Fauna assessment under NVCP Principles for Perth Airport

Banksia menziesii in flower on site (Photo: J. Wadey)

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Executive Summary

As part of a 132 kV power line relocation project undertaken by Western Power, Perth Airport Pty Ltd is investigating the baseline environmental values present within four parcels of land totalling c. 3 ha on and adjacent to (but mostly outside) the Perth Airport Estate ('the Estate'). Depending on the outcome of the detailed design, the future construction works for the 132 kV power line relocation may require clearing of native vegetation. To inform future approval requirements, Bamford Consulting Ecologists (BCE) was commissioned to conduct a fauna assessment of the project area.

There have been extensive fauna investigations undertaken across the Estate, with the result that at least the vertebrate fauna assemblage is moderately well-known, with two freshwater fish, 10 frog, 22 reptile, 99 bird and 12 mammal species confirmed. These represent almost 75% of the actual vertebrate fauna assemblage expected to be present. A further 21 species are considered to be locally extinct.

Vegetation in the four parcels of land is degraded to varying degrees, and therefore the fauna assemblage of these areas will be depauperate compared with that of the Estate. Two of the parcels are close to the Estate and have some remnant (or restored) vegetation; these therefore can be expected to support more species than the remaining two parcels, which are isolated and degraded. One of these more degraded parcels, however, has an artificial wetland so can be expected to support some waterbirds.

Fauna species of conservation significance will make limited use of the project area. The Priority 4 Quenda is common on the Estate but probably at best an irregular visitor to some (not all) of the patches that make up the project area. Carnaby's and the Forest Red-tailed Black-Cockatoos may be irregular visitors, but the project area provides very limited foraging habitat and no nesting habitat.

Assessment of the project area against the NVCP principles concluded there would be no significant impacts, but it was noted that created wetlands are present. The proposed clearing of these patches of native vegetation will represent a small loss in fauna habitat and fauna populations, but given the condition of the habitat, nearby restoration, such as along road reserves, may be able to offset loss.

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1.1 Introduction

As part of a 132 kV power line relocation project undertaken by Western Power, Perth Airport Pty Ltd is investigating the baseline environmental values present within four parcels of land totalling c. 3 ha on and adjacent to (but mostly outside) the Perth Airport Estate (termed 'the Estate'). Depending on the outcome of the detailed design, the future construction works for the 132 kV power line relocation may require clearing of native vegetation either on Commonwealth Land (Airport Estate) or on WA State land tenure (adjacent to the Airport Estate). If native vegetation is required to be impacted within WA State land tenure, the project may be required to attain a Native Vegetation Clearing Permit (NVCP) prior to construction. To inform and supplement possible future approval submissions, Bamford Consulting Ecologists (BCE) was commissioned to conduct a fauna assessment of four small survey areas (collectively the 'project area') that may be intersected by the construction design. This involved a Level 1 ('Basic') assessment, targeted conservation significant species and black-cockatoo assessment, and a review of the proposed clearing against the ten Clearing Principles (as listed under Schedule 5 of the Environmental Protection Act (WA) 1986 (EP Act)). This report presents the results of the fauna assessment.

1.2 Baseline review of Estate

In 2020, BCE conducted a baseline review of fauna and environments that provide habitat across the Estate (Bancroft and Bamford 2020). Multiple detailed and targeted fauna investigations have been conducted in remnant native vegetation across the Estate since 1994, and these were all reviewed as part of the baseline review. As the environments in the sites are similar and adjacent to the Estate, the sites are expected to support a similar fauna assemblage and, as such, the current report draws on the baseline review for background information. Refer to the Bancroft and Bamford (2020) review for detailed fauna information and background environmental information for the Estate.

1.3 Description of sites

The four survey sites (also collectively referred to as the 'project area') are located on the southeast corner of the Estate at the corner of Tonkin Highway and Abernethy Road (Figure 1). One linear site is located within the Estate boundary alongside Tonkin Highway, while the others are remnant or replanted vegetation patches bounded by roads and industrial areas (Figure 1). The 'study area' refers to a 25 km radius around the project area, which is the boundary usually used for desktop searches.

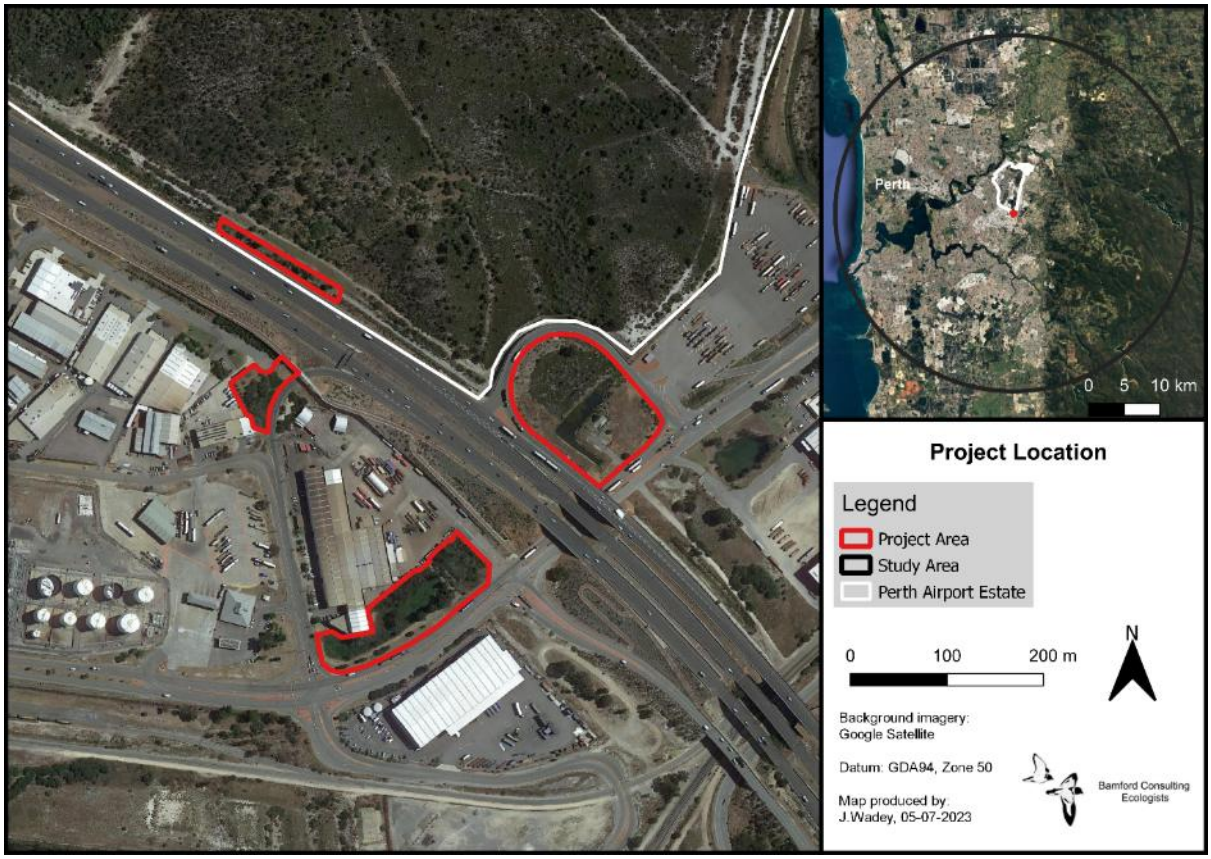

Figure 1. Location of the project area and the Perth Airport Estate.

2 Methods

2.1 Desktop Assessment

2.1.1 Database review and previous studies

Information was taken from Bancroft and Bamford (2020), which accessed state and federal government databases including DBCA Naturemap (incorporating the Western Australian Museum's FaunaBase and the DBCA Threatened and Priority Fauna Database), BirdLife Australia's Atlas Database (BA) and the federal EPBC Protected Matters Search Tool. Information from the above sources was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns were:

- Frogs: Tyler *et al.* (2000);
- Reptiles: Storr *et al.* (1983); Storr *et al*. (1990); Storr *et al*. (1999); Storr *et al.* (2002) and Wilson & Swan (2008);
- Birds: Blakers *et al*. (1984); Johnstone and Storr (1998, 2004) and Barrett et al. (2003); and
- Mammals: Menkhorst & Knight (2001); Churchill (2008); and Van Dyck and Strahan (2008).

The fauna assemblage of the Estate has been the subject of multiple studies dating back to 1994; these have included general fauna surveys and targeted studies on significant species. As a result, there is a considerable body of information available on the fauna assemblage of the Estate. Reports are listed in Table 2. There have been several studies on aquatic invertebrates, two studies on terrestrial invertebrates, several studies investigating the status of the Western Swamp Tortoise on the Estate, multiple studies targeting black-cockatoos, studies investigating specific parts of the Estate and several whole of Estate and vertebrate fauna surveys, most recently in 2008 and 2014.

Table 1. Summary of fauna investigations undertaken in the Perth Airport Estate.

Study	Title / Description
ATA (1994)	Report of a Fauna Survey of the Perth Airport
How (1995)	Objection Assessment of Faunal Values for Perth Airport
ATA (1997)	Perth Airport Rare and Endangered Flora and Fauna
Kuchling and Burbidge (1996)	Perth Airport Western Swamp Tortoise Survey
Burbidge and Kuchling (2005)	Notes on visits to swamps in Perth Airport to assess suitability for Western Swamp Tortoise
Bancroft and Bamford (2008)	Fauna of the Perth Airport: Progress Report (Autumn 2008 Survey)
Strehlow and O'Connor (2009)	Sampling of aquatic macro-invertebrates at Perth Airport
Huang and Bamford (2010)	Perth Airport Graceful Sun-Moth (*Synemon gratiosa*) Survey
Strehlow *et al.* (2011)	Sampling of aquatic macro and microinvertebrates at Perth Airport
Basnett and Bamford (2012a)	Perth Airport Black-Cockatoo Habitat Study – Site 2
Basnett and Bamford (2012b)	Perth Airport Bushland Fauna Assessment

Study	Title / Description
Moore and Bamford (2013)	Perth Airport Black-Cockatoo Habitat Survey
Everard and Bamford (2014)	Fauna Surveys of the Perth Airport Bushland: 2008 and 2014
Syrinx Environmental (2017)	Munday Swamp: Assessment of Northern Main Drain Diversion Works on Wetlands, Vegetation and Fauna
Bamford (2017)	Munday Swamp: Assessment of Fauna Values: Autumn 2017
Bamford *et al.* (2017)	Fauna Assessment of the New Runway Project – Perth Airport
Wetland Research and Management (2018)	Perth Airport Macroinvertebrate Study: Spring 2017
Moore *et al*. (2018)	Black-Cockatoo Foraging Habitat Assessment of the Perth Airport
Bamford and Knowles (2019)	Survey for conservation significant invertebrates on the Perth Airport Estate, January 2019
Bamford and Everard (2019)	Fauna Impact Assessment for the Perth Airport Estate. Included a re-assessment of potential nest-trees for black-cockatoos across the Estate in August and September 2018
Bancroft and Bamford (2020)	Fauna Impact Assessment for the Airport Central Project

NB. Most references cited above do not appear in the main reference list in this report; all are unpubl. reports to the Perth Airport.

2.1.2 Nomenclature and taxonomy

As per the recommendations of EPA (2004a), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's (WAM) *Checklist of the Fauna of Western Australia 2009*. The authorities used for each vertebrate group were: amphibians (Doughty and Maryan 2010a), reptiles (Doughty and Maryan 2010b), birds (Christidis and Boles 2008), and mammals (How *et al*. 2009). In some cases, more widely-recognised names and naming conventions have been followed, particularly for birds where there are national and international naming conventions in place (e.g. the BirdLife Australia working list of names for Australian Birds). This includes the use of capital letters in English names. English names of species, where available, are used throughout the text; Latin species names are presented with corresponding English names in tables in the appendices.

2.1.3 Interpretation of species lists

Species lists generated from the review of sources of information are generous as they include records drawn from a large region and possibly from environments not represented in the survey area. Therefore, some species that were returned by one or more of the data searches have been excluded because their ecology, or the environment within the survey area, meant that it was highly unlikely that these species would be present. Some are also known to be regionally extinct. In general, however, species returned by the desktop review process are considered to be potentially present in the survey area whether or not they were recorded during field surveys, and whether or not the survey area is likely to be important for them. This is because fauna is highly mobile, often

seasonal and frequently cryptic. This is particularly important for significant species that are often rare and hard to find.

Interpretation of species lists generated through the desktop review included assigning an expected status within the survey area to species of conservation significance. This is particularly important for birds that may naturally be migratory or nomadic, and for some mammals that can also be mobile or irruptive. The status categories used are:

- Resident: species with a population permanently present in the survey area;
- Regular migrant or visitor: species that occur within the survey area regularly in at least moderate numbers, such as part of annual cycle;
- Irregular Visitor: species that occur within the survey area irregularly such as nomadic and irruptive species. The length of time between visitations could be decades but when the species is present, it uses the survey area in at least moderate numbers and for some time;
- Vagrant: species that occur within the survey area unpredictably, in small numbers and/or for very brief periods. Therefore, the survey area is unlikely to be of importance for the species; and
- Locally extinct: species that has not been recently recorded in the local area and therefore is almost certainly no longer present in the survey area.

These status categories make it possible to distinguish between vagrant species, which may be recorded at any time but for which the site is not important in a conservation sense, and species which use the site in other ways but for which the site is important at least occasionally. This is particularly useful for birds that may naturally be migratory or nomadic, and for some mammals that can also be mobile or irruptive, and further recognises that even the most detailed field survey can fail to record species which will be present at times, or may have been previously confirmed as present. The status categories are assigned conservatively. For example, a lizard known from the general area is assumed to be a resident unless there is very good evidence that the site will not support it, and even then, it may be classed as a vagrant rather than assumed to be absent if the site might support dispersing individuals.

2.2 Black-cockatoo assessment

2.2.1 Guidelines

The Department of Climate Change, Energy, the Environment and Water (DCCEEW, formerly DAWE) provides guidelines for the referral of actions that may result in impacts to black-cockatoos (for assessment under the EPBC Act) (DAWE, 2022). The survey and analysis reported here have been conducted with reference to both the referral guidelines provided by DSEWPaC (2012) and DAWE (2022) and recommendations listed on the DAWE's Species Profile and Threats Database (DAWE, 2023a, 2023c, 2023b). Ecological values for black-cockatoos within the site were based on the definitions of breeding, foraging and roosting habitat as per the EPBC Act referral guidelines for black-cockatoos (DSEWPaC, 2012). Actual scoring of foraging value and assessment of potential breeding habitat was based on systems developed by BCE that are outlined below and detailed in Appendix 5. The Department of Biodiversity, Conservation and Attractions (DBCA) has indicated that the methods developed and applied previously by BCE are an acceptable approach.

2.2.2 Foraging

The foraging value of the project area was assessed by calculating a foraging Habitat Quality Score (HQS) for areas of similar vegetation type/condition (see Appendix 5). The HQS provides a numerical value that reflects the significance of vegetation as foraging habitat for black-cockatoos, and this numerical value is designed to provide the sort of information needed by the federal DCCEEW, the state Department of Water and Environmental Regulation (DWER) and the WA Environmental Protection Authority (EPA) to assess impact significance and offset requirements. The HQS of the vegetation depends upon the type, density and condition of trees and shrubs in an area, and can be influenced by the context such as the availability of foraging habitat nearby. The BCE scoring system for calculating the HQS has three components as detailed in Appendix 3. These three components are drawn from the DCCEW offset calculator (DCCEEW, undated) but with the scoring approach developed by BCE:

- A score out of six for the vegetation composition, condition and structure.
- A score out of three for the context of the site.
- A score out of one for species density.

Foraging value can thus be assigned a score out of six, based upon site vegetation characteristics, or a score out of 10 (the HQS) if context and species density are also considered. A higher score represents better foraging value. A score out of 10 is presented for the purposes of aiding offset calculations. The approach to assigning scores for vegetation, context and species density are outlined in Appendix 5. Foraging HQS values are calculated differently for the three black-cockatoo species (Appendix 5) depending upon the vegetation present; thus a separate HQS is given for each VSA for each species.

Black-cockatoo foraging signs were also searched for in conjunction with the breeding tree surveys and general site inspections. If foraging signs were observed, the location, tree species and approximate age of the foraging evidence were recorded. Black-cockatoo foraging evidence may persist for some months or years after the foraging event. There is currently no published evidence documenting the deterioration process of foraging evidence. Factors that help to establish the time since foraging include: the colour of nuts/foliage, the degree of weathering or decay of debris, the presence of small fragments of nut debris, the position/compression of the foraging debris relative to surrounding vegetation and leaf litter, and the strength of the eucalypt smell emitted. Despite the absence of empirical data, four categories of foraging activity are recognised in the approach used by BCE, based on the time since foraging:

(i) Active – where birds were observed in the act of foraging;

(ii) Recent – foraging signs (e.g. chewed nuts or vegetation) were ‘fresh’ (i.e. foraging was likely to have occurred within days to weeks). Recent foraging signs were typically green and/or with very little sign of weathering. Approximately less than four weeks old;

(iii) Intermediate – foraging was likely to have occurred within weeks to months previously. Approximately one to six months old; and

(iv) Old – foraging was likely to have occurred months to years previously. Approximately more than six months old.

2.2.3 Breeding

The aim of the breeding surveys was to record all potential hollow-bearing trees (suitable for black-cockatoo nesting) within the project area. The following information was recorded for every suitable tree[1] with a diameter at breast height (DBH) equal to or greater than 500 mm (or 300 mm for Wandoo/Salmon Gum):

- tree location;
- tree species;
- life status;
- DBH; and
- nest-tree rank: trees were assessed (from the ground) for the potential presence/quality of nest-hollows and allocated a nesting rank (developed by BCE) as described in Table 2.

The DBCA threatened species database (DBCA, 2023a) and BirdLife Australia's black-cockatoo breeding/nesting dataset (BirdLife Australia, 2023a) were queried for black-cockatoo breeding sites and these are presented in the relevant section below. These databases were queried in February 2023.

Table 2. Ranking system for the assessment of potential nest-trees for black-cockatoos.

As per information from DAWE (2023c, 2023b, 2023a), a potential nest-tree is any tree with a diameter at breast height >500 mm (or >300 mm for *Eucalyptus salmonophloia* and *E. wandoo*). Note that black-cockatoos favour vertical hollows for the nest chamber, but the hollow entrance may be vertical (a chimney hollow), have a side entrance or have a horizontal spout entrance.

Rank	Description of tree and hollows/activity
1	Activity at hollow observed; adult (or immature) bird seen entering or emerging from hollow. Can also be used for a known nest tree active in the previous 12 months (although this should be noted in the description). Note that activity at a hollow does not absolutely mean that breeding is occurring unless a young bird in hollow is observed.
2	Hollow of suitable size visible with chew marks around entrance. Record if chew-marks are recent or old.
3	Potentially suitable hollow visible but no chew marks present at entrance; or potentially suitable hollow suspected to be present - as suggested by structure of tree, such as large, vertical trunk broken off at a height of >8m; but note that hollow height is contextual. Carnaby's Black-Cockatoo will nest in hollows <5m so in a Wheatbelt breeding site a lower criterion may be more appropriate.
4	Tree with large hollows or broken branches that might contain large hollows, but hollows or potential hollows (nest chamber) are not vertical or near-vertical; thus a tree with or likely to have hollows of sufficient size but not to have hollows of the angle preferred by black-cockatoos. Trees with low but otherwise suitable hollows can also be assigned a rank or 4, depending on the species of black-cockatoo likely to be present.
5	Tree lacking large hollows or broken branches that might have large hollows; a tree with more or less intact branches and a spreading crown.

[1] the draft revised EPBC Act study guidelines (DAWE, 2022) stress that any tree species may provide suitable hollows.

2.2.4 Roosting

As the breeding and foraging surveys were conducted, areas likely to be used as roosting sites (e.g. sites adjacent to watercourses with large trees) or areas that had black-cockatoo activity in the late-afternoon were noted. The DBCA threatened species database (DBCA, 2023a) and BirdLife Australia's black-cockatoo roosting dataset (BirdLife Australia, 2023b) were queried for black-cockatoo roosting sites and these are presented in the relevant section below.

2.3 Native Vegetation Clearing Principles

The sites are discussed (see Section 4) with regard to each of the Clearing Principles as listed in Schedule 5 of the Environmental Protection Act (WA) 1986. For each of the Clearing Principles (listed as titles in Section 5.2 (A) to (J)), a general statement is made on how the fauna values of the sites relate to that Clearing Principle, with further discussion providing the basis for this general statement.

2.4 Site visit and personnel

The sites were visited on 31st March 2023 by Dr Jamie Wadey, with the route followed illustrated on Figure 2. Personnel involved in the report were Dr Jamie Wady (B.Sc. Hons. Ph.D.), Natalia Huang (B.Sc. Hons. MBA) and Dr Mike Bamford (B.Sc. Hons. Ph.D.). Desktop assessment results were drawn from previous assessments conducted for Perth Airport, and these were conducted by various BCE personnel.

2.5 Survey limitations

The EPA Guidance Statement 56 (EPA 2004) outlines a number of limitations that may arise during surveying. These survey limitations are discussed in the context of the BCE fauna survey at the project area in Table 3. Because of extensive previous studies in the area, there were considered to be no limitations to the current assessment.

Table 3. Survey limitations as outlined by EPA (2004).

EPA Limitation	BCE Comment
Level of survey.	Level 1 (desktop study).
Competency/experience of the consultant(s) carrying out the survey.	The authors have had extensive experience in conducting desktop reviews and site inspections.
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	Level 1 (desktop study)-there was abundant desktop data on the fauna assemblage in the immediate area.
Proportion of fauna identified, recorded and/or collected.	All fauna seen or heard or evidence of were recorded.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Sources include previous reports on the fauna of the Perth Airport conducted by BCE; databases (BA, DBCA, WAM, EPBC).
The proportion of the task achieved and further work.	Task achieved in its entirety.
Timing/weather/season/cycle.	Weather was suitable.

EPA Limitation	BCE Comment
Disturbances (e.g. fire, flood, accidental human intervention etc.) which affected results of survey.	No disturbance affected survey.
Intensity. (In retrospect, was the intensity adequate?)	Survey intensity was sufficient for size of sites and extent of surveys conducted in the area.
Completeness (e.g. was relevant area fully surveyed).	All sites were fully surveyed.
Resources (e.g. degree of expertise available in animal identification to taxon level).	All species identified to taxon level.
Remoteness and/or access problems.	No access problems.
Availability of contextual (e.g. biogeographic) information on the region.	Extensive regional information was available and was consulted.

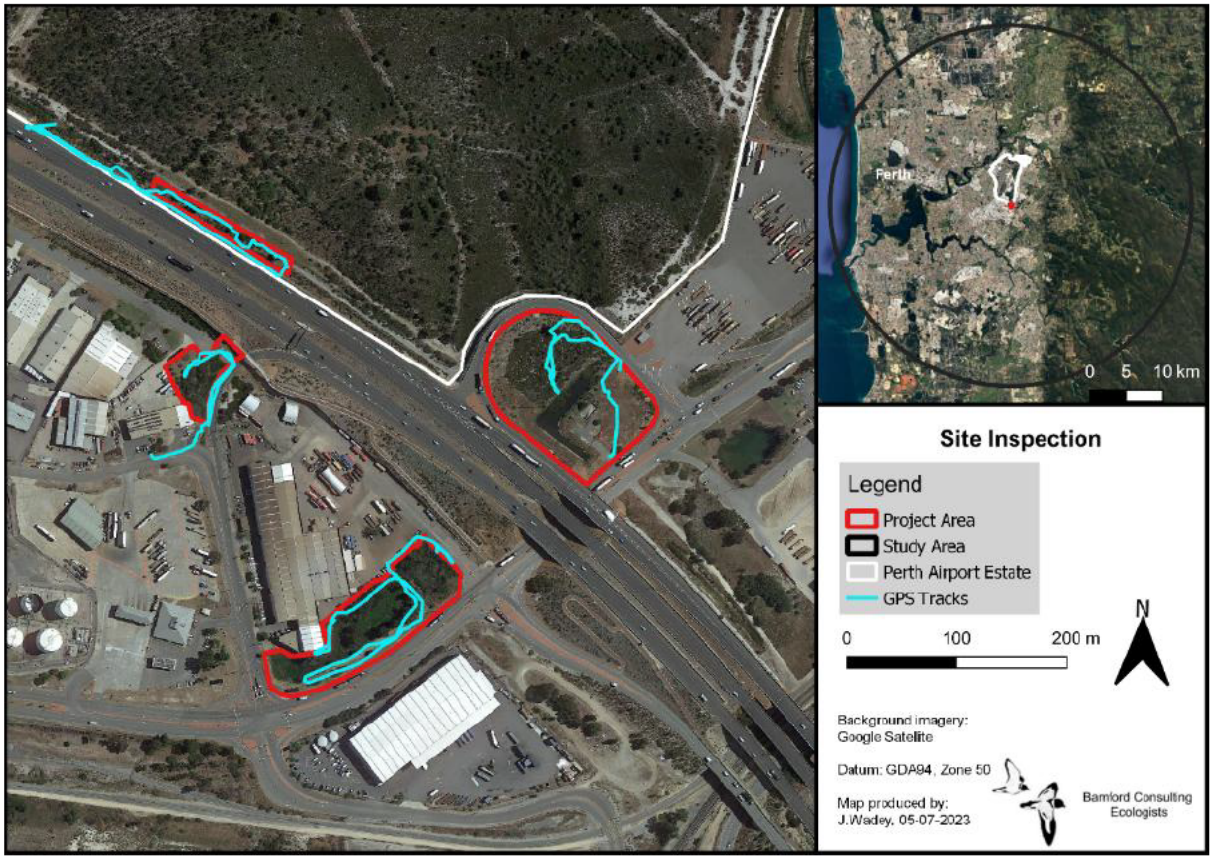

Figure 2. GPS tracks of the site inspection.

3 Results

3.1 Vegetation and Substrate Associations (VSAs)

Five major vegetation and substrate associations (VSAs) were identified in relation to fauna in the project area. Their distribution across the project area is shown in Figure 3 and each type is illustrated in Plates 1 to 5. VSAs identified are:

VSA 1. Revegetated Shrubland: Closed Shrubland with diverse midstory species such as *Banksia menziesii* and *Banksia prionotes* with scattered tree species such as *Eucalyptus todtiana, Allocasuarina fraseriana* and *Corymbia calophylla* and several varieties of tall *Melaleuca* and *Acacia* shrubs. Understory consisted of invasive grasses and weeds on white sand. Estimated revegetation age of 15-20 years old. This is located within three of the four sites.

VSA 2. Mixed Shrubland: Open mixed shrubland of scattered remnant midstorey of *Banksia menziesii, Nuytsia floribunda* and *Xanthorrhoea preissii*. Understorey contained revegetated shrubs and ground covers and invasive grasses throughout over white sand. This is only located in the eastern site which is separated from the rest of the Estate by a major road. It is currently Commonwealth land.

VSA 3. Created Wetland: Water bodies that are flooded excavations and have been vegetated such as with planted, non-local eucalypts on the water's edge. Emergent aquatic plants (rushes) are also established possibly through natural colonization. These wetlands appear to be permanent water over clay and white sand. They occur in the southwestern site where a drain compensating basin has been constructed, and the southeastern site, where a sewer pump station has been constructed.

VSA 4. Cleared: Mostly cleared areas with scattered disturbance shrub species e.g. *Acacia* with invasive grasses and weeds over white sand. This is located at all sites and likely supports disturbance-tolerant species such as urban birds.

VSA 5. Infrastructure: Mostly concreted areas with infrastructure and occasional shrubs. This is located in the eastern site.

All of the VSAs have some degree of degradation, with VSA 2 the most intact. VSA 3 is notable as being a wetland in an immediate region with only scattered and often small wetlands. All the component patches of the project area are small, but the patch in the east is the largest and has the most intact vegetation, while the patch in the south contains the main wetland area. Degradation, fragmentation, isolation and size will affect the fauna able to utilise each patch.

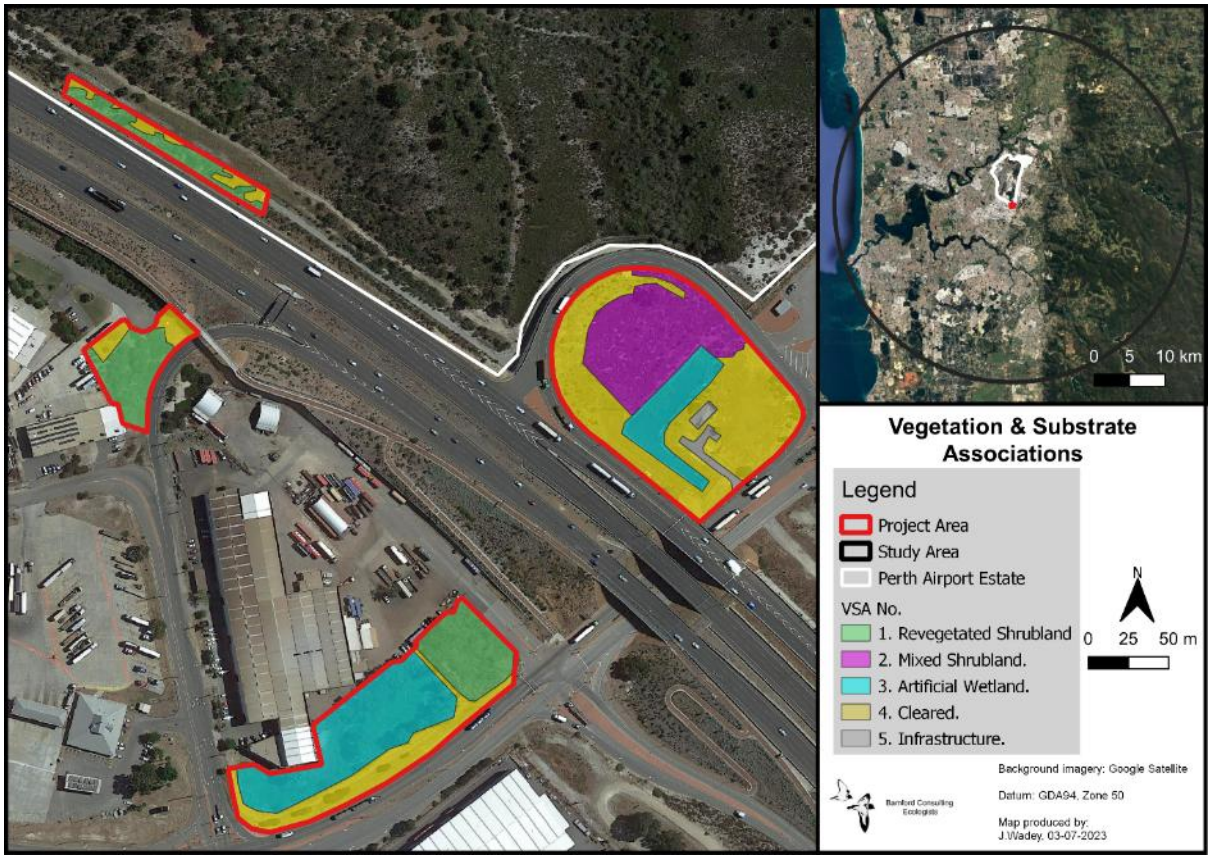

Figure 3. Distribution of VSAs in the project area.

Plate 1. VSA1: Revegetated Shrubland.

Plate 2. VSA2: Mixed Shrubland.

Plate 3. VSA3: Created Wetland.

Plate 4. VSA 4: Cleared.

Plate 5. VSA 5: Infrastructure.

3.2 Vertebrate Fauna

Bancroft and Bamford (2020) present detailed information on the expected and recorded fauna assemblage at the Estate. A summary is provided here with notes specific to the project area provided. Descriptions of the environment of the project area (Vegetation and Substrate Associations) that provides habitat for fauna appears in Section 4.

3.2.1 Overview of fauna assemblage

The desktop study identified 195 vertebrate species as potentially occurring in the Estate: six fish, 12 frogs, 43 reptiles, 121 birds and 13 mammals. Of these, 170 species (two fish, 11 frogs, 32 reptiles, 112 birds and 13 mammals) have been recorded or are considered highly likely to be present in the Perth Airport Estate (Table 4 and Appendix 4). Species that may have occurred within the Estate historically but are now considered to be locally extinct are listed separately in Appendix 4. Eight species (six birds and two mammals) have been recorded in the Estate historically but are now probably locally extinct (see Appendix 4). A summary of the number of species of each vertebrate class within the expected fauna assemblage in the Estate is provided in Table 4.

Because the sites contain wetlands and terrestrial vegetation, the entire fauna assemblage described for the Estate has the potential to be present, but because of the small areas involved and availability of suitable and better-quality habitat nearby, many species may only be very occasional visitors and therefore the function of the sites in supporting local populations may be low. Each major group is discussed with respect to the project area below, with discussion on species of conservation significance in Section 3.1.2.

Table 4. Composition of vertebrate fauna assemblage of the Perth Airport Estate.

	Potential	Recorded	Locally extinct
Fish	6 (1 int.)	2 (2 int.)	1
Frogs	12	10	0
Reptiles	43	22	3
Birds	121 (7 int.)	99 (4 int.)	9
Mammals	13 (5 int.)	12 (5 int.)	8
TOTAL	**195 (14 int.)**	**145**	**21**

Fish.
Only two fish, the introduced Mosquitofish and the introduced Goldfish, have been recorded on the Estate. There is a wetland within the project area and both species may be present. The likelihood of a native species in this wetland is very low.

Frogs.
The majority of frog species expected on the Estate have been recorded. Most of those recorded on the Estate could potentially occur in the project area, and the wetland may support breeding. This wetland is in the southern block of the project area. The eastern block is close to wetlands within the Estate, whereas the most westerly block is small, degraded and isolated, so may have few or even no species. Frogs will be present, at least seasonally, in upland areas of the larger blocks of the project area. Two of the species recorded on the Estate, Lea's Frog and Gunther's Toadlet, may not be present as both have restricted distributions on the Estate and the project area does not provide suitable habitat.

Reptiles.
While the areas of native vegetation in the project area are small, many reptiles can persist in such landscapes (Bamford and Calver 2012) and therefore the majority of the 22 species recorded across the Estate are likely to be present. More reptile species are likely to be present in the large area to the east, and the small, narrow area to the north, as these are adjacent to much larger areas of bushland within the estate. In contrast, the small and isolated patches of native vegetation to the west and south have probably lost some species.

Birds.
The Airport Estate has a rich bird assemblage with a high proportion of expected species recorded. There are also at least nine species considered to be locally extinct, with some of these thought to have disappeared from the Estate in recent decades. Due to the mobility of birds, almost any species recorded on the Estate could occasionally occur in the project area, with waterbirds visiting the wetland in the southern block. However, vegetation is generally in poor condition and a lot of the project area is cleared (see Figure 3), so few bird species are likely to regularly visit the blocks of the project area. The wetland in the southern block, and the area of shrubland in the eastern block, are likely to be the main locations where birds are present regularly.

Mammals.
The mammals assemblage of the Estate overall is depauperate and the remaining species include a high proportion that are introduced. Because the project area consists of small, degraded and isolated patches, very few mammals may be present except for the most persistent introduced species such as the House Mouse, Rabbit and Red Fox. The easterly block may get Quenda and occasional bats from bushland on the adjacent Estate.

Overall, the vertebrate fauna assemblage of the project area is likely to be poor due to the component patches being small, degraded and isolated. The most easterly patch is likely to be richest in species because it has some native vegetation of fair quality, and is alongside bushland of the Estate. Due to the small and isolated nature of the two southwestern sites, however, fauna which may be supported at these sites is likely to be restricted to birds which can reach the sites, or smaller

fauna such as frogs and reptiles which will spend their entire lifetime within either site. The linear strip of VSA 1 is expected to support the fauna of the adjacent Estate. The most southerly site contains the main wetland so can expect waterbirds at least as irregular visitors.

3.2.2 Species of conservation significance

Of the 170 species of vertebrate fauna that have been recorded or that are highly likely to occur on the Perth Airport Estate, 39 are of conservation significance (Table 5 and Table 6). These species also appear in Appendix 4.

Table 5. Composition of extant conservation significant fauna recorded or highly likely to occur within the Perth Airport Estate**.** CS1 (listed under legislation) CS2 (priority) and CS (locally significant) are defined in Appendix 1; also see footnote to Table 7..

Taxon	Conservation Significant fauna			Total
	CS1[1]	CS2[1]	CS3	
Fish	-	-	-	0
Frogs	-	-	2	2
Reptiles	-	-	1	1
Birds	6	1	26	33
Mammals	-	2	1	3
Invertebrates	-	1	-	1
Total	**6**	**4**	**30**	**40**

In addition, database reviews returned four invertebrate species of conservation significance; this list is likely to be incomplete. Those that are highly likely to be present are included in Table 8. One of these invertebrates, the Graceful Sun-Moth, was searched for in 2010 and it was concluded to be absent due to low habitat quality (Huang and Bamford 2010); it is therefore not included in Table 8. Three other significant invertebrates were searched for in 2019, and it was concluded that two of these (the crickets *Austrosaga spinifer* and *Throscodectes xiphos* were locally extinct, but the native bee *Hylaeus globuliferus* might still be present or could be a regular visitor (Bamford and Knowles 2019). Only the bee is included in Table 5 and is considered to be absent from the project area.

The status and expected occurrence of significant species in Table 6 is given for the overall Airport Estate and for the project area. The majority of species are expected to use the project area less often than the Estate. For example, 10 species are expected only as vagrants or to be absent from the project area but are considered to be residents or regular visitors across the Estate, while most other species have been downgraded from Resident or Regular visitor to Irregular visitor. The only species with the same expected occurrence on the Estate and in the project area are waterbirds (considered Irregular visitors across wetlands) and a few largely aerial species that will occasionally fly over both the Estate and the project area (eg. Peregrine Falcon and Fork-tailed Swift). These differences in expected occurrence between the Estate and the project area are due to the small size, poor condition and fragmented nature of the sites.

Table 6. Species of conservation significance recorded or that are highly likely to occur on the Perth Airport Estate. Expected occurrence on the Estate (from Bancroft and Bamford 2020) and in the project area are indicated.

Species		Conservation Category[1]	Presence (Estate)[2]	Expected Occurrence Estate[2]	Expected Occurrence project area[2]
CONSERVATION SIGNIFICANCE 1					
Plegadis falcinellus	Glossy Ibis	M,S5	Highly likely	Irregular visitor	Irregular visitor
Falco peregrinus	Peregrine Falcon	S7	Highly likely	Irregular visitor	Irregular visitor
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	V,S3	Recorded	Regular visitor	Irregular visitor
Calyptorhynchus baudinii	Baudin's Black-Cockatoo	E,S2,WR	Recorded	Irregular visitor	Vagrant
Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	E,S2,WR	Recorded	Regular visitor	Irregular visitor
Apus pacificus	Fork-tailed Swift	M,S5	Highly likely	Irregular visitor	Irregular visitor
CONSERVATION SIGNIFICANCE 2					
Oxyura australis	Blue-billed Duck	P4,HS	Highly likely	Irregular visitor	Irregular visitor
Isoodon fusciventer	Quenda, Southern Brown Bandicoot	P4	Recorded	Resident	Irregular visitor
Hydromys chrysogaster	Water-rat, Rakali	P4	Recorded	Resident	Absent
Hylaeus globuliferus	a native bee	P3	Highly likely	Resident	Absent
CONSERVATION SIGNIFICANCE 3					
Heleioporus barycragus	Hooting Frog, Western Marsh Frog	LS	Highly likely	Resident	Absent
Geocrinia leai	Lea's Froglet	LS	Recorded	Resident	Absent
Elapognathus coronatus	Crowned Snake	LS	Recorded	Resident	Absent

Species		Conservation Category[1]	Presence (Estate) [2]	Expected Occurrence Estate[2]	Expected Occurrence project area[2]
Biziura lobata	Musk Duck	HS	Recorded	Irregular visitor	Irregular visitor
Malacorhynchus membranaceus	Pink-eared Duck	HS	Recorded	Irregular visitor	Irregular visitor
Anas rhynchotis	Australasian Shoveler	HS	Recorded	Irregular visitor	Irregular visitor
Phaps chalcoptera	Common Bronzewing	HS	Recorded	Resident	Irregular visitor
Accipiter fasciatus	Brown Goshawk	WR	Recorded	Resident	Irregular visitor
Accipiter cirrocephalus	Collared Sparrowhawk	WR	Recorded	Resident	Irregular visitor
Aquila audax	Wedge-tailed Eagle	WR	Recorded	Resident	Irregular visitor
Hieraaetus morphnoides	Little Eagle	WR	Recorded	Regular visitor	Irregular visitor
Haliastur sphenurus	Whistling Kite	WR	Recorded	Regular visitor	Irregular visitor
Lophoictinia isura	Square-tailed Kite	WR	Highly likely	Irregular visitor	Irregular visitor
Falco berigora	Brown Falcon	WR	Recorded	Irregular visitor	Irregular visitor
Gallinula tenebrosa	Dusky Moorhen	HS	Recorded	Irregular visitor	Irregular visitor
Merops ornatus	Rainbow Bee-eater	LS	Recorded	Regular visitor	Regular visitor
Malurus splendens	Splendid Fairy-wren	HS	Recorded	Resident	Irregular visitor
Sericornis frontalis	White-browed Scrubwren	HS	Recorded	Resident	Irregular visitor
Smicrornis brevirostris	Weebill	HS	Recorded	Resident	Regular visitor
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	HS	Recorded	Resident	Irregular visitor
Acanthorhynchus superciliosus	Western Spinebill	WR	Recorded	Irregular visitor	Vagrant
Anthochaera lunulata	Western Wattlebird	WR	Recorded	Resident	Regular visitor
Melithreptus chloropsis	Gilbert's Honeyeater	WR	Highly likely	Irregular visitor	Vagrant

Species		Conservation Category[1]	Presence (Estate) [2]	Expected Occurrence Estate[2]	Expected Occurrence project area[2]
Phylidonyris novaehollandiae	New Holland Honeyeater	WR	Recorded	Resident	Regular visitor
Glyciphila melanops	Tawny-crowned Honeyeater	WR	Recorded	Regular visitor	Irregular visitor
Phylidonyris niger	White-cheeked Honeyeater	WR	Recorded	Resident	Regular visitor
Epthianura albifrons	White-fronted Chat	LS	Recorded	Irregular visitor	Irregular visitor
Daphoenositta chrysoptera	Varied Sittella	HS	Recorded	Regular visitor	Irregular visitor
Artamus cinereus	Black-faced Woodswallow	WR	Recorded	Irregular visitor	Vagrant
Trichosurus vulpecula	Brush-tailed Possum	LS	Highly likely	Resident	Absent

Conservation Category Codes[1]:

Conservation significance 1 (CS1)

- EPBC Act listings: E = Endangered, V = Vulnerable, M = Migratory, Mar = Marine (Appendix 1).
- Wildlife Conservation Act listings: S1 to S7 = Schedules 1 to 7 (Appendix 1).

Conservation significance 2 (CS2)

- DBCA Priority species: P1 to P5 = Priority 1 to 5 (Appendix 1).

Conservation significance 3 (CS3)

- Bush Forever (Dell and Banyard 2000) status: HS = habitat specialists with a reduced distribution on the Swan Coastal Plain, LE = locally extinct, WR = wide ranging species with reduced populations on the Swan Coastal Plain (Appendix 2).
- LS = considered to be of local significance by Bamford Consulting Ecologists (Appendix 2).

Expected occurrence categories[2]:

- Resident: species with a population permanently present in the project area;
- Regular visitor or migrant: species that occur within the project area regularly in at least moderate numbers, such as part of annual cycle;
- Irregular Visitor: species that occur within the project area irregularly such as nomadic and irruptive species. The length of time between visitations could be decades but when the species is present, it uses the survey area in at least moderate numbers and for some time;
- Vagrant: species that occur within the project area unpredictably, in small numbers and/or for very brief periods. Therefore, the project area is unlikely to be of importance for the species; and
- Locally extinct: species that has not been recently recorded in the local area and therefore is almost certainly no longer present in the project area.

3.3 Black-Cockatoo habitat analysis

3.3.1 Black-Cockatoo presence

Carnaby's Black-Cockatoo

Carnaby's Black-Cockatoo was not recorded during the site inspection but is expected to be a irregular visitor to the project area. It could be a regular visitor, but intact Marri nuts of intermediate and old age was recorded abundantly throughout VSAs 1 and 2, but no foraging evidence was recorded (Plate 6). There was also no evidence of foraging on Banksia species though Banksias are the mainstay of this species' diet (Plate 7). Fresh foraging evidence of Carnaby's Black-Cockatoo on Marri, Banksia and Pines has been recorded regularly in the Perth Airport Estate in previous studies (Bamford *et al*. (2017). Everard and Bamford (2014) reported that a flock of about 100 Carnaby's Black-Cockatoos was regularly seen across the Estate. A "large flock" of this species was reported by Airport staff in April 2016.

Forest Red-tailed Black-Cockatoo

Three birds were recorded flying overhead during the site inspection; since 2008 this species has been a regular record on the Perth Airport Estate (Bancroft and Bamford 2020) and is expected to be an irregular and possibly even regular visitor to the project area. Small numbers of Forest Red-tailed Black-Cockatoos occur around the Estate more or less consistently, with flocks of two to five birds seen daily around Brearley/Dunreath Avenue intersection while BCE personnel were conducting a fauna relocation in May 2016. The project area supports few forage plants and there was no evidence of foraging.

Baudin's Black-Cockatoo

This species is reliant on eucalypt forests of the south-west with birds moving on the eastern coastal plain to forage on Marri. It is more common in south-west Western Australia and is considered likely to occur as a vagrant the project area. It has only recently been reported from the Estate (2018; (Bancroft and Bamford 2020) and it is uncertain if it still occurs regularly there. The project area provides little foraging habitat.

Plate 6. Intact Marri nuts; no evidence of Black-Cockatoo foraging through the project area.

Plate 7. No evidence of Black-Cockatoo foraging through the project area. Figure of intact banksia cones.

3.3.2 Black-Cockatoo foraging habitat assessment

3.3.2.1 Carnaby's Black-Cockatoo

The project area is likely to provide some foraging opportunities for Carnaby's Black-Cockatoo due to the presence of foraging plants and the rapid loss of foraging habitat across the Swan Coastal Plain. At the local scale, some areas within the project area will likely be utilised seasonally in conjunction with the neighbouring Perth Airport Estate habitat.

Based on the foraging assessment outlined in Section 2.2, the project area is of low to moderate foraging value, with foraging HQS values ranging from 0 to 5 out of 10 for each VSA (Table 7). There were foraging plants (*Banksia* spp., Marri and *E. todtiana*) only within VSAs 1 and 2. Approximately 17.9% (0.53 hectares) of the project area consists of Revegetated Shrubland and this is considered to have a moderate HQS (5 out of 10) for Carnaby's Black-Cockatoo (Table 7). Mixed Shrubland VSA was given a similar moderate HQS of 4 out of 10 and equated to an area of 16.3% of the project area (0.487 hectares; Table 7). VSAs 3, 4 and 5all had low or no HQS values for Carnaby's Black-Cockatoo with scores of one, one and zero out of ten respectively (Table 7). The HQS values (Table 7) included context and species presence values of 1 for VSAs 1 and 2, but 0 for VSAs 3, 4 and 5.

The Revegetated Shrubland (VSA 1) was given a condition score of 3 (out of 6) due to the moderate density of banksia trees (*B. menziesii* and *B. prionotes*) and scattered trees of *E. todtiana* and Marri (*C. calophylla*). The score was limited due to the lack of mature trees as the vegetation is estimated to be only 15-20 years old. The Mixed Shrubland (VSA 2) was given a condition score of 2 (out of 6) due to the low density of mature foraging trees in the form of *B. menziesii* and Marri (*C. calophylla*). In addition, the understory of revegetated shrubs contained little foraging options for Carnaby's due to melaleuca shrubs being the dominant genus of shrub which is not a foraging plant. Foraging opportunities for Carnaby's were extremely limited in VSAs 3, 4 and 5 with almost complete absence of any foraging species persisting, such as bare ground, infrastructure, disturbance and invasive grasses and weeds.

VSAs 1 and 2 receive a site context score of 1 (out of 3) because while they are small in area, they are in an urban landscape that has experienced extensive loss of foraging habitat. They also receive a score of 1 for stocking rate as the species has been recorded in similar habitat in the Estate. VSAs 3, 4 and 5 do not receive context or stocking rate scores due to their low condition score. The distribution of foraging scores by VSA is shown in Figure 4.

Table 7. Carnaby's Black-Cockatoo values for Site Condition, Site Context, Species Stocking Rate and overall Foraging Habitat Quality Score (HQS) for each VSA

VSA	VSA Name	Area (ha)	Site Condition (out of 6)	Site Condition Score Description	Site Context (out of 3)	Species Stocking Rate (0 or 1)	HQS (out of 10)
1	Revegetated Shrubland	0.535	3	Low to Moderate	1	1	**5**
2	Mixed Shrubland	0.487	2	Low	1	1	**4**
3	Created Wetland	0.686	1	Negligible to Low	0	0	**1**
4	Cleared	1.27	1	Negligible to Low	0	0	**1**
5	Infrastructure	0.046	0	No Value	0	0	**0**

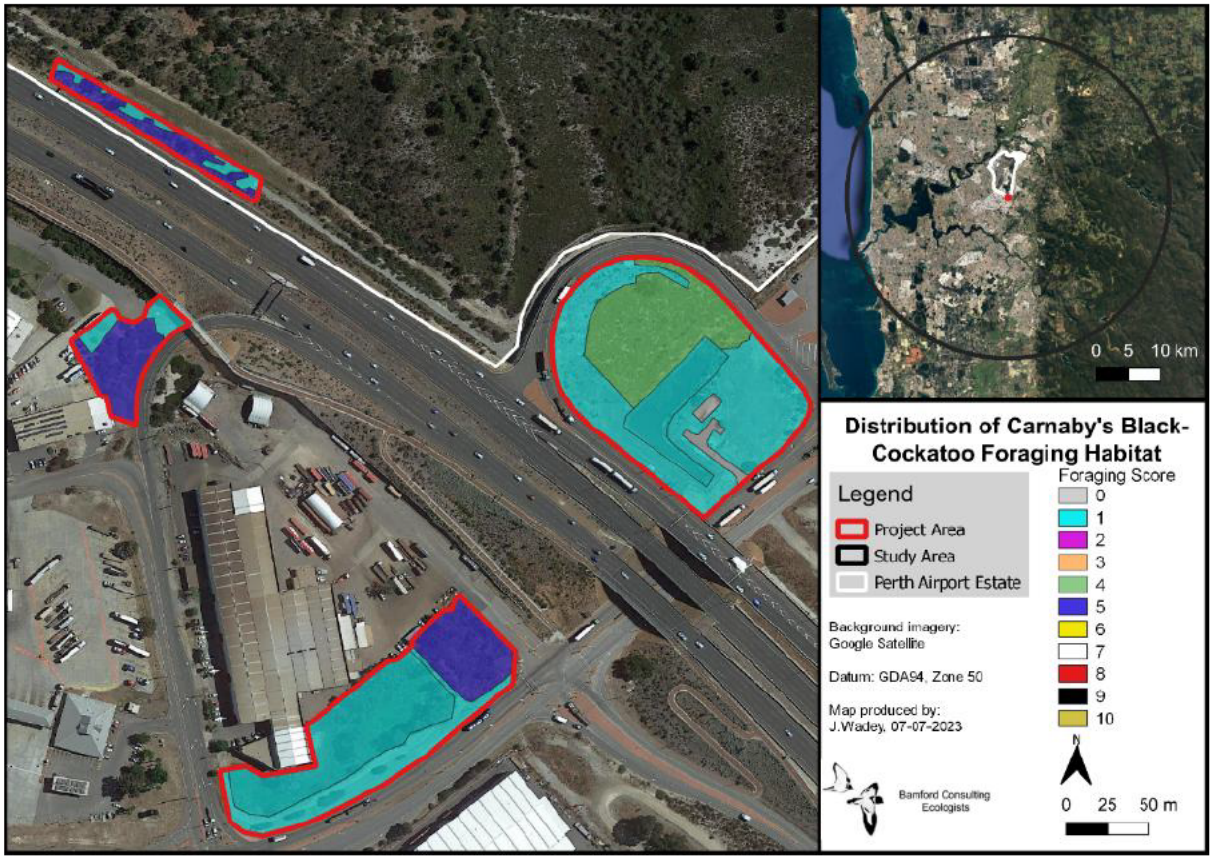

Figure 4. Distribution of Carnaby's Black-Cockatoo foraging Habitat Quality Scores (HQS) for each VSA.

3.3.2.2 Forest Red-tailed Black-Cockatoo

Based on the foraging assessment outlined in Section 2.2, the project area is considered to be of low to moderate value for foraging by the Forest Red-tailed Black-Cockatoo, with HQS values ranging from 0 to 4 out of 10.

There were foraging plants within each site but only within VSAs 1 and 2. Each site contained scattered Marri and *E. todtiana*, which provide foraging value. VSAs 1 and 2 were both given a moderate HQS of 4 out of 10, while VSAs 3, 4 and 5 were all given low or zero HQS values for Forest Red-tailed Black-Cockatoo with scores of one, one and zero out of ten respectively (Table 8).

The Revegetated Shrubland (VSA 1) was given a condition score of 2 (out of 6) due to the low number of *E. todtiana* and Marri (*C. calophylla*) present. The score was limited due to the lack of mature trees as the vegetation is estimated to be only 15-20 years old. The Mixed Shrubland (VSA 2) was given a condition score of 2 (out of 6) due to the low density of mature foraging trees in the form of Marri tree (*C. calophylla*). In addition, the understorey of revegetated shrubs contained little foraging options for Forest Red-tailed Black-Cockatoos due to melaleuca being the dominant genus of shrub. Foraging opportunities for Forest Red-tailed Black-Cockatoo were extremely limited in VSAs 3, 4 and 5 with almost complete absence of any foraging species and extensive bare ground, infrastructure, disturbance and invasive grasses and weeds.

VSAs 1 and 2 receive a site context score of 1 (out of 3) because while they are small in area, they are in an urban landscape that has experienced extensive loss of foraging habitat. They also receive a score of 1 for stocking rate as the species has been recorded foraging in similar habitat in the Estate. VSAs 3, 4 and 5 do not receive context or stocking rate scores due to their low condition score. The distribution of foraging scores by VSA is shown in Figure 5Figure 4.

Table 8. Forest Red-tailed Black-Cockatoo values for Site Condition, Site Context, Species Stocking Rate and overall Foraging Habitat Quality Score (HQS) for each VSA.

VSA	VSA Name	VSA area (ha)	Site Condition (out of 6)	Site Condition Score Description	Site Context (out of 3)	Species Stocking Rate (0 or 1)	HQS (out of 10)
1	Revegetated Shrubland	0.535	2	Low	1	1	**4**
2	Mixed Shrubland	0.487	2	Low	1	1	**4**
3	Created Wetland	0.686	1	Negligible to Low	0	0	**1**
4	Cleared	1.27	1	Negligible to Low	0	0	**1**
5	Infrastructure	0.046	0	No Value	0	0	**0**

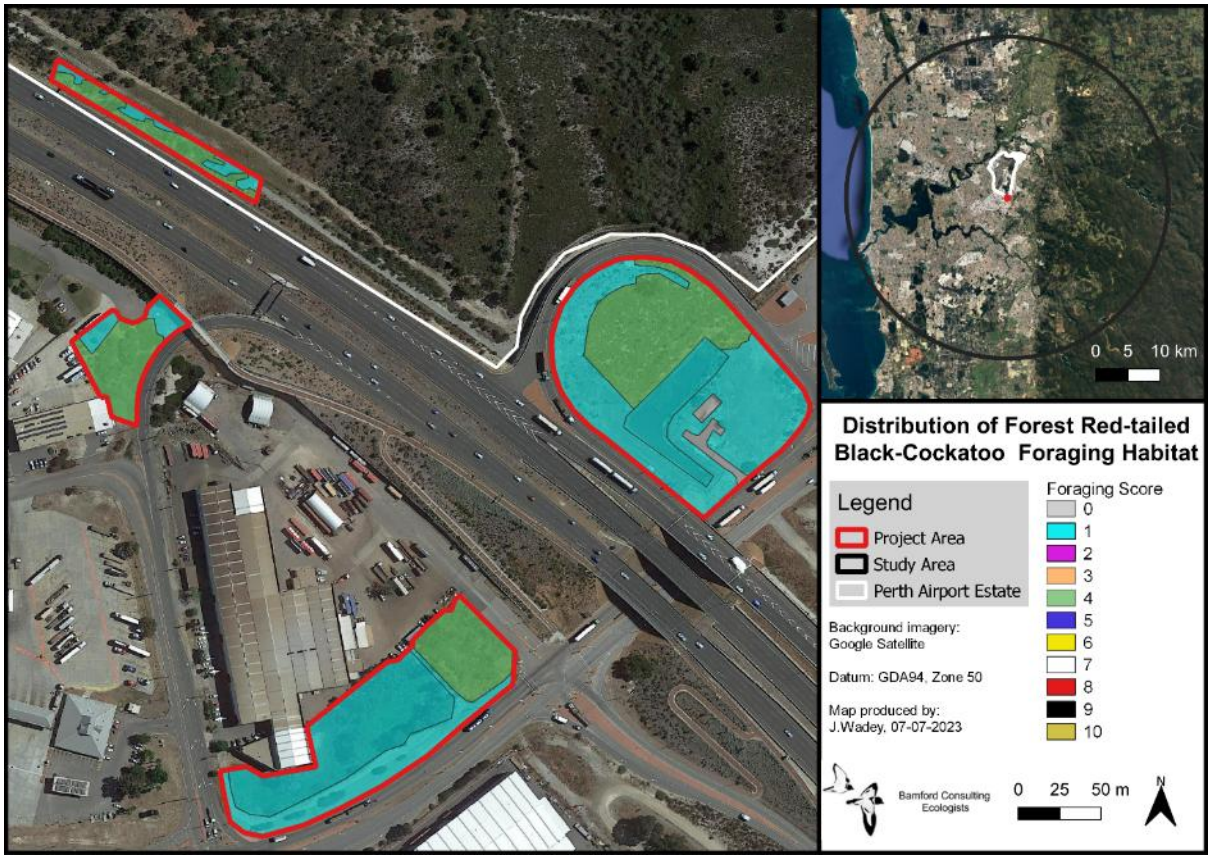

Figure 5. Distribution of Forest Red-tailed Black-Cockatoo foraging Habitat Quality scores (HQS) for each VSA.

3.3.2.3 Baudin's Black-Cockatoo

Baudin's Black-Cockatoo is primarily a species of tall eucalypt forests of the South-West, and Perth is at the northern limit of its range. It is present and breeds in the forests of the escarpment east of Perth. Bamford *et al.* (2017) concluded that the species "is probably only an irregular visitor, with a single record in 2014 (Everard and Bamford 2014)". The single record was of distinctive foraging signs on Marri fruit under one tree and these could have been made by a few birds in one feeding session. There were no other records despite multiple visits to the site by experienced zoologists. In August and September 2018, however, surveys by BCE found recent and intermediate foraging evidence (chewed Marri nuts) in 14 locations in the north, west and south of the Airport Estate. Birds were also seen actively foraging in Marri trees in the north and south of the Estate. It is not known if these records are indicative of a movement of the species onto the coastal plain, or was only an infrequent event that might not happen again. Note that the Forest Red-tailed Black-Cockatoo has only recently (since about 2008) been recorded regularly on the coastal plain in the Perth area, including on the Estate, and previously was also restricted to eucalypt forests of the escarpment. The possibility of Baudin's Black-Cockatoo making a similar behavioural change has to be considered. Prior to 2018, it was considered that the Estate was so little-used by Baudin's Black-Cockatoo that it was not considered in impact assessment and that at such a low level of usage, the impact would be negligible (Bamford *et al.* 2017).

Recent surveys suggest that the species may forage within the Estate more often than previously thought, but it is still likely to be an irregular visitor. Based on the foraging assessment outlined in Section 2.2, the project area is considered to be of low value for foraging by the Baudin's Black-Cockatoo, with HQS values ranging from 0 to 3 out of 10 (Table 9). These low scores are due to the low density of Marri trees (the mainstay feeding tree of the species) across the project area which may only support small numbers of individuals occasionally.

VSAs 1 and 2 receive a site context score of 1 (out of 3) because while they are small in area, they are in an urban landscape that has experienced extensive loss of foraging habitat. All VSAs receive a score of 0 for stocking rate as the species is not commonly-recorded in the area. VSAs 3, 4 and 5 do not receive context or stocking rate scores due to their low condition score. The distribution of foraging scores by VSA is shown in Figure 6.

Table 9. Baudin's Black-Cockatoo values for Site Condition, Site Context, Species Stocking Rate and overall Foraging Habitat Quality Score (HQS) for each VSA.

VSA	VSA Name	VSA area	Site Condition (out of 6)	Site Condition Score Description	Site Context (out of 3)	Species Stocking Rate (0 or 1)	HQS (out of 10)
1	Revegetated Shrubland	0.535	2	Low	1	0	3
2	Mixed Shrubland	0.487	1	Negligible to Low	1	0	2
3	Created Wetland	0.686	1	Negligible to Low	0	0	1
4	Cleared	1.27	1	Negligible to Low	0	0	1
5	Infrastructure	0.046	0	No Value	0	0	0

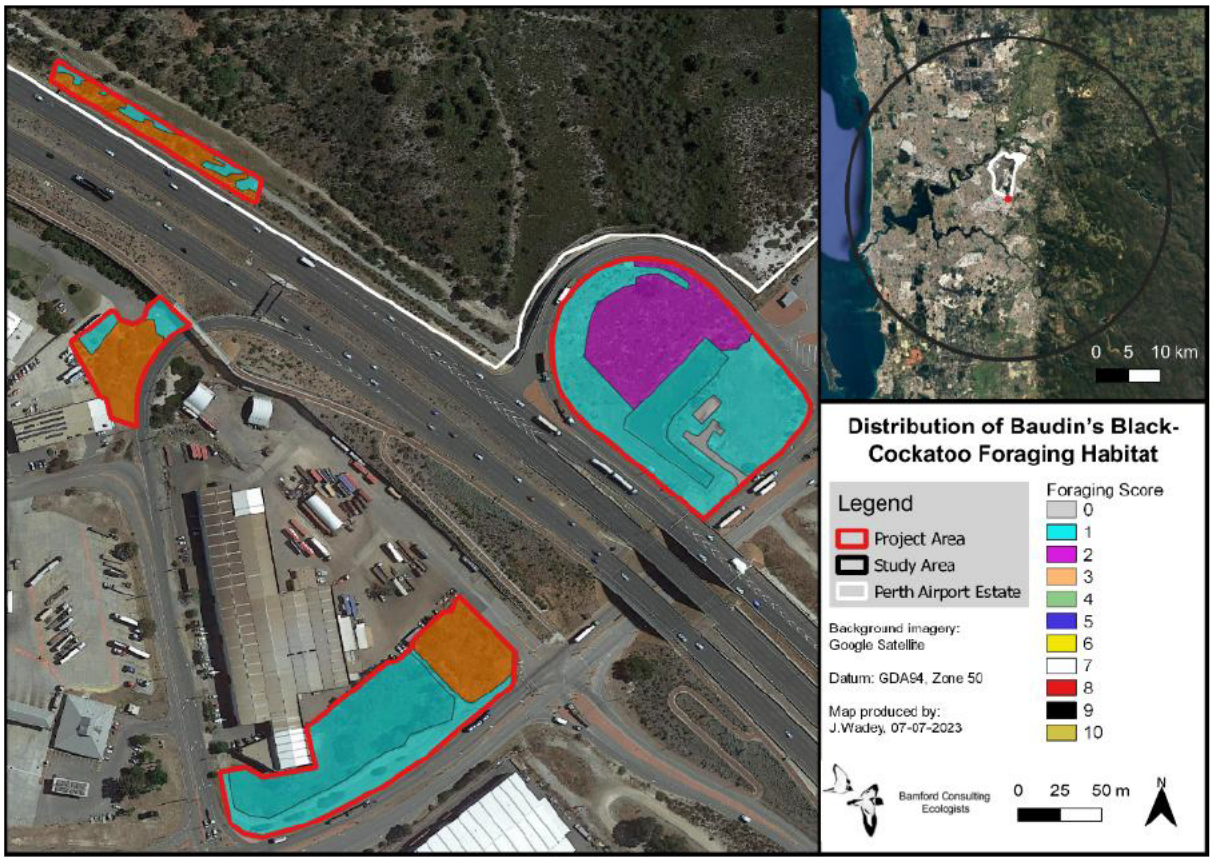

Figure 6. Distribution of Baudin's Black-Cockatoo foraging scores within each VSA.

3.3.3 Black-Cockatoo breeding habitat

There were 15 trees that met the potential nest-tree criterion of DAWE and DEE within the project area (see Figure 7 and Appendix 10). Most of these trees (13 out of 15) were introduced eucalypts,

while the other two species were Marri (*C. calophylla*) and Sheoak (*A. fraseriana*). All 15 trees were recorded as rank 5 – these were trees which met the minimum DBH but which did not contain any hollows. The introduced eucalypts were likely planted and therefore probably too young to form suitable breeding hollows for black-cockatoos. Details of each of the trees identified are given in Appendix 6 and their locations are shown in Figure 7. **Figure 9** and **Figure 10** illustrate examples of trees assigned a rank of 5.

The closest records of known breeding are ca. 11 km north-east of the project area in the suburbs of Darlington and Glen Forrest (Figure 8; DBCA threatened species database records). Additional records were recorded 13 km north-west, 14 km south-east and 16 km southwest (Figure 8).

BirdLife's Great Cocky Count database had 20 breeding sites within a 25 km radius (see Figure 8). These comprise a combination of 'potential' and 'confirmed' sites and both 'natural' and 'artificial' breeding hollows.

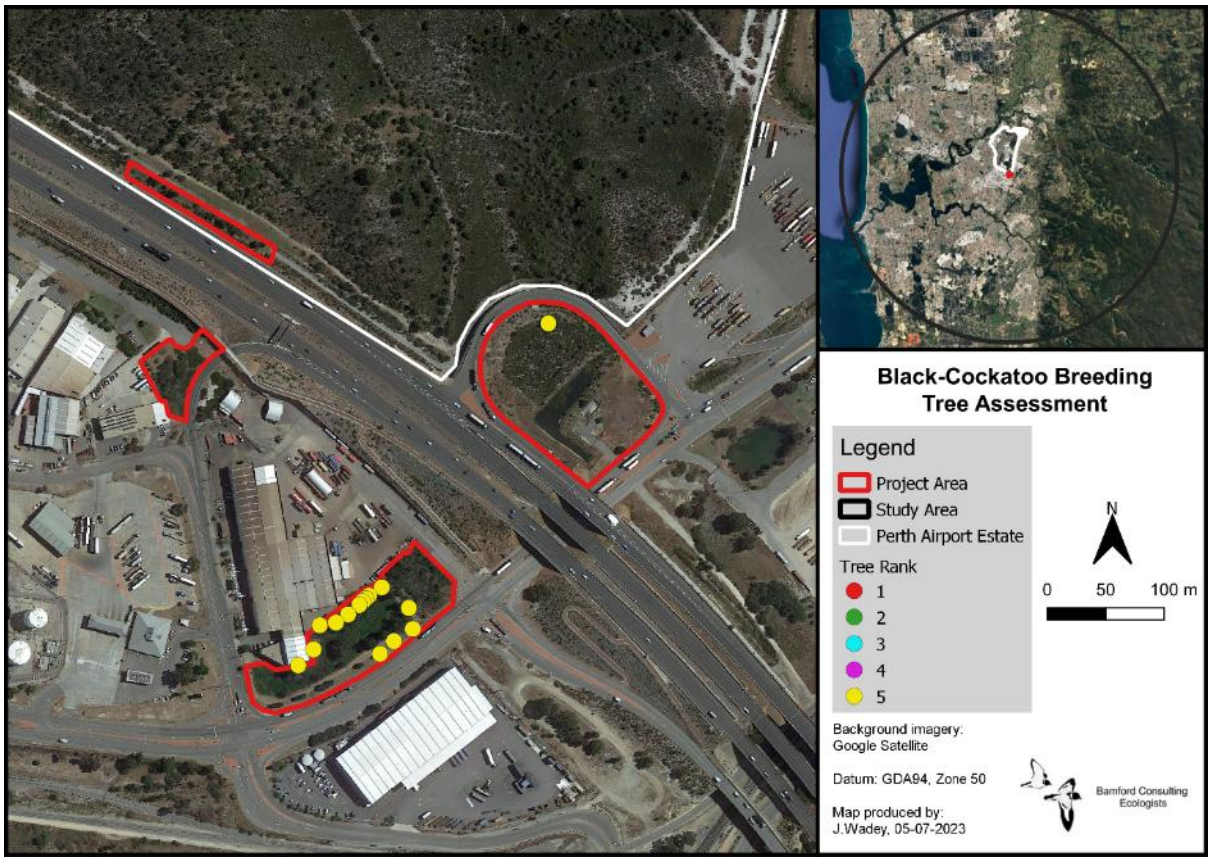

Figure 7. Locations and ranks of potential black-cockatoo nest trees.

Figure 8. Black-cockatoo breeding sites within 6 km (no sites present) and 25 km (inset) of the project area (DBCA 2022), including a BCE record.

Figure 9. Only Marri tree recorded that reached potential breeding DBH. No hollows were recorded.

Figure 10. Example of an introduced eucalyptus species that reached minimum DBH to be identified as a potential breeding tree. No hollows were recorded.

3.3.4 Black-Cockatoo roosting habitat

There is no known roost within the project area, but potentially 14 roosts within a 6 km radius of the project area (see Figure 11; BirdLife Australia's database). The distance of 6 km was used as it has been reported as the maximum normal foraging distance from a roost on the Swan Coastal Plain (Kabat *et al*. 2012). Therefore, there are potentially several different flocks (up to 14 based on the number of roosts) that could use the project area as a foraging resource. A targeted roost survey was not conducted (which requires visiting the site at dusk and preferably in autumn), but the multiple roosting surveys conducted in the region for many years as part of the Great Cocky Count make it unlikely that the site supports a regularly-used roost. Patterns of roosting can be somewhat dynamic, however, there are limited number of tall trees throughout the project area. VSA 3 is the only VSA with some potential for roosting to occur. The presence of water at VSA 3 is an additional benefit for black-cockatoos as the presence of nearby water is known to be an important factor in roost selection.

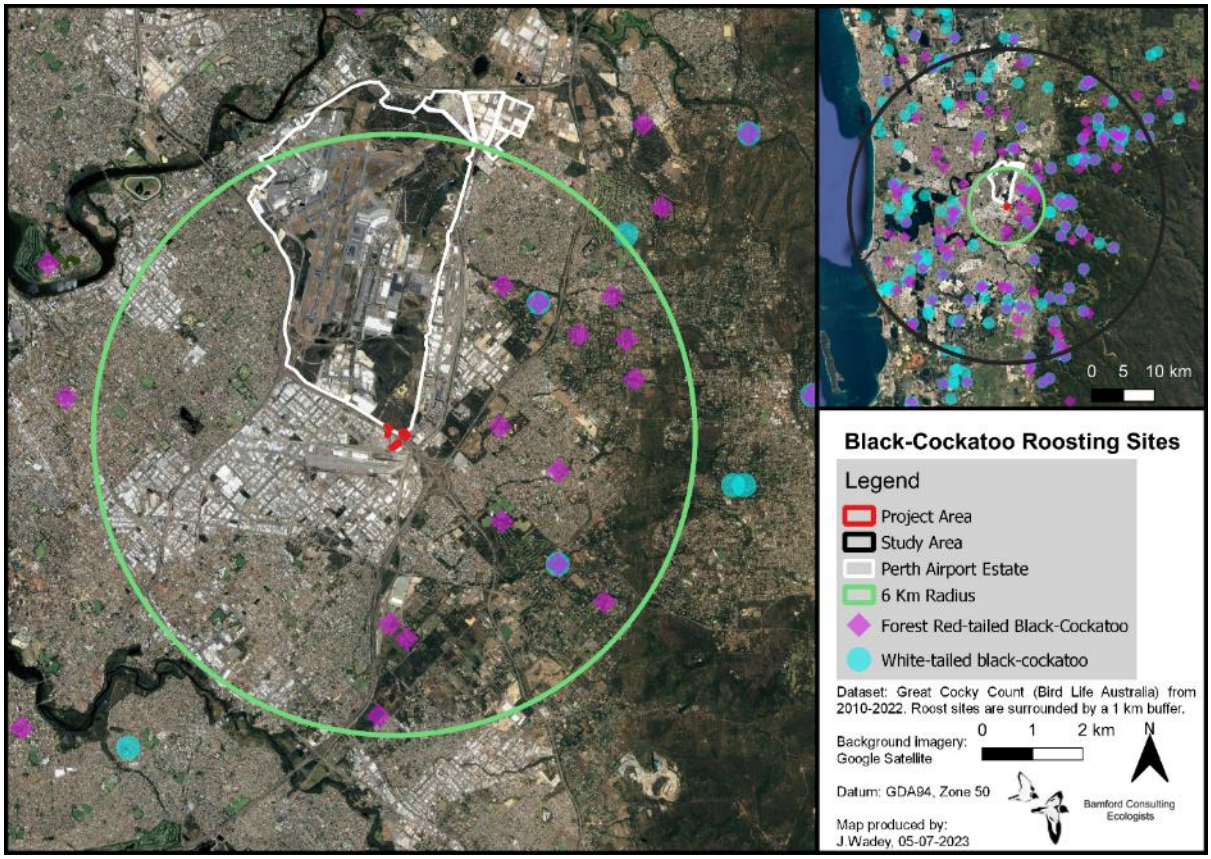

Figure 11. Known black-cockatoo roost locations in the vicinity of the project area.

3.4 Ecological processes

The nature of the landscape and the fauna assemblage indicate some of the ecological processes that may be important for ecosystem function (see Appendix 1 for description). These are the processes that sustain and influence the fauna assemblage. These include:

Cumulative habitat loss

The project area is located in suburbia on the Swan Coastal Plain where native vegetation has been cleared historically and is experiencing ongoing and rapid loss. Banksia woodland is reducing drastically with the cumulative loss of vegetation patches, even tiny ones, having the potential to lead to population decline of fauna. The small size of the patches within the project area almost certainly means they support far fewer species than would be the case if they were set within a more intact landscape.

Connectivity. The lack of direct connectivity for three of the four sites is expected to influence the composition of the fauna assemblage. For fauna which readily cross roads, the sites likely provide stepping stones to move between the Estate and surrounding native vegetation patches. Although the sites are small, even tiny fragments of native vegetation can be important throughout an already highly-fragmented landscape. However, the patches of the project area do not provide connectivity to off-site areas of native vegetation, and are separated by a major road.

Feral species and interactions with over-abundant native species. Feral species occur throughout Western Australia and are a considerable component of the current mammal fauna of the area. They have contributed to local mammal extinctions and may be affecting populations of extant species. Feral species are expected to occur in the project area. Feral Cats, Foxes and Rabbits, and to a lesser extent the Rainbow Lorikeet, are likely to be placing considerable pressure on the native fauna in the region. Feral fish are expected in the wetlands. Feral Bees may be competing with native nectarivores and could displace hollow-nesting species.

Fire. Native vegetation throughout the area is subject to fire and is likely to be burnt on a regular basis. While appropriate fire regimes can benefit biodiversity, inappropriate regimes can lead to a loss of biodiversity. No evidence was found that indicated recent fire in or adjacent to the project area. Fire may be infrequent but the small areas of remnant vegetation mean that the total area is very likely to be burnt in one fire event.

Local hydrology. The created wetland in the southern block is likely to support species that would not otherwise be present, and has potential as a drinking site for black-cockatoos. Its presence indicates that the water table is close to the surface over at least part of the project area.

4 Review of project against NVCP principles

The four survey area sites are discussed below with regard to each of the ten Clearing Principles as listed in Schedule 5 of the Environmental Protection Act (WA) 1986 (EP Act). For each of the Clearing Principles, a general statement is made on how the fauna values of the project area relate to that Clearing Principle, with further discussion providing the basis for this general statement. Under the EP Act it is an offence to clear native vegetation unless the clearing is done in accordance with a clearing permit, or an exemption applies. Under this legislation, clearing is not generally permitted where the biodiversity values, land conservation and water protection roles of native vegetation would be significantly adversely impacted. If a clearing permit is required under the EP Act and the proposed clearing will have or is likely to have an impact on a matter of national environmental significance (matter of NES) identified under the EPBC Act, the clearing application may be assessed under the assessment bilateral agreement under the EPBC Act.

Principles for clearing native vegetation under Schedule 5 of the EP Act:
Native vegetation should not be cleared if –

(a) it comprises a high level of biological diversity.
The project is considered not to be at variance with this Principle.
The sites are generally degraded, with vegetation altered (or cleared) and created waterbodies. The native vegetation includes some that is remnant and some revegetated within the past 20 years. The patches are small in size, connectivity is poor for three out of four sites, and they are located in a highly-disturbed location of a road intersection; therefore the sites are not expected to be rich in fauna species.

(b) it comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.
The project is considered not to be at variance with this Principle.
The sites are generally degraded and are not considered likely to support significant habitat for native fauna, with very small areas of habitat present and extensive habitat present nearby in the Estate (although it should be noted that some of this is at risk). Due to the small areas of native vegetation in the development area, and the poor condition of some of this vegetation, the only significant species that may be impacted is Carnaby's Black-Cockatoo. Two of the VSAs in the sites contain foraging habitat of moderate value. However, the area of foraging habitat within the sites is small, and similar (and better quality) foraging habitat is extensive in the adjacent Estate. This does represent further loss in an area of existing loss, but the amount of loss is very small.
The possible effect of the development upon Carnaby's Black-Cockatoo is assessed against the federal Guidelines 1.1 (Department of the Environment 2014b) in **Table 10**. This concludes that no significant impact criteria will be met.

Table 10. Carnaby's Black-Cockatoo assessed as per Guidelines 1.1.

Significance Criteria under Guidelines 1.1	Likelihood and rationale
	Carnaby's Black-Cockatoo
Lead to a long-term decrease in the size of a population[2] (or an important population[3]).	**Not likely to occur.** Carnaby's is a regular visitor to the Estate with breeding in the region. Native vegetation within the project area does provide some foraging habitat but it is a very small proportion of such habitat available regionally.
Reduce the area of occupancy of the species (or an important population).	**Unlikely to occur.** Area of loss of habitat will be very small and the species will remain within and still be able to move through the area.
Fragment an existing population (or important population) into two or more populations.	**Unlikely to occur.** This is a highly mobile species and the sites are small and considered unlikely to fragment populations.
Adversely affect habitat critical to the survival of a species[4].	**Unlikely to occur.** Foraging habitat areas are too small to be critical, and no breeding or roosting sites will be affected.
Disrupt the breeding cycle of a population (or important population).	**Unlikely to occur.** No loss of potential nest-trees and minimal loss of foraging habitat.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.	**Unlikely to occur.** Small and localised loss of foraging habitat only.
Result in invasive species that are harmful to a threatened species becoming established in the threatened species' habitat.	**Unlikely to occur.** Feral species and other competitors (e.g. feral bees, cats and foxes) are likely to be present in the region already and the development is unlikely to affect their abundance in a manner that will adversely impact Carnaby's Black-Cockatoo.

[2] A 'population of a species' is defined under the EPBC Act as an occurrence of the species in a particular area (includes a geographically distinct regional population, or collection of local populations, or a population, or collection of local populations, that occurs within a particular bioregion). Pertains to endangered and vulnerable species.

[3] An 'important population' is a population that is necessary for a species' long-term survival and recovery (includes populations identified as such in recovery plans, and/or key source populations either for breeding or dispersal, populations that are necessary for maintaining genetic diversity, and/or populations that are near the limit of the species range). Pertains to vulnerable species.

[4] 'Habitat critical to the survival of a species' refers to areas that are necessary: for activities such as foraging, breeding, roosting, or dispersal; for the long-term maintenance of the species; to maintain genetic diversity and long term evolutionary development; or for the reintroduction of populations or recovery of the species or ecological community. Pertains to endangered and vulnerable species.

Significance Criteria under Guidelines 1.1	Likelihood and rationale
	Carnaby's Black-Cockatoo
Introduce disease that may cause the species to decline.	**Unlikely to occur.** Sites are isolated and unlikely to affect nearby areas; hygiene management plan will be implemented for sites where appropriate.
Interfere with the recovery of the species.	**Unlikely to occur.** Minimal impacts expected as foraging area is so small. Broad-scale threatening processes (i.e. habitat loss) are of greatest concern for the species.

(c) it includes, or is necessary for the continued existence of, rare flora
Not assessed.

(d) it comprises the whole or a part of, or is necessary for the maintenance of a threatened ecological community
Not assessed.

(e) it is significant as a remnant of native vegetation in an area that has been extensively cleared
The project is considered not to be at variance with this Principle.
The project area is located on the Swan Coastal Plain which is experiencing ongoing vegetation urban development making any remnant of native vegetation valuable. However, the remnant vegetation in the project area is small in extent and degraded; it therefore cannot be considered significant.

(f) it is growing in, or in association with, an environment associated with a watercourse or wetland
The project may be at variance to this Principle.
Two of the sites contain what appear to be man-made wetlands which may contain permanent water. The wetlands are not typical of natural wetlands on the Swan Coastal Plain in having no banks and little riparianvegetation, and at least some of the vegetation that is present is planted rather than natural. It may therefore not strictly meet the definition of native vegetation, but the wetlands are present.

(g) the clearing of the vegetation is likely to cause appreciable land degradation
The project is considered not to be at variance with this Principle.
The sites are small and isolated, and the linear strip part of the Estate is small; their clearance are unlikely to cause appreciable land degradation.

(h) the clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area
The project is not considered to be at variance with this Principle.
The sites are isolated and not adjacent to conservation areas.

(i) the clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water
Not assessed.

(j) the clearing of the vegetation is likely to cause, or exacerbate, the incidence or intensity of

flooding.

The project is considered not to be at variance to this Principle.

Runoff from hard surfaces will need to be managed.

5 Conclusions

The four small patches of the project area support mostly degraded habitat, although the created wetlands and VSAs 1 and 2 support some fauna of local interest. Fauna present will be a subset of those present in the adjacent airport Estate, and the value for species of conservation significance is low. The proposed clearing of these patches will represent a small loss in fauna habitat and fauna populations, but given the condition of the habitat, nearby restoration, such as along road reserves, may be able to offset loss. Assessment of the project area against the NVCP principles concludes there would be no significant impacts as a result of construction within the project area.

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7 Appendices

Appendix 1. Explanation of fauna values.

Fauna values are the features of a site and its fauna that contribute to biodiversity, and it is these values that are potentially at threat from a development proposal. Fauna values can be examined under the five headings outlined below. It must be stressed that these values are interdependent and should not be considered equal, but to contribute to an understanding of the biodiversity of a site. Understanding fauna values provides opportunities to predict and therefore mitigate impacts.

Assemblage characteristics

Uniqueness. This refers to the combination of species present at a site. For example, a site may support an unusual assemblage that has elements from adjacent biogeographic zones, it may have species present or absent that might be otherwise expected, or it may have an assemblage that is typical of a very large region. For the purposes of impact assessment, an unusual assemblage has greater value for biodiversity than a typical assemblage.

Completeness. An assemblage may be complete (i.e. has all the species that would have been present at the time of European settlement), or it may have lost species due to a variety of factors. Note that a complete assemblage, such as on an island, may have fewer species than an incomplete assemblage (such as in a species-rich but degraded site on the mainland).

Richness. This is a measure of the number of species at a site. At a simple level, a species rich site is more valuable than a species poor site, but value is also determined, for example, by the sorts of species present.

Vegetation/substrate associations (VSAs)

VSAs combine broad vegetation types, the soils or other substrate with which they are associated, and the landform. In the context of fauna assessment, VSAs are the environments that provide habitats for fauna. The term habitat is widely used in this context, but by definition an animal's habitat is the environment that it utilises (Calver *et al.* 2009), not the environment as a whole. Habitat is a function of the animal and its ecology, rather than being a function of the environment. For example, a species may occur in eucalypt canopy or in leaf-litter on sand, and that habitat may be found in only one or in several VSAs. VSAs are not the same as vegetation types since these may not incorporate soil and landform, and recognise floristics to a degree that VSAs do not. Vegetation types may also not recognise minor but often significant (for fauna) structural differences in the environment. VSAs also do not necessarily correspond with soil types, but may reflect some of these elements.

Because VSAs provide the habitat for fauna, they are important in determining assemblage characteristics. For the purposes of impact assessment, VSAs can also provide a surrogate for detailed information on the fauna assemblage. For example, rare, relict or restricted VSAs should automatically be considered a significant fauna value. Impacts may be significant if the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna. The disturbance of even small amounts of habitat in a localised area can have significant impacts to fauna if rare or unusual habitats are disturbed.

Patterns of biodiversity across the landscape

This fauna value relates to how the assemblage is organised across the landscape. Generally, the fauna assemblage is not distributed evenly across the landscape or even within one VSA. There may be zones of high biodiversity such as particular environments or ecotones (transitions between VSAs). There may also be zones of low biodiversity. Impacts may be significant if a wide range of species is affected even if most of those species are not significant per se.

Species of conservation significance

Species of conservation significance are of special importance in impact assessment. The conservation status of fauna species in Australia is assessed under Commonwealth and State Acts such as the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) and the Western Australian Wildlife Conservation Act 1950 (Wildlife Conservation Act). In addition, the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA) recognises priority levels, while local populations of some species may be significant even if the species as a whole has no formal recognition. Therefore, three broad levels of conservation significance can be recognised and are used for the purposes of this report, and are outlined below. A full description of the conservation significance categories, schedules and priority levels mentioned below is provided in Appendix 2.

Conservation Significance (CS) 1: Species listed under State or Commonwealth Acts.

Species listed under the EPBC Act are assigned to categories recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN) and reviewed by Mace and Stuart (1994), or are listed as migratory. Migratory species are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA), the Republic of South Korea Australia Migratory Bird Agreement (ROKAMBA), and/or the Convention on the Conservation of Migratory Species of Wild Animals (CMS; also referred to as the Bonn Convention). The Wildlife Conservation Act uses a series of Schedules and Divisions to classify status, but also recognizes the IUCN categories and ranks species within the Schedules using the categories of Mace and Stuart (1994).

Conservation Significance (CS) 2: Species listed as Priority by the DEC but not listed under State or Commonwealth Acts.

In Western Australia, the DEC has produced a supplementary list of Priority Fauna, being species that are not considered threatened under the Wildlife Conservation Act but for which the DEC feels there is cause for concern. Some Priority species are also assigned to the Conservation Dependent category of the IUCN.

Conservation Significance (CS) 3: Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution.

This level of significance has no legislative or published recognition and is based on interpretation of distribution information, but is used here as it may have links to preserving biodiversity at the genetic level (EPA 2002). If a population is isolated but a subset of a widespread (common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Conservation significance is applied to allow for the preservation of genetic richness at a population

level, and not just at a species level. Populations on the edge of a species' range are often less abundant and more vulnerable to local extinction than populations at the centre of the range (Curnutt *et al*. 1996), and thus such populations can be considered significant. In addition, species that are sensitive to impacts such as habitat fragmentation may be classed as CS3, as may colonies of waterbirds. The Western Australian Department of Environmental Protection, now DPaW, used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan (Dell and Banyard 2000).

Invertebrate species considered to be short range endemics (SREs) also fall within the CS3 category, as they have no legislative or published recognition and their significance is based on interpretation of distribution information. Harvey (2002) notes that the majority of species that have been classified as short-range endemics have common life history characteristics such as poor powers of dispersal or confinement to discontinuous habitats. Several groups, therefore, have particularly high instances of short-range endemic species: Gastropoda (snails and slugs), Oligochaeta (earthworms), Onychophora (velvet worms), Araneae (mygalomorph spiders), Pseudoscorpionida (pseudoscorpions), Schizomida (schizomids), Diplopoda (millipedes), Phreatoicidea (phreatoicidean crustaceans), and Decapoda (freshwater crayfish). The poor understanding of the taxonomy of many of the short-range endemic species hinders their conservation (Harvey 2002).

Introduced species

In addition to these conservation levels, species that have been introduced (INT) are indicated throughout the report. Introduced species may be important to the native fauna assemblage through effects by predation and/or competition.

Ecological processes upon which the fauna depend

These are the processes that affect and maintain fauna populations in an area and as such are very complex; for example, populations are maintained through the dynamic of mortality, survival and recruitment being more or less in balance, and these are affected by a myriad of factors. The dynamics of fauna populations in a project may be affected by processes such as fire regime, landscape patterns (such as fragmentation and/or linkage), the presence of feral species and hydrology. Impacts may be significant if processes are altered such that fauna populations are adversely affected, resulting in declines and even localised loss of species. Threatening processes as outlined below are effectively the ecological processes that can be altered to result in impacts upon fauna.

Appendix 2. Explanation of threatening processes.

Potential impacts of proposed developments upon fauna values can be related to threatening processes. This is recognised in the literature (e.g. Gleeson and Gleeson 2012) and under the EPBC Act, in which threatening processes are listed. Processes that may impact fauna values are discussed below. Rather than being independent of one another, processes are complex and often interrelated. They are the mechanisms by which fauna can be affected by development. Impacts may be significant if large numbers of species or large proportions of populations are affected.

Note that the terms direct and indirect impacts are used by the DotE (2013), SEWPaC (2013) and EPA (2016), but there is some inconsistency in how these are defined. The federal guidance does not define direct impact but has a very broad definition of indirect, and makes the statement (DotE 2013) '*Consideration should be given to all adverse impacts that could reasonably be predicted to follow from the action, whether these impacts are within the control of the person proposing to take the action or not. Indirect impacts will be relevant where they are sufficiently close to the proposed action to be said to be a consequence of the action, and they can reasonably be imputed to be within the contemplation of the person proposing to take the action*.' Indirect impacts therefore can even include what the DotE (2013) calls facilitated impacts, which are the result of third party actions triggered by the primary action. In contrast, the EPA (2016) defines direct impacts to '*include the removal, fragmentation or modification of habitat, and mortality or displacement of individuals or populations.*' This document then lists as indirect impacts what in many cases are the consequences of the removal, fragmentation or modification of habitat. For example, '*disruption of the dispersal of individuals required to colonise new areas inhibiting maintenance of genetic diversity between populations*' is a consequence of habitat fragmentation. Impacts of light, noise and even roadkill are defined as indirect but they are clearly the result of the action and in control of the person taking the action. Roadkill is as direct a form of mortality as can be observed, but it is considered as an indirect impact in the context of a development presumably because it is not directly linked to land clearing. The EPA (2016) makes a strong distinction between removal of vegetation (direct impact) and the consequences of such clearing and other aspects of a development (indirect impacts). It is not obvious how this distinction between direct and indirect impacts is helpful in the EIA process, as the key aim is to ensure that all impacts that result from a project are addressed in this assessment process. Interestingly, Gleeson and Gleeson (2012), in a major review of impacts of development on wildlife, do not use the terms direct or indirect. In the following outlines of threatening processes that can cause impacts, the emphasis is upon interpreting how a threatening process will cause an impact. for example, loss of habitat (threatening process) can lead to population decline and to population fragmentation, which are two distinct impacts.

Loss of habitat affecting population survival

Clearing for a development can lead to habitat loss for a species with a consequent decline in population size. This may be significant if the smaller population has reduced viability. Conservation significant species or species that already occur at low densities may be particularly sensitive to habitat loss affecting population survival.

Loss of habitat leading to population fragmentation

Loss of habitat can affect population movements by limiting movement of individuals throughout the landscape as a result of fragmentation (Gleeson and Gleeson 2012, Soule *et al.* 2004). Obstructions associated with the development, such as roads, pipes and drainage channels, may also affect movement of small, terrestrial species. Fragmented populations may not be sustainable and may be sensitive to effects such as reduced gene flow.

Degradation of habitat due to weed invasion leading to population decline

Weed invasion can occur as a result of development and if this alters habitat quality, can lead to effects similar to habitat loss.

Increased mortality

Increased mortality can occur during project operations; for example from roadkill, animals striking infrastructure and entrapment in trenches. Roadkill as a cause of population decline has been documented for several medium-sized mammals in eastern Australia (Dufty 1989; Jones 2000). Increased mortality due to roadkill is often more prevalent in habitats that have been fragmented (Scheick and Jones 1999; Clevenger and Waltho 2000; Jackson and Griffin 2000).

Increased mortality of common species during development is unavoidable and may not be significant for a population. However, the cumulative impacts of increased mortality of conservation significant species or species that already occur at low densities may have a significant impact on the population.

Species interactions, including predation and competition

Changes in species interactions often occur with development. Introduced species, including the feral Cat, Red Fox and Rabbit may have adverse impacts upon native species and development can alter their abundance. In particular, some mammal species are very sensitive to introduced predators and the decline of many mammals in Australia has been linked to predation by the Red Fox, and to a lesser extent the feral Cat (Burbidge and McKenzie 1989). Introduced grazing species, such as the Rabbit, Goat, Camel and domestic livestock, can also degrade habitats and deplete vegetation that may be a food source for other species.

Changes in the abundance of some native species at the expense of others, due to the provision of fresh watering points, can also be a concern. Harrington (2002) and Read *et al.* (2015) found the presence of artificial fresh waterpoints in the semi-arid mallee rangelands to influence the abundance and distribution of certain bird species. Common, water-dependent birds were found to out-compete some less common, water-independent species. Over-abundant native herbivores, such as kangaroos, can also adversely affect less abundant native species through competition and displacement.

Hydroecology

Interruptions of hydroecological processes can have major effects because they underpin primary production in ecosystems and there are specific, generally rare habitats that are hydrology-dependent. Fauna may be impacted by potential changes to groundwater level and chemistry and

altered flow regime. These changes may alter vegetation across large areas and may lead to habitat degradation or loss. Impacts upon fauna can be widespread and major.

Changes to flow regime across the landscape may alter vegetation and may lead to habitat degradation or loss, affecting fauna. For example, Mulga has a shallow root system and relies on surface sheet flow during flood events. If surface sheet flow is impeded, Mulga can die (Kofoed 1998), which may impact on a range of fauna associated with this vegetation type.

Fire

The role of fire in the Australian environment and its importance to vertebrate fauna has been widely acknowledged (Gill *et al.* 1981; Fox 1982; Letnic *et al.* 2004; Bamford and Roberts 2003). It is also one of the factors that has contributed to the decline and local extinction of some mammal and bird species (Burbidge and McKenzie 1998). Fire is a natural feature of the environment but frequent, extensive fires may adversely impact some fauna, particularly mammals and short-range endemic species. Changes in fire regime, whether to more frequent or less frequent fires, may be significant to some fauna. Impacts of severe fire may be devastating to species already occurring at low densities or to species requiring long unburnt habitats to survive. In terms of conservation management, it is not fire *per se* but the fire regime that is important, with evidence that infrequent, extensive and intense fires adversely affect biodiversity, whereas frequent fires that cover small areas and are variable in both season and intensity can enhance biodiversity. Fire management may be considered the responsibility of managers of large tracts of land.

Dust, light, noise and vibration

Impacts of dust, light, noise and vibration upon fauna are difficult to predict. Some studies have demonstrated the impact of artificial night lighting on fauna, with lighting affecting fauna behaviour more than noise (Rich and Longcore 2006). Effects can include impacts on predator-prey interactions, changes to mating and nesting behaviour, and increased competition and predation within and between invertebrates, frogs, birds and mammals.

The death of very large numbers of insects has been observed around some remote mine sites and attracts other fauna, notably native and introduced predators (M. Bamford pers. obs). The abundance of some insects can decline due to mortality around lights, although this has previously been recorded in fragmented landscapes where populations are already under stress (Rich and Longcore 2006). Artificial night lighting may also lead to disorientation of migratory birds. Aquatic habitats and open habitats such as grasslands and dunes may be vulnerable to light spill.

Appendix 3. Categories used in the assessment of conservation status.

IUCN categories (based on review by Mace and Stuart 1994) as used for the Environment Protection and Biodiversity Conservation Act 1999 and the Western Australian Wildlife Conservation Act 1950.

Extinct	Taxa not definitely located in the wild during the past 50 years.
Extinct in the Wild (Ex)	Taxa known to survive only in captivity.
Critically Endangered (CR)	Taxa facing an extremely high risk of extinction in the wild in the immediate future.
Endangered (E)	Taxa facing a very high risk of extinction in the wild in the near future.
Vulnerable (V)	Taxa facing a high risk of extinction in the wild in the medium-term future.
Near Threatened	Taxa that risk becoming Vulnerable in the wild.
Conservation Dependent	Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened.
Data Deficient (Insufficiently Known)	Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.
Least Concern.	Taxa that are not Threatened.

Schedules used in the WA *Biodiversity Conservation Act 2016, updated 2023*

Schedule 1	Specially protected fauna Division 1 – Species of special conservation interest (S1D1) Division 2 – Migratory species (S1D2) Division 3 – Species otherwise in need of special protection (S1D3)
Schedule 2	Threatened species Division 1 – Critically endangered species (S2D1) Division 2 – Endangered species(S2D2) Division 3 – Vulnerable species (S2D3)
Schedule 3	Extinct species (S3)

WA Department of Environment and Conservation Priority species (species not listed under the Wildlife Conservation Act 1950, but for which there is some concern).

Priority 1 (P1)	Taxa with few, poorly known populations on threatened lands.
Priority 2 (P2)	Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.
Priority 3 (P3)	Taxa with several, poorly known populations, some on conservation lands.
Priority 4. (P4)	Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change.
Priority 5 (P5)	Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years (IUCN Conservation Dependent).

Appendix 4. Vertebrate fauna of the Perth Airport Estate (taken from Bancroft and Bamford 2020).

Fauna species that could potentially occur in the vicinity of the Perth Airport Estate. Conservation significance (CS) shown as described in Section 1.1.2. Species recorded by ATA (1994), How (1995) and recent BCE field surveys (Bancroft and Bamford 2008; Everard and Bamford 2014, Bamford 2022) are indicated by an "X"; as are species recorded in recent field investigations (BCE 2016-2021). Species that have not been recorded but are still considered highly likely to be present are indicated by a "†". Species returned from the literature review but considered to be locally extinct are listed separately below. In addition, several species have been previously recorded on the Airport Estate but are now (in 2016) considered likely to be locally extinct; and are labelled 'LE' in the Presence column.
CS1, CS2, CS3 = (summary) levels of conservation significance. See Section 1.1.2 for full explanation.
EPBC Act listings: E = Endangered, V = Vulnerable, M = Migratory (Appendix 1).
Wildlife Conservation Act 1950 listings: S1 to S7 = Schedules 1 to 7 (Appendix 1).
DBCA Priority species: P1 to P5 = Priority 1 to 5 (Appendix 1).
Bush Forever (Dell and Banyard 2000) status: HS = habitat specialists with a reduced distribution on the Swan Coastal Plain, LE = locally extinct, WR = wide ranging species with reduced populations on the Swan Coastal Plain (see Section 1.1.2.3).
LS = considered to be of local significance by Bamford Consulting Ecologists (see Section 1.1.2.3).
Int = introduced species.

Freshwater fish

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2021	Presence
Galaxiidae (Jollytails or native minnows)								
Galaxias occidentalis	Western Minnow							
Galaxiella nigrostriata	Black-striped Minnow							LE
Nannopercidae (Pygmy-perches)								
Edelia vittata	Western Pygmy-perch							
Percichthyidae (Australian basses and cods)								
Bostockia porosa	Nightfish							
Cyprinidae (carp and allies)								

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2021	Presence
Carassius auratus	Goldfish							X
Poeciliidae (Live-bearers)								
Gambusia holbrooki	Mosquitofish	Int				X	X	X
Gobiidae (gobies)								
Pseudogobius olorum	Swan River Goby							†

Frogs (“PG” indicates species recorded at Poison Gully, adjacent to the Perth Airport Estate)

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Hylidae (Tree frogs)								
Litoria adelaidensis	Slender Tree Frog		X	X	X	X	X	X
Litoria moorei	Motorbike Frog			X	X	X	X	X
Limnodynastidae (Burrowing frogs)								
Heleioporus eyrei	Moaning Frog		X	X	X	X	X	X
Heleioporus barycragus	Hooting Frog	LS					PG	†
Heleioporus psammophilus	Sand Frog							
Limnodynastes dorsalis	Banjo Frog, Pobblebonk			X	X	X	X	X
Myobatrachidae (Ground frogs)								
Crinia georgiana	Quacking Frog					X		X
Crinia glauerti	Glauert's Froglet		X	X	X	X		X
Crinia insignifera	Squelching Froglet		X	X	X	X		X

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Geocrinia leai	Lea's Froglet	LS					X	X
Myobatrachus gouldii	Turtle Frog			X				X
Pseudophryne guentheri	Günther's Toadlet		X	X	X		X	X

Reptiles

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Cheluidae (Side-necked freshwater tortoises)								
Chelodina colliei (oblonga)	Oblong Tortoise		X	X	X	X	X	X
Pseudemydura umbrina	Western Swamp Tortoise	CS1						LE
Carphodactylidae (Carphodactylid geckoes)								
Underwoodisauraus milii	Southern Barking Gecko							
Diplodactylidae (Diplodactylid geckoes)								
Crenadactylus ocellatus	Clawless Gecko							
Diplodactylus polyophthalmus	Spotted Sandplain Gecko							
Strophurus spinigerus	Spiny-tailed Gecko							†
Gekkonidae (Gekkonid geckoes)								
Christinus marmoratus	Marbled Gecko							†
Pygopodidae (Legless lizards)								
Aprasia repens	Sand-plain Worm-Lizard							†
Delma fraseri	Fraser's Legless Lizard		X					X

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Delma grayii	Gray's Legless Lizard			X				X
Lialis burtonis	Burton's Legless Lizard			X				X
Pletholax gracilis	Keeled Legless Lizard			X	X			X
Pygopus lepidopodus	Common Scaly Foot							†
Agamidae (Dragons)								
Ctenophorus adelaidensis	Western Heath Dragon							†
Pogona minor	Western Bearded Dragon		X	X	X	X		X
Egerniidae (Egerniid skinks)								
Egernia kingii	King's Skink							
Tiliqua occipitalis	Western Bluetongue							†
Tiliqua rugosa	Bobtail		X	X	X	X	X	X
Eugongylidae (Eugongylid skinks)								
Acritoscincus trilineatum	Cool Skink		X	X	X	X	X	X
Cryptoblepharus buchananii	Buchanan's Snake-eyed Skink		X	X	X	X	X	X
Menetia greyii	Common Dwarf Skink		X	X	X	X		X
Morethia lineoocellata								†
Morethia obscura								†
Sphenomorphidae (Sphenomorphid skinks)								
Ctenotus australis						X	X	X
Ctenotus fallens	West Coast Ctenotus			X	X	X	X	X

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Ctenotus gemmula	Jewelled Ctenotus							
Ctenotus impar	South-western Odd-striped Ctenotus		X	X				X
Hemiergis quadrilineata	Two-toed Earless Skink		X	X	X	X	X	X
Lerista elegans	West Coast Four-toed Lerista		X	X	X	X	X	X
Lerista lineata	Perth Slider, Lined Skink	CS2 (P3)						
Lerista praepedita								†
Varanidae (Monitors and goannas)								
Varanus gouldii	Sand Goanna		X	X	X	X	X	X
Varanus tristis	Black-headed Monitor		X	X				X
Typhlopidae (Blind snakes)								
Anilios australis	Southern Blind Snake			X				X
Anilios waitii								
Pythonidae (Pythons)								
Antaresia stimsoni stimsoni	Stimson's Python							LE
Morelia spilota imbricate	Carpet Python (southwest)	LS						LE
Elapidae (Venomous land snakes)								
Brachyurophis fasciolatus	Narrow-banded Shovel-nosed Snake	LS						
Brachyurophis semifasciatas	Southern Shovel-nosed Snake	LS						
Elapognathus coronatus	Crowned Snake	LS	X	X				X
Neelaps bimaculatus	Black-naped Snake	LS						

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Neelaps calonotos	Black-striped Snake	CS2 (P3)						
Notechis scutatus	Tiger Snake							†
Parasuta gouldii	Gould's Snake			X				X
Pseudonaja affinis	Dugite		X	X	X	X		X
Simoselaps bertholdi	Jan's Banded Snake			X				X

Birds

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Phasianidae (Quails)								
Coturnix pectoralis	Stubble Quail							†
Anatidae (Ducks and allies)								
Biziura lobata	Musk Duck	LS (HS)			X			X
Cygnus atratus	Black Swan				X			X
Tadorna tadornoides	Australian Shelduck		X		X	X		X
Chenonetta jubata	Australian Wood Duck		X		X	X	X	X
Aythya australis	Hardhead					.	X	X
Malacorhynchus membranaceus	Pink-eared Duck	LS (HS)			X		X	X
Anas rhynchotis	Australasian Shoveler	LS (HS)	X		X			X
Anas gracilis	Grey Teal		X		X	X	X	X
Anas castanea	Chestnut Teal				X			X

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Anas superciliosa	Pacific Black Duck		X		X	X	X	X
Oxyura australis	Blue-billed Duck	CS2 (P4,HS)				.		†
Megapodiidae (Megapodes)								
Leipoa ocellata	Malleefowl	CS1 (V,S3)						LE
Podicipedidae (Grebes)								
Poliocephalus poliocephalus	Hoary-headed Grebe						X	X
Tachybaptus novaehollandiae	Australasian Grebe				X		X	X
Columbidae (Pigeons and doves)								
Columba livia	Domestic Pigeon					X	X	X
Streptopelia senegalensis	Laughing Dove	Int	X	X	X	X	X	X
Streptopelia chinensis	Spotted Dove	Int		X		X	X	X
Phaps chalcoptera	Common Bronzewing	LS (HS)		X		X		X
Ocyphaps lophotes	Crested Pigeon		X	X	X	X	X	X
Geopelia cuneata	Diamond Dove					X[5]		
Anhingidae (Darters)								
Anhinga novaehollandiae	Australasian Darter				X			X
Phalacrocoracidae (Cormorants)								
Microcarbo melanoleucos	Little Pied Cormorant		X	X	X			X
Phalacrocorax carbo	Great Cormorant			X				X

[5] Highly likely to have been an aviary escapee.

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Phalacrocorax sulcirostris	Little Black Cormorant			X				X
Pelicanidae (Pelican)								
Pelecanus conspicillatus	Australian Pelican			X				X
Ardeidae (Herons, bitterns and egrets)								
Ardea pacifica	White-necked Heron					X		X
Ardea modesta	Eastern Great Egret		X	X				X
Ardea ibis	Cattle Egret							
Egretta novaehollandiae	White-faced Heron		X	X	X	X	X	X
Nycticorax caledonicus	Nankeen Night Heron					X	X	X
Threskiornithidae (Ibises and spoonbills)								
Threskiornis molucca	Australian White Ibis		X	X	X	X		X
Threskiornis spinicollis	Straw-necked Ibis		X	X	X			X
Plegadis falcinellus	Glossy Ibis	CS1 (M,S5)				†		†
Platalea flavipes	Yellow-billed Spoonbill		X	X				X
Accipitridae (Osprey, hawks and eagles)								
Pandion cristatus	Eastern Osprey							†
Elanus axillaris	Black-shouldered Kite		X	X	X	X	X	X
Accipiter fasciatus	Brown Goshawk	LS (WR)	X	X	X		X	X
Accipiter cirrocephalus	Collared Sparrowhawk	LS (WR)		X	X	X		X
Aquila audax	Wedge-tailed Eagle	LS (WR)	X		X		X	X

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Hieraaetus morphnoides	Little Eagle	LS (WR)	X	X	X	X		X
Haliastur sphenurus	Whistling Kite	LS (WR)				†	X	X
Lophoictinia isura	Square-tailed Kite	LS (WR)				†		†
Circus approximans	Swamp Harrier					†		†
Falconidae (Falcons)								
Falco peregrinus	Peregrine Falcon	CS1 (S7)				†		†
Falco longipennis	Australian Hobby					†	X	X
Falco cenchroides	Nankeen Kestrel		X	X	X	X	X	X
Falco berigora	Brown Falcon	LS (WR)		X				X
Rallidae (Rails, gallinules and coots)								
Gallirallus philippensis	Buff-banded Rail					†	X	X
Gallinula ventralis	Black-tailed Native-hen					†		
Porphyrio porphyrio	Purple Swamphen		X				X	X
Porzana tabuensis	Spotless Crake						X	X
Gallinula tenebrosa	Dusky Moorhen	LS (HS)	X		X			X
Fulica atra	Eurasian Coot		X	X	X	X	X	X
Recurvirostridae (Stilts and avocets)								
Himantopus himantopus	Black-winged Stilt		X	X				X
Cladorhynchus leucocephalus	Banded Stilt							
Charadriidae (Lapwings, plovers and dotterels)								

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Elseyornis melanops	Black-fronted Dotterel			X	X			X
Vanellus tricolor	Banded Lapwing				X			X
Cacatuidae (Cockatoos)								
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	CS1 (V,S3)			X	X	X	X
Calyptorhynchus baudinii	Baudin's Black-Cockatoo	CS1 (E,S2,WR)				X	X	X
Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	CS1 (E,S2,WR)			X	X	X	X
Eolophus roseicapillus	Galah			X	X	X	X	X
Cacatua galerita	Sulphur-crested Cockatoo	Int						
Cacatua pastinator	Western Corella					†		†
Cacatua sanguinea	Little Corella	Int				†		†
Cacatua tenuirostris	Long-billed Corella	Int				†		†
Psittacidae (Parrots)								
Trichoglossus haematodus	Rainbow Lorikeet	Int			X	X	X	X
Barnardius zonarius	Australian Ringneck				X	X	X	X
Purpureicephalus spurius	Red-capped Parrot		X	X	X	X		X
Neophema elegans	Elegant Parrot		X	X				X
Cuculidae (Old world cuckoos)								
Chalcites basalis	Horsfield's Bronze-Cuckoo				X			X
Chalcites lucidus	Shining Bronze-Cuckoo			X	X			X

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Cacomantis pallidus	Pallid Cuckoo		X	X				X
Cacomantis flabelliformis	Fan-tailed Cuckoo			X	X			X
Strigidae (Hawk Owls)								
Ninox boobook	Southern Boobook					X		X
Ninox connivens connivens	Barking Owl (south-west population)	CS2 (P2)						
Tytonidae (Barn Owls)								
Tyto novaehollandiae novaehollandiae	Masked Owl (south-west population)	CS2 (P2)						
Tyto javanica	Eastern Barn Owl					X		X
Podargidae (Frogmouths)								
Podargus strigoides	Tawny Frogmouth					†		†
Apodidae (Swifts and Swiftlets)								
Apus pacificus	Fork-tailed Swift	CS1 (M,S5)				†		†
Halcyonidae (Tree kingfishers)								
Dacelo novaeguineae	Laughing Kookaburra	Int			X		X	X
Todiramphus sanctus	Sacred Kingfisher		X	X	X			X
Meropidae (Bee-eaters)								
Merops ornatus	Rainbow Bee-eater	LS	X	X	X			X
Maluridae (Fairy-wrens, emu-wrens and grasswrens)								
Malurus splendens	Splendid Fairy-wren	LS (HS)			X	X	X	X
Malurus leucopterus	White-winged Fairy-wren	LS (HS)						LE

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Acanthizidae (Australasian warblers)								
Sericornis frontalis	White-browed Scrubwren	LS (HS)			X	X	X	X
Smicrornis brevirostris	Weebill	LS (HS)			X	X	X	X
Gerygone fusca	Western Gerygone				X	X	X	X
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	LS (HS)	X	X	X	X	X	X
Acanthiza apicalis	Inland Thornbill	LS (HS)	X	X	X			X/LE
Acanthiza inornata	Western Thornbill	LS (HS)				†		LE
Pardalotidae (Pardalotes)								
Pardalotus punctatus	Spotted Pardalote		X	X				X
Pardalotus striatus	Striated Pardalote			X	X	X	X	X
Meliphagidae (Honeyeaters)								
Acanthorhynchus superciliosus	Western Spinebill		X	X	X			X
Anthochaera lunulata	Western Wattlebird	LS (WR)	X	X	X	X		X
Anthochaera carunculata	Red Wattlebird		X	X	X		X	X
Manorina flavigula	Yellow-throated Miner							
Lichenostomus virescens	Singing Honeyeater		X	X	X	X	X	X
Lichenostomus ornatus	Yellow-plumed Honeyeater							
Melithreptus chloropsis	Gilbert's Honeyeater	LS (WR)				†		†
Phylidonyris novaehollandiae	New Holland Honeyeater	LS (WR)	X	X	X		X	X
Glyciphila melanops	Tawny-crowned Honeyeater	LS (WR)	X	X	X	X		X

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Lichmera indistincta	Brown Honeyeater			X	X	X	X	X
Phylidonyris niger	White-cheeked Honeyeater	LS (WR)	X		X	X	X	X
Epthianura albifrons	White-fronted Chat	LS	X	X				X
Neosittidae (Sitellas)								
Daphoenositta chrysoptera	Varied Sittella	LS (HS)	X	X	X			X
Campephagidae (Cuckoo-shrikes and trillers)								
Coracina novaehollandiae	Black-faced Cuckoo-shrike		X	X	X			X
Lalage tricolor	White-winged Triller		X	X	X			X
Pachycephalidae (Whistlers, shrike-thrushes and allies)								
Pachycephala occidentalis	Western (Golden) Whistler	LS (HS)		X	X			LE
Pachycephala rufiventris	Rufous Whistler			X	X	X		X
Colluricincla harmonica	Grey Shrike-thrush	LS (HS)	X	X				LE
Artamidae (Woodswallows, butcherbirds and currawongs)								
Artamus cinereus	Black-faced Woodswallow	LS (WR)			X			X
Artamus cyanopterus	Dusky Woodswallow	LS (WR)	X	X				LE
Cracticus torquatus	Grey Butcherbird		X		X	X		X
Cracticus tibicen	Australian Magpie		X	X	X	X	X	X
Rhipiduridae (Fantails)								
Rhipidura albiscapa	Grey Fantail		X	X	X	X	X	X
Rhipidura leucophrys	Willie Wagtail		X	X	X	X	X	X

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Corvidae (Crows and allies)								
Corvus coronoides	Australian Raven		X	X	X	X	X	X
Monarchidae (Flycatchers, monarchs and magpie-lark)								
Grallina cyanoleuca	Magpie-lark		X	X	X	X	X	X
Petroicidae (Robins)								
Petroica boodang	Scarlet Robin	LS (HS)						LE
Petroica goodenovii	Red-capped Robin	LS	X	X				LE
Acrocephalidae (Reed-warblers)								
Acrocephalus australis	Australian Reed-Warbler		X	X			X	X
Megaluridae (Grassbirds)								
Cincloramphus mathewsi	Rufous Songlark		X					X
Cincloramphus cruralis	Brown Songlark			X				X
Timaliidae (White-eyes)								
Zosterops lateralis	Silvereye			X	X	X	X	X
Hirundinidae (Swallows and martins)								
Hirundo neoxena	Welcome Swallow		X	X	X	X		X
Petrochelidon nigricans	Tree Martin		X	X	X	X		X
Petrochelidon ariel	Fairy Martin		X	X			X	X
Nectariniidae (Sunbirds and allies)								
Dicaeum hirundinaceum	Mistletoebird			X	X			X

Species		CS	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Motacillidae (Old world wagtails and pipits)								
Anthus novaeseelandiae	Australasian Pipit			X	X	X		X

Mammals

Species		Status	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Tachyglossidae (Echidnas)								
Tachyglossus aculeatus	Echidna		X	X				LE
Dasyuridae (Dasyurids)								
Dasyurus geoffroii fortis	Chuditch	CS1 (V,S3)						LE
Peremelidae (Bandicoots)								
Isoodon fusciventer	Quenda (Southern Brown Bandicoot)	CS2 (P4)			X	X	X	X
Pseudocheiridae (Ringtail possums)								
Pseudocheirus occidentalis	Western Ringtail Possum	CS1 (V,S1)						LE
Phalangeridae (brush-tailed possums)								
Trichosurus vulpecula	Brush-tailed Possum	LS						†
Potoroidae (Potoroos and bettongs)								
Bettongia penicillata ogilbyi	Brush-tailed Bettong, Woylie	CS1 (E,S1)						LE
Macopodidae (kangaroos and wallabies)								
Macropus fuliginosus	Western Grey Kangaroo		X		X	X		LE

Species		Status	ATA 1994	How 1995	BCE 2008	BCE 2014	BCE 2016-2019	Presence
Notamacropus Irma	Brush Wallaby	CS2 (P4)						LE
Petrogale lateralis lateralis	Black-footed Rock-wallaby	CS1 (V,S2)						LE
Setonix brachyurus	Quokka	CS1 (V,S3)						LE
Muridae (Rats and mice)								
Hydromys chrysogaster	Water-rat, Rakali	CS2 (P4)				.	X	X
Mus musculus	House Mouse	Int			X	X		X
Rattus rattus	Black Rat	Int	X		X	X	X	X
Leporidae (Rabbits and hares)								
Oryctolagus cuniculus	Rabbit	Int	X		X	X	X	X
Molossidae (Freetail bats)								
Austronomus australis	White-striped Free-tailed Bat				X		X	X
Vespertilionidae (Vespertillionid bats)								
Chalinolobus gouldii	Gould's Wattled Bat					.	X	X
Chalinolobus morio	Chocolate Wattled Bat				X			X
Nyctophilus geoffroyi	Lesser Long-eared Bat					.	X	X
Vespadelus regulus	Southern Forest-Bat					.	X	X
Canidae (Dogs and foxes)								
Vulpes vulpes	Red Fox	Int			X	X	X	X
Felidae (Cats)								
Felis catus	Cat	Int			X	X	X	X

Species returned from the EPBC Protected Matters Search but never confirmed for the Perth Airport Estate and considered extinct in the immediate region.

Species			EPBC listing
Fish			
Black-striped Minnow	*Galaxiella nigrostriata*		End
Birds			
Malleefowl	*Leipoa ocellata*		Vul
Mammals			
Woylie	*Bettongia penicillata ogilbyi*		End
Chuditch	*Dasyurus geoffroii*		Vul
Black Flanked Rock-Wallaby	*Petrogale lateralis lateralis*		End
Western Ringtail Possum	*Pseudocheirus occidentalis*		Cr End
Quokka	*Setonix brachyurus*		Vul

Invertebrates recorded at Perth Airport January 2019 (Bamford and Knowles 2019).

Order	Family	Species
Blattodea (cockroaches)	Blattidae	*Platyzosteria similis*
	Blattidae	*Polyzosteria fulgens*
	Blattidae	*Drymaplaneta semivitta*
Coleoptera (beetles)	Cerambycidae	*Dioclides prionoides*
	Cerambycidae	*Rhytiphora albospilota*
	Curculionidae	*nr. Evas (WA Museum) acuminatus*
	Scarabaeidae	*Heteronyx sp.*
	Scarabaeidae	*Heteronyx sp.*
	Scarabaeidae	*Heteronyx sp.*
	Tenebrionidae	*Pterohelaeus sp.*
	Tenebrionidae	*Pterohelaeus sp.*
Hemiptera (true bugs)	Alydidae	*Melanacanthus sp.*
	Coreidae	*Mictis profana*
Hymenoptera (ants, wasps and bees)	Formicidae	*Camponotus terebrans*
	Ichneumonidae	*Dicamptus sp*
	Leucopsidae	*Gen. sp.*
	Leucopsidae	*Leucopsis rieki*
Lepidoptera (butterflies and moths)	Cosmopterigidae	*Limnaecia chionospila*
	Cossidae	*Brevicyttara cyclospila*
	Crambidae	*Heliothela oreias*
	Geometridae	*Dichromodes anelictis*
	Oecophoridae	*Barea sp.*
	Oecophoridae	*nr. Leptosaces sp.*
	Psychidae	*Iphierga sp.*
	Tineidae	*Edosa sp.*
	Xyloryctidae	*Scieropepla trinervis*
Mantodea (mantids)	Mantidae	*Archimantis sobrina*
Neuroptera (lacewings)	Chrysopidae	*Mallada tripunctatus*
	Mantispidae	*Theristria sp.*
	Myrmeleontidae	*Gen. sp.*
Orthoptera (crickets and grasshoppers)	Acrididae	*Eumecistes gratiosus*
	Gryllacrididae	*Pareremus sp.*
	Morabidae	*Heide sp.*
	Tettigoniidae	*Polichne parvicauda*
	Tettigoniidae	*Glenbalodectes sp.*
	Tettigoniidae	*Ixalodectes sp.*
Phasmida (stick insects)	Phasmatidae	*Echetlus peristhenes*
Trichoptera	Leptoceridae	*Triplectides sp.*

Order	Family	Species
Araneae	Araneidae	*Eriophora sp.*
	Araneidae	*Eriophora sp.*
	Hersiliidae	*Eriophora sp.*
	Hersiliidae	*Tamopsis sp.*
	Oxyopidae	*Oxyopes variabilis*
	Sparassidae	*Isopeda sp.*
	Sparassidae	*Holconia westralia*
	Theridiidae	*Ariamnes sp.*
	Thomisidae	*Zygometis xanthogaster (yellow form)*
	Thomisidae	*Zygometis xanthogaster*

Appendix 5. Scoring system for the assessment of foraging value of vegetation for black-cockatoos.

Introduction

Application of the Offset Assessment Guide (offsets guide) developed by the federal environment department for assessing Black-Cockatoo foraging habitat requires the calculation of a score out of 10. The following system has been developed by Bamford Consulting Ecologists (BCE) with assistance from Quessentia Consulting to provide an objective scoring system that is practical and can be used by trained field zoologists with experience in the environments frequented by the species.

The foraging value score provides a numerical value that reflects the significance of vegetation as foraging habitat for Black-Cockatoos, and this numerical value is designed to provide the information needed by the Federal Department of Agriculture, Water and the Environment (DAWE) to assess impact significance and offset requirements. The foraging value of the vegetation depends upon the type, density and condition of trees and shrubs in an area and can be influenced by the context such as the availability of foraging habitat nearby. The BCE scoring system for value of foraging habitat has three components as detailed above. These three components are drawn from the DAWE offsets guide but the scoring approach was developed by BCE and includes a fourth (moderation) component. Note that the scoring system can only be applied within the range of the species or at least where the species could reasonably be expected to occur based upon existing information.

Calculating the total score (out of 10) requires the following steps:

A. Site condition. Determining a score out of six for the vegetation composition, condition and structure; plus
B. Site context. Determining a score out of three for the context of the site; plus
C. Species stocking rate. Determining a score out of one for species density.
D. Determining the total score out of 10, which may require moderation for context and species density with respect to the site condition (vegetation) score. Moderation also includes consideration of pine plantations as a special case for foraging value.

The BCE scoring system places the greatest weight on site condition (scale of 0 to 6) because this has the highest influence on the foraging values of a site, which in turn is the fundamental driver in meeting ecological requirements for continued survival.

Site context has a lower weight (scale of 0 to 3) in recognition of the mobility of the species, which means they can access good foraging habitat even in fragmented landscapes, but allowing for recognition of the extent of available habitat in a region and context in relation to activity (such as breeding and roosting). The application of scoring site context is further discussed below.

Species stocking rate is given a low weight (0 to 1) as it is a means only of recognising that a species may or may not be abundant at a site, but that abundance is dependent upon site condition and context and is thus not an independent variable. The abundance of a species is also sensitive to sampling effort, and to seasonal and annual variation, and is therefore an unreliable indicator of actual importance of a site to a species. Calculation of scores and the moderation process are described in detail below.

A. <u>Site condition. Vegetation composition, condition and structure scoring</u>

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	**Baudin's Black-Cockatoo**	**Forest Red-tailed Black-Cockatoo**
0	No foraging value. No Proteaceae, eucalypts or other potential sources of food. Examples: • Water bodies (e.g. salt lakes, dams, rivers); • Bare ground; • Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits) or with vegetation of no food value, such as some suburban landscapes. • Mown grass	No foraging value. No eucalypts or other potential sources of food. Examples: • Water bodies (e.g. dams, rivers); • Bare ground; • Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits).	No foraging value. No eucalypts or other potential sources of food. Examples: • Water bodies (e.g. dams, rivers); • Bare ground; • Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits).
1	Negligible to low foraging value. Examples: • Scattered specimens of known food plants but projected foliage cover of these is < 2%. This could include urban areas with scattered foraging trees; • Paddocks that are lightly vegetated with melons or other known food-source weeds (e.g. *Erodium* spp.) that represent a short-term and/or seasonal food source; • Blue Gum plantations (foraging by Carnaby's Black-Cockatoos has been reported but appears to be unusual).	Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these < 1%. This could include urban areas with scattered foraging trees.	Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these < 1%. Could include urban areas with scattered foraging trees.

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	**Baudin's Black-Cockatoo**	**Forest Red-tailed Black-Cockatoo**
2	Low foraging value. Examples: • Shrubland in which species of foraging value, such as shrubby banksias, have < 10% projected foliage cover; • Woodland with tree banksias 2-5% projected foliage cover; • Woodland with tree banksias (of key species *B. attenuata* and *B. menziesii*) with <10% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Open eucalypt woodland/mallee of small-fruited species; • Paddocks that are densely vegetated with melons or other known food-source weeds (e.g. *Erodium* spp.) that represent a short-term and/or seasonal food source.	Low foraging value. Examples: • Woodland with scattered specimens of known food plants (e.g. Marri and Jarrah) 1-5% projected foliage cover; • Marri-Jarrah Woodland with <10% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Parkland-cleared Eucalypt Woodland/Forest with known food plants <10% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants <10% projected foliage cover (establishing food sources with good long-term viability); • Urban areas with scattered foraging trees.	Low foraging value. Examples: • Woodland with scattered specimens of known food plants (e.g. Marri, Jarrah) 1-5% projected foliage cover; • Marri-Jarrah Woodland with <10% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Sheoak Woodland with <10% projected foliage cover; • Parkland-cleared Eucalypt Woodland/Forest with known food plants <10% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants <10% projected foliage cover (establishing food sources with good long-term viability); • Urban areas with scattered food plants such as Cape Lilac, *Eucalyptus caesia* and *E. erythrocorys*.

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	**Baudin's Black-Cockatoo**	**Forest Red-tailed Black-Cockatoo**
3	Low to Moderate foraging value. Examples: • Shrubland in which species of foraging value, such as shrubby banksias, have 10-20% projected foliage cover; • Woodland with tree banksias 5-20% projected foliage cover; • Woodland with tree banksias (of key species *B. attenuata* and *B. menziesii*) with 10-40% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Eucalypt Woodland/Mallee of small-fruited species; • Eucalypt Woodland with Marri < 10% projected foliage cover.	Low to Moderate foraging value. Examples: • Eucalypt Woodland with known food plants (especially Marri) 5-20% projected foliage cover; • Marri-Jarrah Woodland with 10-40% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Parkland-cleared Eucalypt Woodland/Forest with known food plants 10-40% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants 10-40% projected foliage cover (establishing food sources with good long-term viability).	Low to Moderate foraging value. Examples: • Eucalypt Woodland with known food plants (especially Marri and Jarrah) 5-20% projected foliage cover; • Marri-Jarrah Woodland with 10-40% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Sheoak Forest with 10-40% projected foliage cover; • Parkland-cleared Eucalypt Woodland/Forest with known food plants 10-40% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants 10-40% projected foliage cover (establishing food sources with good long-term viability).

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	**Baudin's Black-Cockatoo**	**Forest Red-tailed Black-Cockatoo**
4	Moderate foraging value. Examples: • Woodland/low forest with tree banksias (of key species *B. attenuata* and *B. menziesii*) 20-40% projected foliage cover; • Woodland/low forest with tree banksias (of key species *B. attenuata* and *B. menziesii*) with 40-60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Kwongan/ Shrubland in which species of foraging value, such as shrubby banksias, have 20-40% projected foliage cover; • Eucalypt Woodland/Forest with Marri 20-40% projected foliage cover.	Moderate foraging value. Examples: • Marri-Jarrah Woodland/Forest with 20-40% projected foliage cover; • Marri-Jarrah Forest with 40-60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Parkland-cleared Eucalypt Woodland/Forest with known food plants 40-60% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants 40-60% projected foliage cover (establishing food sources with good long-term viability); • Orchards with highly desirable food sources (e.g. apples, pears, some stone fruits).	Moderate foraging value. Examples: • Marri-Jarrah Woodland/Forest with 20-40% projected foliage cover; • Marri-Jarrah Forest with 40-60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Sheoak Forest with 40-60% projected foliage cover; • Parkland-cleared Eucalypt Woodland/Forest with known food plants 40-60% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants 40-60% projected foliage cover (establishing food sources with good long-term viability).

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	**Baudin's Black-Cockatoo**	**Forest Red-tailed Black-Cockatoo**
5	Moderate to High foraging value. Examples: • Banksia Low Forest (of key species *B. attenuata* and *B. menziesii*) with 40-60% projected foliage cover; • Banksia Low Forest (of key species *B. attenuata* and *B. menziesii*) with > 60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Kwongan/ Shrubland in which species of foraging value, such as shrubby banksias, have 40-60% projected foliage cover; • Marri-Jarrah Forest with 40-60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term). • Pine plantations with trees more than 10 years old (but see pine note below in moderation section).	Moderate to High foraging value. Examples: • Marri-Jarrah Forest with 40-60% projected foliage cover; • Marri-Jarrah Forest with > 60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Parkland-cleared Eucalypt Woodland/Forest with known food plants >60% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants >60% projected foliage cover (establishing food sources with good long-term viability).	Moderate to High foraging value. Examples: • Marri-Jarrah Forest with 40-60% projected foliage cover; • Marri-Jarrah Forest with > 60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; • Sheoak Forest with > 60% projected foliage cover; • Parkland-cleared Eucalypt Woodland/Forest with known food plants >60% projected foliage cover (poor long-term viability without management); • Younger areas of (managed) revegetation with known food plants >60% projected foliage cover (establishing food sources with good long-term viability).

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	**Baudin's Black-Cockatoo**	**Forest Red-tailed Black-Cockatoo**
6	High foraging value. Example: • Banksia Low Forest (of key species *B. attenuata* and *B. menziesii*) with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term). • Kwongan/ Shrubland in which species of foraging value, such as shrubby banksias, have >60% projected foliage cover; • Marri-Jarrah Forest with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term).	High foraging value. Example: • Marri-Jarrah Forest with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term).	High foraging value. Example: • Marri-Jarrah Forest with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term).

Vegetation structural class terminology follows Keighery (1994).

B. Site context.

Site Context is a function of site size, availability of nearby habitat and the availability of nearby breeding areas. Site context includes consideration of connectivity, although Black-Cockatoos are very mobile and will fly across paddocks to access foraging sites. Based on BCE observations, Black-Cockatoos are unlikely to regularly go over open ground for a distance of more than a few kilometres and prefer to follow tree-lines.

The maximum score for site context is 3, and because it is effectively a function of presence/absence of nearby breeding and the distribution of foraging habitat across the landscape, the following table, developed by Bamford Consulting in conjunction with the Department of the Environment and Energy (DEE), provides a *guide* to the assignation of site context scores. Note that 'local area' is defined as within a 15 km radius of the centre point of the study site. This is greater than the maximum distance of 12km known to be flown by Carnaby's Black-Cockatoo when feeding chicks in the nest.

Site Context Score	Percentage of the existing native vegetation within the 'local' area that the study site represents.	
	'Local' breeding known/likely	'Local' breeding unlikely
3	> 5%	> 10%
2	1 - 5%	5 - 10%
1	0.1 - 1%	1 - 5%
0	< 0.1%	< 1%

The table above provides weighting for where nearby breeding is known (or suspected) and for the proportion of foraging habitat within 15 km represented by the site being assessed. Some adjustments may be needed based on the judgement of the assessor and in relation to the likely function of the site. For example, a small area of foraging habitat (e.g. 0.5% of such habitat within 15 km) could be upgraded to a context of 2 if it formed part of a critical movement corridor. In contrast, the same sized area of habitat, of the same local proportion, could be downgraded if it were so isolated that birds could never access it.

C. Species density (stocking rate).

Species stocking rate is described as "the usage and/or density of a species at a particular site" in the offsets guide. The description also implies that a site supports a discrete population, which is unlikely in the case of very mobile black-cockatoos. Assignation of the species density score (0 or 1) is based upon the black-cockatoo species being either abundant or not abundant. A score of 1 is used where the species is seen or reported regularly and/or there is abundant foraging evidence. Regularly is when the species is seen at intervals of every few days or weeks for at least several months of the year. A score of 0 is used when the species is recorded or reported very infrequently and there is little or no foraging evidence. Where information on actual presence of birds is lacking, a species density score can be assigned by interpreting the landscape and the site context. For example, a site with a moderate condition score that is part of a network of such habitat where a black-cockatoo species is

known would get a species density score of 1 even without clear presence data, while a species density score of 0 can be assigned to a site where the level of usage can confidently be predicted to be low.

D. Moderation of scores for the calculation of a value out of 10.

The calculation out of 10 requires the vegetation characteristics (out of 6) to be combined with the scores given for context and species density. It is considered that the context and density scores are not independent of vegetation characteristics; otherwise habitat of absolutely no value for black-cockatoo foraging (such as concrete or a wetland) could get a foraging score out of 10 as high as 4 if it occurred in an area where the species breed (context score of 3) and are abundant (species density score of 1). Similarly, vegetation of negligible or low characteristics which could not support black-cockatoos could be assigned a score as high as 6 out of 10. In that case, the score of 6 would be more a reflection of nearby vegetation of high characteristics than of the foraging value of the negligible to low scoring vegetation. The Black-Cockatoos would only be present because of vegetation of high characteristics, so applying the context and species density scores to vegetation of low characteristics would not give a true reflection of their foraging value.

For this reason, the context and species density scores need to be moderated for the vegetation characteristic score to prevent vegetation of little or no foraging value receiving an excessive score out of 10. A simple approach is to assign a context and species density score of zero to sites with a Condition score of low (2), negligible (1) or none (0), on the basis that birds will not use such areas unless they are adjacent to at least low-moderate quality foraging habitat ($\geq$3). The approach to calculating a score out of 10 can be summarised as follows:

Vegetation composition, condition and structure score	Context score	Species density score
3-6 (low/moderate to high value)	Assessed as per B above	Assessed as per C above
0-2 (no to low value)	0	0

Note that this moderation approach may require interpretation depending on the context. For example, vegetation with a condition score of 2 could be given a context score of 1 under special circumstances. Such as when very close to a major breeding area or if strategically located along a movement corridor.

Pine plantations

Pine plantations are an important foraging resource for Carnaby's Black-Cockatoo (only) but are not directly comparable with native vegetation. In comparing native vegetation with pine plantations for the purpose of calculating offsets, the following should be noted:

- Pine plantations are a commercial crop established with the intention of being harvested and thus have short-term availability (30-50 years), whereas native vegetation is available indefinitely if protected. Due to the temporary nature of pines as a food source, site condition and context differs between pines and native vegetation.
- Although pines provide a high abundance of food in the form of seeds, they are a limited food resource compared with native vegetation which provides seeds, insect larvae, flowers and nectar. The value of insect larvae in the diet of Carnaby's Black-Cockatoo has not been quantified, but in the vicinity of Perth, the birds forage very heavily on insect larvae in young cones of *Banksia attenuata* in winter, ignoring the seeds in these cones and seeds in older cones on the same trees (Scott and Black 1981; M. Bamford pers. obs.). This suggests that insect larvae are of high nutritional importance immediately prior to the breeding season.
- Pine plantations have very little biodiversity value other than their importance as a food source for Carnaby's Black-Cockatoos. They inhibit growth of other flora. While this is not a factor for direct consideration with respect to Carnaby's Black-Cockatoo, it is a factor in regional conservation planning of which offsets for the cockatoos are a part.

Taking the above points into consideration, it is possible to assign pine plantations a foraging value as follows:

- Site condition. The actual foraging value of pines is high. Stock *et al.* (2013) report that it takes nearly twice as many seeds of *Pinus pinaster* to meet the daily energy requirements for Carnaby's Black-Cockatoo compared with Marri, and three times as many *P. pinaster* seeds compared with Slender Banksia. However, pines are planted at a high density so the food supply per hectare can be high. Taking account of the lack of variety of food from pines, this suggests a site condition score of 4 or 5 out of 6 (5 is used in Section A above). As a source of food, pines are thus comparable to the best banksia woodland. This site condition score then needs to be adjusted to take account of the short-term nature of the food supply (for pine plantations to be harvested. Where pines are 'ornamental, such as in some urban contexts, they can be treated as with other trees in urban landscapes). The foraging value of a site after pines are harvested will effectively be 0, or possibly 1 if there is some retention. It is proposed that this should approximately halve the site condition score; young pine plantations could be redacted slightly less than old plantations on the basis that a young plantation provides a slightly longer term food supply. If a maximum site condition score of 5 is given, then a young plantation (>10 but <30 years old) could be assigned a score of 3, and an old plantation (>30 years old) could be assigned a score of 2. Plantations <10 years old and thus not producing large quantities of cones could also get a score of 2, but recognising they may increase in value.
- Site context. Although a temporary food source, pines can be very important for Carnaby's Black-Cockatoo in some contexts; they could be said to carry populations in areas where there is little native vegetation. The system for assigning a context score as outlined above (Section B) also applies to pines. Thus, a context score of 3 can be given where pines are a significant

proportion of foraging habitat (>5% if breeding occurs; >10% if no breeding), but where pines are a small part of the foraging landscape they will receive a context score of less than this.

- Species density. As outlined above (Section C), pines will receive a species density score of 1 where Carnaby's Black-Cockatoo are regular visitors. This is irrespective of an old plantation having a moderated condition score of 2.

Based on the above, pine plantations that represent a substantial part of the foraging landscape, such as in the region immediately north of Perth, would receive a total score (out of 10) of 6; young plantations in this area would receive a score of 7. In contrast, isolated and small plantations in rural landscapes could receive a score of just 2 if they are only a small proportion of foraging habitat and Carnaby's Black-Cockatoos are not regularly present.

Appendix 6. Trees in the project area that meet the basic criterion as a potential nest tree for black-cockatoos. Rank 5 trees have no suitable hollows.

Way Point	Species	Common Name	DBH	Status	Rank[6]
2458	*Eucalyptus sp.*	Introduced eucalypt	500	Alive	5
2459	*Allocasuarina fraseriana*	Sheoak	500	Alive	5
2460	*Eucalyptus sp.*	Introduced eucalypt	600	Alive	5
2461	*Eucalyptus sp.*	Introduced eucalypt	500	Alive	5
2462	*Eucalyptus sp.*	Introduced eucalypt	700	Alive	5
2463	*Eucalyptus sp.*	Introduced eucalypt	700	Alive	5
2464	*Eucalyptus sp.*	Introduced eucalypt	800	Alive	5
2465	*Eucalyptus sp.*	Introduced eucalypt	600	Alive	5
2466	*Eucalyptus sp.*	Introduced eucalypt	600	Alive	5
2467	*Eucalyptus sp.*	Introduced eucalypt	500	Alive	5
2468	*Eucalyptus sp.*	Introduced eucalypt	600	Alive	5
2469	*Eucalyptus sp.*	Introduced eucalypt	500	Alive	5
2470	*Eucalyptus sp.*	Introduced eucalypt	500	Alive	5
2471	*Eucalyptus sp.*	Introduced eucalypt	700	Alive	5
2457	*Corymbia calophylla*	Marri	500	Alive	5

[6] The tree rank is defined in Table 2.