.

9. IMPLICATIONS OF THE SURVEY FINDINGS

The proposed wind farm is proposed to occupy part of the site. The most likely layouts, which have been assessed here, are:

- 41 x 3 MW turbines in the north and south of the site;
- 65 x 2 MW turbines in the north and south of the site;
- 43 x 3 MW turbines in the north and north-east of the site; and
- 65 x 2 MW turbines in the north and north-east of the site.

These layouts are shown in Figure 8 to 11. This section of the report discusses the impacts that the proposed Badgingarra Wind Farm may have on flora and fauna, and discusses the significance of this impact under relevant Commonwealth and state legislation and regulations. Flora and native vegetation are considered first, followed by discussion of the general impacts the wind farm may have on birds. This is followed by assessment of the impacts of the proposed wind farm on the Carnaby's Black-Cockatoo.

9.1. Potential impacts on native flora and vegetation

The majority of the land at the proposed wind farm is made up of introduced pasture and has been subject to a long history of stock grazing and pasture improvement or cropping. The limited areas of native vegetation support populations of threatened flora species considered in Section 4, as well as the threatened Carnaby's Black-Cockatoo.

To ensure that every effort is made to avoid and minimise the removal of native vegetation, the areas of mapped native vegetation in Figure 1 can be used to guide the layout of the turbines and placement of access tracks. Inspection of all proposed turbine sites found none to support remnant native vegetation.

As the access tracks collectively remove more vegetation than the turbines, and their location is not so constrained, the limited extent of native vegetation on the site should enable access track routes to be chosen that completely avoid any need to remove native vegetation, in most cases.

The turbine layouts presented for the southern part of the site include up to four turbine sites located in patches of remnant native vegetation. Two are in woodland and two are in Kwongan Hethland. The two in Kwongan Heathland lie close to the southern boundary of the Badgingarra National Park where several specimens of the Leseur Hakea (*Hakea megalosperma*) were found. The extent of this occurrence is limited and avoiding it during the micro-siting of turbines, access tracks and underground power cables will be possible.

Scope exists to avoid the removal of native vegetation in siting the underground power cables, in most cases. The substation location should be carefully chosen to avoid native vegetation.

If removal of native vegetation is required, then this should be planned to keep the extent of affected vegetation to minimal levels. A spring rare flora survey should be considered in any such areas and careful micro-siting of

works should be considered to avoid any rare or threatened plant species found.

9.2. Potential impacts of wind farms on birds

This sub-section of the report considers the potential impact on birds of the proposed Badgingarra Wind Farm.

Wind turbines may affect birds in three ways:

- Birds may be killed or injured by colliding with rotors, towers, guy wires, or related structures.
- Birds may avoid wind energy developments and surrounding habitat.
- The footprint of the turbines, roads, power lines, and auxiliary buildings may directly impact habitat.

9.2.1. Mortality caused by wind turbines

The impact of operating wind turbines on birds appears to be small, but mortality does occur, although it appears to be very site-specific.

Table 13 summarises reported collision rates from a range of European and North American wind farms. The rate varied between 0.04 and 3.4 birds per turbine per year. A rate of 4.3 birds per turbine per year was recorded from two wind farms in the eastern U.S. outside California. However, variation among wind farms depends on several factors, including the amount of bird use, vegetation and other physical and biological characteristics of the specific wind farm and its surrounding area.

Studies at upland sites in the UK have generally reported very low collision rates, with some studies finding no collisions at all. This probably reflects the generally low bird densities present in these areas.

Overall it is clear that birds are generally able to avoid collisions and do not simply blindly fly into wind turbines. Collision rates typically in range of only 1 in 1,000-10,000 bird flights through wind farm, even in studies such as Zeebrugge where relatively high numbers of collisions have been reported.

Studies using radar tracking have helped to provide further information on birds' general ability to avoid collisions. Dirksen *et al.* (1998), for example, showed that Pochard (*Aythya farina*) and Tufted Duck (*Aythya fuligula*) flew regularly through a wind farm in the Netherlands at night under moonlight but flew around the turbines at greater distance from them when it was dark and foggy.

Analysis of North American and European bird collisions at wind farms (Erickson *et al* 2001; Percival 2003; NWCC 2004) shows that bird species affected by operational turbines varied but mostly depended on the type of habitat on which the wind farm is built (Table 13). Most wind farm bird mortality was due to migrating birds. The Northern Hemisphere has a large number of both species and individuals of this bird group due to the large area of land at high latitudes that becomes unsuitable for birds in winter. Australia's geography and latitude means that there are few night-migrating

birds. For this reason, the numbers of birds likely to collide with operating wind farms in Australia would be about half that in Europe and North America.

It is also clear, however, that bird collisions with wind turbines can be a problem under some circumstances. It would seem from the evidence available from existing wind farms that there are two main types of sites that have had collision problems:

1. Sites with large raptors occurring regularly within the wind farm at the same height as the rotor blades. In Australia the main species that would fall into this category would be Wedge-tailed Eagle and Nankeen Kestrel.
2. Sites with very high densities of other birds flying at rotor height. These could include seabird breeding colonies and feeding concentrations, and wetlands (including coastal sites) with large waterfowl concentrations, and significant migration flyways (mainly a northern hemisphere phenomenon).

Table 13: Summary of bird mortality estimates for wind farms in Europe and North America (Sources: Erickson *et al* 2001; Percival 2003; NWCC 2004).

Site	Habitat	Species present	Size of Wind farm	Collision rate*
USA sites (review of 12 projects outside California)	Various	Various	Mixed	2.3 (1.5–4.3)
Altamont, California	Ranch land	Raptors	VL	0.05– 0.06
Buffalo Ridge (all phases), Minnesota, USA	Various	Waterfowl & passerines	L	2.83
Tarifa, S. Spain	Coastal Hills	Raptors, storks and many migrants	VL	0.34
Navarre, Spain	Inland hills	Various, including raptors and passerines	VL	0.34
Burgar Hill, Orkney	Coastal moorland	Upland species	S	0.15
Blyth, Northumberland	Coastal Shoreline	Shorebirds	S	2.52
Zeebrugge, Belgium	Coastal shoreline	Gulls, terns & migrants	M	11–29**
Bryn Tytli, Wales	Upland moorland	Upland species, including peregrine falcon	M	0.0
Cemmaes, Wales	Upland moorland	Upland species	M	0.04
Urk, Netherlands	Coastal-on dyke wall	Waterfowl	M	1.7
Oosterbierum, Netherlands	Coastal-on Dyke wall	Waterfowl & migrants	M	1.8
Kreekrak, Netherlands	Coastal-on dyke wall	Waterfowl	S	3.4
Ovenden Moor, S. Pennines	Upland moorland	Upland species	M	0.04
Tjaereborg, Denmark	Coastal	Waders and gulls	S	3.0
Nasudden, Gothland,	Coastal	Waterfowl, including	L	0.7

Site	Habitat	Species present	Size of Wind farm	Collision rate*
Sweden	marsh & arable	breeding waders & migrants		
Utgrunden	Offshore	Eiders	S	0.0

Collision rate = Number of birds killed per turbine per year; all rates are corrected for observer efficiency and scavenging rate.
** The study included high correction factors (detecting only 11% of collisions).
VL=very large (>200 turbines); L=large (50–200); M=medium (10–50); S=small (<10).

9.2.2. Australian studies

Experience at wind farms in Australia is informative. Monitoring results in the public domain include:

- Codrington (14 generators): 3 birds (2.5 years, weekly, monthly or six-weekly searches);
- King Island (3 generators): 1 bird (5 years, weekly – monthly searches);
- Woolnorth (6 generators): 8 birds, <1 year, daily to weekly searches);
- Toora Wind farm (12 generators): 2 birds (2 years – monthly searches); and
- Starfish Hill (23 generators): 2 birds (2 years – monthly searches).

(Source: Meredith, C [2003] Australian Wind Energy Association presentation, Sydney, July 2003; Brett Lane and Associates, unpublished reports).

Allowing for observer efficiency and scavenger correction, these figures corresponded to a collision rate of between one and four birds per generator per year.

The Australian wind farms, which were monitored for bird mortality, are mostly in agricultural settings although all are located on or close to the coast. Birds that fatally collided with turbines were mostly farmland birds, except at Woolnorth, where the list included three marine species. Bird mortality at these wind farms varied between two to four birds/turbine/year.

9.2.3. Indirect habitat disturbance

The second potential impact of wind farms on birds is through displacement from an area around the wind turbines, effectively resulting in habitat loss. Numerous studies have investigated this potential problem, with a range of results. In many cases, no significant disturbance effect at all has been detected, including studies at upland, coastal and offshore wind farms (Percival 2003) (see Table 14). European studies suggest that most displacement involves migrating, resting and foraging birds. Studies have reported displacement effects ranging from 75 m to as far as 800 m away from turbines and up to 300 m for breeding birds (Percival 2003; Strickland 2004). Often studies have had confounding factors, such as increased human disturbance, lack of habitat studies to determine birds' preferences in relation to wind farm location, and lack of proper statistical testing/experimental design.

While birds appear to avoid flying near turbines, the presence of these structures does not seem to deter birds from their foraging areas (Danish Wind Industry Association 2001). Breeding birds appear to have a greater tolerance to turbines than migrating birds. Local breeding populations of waterfowl, grouse, shorebirds, gulls and passerines were not significantly affected by the construction of turbines in a bog in the Orkney Islands (Meek *et al.* 1993). There was also little effect on breeding birds at other wind sites in Great Britain with many examples of birds in close proximity to wind turbines (Percival 1998).

Table 14: Studies of the possible effects that wind farms impose on birds (after Percival 2003).

Site	Habitat	Species present	Size of Wind farm	Distance affected (m)
Tjaereborg, Denmark*	Coastal grassland	Waterfowl, mainly waders and gulls	S	Max 800
Urk, Netherlands	Coastal-on dyke wall	Waterfowl, including geese and swans	M	Max 300
Oosterbierum, Netherlands**	Coastal-on dyke wall	Waterfowl	M	Max 500
Vejlerne, Denmark	Farmland	Pink-footed Geese	L	1–200
Westermarsch, Germany	Farmland	Barnacle Geese	M	Max 600
Haverigg, Cumbria	Coastal grassland	Golden Plover, gulls	S	None
Blyth, Northumberland	Coastal shoreline	Cormorants, waders, gulls	S	None
Bryn Tytli, Wales	Upland moorland	Upland species, raptors	M	None
Carno, Wales	Upland moorland	Upland species	L	None
Ovenden Moor, NW England	Upland moorland	Golden Plover and Curlew	M	None
Nasudden, Gotland, Sweden	Coastal marsh	Waterfowl inc. geese and breeding waders	L	None
Various UK sites	Uplands	Lapwings, curlews, skylarks and pipits	M	None
Zeebrugge, Belgium	Coastal shoreline	Waterfowl	M	Up to 300
Novar	Upland Moorland	Upland species	M	None
Urgrunden	Offshore	Long-tailed Duck	S	None

* Breeding lapwing up to 300 m.
** No effect on breeding waders.
L=large (50–200 turbines); M=medium (10–50); S=small (<10).

9.2.4. Direct habitat disturbance

There are a variety of direct, long-term and short-term non-collision impacts that wind farms may have on birds and other vertebrate fauna. Direct loss of habitat results from the construction of turbine pads, roads, underground power cables and substations. Long-term habitat impacts result from the construction of relatively permanent structures that remove habitat for the life

of the project and short-term impacts occur while habitat is disturbed temporarily during construction of the wind farm.

Examples of impacts could be found in studies from some American wind farms. Temporary impacts from the construction of roads, turbine pads and substation were 0.4, to 2.6 acres per turbine or 0.6 to 1.7 acres per MW. Long-term impacts from permanent facilities were o.7 to 1 acre per turbine, or 0.4 to 0.7 acres per MW (Strickland 2004). The overall magnitude of impacts and the potential for successful reclamation of sites depends on the ecological context and characteristics of the site, the type of turbines being built, and the design of reclamation plan. Flat sites require less topographic restructuring than rougher terrain, and arranging turbines in compact strings requires less road-building than widely dispersed turbines.

9.3. Impacts of the proposed Badgingarra Wind Farm on fauna

The fauna assessment and the bird utilisation survey have been undertaken to inform a fauna impact assessment of the proposed Badgingarra Wind Farm. The potential impacts of the project are discussed below.

9.3.1. Impacts on Birds

The proposed wind farm site is a largely altered agricultural landscape supporting a low density and diversity of predominantly opportunistic and adaptable native bird species and some woodland, heathland and wetland bird species.

Studies of wind farms in many parts of the world indicate that the rate of bird collisions is between 0.04 and 4 birds per turbine per year. Similar collision rates have been observed at Australian wind farms. The proposed Badgingarra Wind Farm is broadly comparable in terms of bird habitat characteristics and setting to other wind farms in southern Australia and a similar level of mortality of common farmland birds is expected. A wind farm of up to 65 turbines could therefore lead to collisions involving between three and 260 birds per turbine per year. The bird utilisation survey results show that this would involve mostly common farmland birds.

The site had fewer birds flying at rotor swept area height than comparable wind farms in South Australia and Victoria (BL&A, unpublished data). Therefore, collision rates would be expected to be at the lower end of the range of collision rates observed in Australia (i.e. closer to one than four birds per turbine per year).

Use of the proposed wind farm site by migratory species has been considered. These birds are summer visitors to the area. Based on the location of the proposed wind farm and the known summer distribution of migratory species listed on the EPBC Act and their habitat requirements, significant impacts on regional populations of these species are not expected to occur as the species of concern (Great Egret, Rainbow Bee-eater) are likely to occur very rarely over the site.

No threatened bird species is considered likely to occur regularly on the proposed wind farm site, so impacts are unlikely. The exception is the Carnaby's Black-Cockatoo, which is discussed below.

9.3.2. Impacts on the Carnaby's Black-Cockatoo

The proposed wind farm has the potential to impact on the nationally endangered Carnaby's Cockatoo through a combination of one or both of:

- Collision with operating wind turbines while flying through the site;
- Direct removal of habitat;
- Indirect disturbance from the proposed wind farm, preventing access to foraging habitat on the site (the 'quarantine' effect); and
- Barrier effects that may prevent access to resources around and on the proposed wind farm site.

The probability of significant impacts arising from these effects is explored below.

Collision risk

The cockatoos were seen in many parts of the site and their preferred habitat is Kwongan Heathland, planted trees and woodlands. During the bird utilisation survey at the site, the Carnaby's Black-Cockatoo was recorded once from observation points, which were located where turbines are proposed to be sited. The cockatoos were regularly observed feeding in remnant heathland in paddocks and along roadside verges. They were not seen flying above tree height (10 metres) and generally preferred to fly low in the more sheltered parts of the site, between ridges and along gullies. No foraging habitat exists near most of the turbine locations in the proposed wind farm, with exotic pasture grass dominating the landscape in these localities.

The observations during site studies of the behaviour, habitat choice and movements of the Carnaby's Black-Cockatoo suggest strongly that it utilises the site in a particular way, generally avoiding the higher parts of the landscape that lack habitat, where most wind turbines are proposed to be located.

During the current site investigations, a detailed mortality monitoring program was underway at the nearby Emu Downs Wind Farm (within 5 km of the site and south of Bibby Road). Monitoring had commenced in late January and was completed at the end of April. This included detailed searches under operating wind turbines for collision-related fatalities. No cockatoo fatalities were recorded, despite significant numbers occurring in the region at the time. In addition, Carnaby's Black-Cockatoos were observed in a number of nearby locations but very few were observed within the operating wind farm, suggesting significant avoidance of operating wind turbines.

Of further interest in this assessment is the observation at the Toora Wind Farm in Victoria that the closely related and behaviourally similar Yellow-tailed Black-Cockatoo (*C. funereus*) occurred regularly on the site before the wind

farm was constructed but avoided the site after the wind farm commenced operations.

If the Carnaby's Black-Cockatoo reacts in the same way then avoidance of wind turbines is a significant factor reducing the likelihood of collision risk. There is some justification for using the closely related Yellow-tailed Black-Cockatoo as an analogue in this discussion. Both species move about the landscape in search of food on a seasonal and/or nomadic basis. Both species forage on the seeds of trees, and both have adapted to obtaining food from introduced pine trees (*Pinus* spp.). They are taxonomically, anatomically, behaviourally and ecologically quite similar.

The low number of observations of the species within the existing Emu Downs Wind Farm compared with surrounding areas, notwithstanding regular observations outside the existing wind farm, suggests that the species may be avoiding a wind farm in the same way as the Yellow-tailed Black-Cockatoo has been observed to.

This, combined with the low occurrence during bird utilisation surveys at turbine sites on the Badgingarra site itself, and the observed patterns of site usage there, indicate that regular collision-related mortality of the species at Badgingarra is highly unlikely.

Direct removal of habitat

A range of possible wind farm layouts within the site are shown in Appendix 5. In Figure 4, the location of potential Carnaby's Black-Cockatoo habitat in relation to the wind farm site has been shown. Turbines have been sited on the highest ridges and these generally lack remnant native vegetation and are dominated by exotic pasture, including introduced pasture species of limited value to the Carnaby's Black-Cockatoo. Turbines and access tracks are capable of being located in agricultural areas that avoid any need to remove remnant native vegetation for layouts that involve the north and north-east parts of the site. Here, no native vegetation or significant Cockatoo foraging habitat will be removed as a consequence of the proposed wind farm.

The two layouts that include the north and south parts of the site include up to four turbine sites that lie in areas of remnant native vegetation suitable as foraging or roosting habitat for the Carnaby's Black-Cockatoo. Their removal is unlikely to effect the cockatoo incrementally, as the area is likely to be excluded from future use by disturbance effects (see below).

Disturbance effects

A further investigation (Level Two risk assessment as per the AusWEA 2005 interim risk assessment standards) was undertaken to examine how the cockatoos were behaving around the existing Emu Downs Wind Farm, south of Bibby Road, about 5 km south of the Badgingarra project site (see Section 7.4.2). This investigation was undertaken in the first season that the species occurred in the region since this wind farm commenced operations.

The results of this investigation showed that few cockatoos occurred in potential habitats within the wind farm but that within 1 km of the wind farm,

habitats were more regularly used. This indicated that the species avoided noticeably the existing wind farm but regularly fed within 500m to 1 km of turbines. This suggested that the indirect, disturbance effect of the wind farm may extend in the order of this distance, and that some of the available habitat on the Badgingarra site would be excluded from use by the species as a consequence of disturbance by the proposed wind farm.

The area of habitat loss arising from the disturbance effect of operating wind turbines has been estimated for four alternative development layouts:

- 41 x 3 MW turbines in the north and south of the site;
- 65 x 2 MW turbines in the north and south of the site;
- 43 x 3 MW turbines in the north and north-east of the site; and
- 65 x 2 MW turbines in the north and north-east of the site.

The final layout will be one of these alternatives, as there is a cap on the generating capacity of the wind farm of 140 MW.

For each layout, the area of affected habitat has been estimated in three ways, to provide an estimate of the potential range of impacts:

- A: the area of habitat within 500m of each turbine for both the 3MW and 2MW turbine scenarios (considered the best-case scenario);
- B: The area of habitat lying within a line connecting the edges of the areas within 500m of each turbine in the two main groups of turbines (east and west); and
- C: The area of habitat within a line around the entire wind farm out to 500m from the turbines (considered the worst-case scenario).

Figures 8, 9, 10 and 11 show the area affected under these three scenarios for the four potential wind farm layouts. A range of layouts and disturbance envelopes has been analysed to show the likely magnitude of the disturbance effect on suitable habitat for the species, as well an approximate estimate of the boundaries within which this impact would lie.

Tables 15 to 18 analyse the effects each turbine layout for the three disturbance scenarios described earlier (i.e. A, B and C).

The results of this analysis show that between 290 ha and 1,400 ha of potential cockatoo habitat may be excluded from usage by the species as a consequence of the disturbance effect of the proposed wind farm.

Table 15: Area and percentage of habitat on the site affected by 65 x 2 MW turbines in the north and north east of the site.

Cockatoo Habitat	Area of existing Habitat (ha)	Area A within 500m buffer (ha)	*Percent area affected (A)*	Area B within envelopes	*Percent area affected (B)*	Area C within connected envelopes	*Percent Area affected (C)*
Woodland	1,242.60	0	*0*	0.55	*0.04*	162.49	*13.08*
Kwongan Heathland	1,804.93	394.04	*21.8*	588.89	*32.63*	786.6	*43.58*
Pines	28.59	0	*0*	3.21	*11.24*	14.65	*51.24*
Planted Eucalypts	163.77	28.02	*17.1*	60.54	*36.97*	124.27	*75.88*
Total	3,239.88	422.05	*13*	653.20	*20.16*	1088.01	*33.58*

Table 16: Area and percentage of habitat on the site affected by 43 x 2 MW turbines in the north and north east of the site.

Cockatoo Habitat	Area of existing Habitat (ha)	Area A within 500m buffer (ha)	*Percent area affected (A)*	Area B within envelopes	*Percent area affected (B)*	Area C within connected envelopes	*Percent Area affected (C)*
Woodland	1,242.60*	118.34*	*9.52*	166.43*	*13.39*	330.57*	*26.60*
Kwongan Heathland	1,804.93*	419.38*	*23.24*	551.78*	*30.57*	684.81*	*37.94*
Pines	28.59	0	*0.00*	0	*0.00*	9.62	*33.65*
Planted Eucalypts	163.77	0	*0.00*	0	*0.00*	0	*0.00*
National Park#	13,108.00	87.67	*0.67*	87.67	*0.67*	341.18	*2.60*
Total		625.39		805.88		1366.18	

Table 17: Area and percentage of habitat on the site affected by 65 x 2 MW turbines in the north and south of the site.

Cockatoo Habitat	Area of existing Habitat (ha)	Area A within 500m buffer (ha)	*Percent area affected (A)*	Area B within envelopes	*Percent area affected (B)*	Area C within connected envelopes	*Percent Area affected (C)*
Woodland	1,242.60	0	*0.00*	0	*0.00*	157.67	*12.69*
Kwongan Heathland	1,804.93	270.35	*14.98*	491.49	*27.23*	659.65	*36.55*
Pines	28.59	0	*0.00*	3.21	*11.24*	14.65	*51.23*
Planted Eucalypts	163.77	19.93	*12.17*	58.52	*35.73*	122.65	*74.89*
Total	3,239.89	290.28		553.22		954.61	

*Note that this excludes habitat in the Badgingarra National Park, adjacent to the southern part of the site.

Table 18: Area and percentage of habitat on the site affected by 41 x 3 MW turbines in the north and south of the site.

Cockatoo Habitat	Area of existing Habitat (ha)	Area A within 500m buffer (ha)	*Percent area affected (A)*	Area B within envelopes	*Percent area affected (B)*	Area C within connected envelopes	*Percent Area affected (C)*
Woodland	1,242.60*	69.90*	*5.63*	87.28*	*7.02*	301.11*	*24.23*
Kwongan Heathland	1,804.93*	227.81*	*12.62*	491.87*	*27.25*	592.75*	*32.84*
Pines	28.59	0	*0.00*	0	*0.00*	5.28	*18.47*
Planted Eucalypts	163.77	0	*0.00*	0	*0.00*	0	*0.00*
National Park#	13,108.00	85.24	*0.65*	85.24	*0.65*	260.80	*1.99*
Total		382.95		664.39		1159.94	

*Note that this excludes habitat in the Badgingarra National Park, adjacent to the southern part of the site; # Affected parts of National Park are also Kwongan Heathland

The results of this analysis show that between 290 ha and 1,400 ha of potential cockatoo habitat may be excluded from usage by the species as a consequence of the disturbance effect of the proposed wind farm.

Protected areas, totalling over 44,000 hectares, occur within 40 km of the wind farm site that support significant areas of suitable habitat, including:

- Badgingarra National Park: 13,108 ha;
- Coomallo Nature Reserve: 8,807 ha;
- Southern Beekeepers Nature Reserve: 10,808 ha;
- Nambung National Park: 8,362 ha;
- Hill River Nature Reserve: 882 ha; and
- Un-named Conservation Park: 2,369 ha.

To ascertain more accurately whether these areas and other remnant native vegetation outside the conservation reserve system supported suitable habitat for the Carnaby's Black-Cockatoo, vegetation mapping information was accessed from the Western Australian Department of Agriculture (2007). Specifically, data on the type and extent of vegetation that occurs within the region within which the proposed wind farm is sited was obtained at three scales (10 km radius, 40 km radius and 100km radius from the site). Vegetation types mapped were those that support proteaceous shrubs, the principal food plant group used by the cockatoo during dispersal between breeding and non-breeding grounds. The details of this analysis are provided in Appendix 5.

Although it is mapped at a fairly coarse scale of 1:250,000, this is the most accurate information on vegetation types and extent in southern WA from which to determine the location of potential habitat in the surrounding region and with which to place the impact of the proposed development in a wider perspective. Summarised below is the extent of suitable habitat (i.e. vegetation types that support proteaceous shrubs) within 10, 40 and 100 km of the proposed wind farm. These habitats are shown on the map in Appendix 5.

- Within 10 km: 7,967 ha, or c. 0.79 square kilometres;
- Within 40 km: 182,926 ha, or c. 18.3 square kilometres; and
- Within 100 km: 714,304 ha, or c.71.4 square kilometres.

Tables 19 to 22 below summarise the area and percentage of the region's Carnaby's Black-Cockatoo habitat subject to potential disturbance effects.

Table 19: Area of regional habitat subject to disturbance effect (65 x 2 MW turbines in north and north-east of site.

	Area affected (ha)	Area within radius from site (ha)					
		10km	*Percent affected*	40 km	*Percent affected*	100 km	*Percent affected*
500m buffer	422.06	7967	*5.30*	182926	*0.23*	714304	*0.06*
Envelopes	653.19	7967	*8.20*	182926	*0.36*	714304	*0.09*
Connected envelopes	1088.01	7967	*13.66*	182926	*0.59*	714304	*0.15*

Table 20: Area of regional habitat subject to disturbance effect (43 x 3 MW turbines in north and north-east of site.

	Area affected (ha)	Area within radius from site (ha)					
		10km	*Percent affected*	40 km	*Percent affected*	100 km	*Percent affected*
500m buffer	290.28	7967	*3.64*	182926	*0.16*	714304	*0.04*
Envelopes	553.22	7967	*6.94*	182926	*0.30*	714304	*0.08*
Connected envelopes	954.61	7967	*11.98*	182926	*0.52*	714304	*0.13*

Table 21: Area of regional habitat subject to disturbance effect (65 x 2 MW turbines in north and south of site.

	Area affected (ha)	Area within radius from site (ha)					
		10km	*Percent affected*	40 km	*Percent affected*	100 km	*Percent affected*
500m buffer	625.39	7967	*7.85*	182926	*0.34*	714304	*0.09*
Envelopes	805.88	7967	*10.12*	182926	*0.44*	714304	*0.11*
Connected envelopes	1366.18	7967	*17.15*	182926	*0.75*	714304	*0.19*

Table 22: Area of regional habitat subject to disturbance effect (43 x 3 MW turbines in north and south of site.

	Area affected (ha)	Area within radius from site (ha)					
		10km	*Percent affected*	40 km	*Percent affected*	100 km	*Percent affected*
500m buffer	382.95	7967	*4.81*	182,926	*0.21*	714,304	*0.05*
Envelopes	664.39	7967	*8.34*	182,926	*0.36*	714,304	*0.09*
Connected envelopes	1159.94	7967	*14.56*	182,926	*0.63*	714,304	*0.16*

Within 10 km of the site, between 3.6 percent (best case) and 17 percent (worst case) of habitat could be subject to disturbance effects from the wind farm layouts.

Within 40 km of the site, between 0.1 percent (best case) and 0.75 percent (worst case) of habitat could be subject to disturbance effects from the wind farm layouts.

Within 100 km of the site, between 0.04 percent (best case) and 0.2 percent (worst case) of habitat could be subject to disturbance effects from the wind farm layouts.

The 40km and 100km scales are considered a more appropriate scale at which to assess the impact of the proposed wind farm as the species' regional migration covers distances of this order within a matter of weeks. Based on observations and analysis, several hundred birds subject to disturbance effects out of a total population of 40,000 individuals (see Appendix 5). Furthermore, less than 0.2 percent of habitat in this region is likely to be effected by the proposal. Ron Johnstone (Western Australian Museum, pers. comm.) has indicated that from year to year, the Carnaby's Cockatoo uses different parts of its non-breeding range depending on food availability, which in turn depends on stochastic variables in the landscape such as rainfall and time since fire.

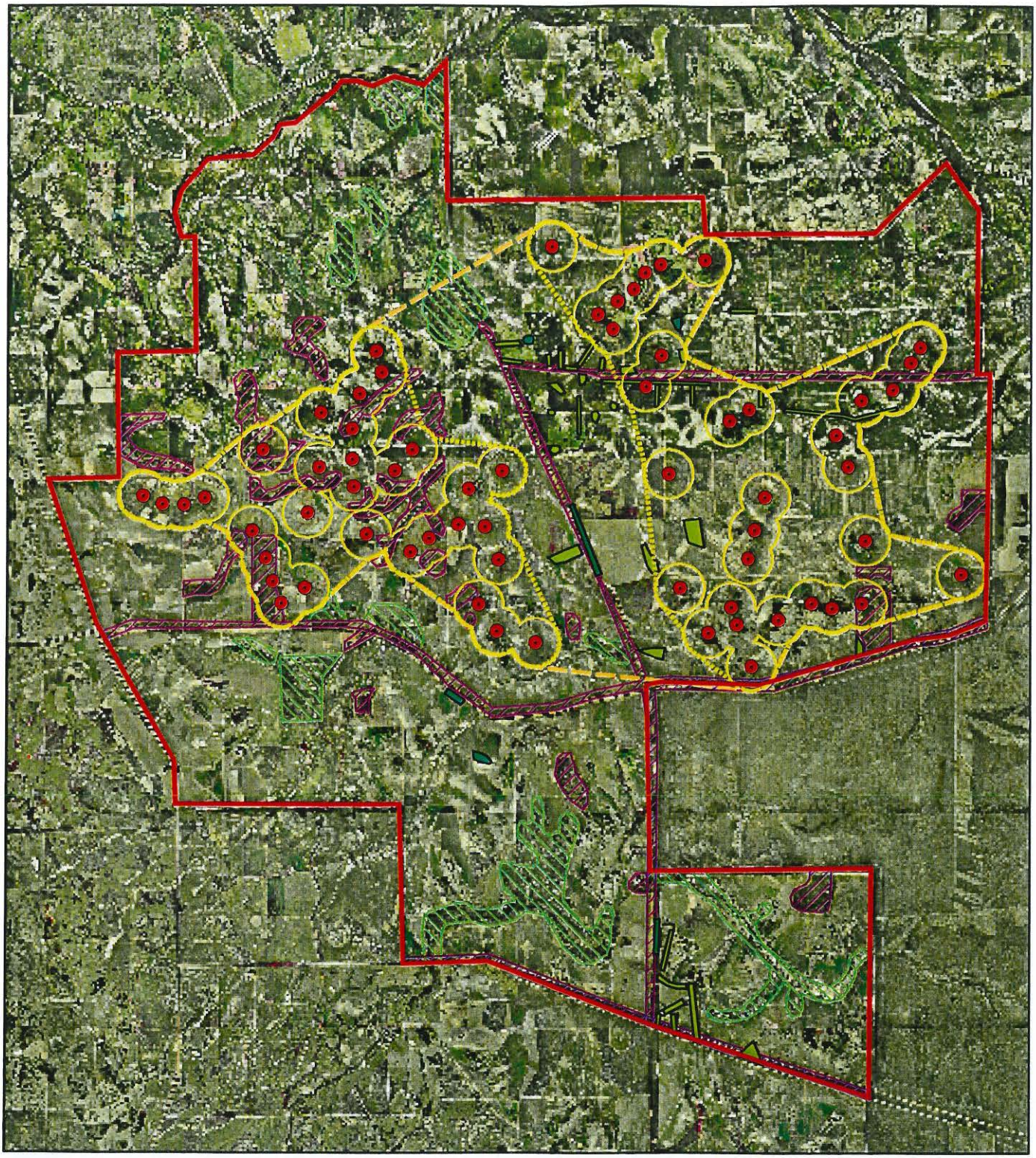
It is likely that, despite several hundred birds being exposed to disturbance effects and electing to move to alternative habitats nearby (of which there are tens of thousands of hectares available), the impact is likely to effect the population in the same way as the stochastic effects that they experience in the normal course of their annual cycle, and to which they are adapted. Therefore, the probability of a significant impact on the population of the species arising from the operation of the proposed Badgingarra Wind Farm is considered to be very low.

Barrier effect

Observations of bird movements on the site during the general bird utilisation survey and during the targeted investigation, indicate that few cross the site in any numbers. Habitats for roosting and foraging differ, with the woodland being used for roosting and the Kwongan heathland being used for foraging. The largest areas of woodland on the site lie near the northern and southern edges of the wind farm envelopes assessed (particularly in the western part of the site). Flight paths from these areas to the Badgingarra National Park to the east may be disrupted, leading to an increased flying distance to this reserve. Alternatively, such disruption may lead to the Cockatoo using the nearby parts of the Badgingarra National Park less frequently, or choosing a different site to roost, possibly in taller woodland that is known to occur east of the wind farm site. Extensive habitats to the west towards Cervantes (e.g. Southern Beekeepers Nature Reserve), would lie mostly north or south of the wind farm envelopes. This suggests that significant disruption to movements between roosting habitats on the site and the largest areas of foraging habitat to the west (see Figure 4) are unlikely to occur.

The wider, regional population of the Carnaby's Black-Cockatoo moves across a much larger area than the proposed wind farm site, as indicated by the availability of habitat in the surrounding region (see tables above and Appendix 5). Individuals are unlikely to be prevented from moving between the more extensive habitat areas in this region or between the breeding grounds to the north-east and east and more westerly non-breeding habitats as a consequence of the wind farm once it is operating.

Potential Impact of the Carnaby's Cockatoo Habitat (2 MW Turbines - Layout June 07)



Legend

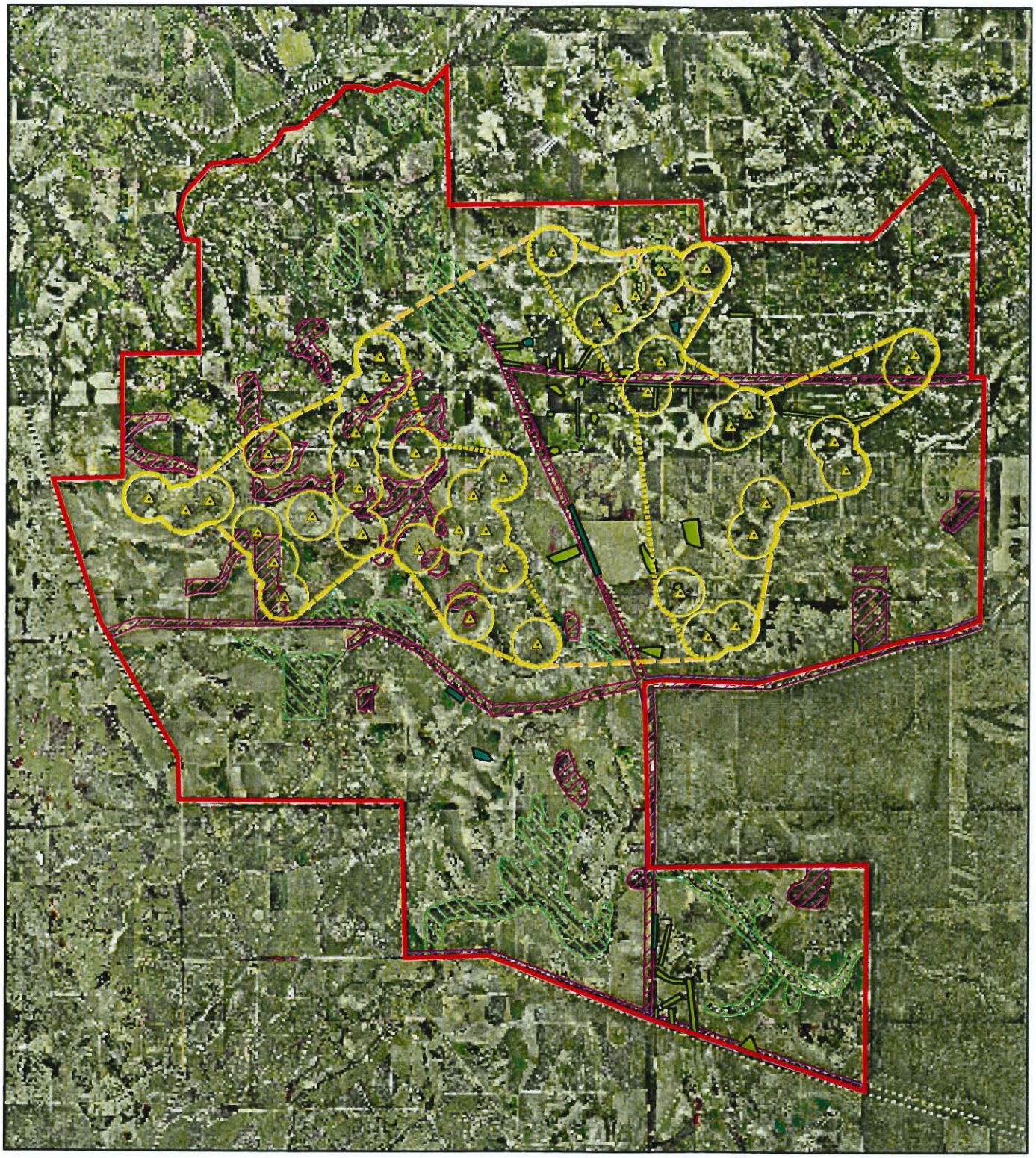
- Woodland
- Kwongan Heathland
- Planted Eucalypts
- Planted Pines
- Proposed Wind Turbine
- 500m Buffer around Wind Turbine
- Windfarm Envelope around 500 m Buffer
- Connected Envelopes
- Study Area

0 1,250 2,500 5,000 7,500 10,000 Metres

Badgingarra Wind Farm		
Figure 8: Potential Impact of the Carnaby's Cockatoo Habitat (2MW - June 07)		
Client: Enthalpy Pty Ltd		
Project No.: 7044	Date: 03/07/2007	Created by: I. Mau / B. Lane

BL&A Brett Lane & Associates Pty. Ltd. Ecological Research & Management
Experience Knowledge Solutions
605 Nicholson Street PO Box 592, Carlton North VIC 3054 Australia
ph (03) 9387 5008 | fax (03) 9387 6115
blane@ecologicalresearch.com.au
www.ecologicalresearch.com.au

Potential Impact of the Carnaby's Cockatoo Habitat (3 MW Turbines - Layout June 07)



Legend

- Woodland
- Kwongan Heathland
- Planted Eucalypts
- Planted Pines
- Proposed Wind Turbine
- 500m Buffer around Wind Turbine
- Windfarm Envelope around 500 m Buffer
- Connected Envelopes
- Study Area

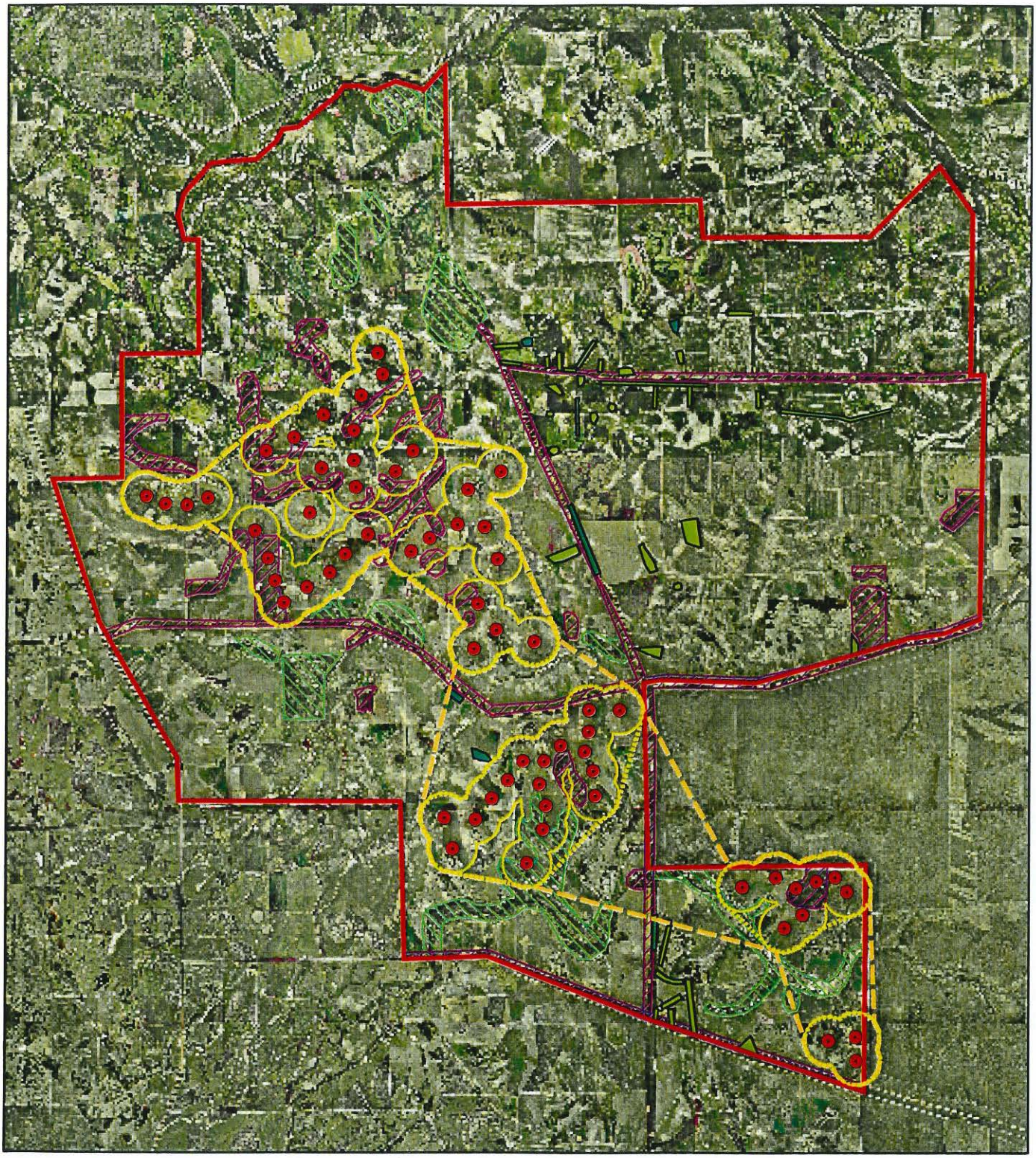
Metres

0 1,250 2,500 5,000 7,500 10,000

Badgingarra Wind Farm		
Figure 9: Potential Impact of the Carnaby's Cockatoo Habitat (3MW - June 07)		
Client: Enthalpy Pty Ltd		
Project No.: 7044	Date: 05/12/2007	Created by: I. Mau / B. Lane

BL&A Brett Lane & Associates Pty. Ltd.
Ecological Research & Management
Experience Knowledge Solutions
605 Nicholson Street PO Box 592, Carlton North VIC 3054 Australia
ph (03) 9387 5008 | fax (03) 9387 6115
blane@ecologicalresearch.com.au
www.ecologicalresearch.com.au

Potential Impact of the Carnaby's Cockatoo Habitat (2 MW Turbines - Layout Nov 07)



Legend

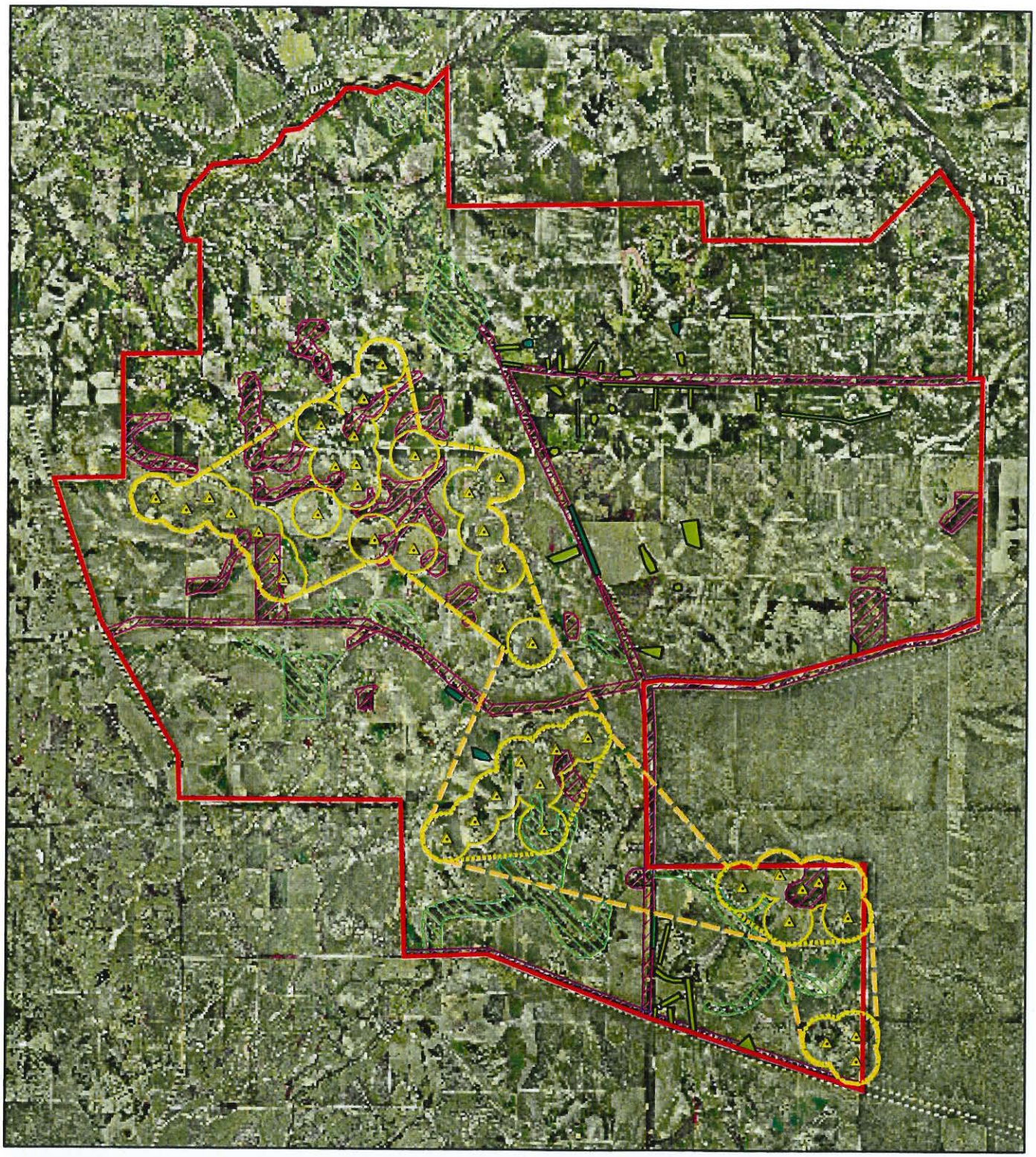
- Woodland
- Kwongan Heathland
- Planted Eucalypts
- Planted Pines
- Proposed Wind Turbine
- 500m Buffer around Wind Turbine
- Windfarm Envelope around 500 m Buffer
- Connected Envelopes
- Study Area

0 1,250 2,500 5,000 7,500 10,000 Metres

Badgingarra Wind Farm		
Figure 10: Potential Impact of the Carnaby's Cockatoo Habitat (2MW - Nov07)		
Client: Enthalpy Pty Ltd		
Project No.: 7044	Date: 21/11/2007	Created by: I. Mau / B. Lane

BL&A Brett Lane & Associates Pty. Ltd. Ecological Research & Management
Experience Knowledge Solutions
605 Nicholson Street PO Box 592, Carlton North VIC 3054 Australia
ph (03) 9387 5008 | fax (03) 9387 8115
blane@ecologicalresearch.com.au
www.ecologicalresearch.com.au

Potential Impact of the Carnaby's Cockatoo Habitat (3 MW Turbines - Layout Nov 07)



Legend

- Woodland
- Kwongan Heathland
- Planted Eucalypts
- Planted Pines
- Proposed Wind Turbine
- 500m Buffer around Wind Turbine
- Windfarm Envelope around 500 m Buffer
- Connected Envelopes
- Study Area

0 1,250 2,500 5,000 7,500 10,000 Metres

Badgingarra Wind Farm		
Figure 11: Potential Impact of the Carnaby's Cockatoo Habitat (3MW - Nov07)		
Client: Enthalpy Pty Ltd		
Project No.: 7044	Date: 21/11/2007	Created by: I. Mau / B. Lane

BL&A Brett Lane & Associates Pty. Ltd. Ecological Research & Management
Experience Knowledge Solutions
605 Nicholson Street PO Box 592, Carlton North Vic. 3054 Australia
ph (03) 9387 5008 | fax (03) 9387 6115
blane@ecologicalresearch.com.au
www.ecologicalresearch.com.au

The total area of habitat potentially excluded from access by the cockatoo as a consequence of indirect effects is a very small proportion of that available within the region.

Observations of bird movements on the site during the general bird utilisation survey and during the targeted investigation, indicate that few cross the site in any numbers. Habitats for roosting and foraging differ, with the woodland being used for roosting and the Kwongan heathland being use for foraging. The largest areas of woodland on the site lie near the northern and southern edges of the wind farm envelopes assessed (particularly in the western part of the site. Flight paths from these areas to the Badgingarra National Park to the east and extensive habitats to the west towards Cervantes (e.g. Southern Beekeepers Nature Reserve, would lie mostly north or south of the wind farm envelopes. This suggests that significant disruption to movements between the most prospective roosting habitats on the site and the largest areas of foraging habitat will not occur.

The wider, regional population of the Carnaby's Black-Cockatoo moves across a much larger area than the proposed wind farm site and individuals are unlikely to be prevented from moving between major habitat areas in the region as a consequence of the wind farm once it is operating.

Table 23: Areas of Carnaby's Black-Cockatoo habitat on the proposed Badgingarra Wind Farm site exposed to estimated deterrence effect from turbines (three cases, 65 turbine 'worst case' option).

Cockatoo Habitat	Area of existing Habitat (ha)	Area A within 500m buffer (ha)	Percent Affected by A	Area B within two envelopes	Percent Affected by B	Area C within large envelope	Percent affected by C
Woodland	1,242.60	0	0	0.55	0.04	162.49	13.08
Kwongan Heathland	1,804.93	394.04	21.8	588.89	32.63	786.6	43.58
Pines	28.59	0	0	3.21	11.24	14.65	51.24
Planted Eucalypts	163.77	28.02	17.1	60.54	36.97	124.27	75.88
Total	3,239.88	422.05	13	653.20	20.16	1088.01	33.58

9.3.3. Impacts on Other Vertebrate Fauna

Impacts on the other vertebrate fauna groups are likely to arise only as a consequence of the removal of remnant native vegetation and planted treed habitats. The removal of this vegetation is discussed in detail earlier, in Section 9.1. Impacts on indigenous habitats for fauna are considered to be minimal as avoiding the need to remove any native vegetation and habitat is considered feasible.

No threatened species of mammals, reptiles or amphibians were recorded at the site during the current assessment. No threatened mammal reptile or frog species are expected to regularly occur at the study site (Section 5.3.2).

9.4. Legislative implications

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) contains a list of threatened fauna species that are considered to be of national conservation significance. It also contains mechanisms for the protection of migratory species (e.g. migratory birds). Any impacts on these species may potentially be deemed as significant and require approval under the EPBC Act.

One nationally threatened bird species was observed on the site and is considered to regularly occur. The Carnaby's Black-Cockatoo is considered to be nationally endangered under the Commonwealth EPBC Act, listed as endangered in Western Australia (WATSSC 2003) and listed under the state *Wildlife Conservation Act 1950.* It is also listed as endangered in the Action Plan for Australian Birds (Garnett and Crowley 2000).

A referral under the EPBC Act is currently being submitted to the Commonwealth.

Impacts on listed migratory species under the EPBC Act (e.g. Great Egret, Fork-tailed Swift and Rainbow-Bee-eater) would be negligible at the proposed wind farm due to the very low rates of utilisation by these species at the site.

9.5. Conclusions

A flora and fauna assessment, bird utilisation survey and a targeted Carnaby's Black-Cockatoo investigation have been undertaken at the proposed Badgingarra Wind Farm site to enable a level one and two bird risk assessment of the project, and an assessment of potential flora and fauna impacts. This approach is consistent with the interim risk assessment standards for birds and wind farms issued by the Australian Wind Energy Association (AusWEA 2005).

The conclusions from this investigation are summarised below.

- The proposed wind farm site supports predominantly exotic pasture grasses. Some sections of the site support Kwongan heathland and grassy woodland communities, particularly along some of the ridges and steep slopes. The proposed turbine locations avoid these areas. Given the predominance of cleared country, it is feasible to locate access tracks underground power cables and the sub station in a way that avoids any requirement to remove native vegetation.
- The site is a largely altered agricultural landscape supporting a low diversity of predominantly opportunistic and adaptable native bird species and potentially one introduced bird species. The site supports species and relative abundances of birds comparable with similar farmland settings elsewhere in Western Australia. The site supports few birds of prey and waterbirds, groups considered vulnerable to collision with operating wind

turbines. Studies of wind farms in many parts of the world indicate that the rate of bird collision is between 0.04 and 4 birds per turbine per year. Rates of between 1 and 4 birds per turbine per year have been observed at Australian wind farms. The proposed Badgingarra Wind Farm had fewer birds flying at rotor swept area height than comparable wind farms in South Australia and Victoria. Therefore, collision rates would be expected to be at the lower end of the range of collision rates observed in Australia (i.e. closer to one than four birds per turbine per year).

- The site lies within the territory of one or two pairs of Wedge-tailed Eagles. Significant impacts on this species are not anticipated from the wind farm due to the comparatively low level of eagle usage.
- The Carnaby's Black-Cockatoo, a nationally endangered species, was the only threatened bird species observed on or near the wind farm site and it is expected to occur regularly in the area. Further investigations were undertaken and it was concluded that the cockatoo avoids turbines and that the probability of regular collision with wind turbines is very low. A disturbance effect was observed associated with the existing Emu Downs Wind Farm. The distance over which this effect was observed was up to 500 meters. Within the proposed Badgingarra Wind Farm site and within 500m from the outer turbines, between 400 and 1,100 hectares of potential habitat may be excluded from use by the cockatoo. The area of habitat involved is a very small proportion of the tens of thousands of hectares of potential habitat available within 20 km of site. Therefore, the risk from the project to the regional non-breeding habitat of the species is considered to be low. A referral under the EPBC Act is being submitted to the Commonwealth.
- The risk to birds from the proposed Badgingarra Wind Farm is considered to be low due to the low utilisation rates of birds compared with elsewhere. At wind farm sites elsewhere in southern South Australia and Victoria where surveys have recorded higher bird utilisation rates before commissioning, collision rates have generally been less than two birds per turbine per year. This is at the lower end of results for wind farms overseas (see Section 9.2). At the proposed Badgingarra Wind Farm, the rate of bird collision is likely to be less than this and involve common farmland species of negligible conservation significance.
- No threatened mammals (including bats), reptiles or frogs were recorded on the site and those present were common species and none are expected to regularly occur at the study site.

In conclusion, the effects on flora and fauna of the proposed wind farm are not expected to be of significant conservation concern. Applicable legislation and policies related to biodiversity conservation can be met, subject to careful consideration to positions of turbines and access tracks to avoid the removal of native vegetation and fauna habitat.

10. REFERENCES

Atkins, K.J. (2006). *Declared Rare and Priority Flora List for Western Australia, 30 June 2006.* Dept of Conservation and Land Management. Como, W.A.

Australian Wind Energy Association. 2005. Wind Farms and Birds: Interim Standards for Risk Assessment. Report prepared by: Brett Lane and Associates and AIRA Professional Services; Report No. 2003.35(2.2), July 2005.

Australian Wind Energy Association. 2006. 'Best Practice Guidelines for Implementation of Wind Energy Projects in Australia.' AusWEA, Melbourne.

ARC 2007. *Frogs of Australia.* http://www.frogs.org.au/ofWA/the_Heartlands. Amphibian Research Centre, Werribee, Victoria.

Barrett, G. *et al.* 2003. The New Atlas of Australian Birds. Birds Australia, Melbourne.

Cale, B. 2003. *Carnaby's Black-Cockatoo (Calyptorhynchus latirostris) Recovery Plan 2002-2012.* Department of Conservation and Land Management, Western Australian Threatened Species and Communities Unit, Wanneroo.

Cogger, H. G. 2000. *Reptiles and Amphibians of Australia,* Reed New Holland, Sydney.

Danish Wind Industry Association 2001. Birds and Wind Turbines. URL: http://www.windpower.dk/tour/env/birds.html.

De Rebeira, C.P.S. and De Rebeira, A.M. 1977. Birds. In: *The Natural History of the Wongan Hills.* (Ed) K.F. Kenneally. Western Australian Naturalist's Club, Perth.

Dirksen, S. Spaans, A.L., and Winden, v.d.J. 1998. Nocturnal collision risks with wind turbines in tidal and semi-offshore areas. In Wind Energy and Landscape. Proc. 2nd European and African Conference on Wind Engineering, 1997., 99–108.

DEWR 2007. *EPBC Act Protected Matters Search Tool.* http://www.deh.gov.au/erin/ert/epbc/imap/map.html. Australian Government, Department of the Environment and Water Resources (formerly Department of the Environment and Heritage), Canberra.

Erickson, W.P., Johnson, G.D.; Strickland, M.D.; Young, D.P. Jr; Sernka, K.J., and Good, R.E. 2001. Avian collisions with wind turbines: a summary of existing studies and comparisons to other sources of avian collision mortality in the United States.' Resource Document of the National Wind Coordinating Committee, Washington.

Garnett, S.T. and Crowley, G.M. 2000. *The Action Plan for Australian Birds.* Environment Australia, Canberra.

Higgins, P.J. (Ed.) 1999. *Handbook of Australian, New Zealand and Antarctic Birds: Volume 4 Parrots to Dollarbirds*, Oxford University Press, Melbourne.

Johnstone, R.E. and Storr, G.M. 1998. *Handbook of Western Australian Birds, Volume I, Non-passerines (Emu to Dollarbird).* Western Australian Museum, Perth.

Langeston, R.H.W., and Pullan, J.D. 2002. Wind farm and birds: An analysis of the effects of wind farms on birds and guidance on environmental assessment criteria and site selection issues. Report written by BirdLife on behalf of the Bern Convention.

Marchant, S. and Higgins, P.J. 1990. *Handbook of Australian, New Zealand and Antarctic Birds: Volume 1 Ratities to Ducks,* Oxford University Press, Melbourne.

Marchant, S. and Higgins, P.J. 1993. *Handbook of Australian, New Zealand and Antarctic Birds: Volume 2 Raptors to Lapwings.* Oxford University Press, Melbourne.

Mawson, P.R. 1995. Observations of nectar feeding by Carnaby's Black-Cockatoo *Calyptorhynchus latirostris. Western Australian Naturalist* 20: 93-96.

Meek, E.R., Ribbands, J.B., Christer, W.G., Davt, P.R., and Higginsin, I. 1993. The effects of aerogenerators on moorland bird populations in the Orkney Islands, Scotland. Bird Study 40: 140–143.

Menkorst, P. and Knight, F. 2001. *A Field Guide to the Mammals of Australia.* Oxford University Press, Melbourne.

Meredith, C. 2003. Australian Wind Energy Association presentation, Sydney, July 2003

NWCC 2004. Wind Turbine Interactions with Birds and Bats: A summary of Research Results and Remaining Questions. National Wind Coordinating Committee, 2004.

Percival, S.M. 1998. Birds and Wind Turbines: managing potential planning issues. Proc. Of the 20th British Wind Energy Association Conference, Univ. of Sutherland, UK.

Percival, S.M. 2003. Birds and Wind farms in Ireland: A review of potential issues and impact assessment. Consultant Report, Durham, UK.

Saunders, D.A. 1975. Subspeciation in the White-tailed Black Cockatoo, *Calyptorhynchus baudinii,* in Western Australia. *Australian Wildlife Research* 1: 55-69.

Saunders, D.A. 1977. The effect of agricultural clearing on the breeding success of the White-tailed Black Cockatoo. *Emu* 77: 180-184.

Saunders, D.A. 1980. Food and movements of the short-billed form of the White-tailed Black Cockatoo. *Australian Wildlife Research* 7: 257-269.

Saunders, D.A. 1982. The breeding behaviour and biology of the short-billed form of the White-tailed Black Cockatoo *Calyptorhynchus funereus. Ibis* 124: 422-455.

Saunders, D.A. 1986. Breeding season, nestling success and nestling growth in Carnaby's Black-Cockatoo, *Calyptorhynchus funereus latirostris,* over 16

years at Coomallo Creek, and a method for assessing the viability of populations in other areas. *Australian Wildlife Research* 13: 261-273.

Saunders, D.A. and Ingram, J.A. 1987. Factors affecting survival of breeding populations of Carnaby's Black-Cockatoo *Calyptorhynchus funereus latirostris* in remnants of native vegetation. In: *Nature Conservation: The Role of Remnants of Native Vegetation.* pp. 249-258. (Eds) D.A. Saunders, G.W. Arnold, A.A. Burbidge & A.J.M. Hopkins, Surrey Beatty & Sons, Chipping Norton.

Saunders, D. and Ingram, J. 1995. *Birds of Southwestern Australia: An Atlas of Changes in the Distribution and Abundance of Wheatbelt Avifauna.* Surrey Beatty & Sons, Chipping Norton.

Scott, J.K. and Black, R. 1981. Selective predation by White-tailed Black Cockatoos on fruit of *Banksia attenuata* containing the seed-eating weevil *Alphitopis nivea. Australian Wildlife Research* 8: 421-430.

Storr, G. 1991. Birds of the South-West Division of Western Australia. R*ecords of the Western Australian Museum* Supplement No. 35.

Strickland, D. 2004. Overview of Non-Collision Related Impacts From Wind Projects. In: American Wind Energy Association and American Bird Conservancy. Proc. Wind Energy and Birds/Bats Workshop. Washington, DC, May 18–19, 2004.

Talbot, J. and Talbot, V. 1989. *Tas. Bird Rep.* 18: 30-31.

United States Department of Fish and Wildlife Services. 2003. Interim Guidance on avoiding and minimizing wildlife impacts from wind turbines. Washington, DC, May 2003.

Van Leeuwen, S.J. and Lamont, B.B. 1996. Floral damage by animals and its impact on reproductive success in *Banksia tricuspis* Meisner (Proteaceae). In*: Gondwanan Heritage: Past, Present and Future of the Western Australian Biota.* (Eds) S.D. Hopper, J.A. Chappill, M.S. Harvey & A.S. George. Surrey Beatty & Sons, Chipping Norton.

Wilson, S. and Swan, G. 2003. *A complete guide to reptiles of Australia.* Reed New Holland, Sydney.

WATSSC 2003, *Threatened Fauna Ranking,* endorsed by WA Threatened Species Scientific Committee.

Appendix 1: Incidental list of flora species recorded at the proposed Badgingarra Wind Farm site.

Origin	Scientific Name	Common Name
	Acacia stenoprion	
	Acacia drumondii	
	Acacia pulchella	
	Acacia stenoptera	
	Actinostrobus acuminatus	
	Allocasuarina humilis	
*	*Arctotheca calendula*	Cape Weed
	Banksia attenuata	
	Banksia candolleana	
	Banksia chamaephyton	
	Banksia sphaerocarpa	
	Calothamnus sanguineus	
	Caustis dioica	
	Conostylis sp.	
	Dasypogon bromeliifolius	
	Daviesia daphnoides	
	Daviesia decurrens	
	Daviesia epiphyllum	
*	*Dittrichia graveolens*	Stinkwort
	Dryandra armata var. armata	
	Dryandra bipinnatifida	
	Dryandra carlinoides	
	Dryandra kippistiana	
	Dryandra sclerophylla	
	Dryandra shuttleworthiana	
	Dryandra stenoprion	
	Dryandra tortifolia	
*	*Echium plantagineum*	Patterson's Curse
	Eremea beaufortioides	
	Eucalyptus camaldulensis	River Red Gum
	Eucalyptus calophylla	Marri
	Eucalyptus patens	Blackbutt
	Gastrolobium bidens	
	Gastrolobium oxylobioides	
	Grevillea amplexicaulis	
	Haemodorum simplex	
	Hakea auriculata	
	Hakea conchifolia	
	Hakea incrassata	
	Hakea prostrata	
	Hakea ruscifolia	
	Hakea stenocarpa	

Origin	Scientific Name	Common Name
	Hakea trifurcata	
	Hibbertia sp.	
*	*Hordeum geniculatum*	Barley Grass
	Kingia australis	
	Lambertia multiflora	
*	*Lupinus cosentinii*	Lupin
	Macropidia fuliginosa	
	Mesomelaena tetragona	
	Melaleuca pressiana	
	Petrophile drumondii	
	Petrophile linearis	
	Petrophile macrostachya	
	Petrophile teretifolia	
	Strangea cynanchicarpa	
*	*Trifolium* sp.	Subterranian Clover
	Xanthorrhoea preisii	

Notes: * - introduced species; sp. – species.

APPENDIX 2: List of fauna that could potentially occur at the proposed Badgingarra Wind Farm site.

	Common name	Scientific Name	Recorded	EPBC	WATSSC	WC
		Birds				
	Australasian Grebe	*Tachybaptus novaehollandiae*	X			
	Australian Hobby	*Falco longipennis*	X			
	Australian Kestrel	*Falco cenchroides*	X			
	Australian Magpie	*Cracticus tibicen*	X			
	Australian Pipit	*Anthus australis*	X			
	Australian Raven	*Corvus coronoides*	X			
	Australian Reed Warbler	*Acropcephalus stentoreus*				
	Australian Ringneck	*Platycercus zonarius*	X			
	Australian Shelduck	*Tadorna tadornoides*	X			
	Australian Spotted Crake	*Porzana fluminea*				
	Australian White Ibis	*Threskiornis molucca*	X			
	Australian Wood Duck	*Chenonetta jubata*	X			
	Banded Lapwing	*Vanellus tricolor*	X			
	Barn Owl	*Tyota alba*	X			
	Black Swan	*Cygnus atratus*				
	Black-faced Cuckoo Shrike	*Coracina novaehollandiae*	X			
	Black-faced Woodswallow	*Artamus cinereus*	X			
	Black-fronted Dotterel	*Charadrius melanops*	X			
	Black-shouldered Kite	*Elanus caeruleus*	X			
	Black-tailed Native-hen	*Gallinula ventralis*				
	Black-winged Stilt	*Himantopus himantopus*				
	Blue-breasted Fairy-wren	*Malurus pulcherrimus*	X			
	Brown Falcon	*Falco berigora*	X			
	Brown Goshawk	*Accipiter fasciatus*				
	Brown Honeyeater	*Lichmera indistincta*	X			
	Brown-headed Honeyeater	*Melithreptus brevirostris*	X			
	Brown Songlark	*Cinclorhamphus cruralis*				
	Brush Bronzewing	*Phaps elegans*	X			
	Buff-banded Rail	*Gallirallus philippensis*				
	Carnaby's Cockatoo	*Calyptorhynchus latirostris*	X	E	E	L
	Collared Sparrowhawk	*Accipiter cirrocephalus*	X			
	Crested Bellbird	*Oreoica gutturalis*				
	Crested Pigeon	*Ocyphaps lophodes*	X			
	Elegant Parrot	*Neophema elegans*				
	Emu	*Dromaius novaehollandiae*	X			
	Galah	*Cacatua roseicapilla*	X			
	Great Cormorant	*Phalacrocorax carbo*				
	Great Egret	*Ardea alba*		M		
	Grey Butcherbird	*Cracticus torquatus*	X			
	Grey Fantail	*Rhipidura fuliginosa*	X			
	Grey Shrike-thrush	*Colluricincla harmonica*	X			
	Grey Teal	*Anas gracilis*	X			
	Hoary-headed Grebe	*Poliocephalus poliocephalus*				
	Hooded Robin	*Melanodryas cucullata*	X			
	Horsfield's Bronze Cuckoo	*Chrysococcyx basalis*				

	Common name	Scientific Name	Recorded	EPBC	WATSSC	WC
	Inland Thornbill	*Acanthiza apicalis*	X			
*	Laughing Dove	*Streptopelia senegalensis*				
	Little Black Cormorant	*Phalacrocorax sulcirostris*				
	Little Crow	*Corvus mellori*	X			
	Little Eagle	*Aquila morphnoides*				
	Little Grassbird	*Megalurus gramineus*				
	Little Pied Cormorant	*Phalacrocorax melanoleucos*				
	Little Wattlebird	*Anthochaera lunulata*	X			
	Magpie Lark	*Grallina cyanoleuca*	X			
	Mistletoebird	*Dicaeum hirundinaceum*	X			
	New Holland Honeyeater	*Phylidonyris novaehollandiae*	X			
	Orange Chat	*Ephthianura aurifrons*				
	Pacific Black Duck	*Anas superciliosa*	X			
	Pallid Cuckoo	*Cucullus pallidus*				
	Pied Butcherbird	*Cracticus nigrogularis*	X			
	Rainbow Bee-eater	*Merops ornatus*		M		
	Red Wattlebird	*Anthochaera carunculata*	X			
	Red-capped Plover	*Charadrius ruficapillus*				
	Red-capped Robin	*Petroica goodenovii*	X			
	Red-winged Fairy-wren	*Malurus elegans*	X			
	Regent Parrot	*Polytelis anthopeplus*				
	Rufous Fieldwren	*Calamanthus campestris*	X			
	Rufous Whistler	*Pachycephala rufiventris*	X			
	Sacred Kingfisher	*Todiramphus sanctus*				
	Scarlet Robin	*Petroica multicolor*				
	Shining Bronze Cuckoo	*Chrysococcyx lucidus*				
	Shy Heathwren	*Sericornis cautus*	X			
	Silvereye	*Zosterops lateralis*	X			
	Singing Honeyeater	*Lichenostomus virescens*	X			
	Southern Boobook	*Ninox novaeseelandiae*	X			
	Southern Emu-wren	*Stipiturus malachurus*	X			
	Spiney-cheeked Honeyeater	*Acanthagenys rufogularis*	X			
	Splendid Fairy-wren	*Malurus splendens*				
	Spotted Harrier	*Circus assimilis*	X			
	Straw-necked Ibis	*Threskiornis spinicollis*	X			
	Striated Pardalote	*Pardalotus striatus*	X			
	Stubble Quail	*Coturnix pectoralis*	X			
	Swamp Harrier	*Circus approximans*				
	Tawny Frogmouth	*Podargus strigoides*				
	Tawny-crowned Honeyeater	*Phylidonyris melanops*	X			
	Tree Martin	*Hirundo nigricans*	X			
	Varied Sittella	*Daphoenositta chrysoptera*	X			
	Wedge-tailed Eagle	*Aquila audax*	X			
	Weebill	*Smicrornis brevirostris*	X			
	Welcome Swallow	*Hirundo neoxena*	X			
	Western Corella	*Cacatua pastinator butleri*	X			
	Western Gerygone	*Gerygone fusca*	X			
	Western Spinebill	*Acanthorhynchus*				

	Common name	Scientific Name	Recorded	EPBC	WATSSC	WC
		superciliosus				
	Western Thornbill	*Acanthiza inornata*	X			
	Whistling Kite	*Haliastur sphenurus*				
	White-backed Swallow	*Cheramoeca leucosternus*	X			
	White-browed Scrubwren	*Sericornis frontalis*	X			
	White-cheeked Honeyeater	*Phylidonyris nigra*	X			
	White-faced Heron	*Ardea novaehollandiae*	X			
	White-fronted Chat	*Epthianura albifrons*	X			
	White-winged Fairywren	*Malurus leucopterus*	X			
	Willie Wagtail	*Rhipidura leucophrys*	X			
	Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	X			
	Yellow-throated Miner	*Manorina flavigula*	X			
	Mammals					
	Chocolate Wattled Bat	*Chalinolobus morio*				
*	European Rabbit	*Oryctolagus cuniculus*	X			
*	Feral Cat	*Felis catus*	X			
	Gould's Wattled Bat	*Chalinolobus gouldii*				
	Greater Long-eared Bat	*Nyctophilus timoriensis*				
	Honey Possum	*Tarsipes rostratus*				
	Inland Broad-nosed Bat	*Scotorepens balstoni*				
	Lesser Long-eared Bat	*Nyctophilus geoffroyi*				
	Little Red Flying-fox	*Pteropus scapulatus*				
*	Red Fox	*Vulpes vulpes*	X			
	Short-beaked Echidna	*Tachyglossus aculeatus*	X			
	Southern Forest Bat	*Vespadelus regulus*				
	Western Freetail-bat	*Mormopterus planiceps*				
	Western Grey Kangaroo	*Macropus fuliginosus*	X			
	Western Pygmy Possum	*Cercartetus concinnus*				
	White-striped Freetail-bat	*Tadarida australis*				
	Reptiles					
	Burrowing Snake	*Simoselaps fasciolatus*				
	Common Scaly-foot	*Pygopus lepidopodus*				
	Dugite	*Pseudonaja affins*				
	Dwarf Bearded Dragon	*Pogona minor*				
	Gecko	*Gehyra variegata*				
	Gould's Whip Snake	*Rhinoplocephalus gouldii*				
	King Brown	*Pseudechis australis*				
	Skink sp.	*Cryptoblepharus plagiocephalus*				
	Skink sp.	*Ctenotus schomburgkii*				
	Skink sp.	*Lerista gerardii*				
	Skink sp.	*Lerista planiventralis*				
	Skink sp.	*Menetia greyii*				
	Skink sp.	*Morethia obscura*				
	Stumpy-tail Lizard	*Tiliqua rugosa*	X			
	Western Heath Dragon	*Rankinia adelaidensis*	X			
	Frogs					
	Desert Trilling Frog	*Neobatrachus centralis*				
	False Western Froglet	*Crinia pseudinsignifera*				
	Gunther's Toadlet	*Pseudophryne guentheri*				
	Humming Frog	*Neobatrachus*				

	Common name	Scientific Name	Recorded	EPBC	WATSSC	WC
		pelobatoides				
	Turtle Frog	*Myobatrachus gouldi*				
	Western Banjo Frog	*Limnodynastes dorsalis*	X			
	Western Spotted Frog	*Heleioporus albopunctatus*				

Notes: EPBC: *Environmental Protection and Biodiversity Conservation Act 1999*; WATSSC: Western Australian Threatened Species Scientific Committee (2003); WC: *Wildlife Conservation Act 1950*; X: Confirmed to occur at the study site; E: Listed as endangered; M: Migratory species; L: Listed under the WC Act; * Introduced species.

APPENDIX 3

Results of Anabat® surveys

Specialised Zoological

Bat call identification

from near Badgingarra, WA

Type:	Bat Call Analysis
Prepared for:	Brett Lane and Assoc. Pty Ltd
Date:	15 January 2008
Job No.	SZ026
Prepared by:	Specialised Zoological Kyle Armstrong PhD and Yuki Konishi ABN 92 265 437 422 0404 423 264 (intl: +61 404 423 264) kyle.armstrong@graduate.uwa.edu.au kyle.n.armstrong@gmail.com

SUMMARY

Bat identifications from Anabat echolocation call recordings are provided from near Badgingarra, Western Australia. Five species were identified with a medium to high level of confidence, and nightly counts of each species are included (Tables 1 and 2). The sequences attributed to the chocolate wattled bat *Chalinolobus morio,* were all of very low quality. Many poor quality sequences of the southern forest bat *Vespadelus regulus* resembled calls of long-eared bats *Nyctophilus* sp. and were difficult to distinguish reliably. Furthermore, the calls of *Nyctophilus* are typically difficult to identify to species, and may represent either the lesser long-eared bat *Nyctophilus geoffroyi* or the central greater long-eared bat *Nyctophilus timoriensis* (central form), which is listed under Priority 4 of the WA Department of Environment and Conservation's Priority Fauna List. It is still unclear whether this central form represents a subspecies of *Nyctophilus timoriensis* or a distinct species (McKenzie and Parnaby in press).

Details supporting the identifications are provided, as recommended by the Australasian Bat Society (ABS 2006). A summary of pulse parameters is provided in Table 3, and representative call sequences are illustrated in Figure 1. Further data are available should verification be required.

The counts must be interpreted with caution. There are many factors that influence quantitative estimates of either abundance or activity from acoustic recordings. The most important consideration is that one or a few bats passing regularly near the detector can give the impression of much higher numbers.

METHODS

The signals as recorded with Anabat II – CF-ZCAIM units were supplied as downloaded and interpreted sequence files. Anabat sequences were examined in AnalookW 3.3f software. Nightly counts were made of each species. Identifications were generally not made from lower quality data. Representative call sequences were imported into the software Analyze (Jolly 1997) or AnaScheme (Gibson and Lumsden 2003) where three call variables were measured on good quality search phase pulses: pulse duration (milliseconds), maximum frequency (kHz) and end frequency (equivalent to characteristic frequency; kHz). Species were identified based on information in Fullard et al. (1991), Churchill (1998) and Pennay et al. (2004). Nomenclature follows Armstrong and Reardon (2006).

TABLE 1. Site by species matrix of identifications, with the degree of confidence indicated by a code. Counts of each species are also given. See Table 2 for confidence level codes; and Table 3 for full species names.

	C. morio	*Nyctophilus sp.*	*V. regulus*	*Mormopterus sp.4*	*T. australis*
Bat Call B (CF 384)					
16/04/2007	M – 16	M – 4	H – 21	H – 34	H – 3
17/04/2007	M – 10	M – 0	H – 12	H – 32	H – 10
18/04/2007	M – 3	M – 1	H – 26	H – 39	H – 3
Bat Call C (CF 363)					
16/04/2007	0	0	0	H – 3	0
17/04/2007	0	0	H – 1	H – 2	0
18/04/2007	0	0	H – 1	H – 2	0

TABLE 2. Key to the confidence level of identifications in Table 1. The identification of each species is made based on one or more sequences at each site.

Code	Confidence level
R	Highest. Capture of the species was made at the site, and the identification is supported by measurements, a *Reference* call recording, and/or submission of a specimen/tissue to a museum.
H	High. Unambiguous identification of the species at the site based on measured call characteristics and comparison with available reference material.
M	Medium. Either call quality was poor, or the species cannot be distinguished reliably from another that makes similar calls. Alternative identifications are indicated elsewhere in this report. If this is a species of conservation significance, further survey work might be required to confirm the record.
L	Low. The identification is made very tentatively. Normally such call sequences would be ignored, but in this case they have been given a tentative identification because it was felt that the record might be of general interest. Species of conservation significance will not be assigned to this category.

TABLE 3. Summary of variables from representative call sequences. (Mean ± SD; range; s,p: number of sequences measured, combined total number of pulses measured).

Species	s,p	Duration (ms)	Max Frequency (kHz)	End frequency (kHz)
Chocolate wattled bat *Chalinolobus morio*	4,9	1.6 ± 0.8 0.8 – 3.1	53.1 ± 1.1 51.1 – 54.6	50.0 ± 1.5 46.2 – 51.0
Unidentified long-eared bat *Nyctophilus* sp.	5,23	3.1 ± 1.1 1.2 – 6.4	70.3 ± 7.0 55.2 – 89.9	49.2 ± 4.7 37.8 – 58.9
Southern forest bat *Vespadelus regulus*	5,25	8.5 ± 3.4 4.1 – 15.2	58.5 ± 9.5 44.0 – 84.7	42.3 ± 1.0 40.6 – 44.7
South-western free-tailed bat *Mormopterus* sp. (sp. 4, pop. O)	4,9	7.9 ± 1.9 3.9 – 10.8	30.8 ± 2.2 28.3 – 34.9	27.8 ± 1.3 26.4 – 29.8
White-striped free-tailed bat *Tadarida australis*	3,13	9.5 ± 3.4 4.0 – 16.2	19.3 ± 3.8 14.7 – 26.4	13.7 ± 1.9 11.8 – 17.7

REFERENCES

ABS (2006). Recommendations of the Australasian Bat Society Inc for reporting standards for insectivorous bat surveys using bat detectors. *The Australasian Bat Society Newsletter* 27: 6–9. [ISSN 1448-5877]

Armstrong, K. and Reardon, T. (2006). Standardising common names of bats in Australia. *The Australasian Bat Society Newsletter* 26: 37–42.

Churchill, S.K. (1998). *Australian bats.* Reed New Holland: Frenchs Forest, NSW.

Fullard, J.H., Koehler, C., Surlykke, A. and McKenzie, N.L. (1991). Echolocation ecology and flight morphology of insectivorous bats (Chiroptera) in south-western Australia. *Australian Journal of Zoology* 39: 427–438.

Gibson, M. and Lumsden L. (2003). The AnaScheme automated bat call identification system. *The Australasian Bat Society Newsletter* 20: 24–26.

Jolly, S. (1997). Analysis of Anabat files. *The Australasian Bat Society Newsletter* 9: 25–27.

McKenzie, N.L. and Parnaby, H. (in press). Central long-eared bat *Nyctophilus* sp. In: Mammals of Australia 3rd edition (ed. S. Van Dyck). Australian Museum.

Pennay, M., Law, B. and Reinhold, L. (2004). *Bat calls of New South Wales: Region based guide to the echolocation calls of Microchiropteran bats.* NSW Department of Environment and Conservation, Hurstville.

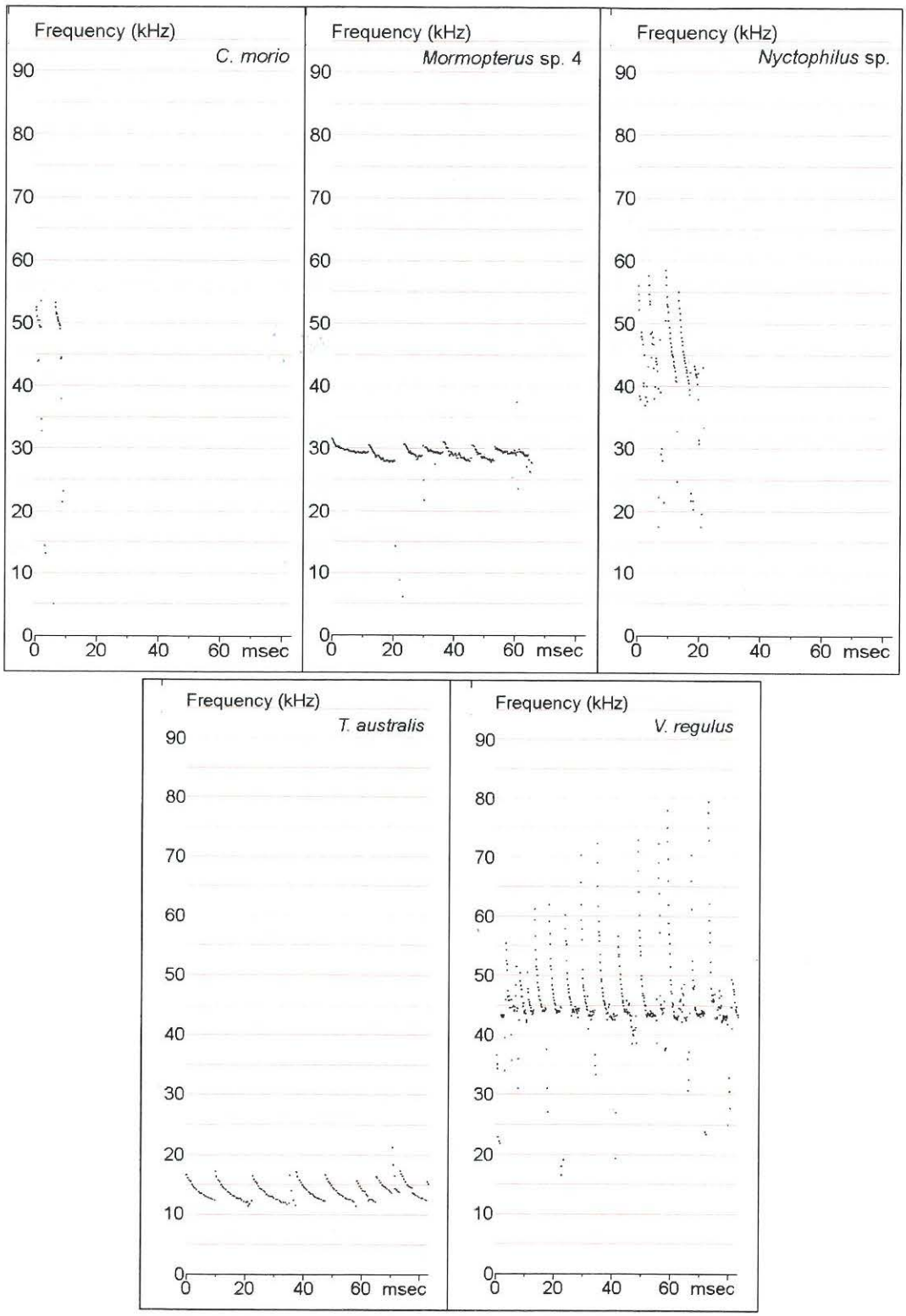


FIGURE 1. Representative call sequences of the five species identified (time is compressed between pulses).

APPENDIX 4

Report by Mr R and Mrs C Johnstone on the regional status of the Carnaby's Black-Cockatoo.

DISTRIBUTION, STATUS AND MOVEMENTS OF CARNABY'S COCKATOO IN THE BADGINGARRA DISTRICT.

R.E. & C. JOHNSTONE.

BACKGROUND INFORMATION

Carnaby's Cockatoo *Calyptorhynchus latirostris*

Listed as Schedule 1 (Endangered) under the *Western Australian Wildlife Conservation Act*, and as Endangered under the *Environmental Protection and Biodiversity Conservation Act 1999.*

Distribution

Endemic to the south-west of Western Australia, north to the lower Murchison River and east to Nabawa, Wilroy, Waddi Forest, Nugadong, Manmanning, Durokoppin , Noogar (Moorine Rock), Lake Cronin, Ravensthorpe Range, head of Oldfield River, 20 km ESE of Coondingup and Cape Arid; also casual on Rottnest Island (Johnstone and Storr 1998).

Status

This species is a postnuptial nomad, tending to move west after breeding. For example; most birds breeding in Three Springs, Carnamah, Coorow, Badgingarra, Dandaragan and Moora regions tend to move west after breeding into higher rainfall areas especially the near-coastal *Banksia* scrubs e.g. at Wanagarren Nature Reserve, Nilgen Nature Reserve and Yanchep area, then many of these move further south onto the southern Swan Coastal Plain including the southern Perth metropolitan area Baldivis, Lake Clifton and Myalup areas.

It is uncommon to common in the subhumid zone and wetter parts of the semiarid zone, scarce and patchily distributed in the drier parts of its range (north of Arrowsmith Lake and east of Marchagee, New Norcia, Toodyay, Tarin Rock and Lake Magenta) and scarce to moderately common in deep south-west (south of Margaret River, Nannup and Bridgetown and east of Albany).

Estimate of total population 40,000.

Usually in pairs or small flocks, also large flocks (up to 10,000) in non-breeding season (late spring to mid-winter), especially at *Banksia* scrubs and pine plantations on the Northern Swan Coastal Plain. Because of the large-scale post-war clearing of semiarid sandplains, this species has declined in much of the wheatbelt. There has been an apparent shift in its breeding range further west and south since the middle of last century with a more rapid increase in the past 10 – 30 years into the Jarrah – Marri forests of the Darling Scarp and the Tuart forests of the Swan Coastal Plain. There are now numerous breeding records for the northern Darling Scarp, including Bindoon, Bullsbrook, Mundaring, Lower Darkin River, near Canning Dam, Bedfordale, Serpentine and near Collie, and on the Swan Coastal Plain at Gingin, Mooliabeenee, Yanchep, Baldivis, near Mandurah, Lake Clifton and near Bunbury (Storr – Johnstone Bird Data Bank).

There is also an indication that this species is expanding its breeding range in the far south-east i.e. Lake Cronin, Lake King and Ravensthorpe region.

Breeding

Breeding is recorded from early July to mid-December. Mainly in semiarid and subhumid interior from the Three Springs district south to the Stirling Range, west to Cockleshell Gully, Cataby, Regans Ford, Gingin, Yanchep, Serpentine, Mandurah, Lake Clifton, Bunbury, Nannup and Tone River and east to Manmanning, Kellerberrin, Woolundra, Lake Cronin and near Ravensthorpe (Storr – Johnstone Bird Data Bank).

Breeding Requirements

Carnaby's Cockatoo display strong pair bonds and mate for life. They nest in hollows of smooth-barked eucalypts especially Salmon Gum *Eucalyptus salmonophloia* and Wandoo *Eucalyptus wandoo* but nests have also been found in other eucalypts including York Gum *Eucalyptus loxophleba,* Flooded Gum *Eucalyptus rudis,* Tuart *Eucalyptus gomphocephala* and the rough-barked Marri *Corymbia calophylla.* On the Swan Coastal Plain most nests are in Tuart.

Judging from breeding records in the Storr – Johnstone Bird Data Bank, this species is currently expanding its breeding range westward and south into the Jarrah – Marri forests of the Darling Scarp and into the Tuart forests of the Swan Coastal Plain including Lake Clifton and near Bunbury.

In the midlands region of the wheatbelt pairs begin to move back to their breeding sites in July – August (some as late as mid-November) and begin renovating or looking for a suitable nest hollow. Eggs are laid on a mat of wood chips at the bottom of a large hollow (mostly top entry hollows) ranging from a few centimetres to 5 m. deep; clutch 1 – 2 (mostly 2 but only one young reared). Incubation last 29 days and only the female incubates and broods. The nestling is brooded by the female for up to three weeks after hatching during which time both rely on the male for food. The

female then broods only at night and leaves the nest each day at dawn, returning mid-morning (with the male) to feed the chick.

Breeding success is largely dependent on suitable feeding habitat adjacent to the nest site to provide the necessary food for the survival of the chick.

Social Organisation, Flocking and Movements

Most breeding in the northern and midlands regions of the wheatbelt (i.e. Three Springs, Coorow and Moora districts) is completed by the end of January or early February and family groups begin to move west towards the coast and amalgamate into larger foraging flocks on the northern section of the Swan Coastal Plain. During February, March, April and occasionally lingering into May large transit flocks (up to 7,000) forage at major food sources including *Banksia* or Kwongan heaths and *Pinus* plantations on the northern Swan Coastal Plain between Lancelin and Perth.

On the northern Swan Coastal Plain the reverse movement of transient birds returning back to their wheatbelt breeding quarters is also evident in July – August with large flocks recorded in *Banksia* and *Dryandra* scrubs in the Yanchep – Lancelin region. There are, however, some exceptions to this westward and southward yearly movement. For example, a flock of over 300 (including adult and juvenile birds) remain during the autumn – winter period in the Eneabba area. These birds roost in tall river gums in and around the township and forage in both remnant native vegetation and adjacent farmlands. While the region of origin of these birds is unknown, it is noteworthy that they remain here during the autumn – winter period when virtually all other Carnaby's Cockatoos from the broader region (i.e. Three Springs, Moora and Badgingarra) vacate it after breeding.

CARNABY'S COCKATOO EXTRACT FROM STORR – JOHNSTONE BIRD DATA BANK.

CSIRO	1954	listed for Dandaragan 30. 41. S, 115. 42. E.
G.M. Storr	1959	large flock 15 miles NNW of Badgingarra at 30. 15. S, 115. 26. E.
G.M. Storr	1959	2 in Marri – Banksia 17 miles WNW of Badgingarra at 30. 13. S, 115. 25. E.
J.R. Ford	1965	10 observed 39 miles NNW of Badgingarra at 29. 54. S, 115. 08. E.

G.M. Storr	1961	25 observed 5 miles SSE of Badgingarra at 30. 27. S, 115. 39. E.
G.M. Storr	1961	2 observed 9 miles SSE of Badgingarra at 30. 30. S, 115. 62. E.
R.E. Johnstone	1973	small flock near Badgingarra township at 30. 24. S, 115. 29. E.
N. Kolichis		clutch 2 eggs from 15 km. S of Dandaragan at 30. 49. S, 115. 42. E.
N. Kolichis		12 November 1998, 12 feeding in *Grevillea* in Badgingarra National Park.
G. Porter		23 January 2007, 60+ in area opposite Badgingarra Roadhouse, mostly roosting, some young calling.
C.& M.A. Reeve		25 April 2006, 200 overhead at Badgingarra.
T. Harris		26 April 2003, 3 overhead at Badgingarra.
T. Harris		29 April 2003, 3 perched at Badgingarra.
M. O'Connor		14 May 2001, 5 perched at Badgingarra.
K. Spurge		26 February 2002, 1000 at Bidgerabbie Hill.
K. Shackleton		10 September 2003, 6 at Cataby.
A. Sutton		8 September 2003, 8 at Coomberdale.
T. Harris		9 April 2003, 5 at Cowalla Road.
T. Harris		29 April 2003, 30 at Cowalla Road.
T. Harris		25 April 2003, 50 at Cowalla Road.
L. Short		12 January 2003, 100 at Dandaragan.
L. Short		13 January 2003, 200 at Dandaragan.
T. Harris		24 April 2003, 100 on Dandaragan Road.
T. Harris		28 April 2003, 100 on Dandaragan Road.
A. Baker		18 March 2005, 500 at Nilgen.
A. Baker		12 May 2004, 200 at Nilgen.

A. Baker	27 May 2003, 300 at Nilgen.
A. Baker	11 June 2003, 550 at Nilgen.
A. Baker	6 June 2003, 600 at Nilgen.
A. Baker	16 June 2003, 3000 at Nilgen feeding - *Dryandra.*
A. Baker	28 May 2003, 2000 at Nilgen feeding - *Banksia.*

DISCUSSION

Conclusions

Judging from our data bank all birds from the Three Springs, Carnamah, Coorow, Badgingarra and Moora regions completely vacate their breeding sites by the end of February and aggregate into large flocks in the Kwongan heaths and pine plantations on the northern Swan Coastal Plain. Occasionally a flock of 60 – 100 birds remain in the Badgingarra National Park area into March – April. The reverse migration occurs in July – August (sometimes later) as birds return back to their breeding sites.

FOOD OF CARNABY'S COCKATOO ON SWAN COASTAL PLAIN.

Carnaby's Cockatoo has been observed feeding on a wide range of foods including the seeds of *Banksis attenuata, B. baxteri, B. coccinea, B. menziesii, B. grandis, B. prionotes, B. speciosa, B. ilicifolia, B. longifolia, B. ericifolia, B. quercifolia, B. hookeriana, Dryandra fraseri, D. praemorsa, D. squarrosa, D. sessilis, D. carlinoides, Corymbia calophylla, C. citriodora, Eucalyptus patens, E. todtiana, E. marginate, E. caesia, E. salmonophloia, Hakea erinacea, H. laurina, H. incrassata, H. lasiantha, H. lissocarpha, H. stenocarpa, H. trifurcata, H. prostrata, H. lasianthoides, Grevillea* spp., *Pinus* spp., (including *P. radiata, P. caribaea* and *P. canariensis*), *Callitris, Mesomelaena* spp. and *Erodium;* flower buds, flowers and nectar of *Banksia attenuata, B. ericifolia, B. grandis, B. ilicifolia, B. menziesii, Callistemon* spp., *Corymbia calophylla, Dryandra lindleyana, D. squarrosa, D. sessilis, Eucalyptus gomphocephala, E. patens, E. robusta, Grevillea robusta, Protea* spp., insect larvae and insects (including weevils) from under bark, from wood of live and dead trees and shrubs, from galls and from flowers and flower stems, of *Acacia* spp. (including *A. saligna* and *A. pentedenia*) *Banksia* spp., *Eucalyptus* spp., *Jacksonia, Agonis* and *Xanthorrhoea.*