

**WA Limestone
8772 Albany Highway, Bannister
Threatened Fauna Assessment**



Wandoo woodland within the survey area. Photo: Wes Bancroft.

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1 Introduction

WA Limestone is investigating the acquisition of properties to offset proposed expansions of their quarrying activities in and around the Perth Metropolitan area. One such property, the western portion of Lot P011005 6 – 8772 Albany Highway, Bannister (in the Shire of Boddington), Western Australia (the ‘survey area’), has potential value for threatened fauna, and was noted particularly for its potential to support black-cockatoos. It is possible that all three of the black-cockatoo taxa that occur in the south-west of Western Australia may use the site:

- *Zanda latirostris* (Carnaby's Black-Cockatoo) – listed as Endangered under the Federal *Environment Protection and Biodiversity Conservation Act 1999* and also as Endangered under the Western Australian *Biodiversity Conservation Act 2016* (see Appendix 1 for more details).
- *Zanda baudinii* (Baudin's Black-Cockatoo) – Endangered under both acts (see Appendix 1).
- *Calyptorhynchus banksii naso* (Forest Red-tailed Black-Cockatoo) – Vulnerable under both acts (see Appendix 1).

In addition, a number of other listed fauna may occur on site, or the vegetation and soils may be suited to their reintroduction at a later stage.

An initial inspection of the property by Western Environmental in August 2022 was favourable and indicated that further examination of the value of the survey area for black-cockatoos, and other threatened fauna, was warranted. Bamford Consulting Ecologists (BCE) was commissioned to conduct a targeted desktop assessment and site inspection to better understand the use, and potential use, of the survey area by black-cockatoos, and also the potential for the site to support other species of conservation significance.

This report presents the findings of that survey.

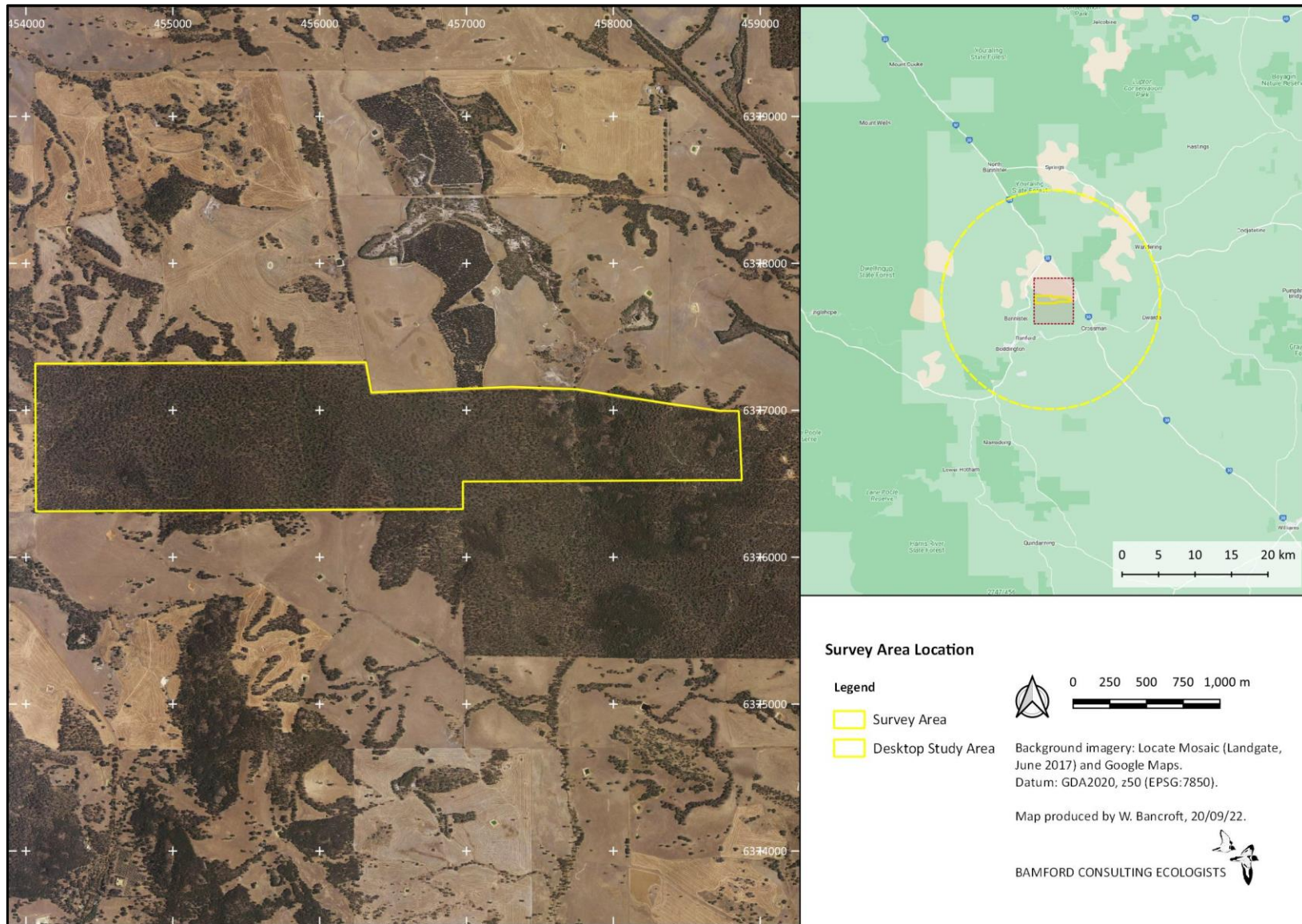


Figure 1. Location of the survey area (the western portion of Lot P011005 6, 8772 Albany Highway, Bannister, Western Australia).

1.1 Background: black-cockatoo ecology

There is considerable published information on the ecology of, and threats to, Carnaby's, Baudin's and Forest Red-tailed Black-Cockatoos. Key references include:

- Action plans (Garnett and Baker 2021);
- Recovery plans (DEC 2008; DPaW 2013);
- EPBC Act referral guidelines (DSEWPaC 2012; DAWE 2022b);
- Commonwealth listing and conservation advice (DEWHA 2009a, b; TSSC 2018);
- The federal Department of Climate Change, Energy, the Environment and Water's (DCCEEW) Species Profile and Threats (SPRAT) Database (DCCEEW 2022a, c, d);
- Scientific literature (Davies 1966; Saunders 1974, 1979a, b, 1980; Saunders *et al.* 1982; Saunders 1986; Johnstone and Storr 1998; Higgins 1999; Johnstone and Kirkby 1999, 2008; Johnstone *et al.* 2013a, b; Whitford *et al.* 2015; Johnston *et al.* 2016; Williams *et al.* 2016; Williams *et al.* 2017); and
- Major reports (Johnstone *et al.* 2011; Kabat *et al.* 2012; Peck *et al.* 2016).

Much of this information has been compiled by DCCEEW (2022a, c, d). Summarising this work further, there are several salient points for assessing the potential value of the site for black-cockatoos:

Key ecology

- All species are long-lived with low annual reproduction rates and cannot, therefore, rapidly increase their population size.
- Carnaby's and Baudin's Black-Cockatoos undergo regular, seasonal migration between breeding and non-breeding areas.
- Forest Red-tailed Black-Cockatoos are not currently considered to undergo regular migration. In recent years there appears to have been a distinct expansion of the range of this species on to the Swan Coastal Plain, including many suburbs within the Perth metropolitan area.
- It is possible that Baudin's Black-Cockatoo is also beginning a similar expansion of its range on to the Swan Coastal Plain.
- In recent years there have been considerable shifts in the breeding ecology, distribution and movement patterns of Forest Red-tailed and Carnaby's Black-Cockatoos. These may be a response to habitat degradation/clearing and/or climatic factors.

Key habitat requirements

- All species are reliant on large tree-hollows in eucalypts, in which they breed. Each species has its own preference for nesting tree species and its own geographical breeding range (although these overlap between species). There is a solid understanding of these preferences (see Appendix 2 for summary).
- All species primarily feed on plant seeds and flowers, but also consume wood-boring insect larvae when available. Each species has its own preference for food plant species (with considerable overlap). There is a solid understanding of these preferences (see Appendix 2 for summary).

Key threats

- Key threatening processes include illegal shooting, habitat loss, habitat degradation, nest hollow shortage, competition for available nest hollows from other parrots and feral Honeybees (*Apis mellifera*), and illegal trade.

1.2 Description of survey area and background environmental information

1.2.1 Survey area

For spatial terminology (i.e. definitions of project, survey and study areas) see Section 2.1.1 below.

The Bannister site ('survey area') is in the locality of Bannister (Shire of Boddington), as shown in Figure 1. The precise boundary of the survey area has yet to be determined but for the purposes of this inspection, the cadastre of Lot P011005 6 that was provided by Landgate (2022) was clipped to reflect the area of interest. The area of this region is approximately 389 ha.

1.2.2 Interim Biogeographic Regionalisation of Australia (IBRA) and landscape characteristics

The Interim Biogeographic Regionalisation of Australia (IBRA) has identified 26 bioregions in Western Australia which are further divided into subregions (DAWE 2022a). Bioregions are classified on the basis of climate, geology, landforms, vegetation and fauna (Thackway and Cresswell 1995). IBRA Bioregions are affected by a range of different threatening processes and have varying levels of sensitivity to impact (EPA 2016). The survey area is within the Northern Jarrah Forest (JAF01) subregion of the Jarrah Forest bioregion.

The vegetation and soil of the Northern Jarrah Forest subregion can be described as follows: "Jarrah-Marri Forest in the west with Bullich and Blackbutt in the valleys grading to Wandoo and Marri woodlands in the east with Powder bark on breakaways. There are extensive but localised sand sheets with Banksia low woodlands. Heath is found on granite rocks and as a common understorey of forests and woodlands in the north and east. The majority of the diversity in the communities occurs on the lower slopes or near granite soils where there are rapid changes in site conditions" (Williams and Mitchell 2001).

1.2.3 Land systems and vegetation complexes

Mattiske and Havel (1998) have defined and described broad vegetation complexes for the South West forest region of Western Australia and the mapping of these is provided by DBCA (2022f).

Three complexes occur within the site:

- **Coolakin** (Ck) - Woodland of *Eucalyptus wandoo* with mixtures of *Eucalyptus patens*, *Eucalyptus marginata* subsp. *thalassica* and *Corymbia calophylla* on the valley slopes in arid and perarid zones.
- **Michibin** (Mi) - Open woodland of *Eucalyptus wandoo* over *Acacia acuminata* with some *Eucalyptus loxophleba* on valley slopes, with low woodland of *Allocasuarina huegeliana* on or near shallow granite outcrops in arid and perarid zones.
- **Yalanbee 6** (Y6) - Woodland of *Eucalyptus wandoo* – *Eucalyptus accedens*, less consistently open forest of *Eucalyptus marginata* subsp. *thalassica* – *Corymbia calophylla* Mixture of open forest of *Eucalyptus marginata* subsp. *thalassica* – *Corymbia calophylla* on lateritic uplands and breakaway landscapes in arid and perarid zones.

Complex definitions were sourced from Mattiske (2019).

The Mattiske and Havel (1998) vegetation complexes within the survey area are mapped in Figure 2 (data provided by DBCA 2022f).

Following their August 2022 site visit, Western Environmental also defined three habitat categories within the survey area:

- **Wandoo Woodland.** Woodland of Wandoo at 20-40% overstory foliar cover. Large mature and large dead Wandoos present with hollow formation evident in some larger trees. Very open mid stratum with few shrub species. Open ground stratum. Old dead logs and leaf litter present. Occurring on skeletal and gravelly/ clay soils.
- **Jarrah, Marri and Wandoo Woodland.** Mixed woodland at 15-30% overstory foliar cover. Typically dominated by Jarrah at 10-20% foliar cover with Marri at 5-10% foliar cover and scattered Wandoo at <5% foliar cover. Large mature and large dead Jarrah and Marri present with hollow formation evident in larger trees. Shrubby midstratum present, mainly comprising *Banksia squarrosa*, *Banksia sessilis* and *Xanthorrhoea* sp. Old dead logs and leaf litter present. Occurring on gravelly and laterite soils.
- **Rock Sheoak Woodland.** Woodland of *Allocasuarina huegeliana* (Rock Sheoak) at 30-40% foliar cover in groves interspersed with open patches of granites. Mid stratum of *Xanthorrhoea* sp. at 10-25% cover.

1.2.4 Land use and tenure

The dominant land uses within the Northern Jarrah Forest (JAF01) subregion are forestry (native forests), conservation, grazing (improved pastures), cultivation (dry land agriculture), forestry (plantations), and mining (Williams and Mitchell 2001). There are lesser areas of rural residential, easements for roads, power lines etc, and urban land use.

1.2.5 Recognised sensitive sites

There are no known Ramsar Sites (DBCA 2022c), Important Wetlands (DBCA 2022b), Threatened Ecological Communities (DBCA 2022d, e), Bush Forever sites (Dell and Banyard 2000; DPLH 2022), Key Biodiversity Areas (KBA 2022) or Environmentally Sensitive Areas (DWER 2022a, b) within the survey area.

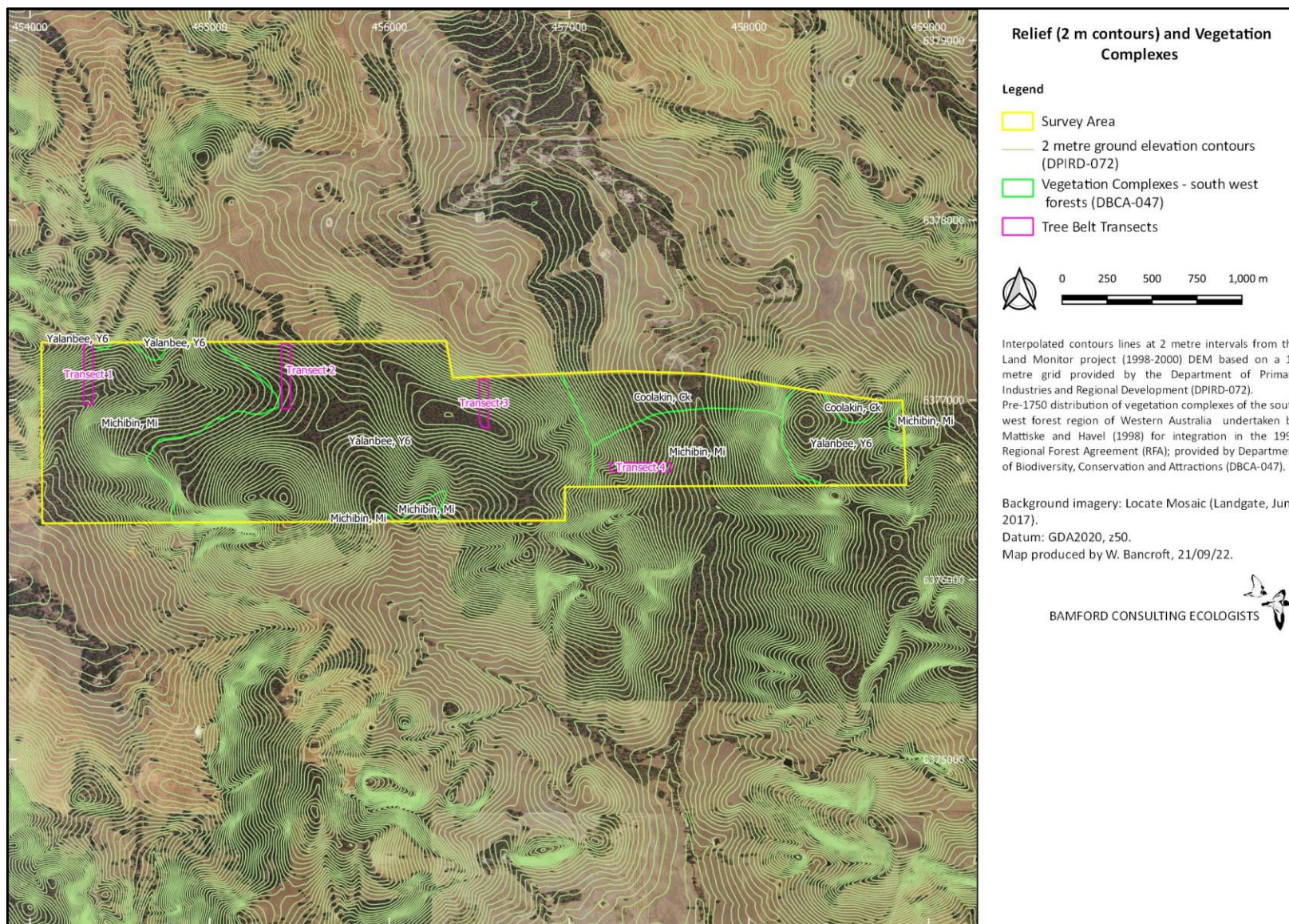


Figure 2. Relief (2 m contours) and vegetation complexes (Matisse and Havel 1998) within the survey area.

2 Methods

2.1 Overview

2.1.1 Spatial terminology

A range of terms are used through the report to refer to the spatial environment around the proposed project, and these are defined below:

- Study area – the outermost boundary of the desktop assessment that is almost always a specified buffer distance around the *survey area*. The study area thus encompasses the *survey area* but includes the area from which databases are sourced.
- Survey area – the *survey area* is the area to which the results of the desktop analysis are directed and/or the area within which field investigations are conducted. Note that while the term '*survey area*' is used throughout the guidance provided by EPA (2020), it does not appear to be explicitly defined and, therefore, the above definition has been developed with interpretation of both the guidance and BCE report structure.
- Project area – this may be equivalent to the *survey area* but is strictly the land over which the proponent has tenure or some control and within which on-site impacts may occur.
- Development footprint – the expected extent of land clearing and/or development.

Where available, these spatial boundaries are mapped in Figure 3.

2.2 Identification of vegetation and substrate associations (VSAs)

Vegetation and substrate associations (VSAs) combine 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.

BCE deliberately makes the distinction between 'habitat' (a species-specific term that may encompass the whole or part of one or more VSAs and is the physical subset of an ecosystem that a given species, or species group, utilises) and 'VSA' (a general, discrete and mutually exclusive spatial division of a target area, based on soil, vegetation and topography). It is recognised, however, that, within the broader EIA literature/guidance, the former term is used more or less synonymously to indicate the latter (e.g. 'habitat assessment' used by EPA 2020). Further discussion is provided in Appendix 3.

For the current assessment, VSAs were identified based on the consultant's previous experience in the area, a vegetation assessment of the site (by Western Environmental), and on observations made during the field investigations.

2.3 Desktop methods

2.3.1 Nomenclature and taxonomy

As per the recommendations of the EPA (2020), the nomenclature and taxonomic order presented in this report are generally based on the Western Australian Museum's (WAM) Checklist of the Fauna of Western Australia 2022. The authorities used for each vertebrate group were: fish (Morgan *et al.* 2014), frogs (Doughty 2022a), reptiles (Doughty 2022b), birds (BirdLife Australia 2022; Gill *et al.* 2022),

and mammals (Travouillon 2022). 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, and the International Ornithological Congress' 'World Bird List'). Similarly, the group name 'black-cockatoo' is consistently used for all three taxa in the South-West. English common names of species, where available, are used throughout the text; Latin names are presented with corresponding English names in tables in the appendices. The use of subspecies is limited to situations where there is an important (and relevant) geographically distinct population, or where the taxonomic distinction has direct relevance to the conservation status or listing of a taxon.

2.4 Field investigations

2.4.1 Overview

Field investigations were focussed on black-cockatoo habitat analysis (comprising breeding, foraging and roosting assessments), with the major focus on identification of trees suited to black-cockatoo nesting. Methods are detailed below.

2.4.2 Dates

The survey area was visited on the 16th September 2022.

2.4.3 Black-cockatoo habitat analysis

2.4.3.1 Guidelines

The Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) provides guidelines for the referral of actions that may result in impact to black-cockatoos (for assessment under the EPBC Act). The survey and analysis reported here have been conducted with strong reference to both the existing guidelines (DAWE 2022b) as well as the previous guidelines (DEE 2017). This includes application of the 'foraging quality scoring tool' in DAWE (2022b). In addition, survey methodology followed the recommendations listed on the DCCEEW's Species Profile and Threats Database (DCCEEW 2022a, c, d);. 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 (DAWE 2022b).

The DBCA has also indicated that the methodology developed and applied previously by BCE (e.g. Bancroft and Bamford 2021), and as described below, is an acceptable approach to score nesting value and foraging habitat.

2.4.3.2 Breeding

The aim of the breeding surveys was to sample the survey area for potential hollow-bearing trees (suitable for black-cockatoo nesting). Four 'belt transects' (as shown in Figure 2 and Figure 3) were surveyed across the site. The following information was recorded for every suitable tree¹ with a diameter at breast height (DBH) equal to or greater than 500 mm (or equal to or greater than 300 mm for *Eucalyptus accedens* and *E. wandoo*):

- 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 1.

The BirdLife Australia database of black-cockatoo breeding surveys was also searched for relevant local records (see Peck 2019).

¹ the revised EPBC Act referral guidelines (DAWE 2022) note that “any species of tree may develop suitable hollows for breeding” however there are some species that are much more likely to provide breeding sites. These species are listed on the DCCEEW SPRAT database and were the focus of the field investigations here.

Table 1. Ranking system for the assessment of potential nest-trees for black-cockatoos (revised 08/01/2021).

As per DCCEEW (2022a, c, d) guidance, a potential nest-tree is any tree with a diameter at breast height >500 mm (or >300 mm for *Eucalyptus accedens*, *E. 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.

2.4.3.3 Foraging

The foraging value of the study area was assessed by calculating a foraging score for areas of similar vegetation type/condition (see Appendix 4). The foraging 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 sort of information needed by DCCEEW, Department of Water and Environmental Regulation (DWER) and the Environmental Protection Authority (EPA) 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 in Appendix 4. These three components are drawn from the DCCEEW offset calculator 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 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 4. Foraging value scores are calculated differently for the three black-cockatoo species (Appendix 4) depending upon the vegetation present; thus a separate score is given for each VSA for each species.

For comparison, the foraging quality scoring tool of DAWE (2022b) was also used to assess the foraging value of the site to black-cockatoos. The template for this tool is provided in Appendix 5.

Black-cockatoo foraging signs were also recorded in conjunction with the breeding tree surveys (see Section 2.4.3.2) and general site inspections. When 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 forage. Factors that help to establish the time since foraging include: the colour of nuts/foilage, 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 were recognised, 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.

As an indication, Appendix 6 shows examples of Forest Red-tailed Black-Cockatoo foraging signs across the range of these categories (note that it is uncertain as to the exact time frame for each stage).

2.4.3.4 *Night roosting*

As the breeding and foraging surveys were conducted, areas likely to be used as night roosting sites (e.g. sites adjacent to watercourses with large trees) or areas that had cockatoo activity in the late-afternoon were noted.

In addition, an evening roost survey was conducted from 17:45 to 18:35 (sunset 18:11) on top of a hill (to provide a good vantage point over much of the site) along the northern boundary of the site (458373E, 6377044N; GDA2020, z50).

It is usual for the BirdLife Australia Great Cocky Count (GCC) database of roost sites to be directly searched for relevant local records (see Peck *et al.* 2019) but for this report the data from the GCC that is provided by DBCA (2022a).

2.4.4 Opportunistic observations

At all times, observations of fauna were noted when they contributed to the accumulation of information on the fauna of the site. These included such casual observations as reptiles, birds or mammals seen while travelling through and near the site.

2.5 Personnel

Personnel involved in the field investigations and report preparation are listed in Table 2.

Table 2. Personnel involved in the field investigations and report preparation.

Personnel	Consulting Experience	Field Investigations	Report Preparation
Dr Mike Bamford <i>BSc (Biol.), Hons (Biol.), PhD (Biol.)</i>	42 years		+
Dr Wes Bancroft <i>BSc (Zool./Microbiol.), Hons (Zool.), PhD (Zool.)</i>	25 years	+	+
Dr Jamie Wadey <i>BSc (Zoology/Ecology), Hons (Ecology), PhD (Movement Ecology)</i>	7 years	+	

2.6 Mapping and spatial data

Low resolution maps have been provided within the body this report. Higher resolution maps and GIS files can be supplied if required. While the recommendation of the EPA (2020) was that maps use the GDA94 datum (and are projected into the appropriate Map Grid of Australia (MGA94) zone), this has been superseded by the GDA2020 (projected to MGA2020) datum used here (and recommended by DWER 2022c).

3 Results and Discussion

3.1 Site overview and ecological processes

3.1.1 Proximity within the landscape and connectivity/ecological linkages

The survey area, of approximately 389 ha, wholly comprises remnant vegetation that sits within a highly modified agricultural landscape. Extensive native vegetation exists c. 5 km to the west (Dwellingup State Forest) and c. 10 km to the north (Youraling State Forest). In addition, large blocks of remnant vegetation also occur c. 2.5 km to the north-east (north and south of the West Wandering Road) and c. 4 km to the east (north of Moramocking Road) of the site (see Figure 1). While not directly connected, a series of smaller belts or patches of vegetation appear to create ‘stepping stones’ across the landscape between the survey area and these remnants. This would likely provide sufficient passage for a wide range of vertebrate fauna, including all of the threatened (and priority) species for which the site is considered suitable (as discussed in Sections 3.3, 3.4 and 3.5).

Discussion with the present landowner (during the field investigations) suggested that the adjoining property to the south of the study area (of at least c. 300 ha, and to which it has a direct and extensive connection) has recently been secured for conservation purposes. It could be expected that this property would have similar fauna values to the study area (as, together, they form a cohesive block with a shared history, as can be seen in Figure 1).

3.1.2 Topography and hydrology

The survey area has considerable variation in topographic relief (see Figure 2), with some steep changes in ground elevation and relatively little in the way of gently sloping or flat ground. At least two drainages run through the site and these connect to the Hotham River to the south. It is understood that at least one of these drainages has a section that provides permanent water (via a natural seep or spring). Water in these drainages was relatively fresh (at the time of inspection) and did not appear to have significant salinity issues.

3.1.3 Fire history

Other than a minor patch burn, the present owner indicated that the survey area has not been burnt in at least the last 20 years. There was no evidence noted during the inspection to suggest otherwise. The vast majority of the site is long-unburnt, intact native woodlands.

3.1.4 Vegetation condition and anthropogenic disturbances

The vegetation is, broadly, in excellent condition with minimal weed incursion and almost no recent anthropogenic disturbance. It has previously been logged but does not appear to have been used for livestock grazing (at least in the last few decades). Several firebreaks and access tracks are currently maintained throughout the site. Erosion issues, pollution and litter/refuse dumping were all negligible or absent for the vast majority of the site. Similarly, there was nothing to indicate that other sources of environmental disturbance such as dust, light, noise and vibration have any appreciable impact on the survey area.

3.1.5 Fauna species interactions, including predation and competition

Feral predators such as cats and foxes may present some risk to fauna within the survey area. A fox was observed during the site inspection, fox dens are known to be present within the survey area and it is expected that cats would also occur.

There was some evince of rabbits using the site but this was minor to negligible in impact most places inspected. Pig diggings were noted and there are anecdotal records of pigs within the survey area. The extent to which pigs affect the fauna values of the site is not certain.

It is noted that, given the surrounding agricultural lands, over-grazing by (native) kangaroos may be a consideration.

3.1.6 Present land use

It is understood that the survey area is presently used for (private) conservation and very low impact recreation activities such as bushwalking.

3.2 Vegetation and substrate associations (VSAs) ['Habitat assessment']

Vegetation and substrate associations within the survey area are a mosaic, largely reflecting soil types and topography. Preliminary vegetation descriptions and mapping were provided by Western Environmental (see Section 1.2.3 above). From these, and observations made during the field investigations here, four major vegetation and substrate associations (VSAs) were identified in relation to fauna in the survey area:

VSA 1. Wandoo woodland. Woodland of Powderbark Wandoo (*Eucalyptus accedens*) and Wandoo (*E. wandoo*) with variable understorey; from shrub thickets dominated by Pingle (*Banksia squarrosa*) to a very open understorey of widely scattered shrubs and/or bare ground. See Plate 1 and Plate 2.

VSA 2. Jarrah, Marri and Wandoo woodland. Woodland dominated by Jarrah (*E. marginata*) with occasional Marri (*Corymbia calophylla*) and wandoos (*E. accedens* or *E. wandoo*) over dense thickets of Pingle (*B. squarrosa*) and Parrot Bush (*B. sessilis*), and other mixed shrubs. See Plate 3.



VSA 3. Rock Sheoak woodland. Woodland of Rock Sheoak (*Allocasuarina huegeliana*), usually surrounding exposed granite, and ranging from almost a monoculture, to having shrub layer of Grasstrees (*Xanthorrhoea priessii*) and/or mixed heaths. See Plate 4.

VSA 4. Drainages. Watercourses. See Plate 5.

The extent of the VSAs in the project area is mapped (based on data provided by Western Environmental) in Figure 3.



Plate 1. VSA 1: Wandoo woodland.

Note dense understorey.



Plate 2. VSA 1: Wandoo woodland.

Note open understorey.



Plate 3. VSA 2: Jarrah, Marri and Wandoo woodland.



Plate 4. VSA 3: Rock Sheoak woodland.



Plate 5. VSA 4: Drainages.

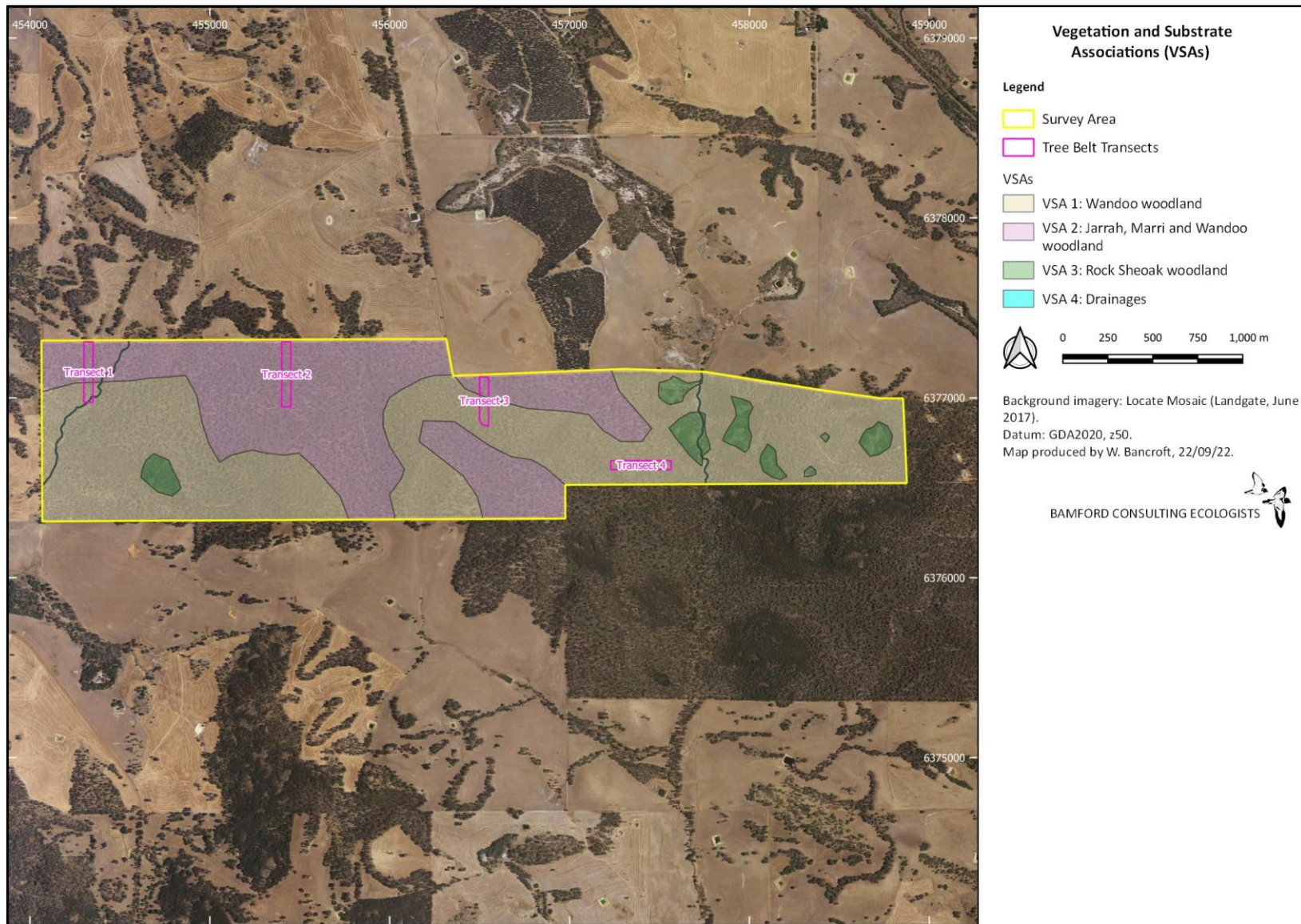


Figure 3. Vegetation and substrate associations.

3.3 Black-cockatoo habitat analysis

3.3.1 Black-cockatoo presence

Only one of the three species of black-cockatoo known to occur in the south-west of Western Australia was directly recorded on the site during the site inspection: Carnaby's Black-Cockatoo. This was in the eastern third of the survey area; a flock of nine birds flew northwards, along the course of a drainage line. Anecdotal evidence suggested a number of Carnaby's Black-Cockatoos and Forest Red-tailed Black-Cockatoos had been seen in the survey area previously (weeks, months and years previously) and this is supported by the indirect (foraging) evidence presented in Section 0 below.

Given these direct observations, indirect (foraging) records (see Section 0 below), roosting data (see Section 3.3.3.4 below) and the literature review (including current species distributions), it is considered that, currently:

- Carnaby's Black-Cockatoo is likely to be a regular breeding and/or non-breeding migrant to the site.
- Forest Red-tailed Black-Cockatoo is likely to be a regular visitor, or possibly even resident, at the site. It is possible that this species breeds within the survey area.
- Baudin's Black-Cockatoo is likely to be a regular non-breeding visitor to the site.

3.3.2 *Black-cockatoo breeding habitat*

Much of the survey area appears to be well suited to breeding by black-cockatoos (although it may be too far north to be a regular breeding location for Baudin's Black-Cockatoo) with key hollow-bearing trees such as Powderbark Wandoo (*Eucalyptus accedens*), Wandoo (*E. wandoo*), Jarrah (*E. marginata*) and Marri (*Corymbia calophylla*) present across the site.

To provide an indication of the potential for breeding, four belt transects (as shown in Figure 2 and Figure 3) were surveyed. These belt transects covered three of the four VSAs (see Section 3.2 above), with no sampling conducted in VSA 3 due to the scarcity of suitable nest-trees. Total areas of each VSA surveyed were:

VSA 1: Wandoo woodland	2.99 ha
VSA 2: Jarrah, Marri and Wandoo woodland	3.47 ha
VSA 3: Rock Sheoak woodland	0.00 ha
VSA 4: Drainages	0.02 ha
<i>Total</i>	<i>6.47 ha</i>

Data are summarised according to VSA in Table 3. Note that no trees were recorded within VSA 4.

Trees that met the potential nest-tree criteria of DCCEEW (2022a, c, d) and DAWE (2022b) were recorded at a density of 31.5 trees/ha within VSA 1, and at 25.6 tree/ha within VSA 2; a slightly higher rate in the wandoo woodland. Unsurprisingly, almost 90% of potential nest-trees were Powderbark Wandoo or Wandoo in this VSA 1, with the percentage of wandoos dropping to below 50% in the mixed Jarrah, Marri and Jarrah woodland of VSA 2.

No active nests (rank 1) or potential hollows with chew-marks (indicating a high likelihood of use by black-cockatoos; rank 2) were recorded but trees with hollow entrances that appeared suitable for black-cockatoo nesting (rank 3) occurred at a density of 7.9 and 4.9 trees/ha in VSAs 1 and 2, respectively (see Table 3).

Extrapolation of these data is possible (with the caveat that current assumption is of no suitable nest-trees within VSAs 3 and 4). There is approximately 220 ha of VSA 1 and 152 ha of VSA 2 within the survey area. Thus, given the sampled tree densities, there is estimated to be in excess of 10,800 potential nest-trees in the survey area (6920 in VSA 1, and 3907 in VSA 2). Of these, approximately 2366 trees (1620 in VSA 1, 746 in VSA 2) are expected to bear hollows that are presently suitable for black-cockatoo nesting (rank 3).

Table 3. The number (and density) of potential black-cockatoo nest-trees of each species in each nest-tree rank category in VSA 1 and VSA 2 (from belt transect sampling data).

See Section 2.4.3.2 for full explanation of tree categories.

Total area sampled: VSA 1 = 2.99 ha, VSA 2 = 3.47 ha.

VSA 1. Wandoo woodland.

Rank	Number of Trees			TOTAL	Total Density (trees/ha)
	Jarrah	Marri	Powderbark Wandoo/Wandoo		
1 Active nest.	0	0	0	0	0.0
2 Potential hollow with chew-marks.	0	0	0	0	0.0
3 Potential hollow, no chew marks.	1	0	21	22	7.4
4 Potential hollow, unsuitable orientation.	2	0	18	20	6.7
5 Sufficient DBH, no observable hollows.	6	1	45	52	17.4
TOTAL:	9	1	84	94	31.5
Percentage (of Grand Total)	9.6%	1.1%	89.4%	100.0%	

VSA 2. Jarrah, Marri and Wandoo woodland.

Rank	Number of Trees			TOTAL	Total Density (trees/ha)
	Jarrah	Marri	Powderbark Wandoo/Wandoo		
1 Active nest.	0	0	0	0	0.0
2 Potential hollow with chew-marks.	0	0	0	0	0.0
3 Potential hollow, no chew marks.	3	11	3	17	4.9
4 Potential hollow, unsuitable orientation.	2	5	1	8	2.3
5 Sufficient DBH, no observable hollows.	17	7	40	64	18.4
TOTAL:	22	23	44	89	25.6
Percentage (of Grand Total)	24.7%	25.8%	49.4%	100.0%	

3.3.3 *Black-cockatoo foraging habitat*

3.3.3.1 *Carnaby's Black-Cockatoo*

Foraging habitat for the Carnaby's Black-Cockatoo was present throughout the survey area. This is predominantly due to the presence of one tree species (Marri, *Corymbia calophylla*) and two shrub species (Parrot Bush, *Banksia sessilis*; and Pingle, *B. squarrosa*) known to be mainstays of the Carnaby's Black-Cockatoo diet (Groom 2011). The most widespread of these was Pingle and, where it occurred, it was generally in moderate to high density. Parrot Bush was often interspersed among the Pingle thickets, in moderate densities. Where it occurred, Marri was scattered at a moderate to low density. The areas (and percentages) of each vegetation score are shown for the Carnaby's Black-Cockatoo in Table 4.

There are approximately 31,325 ha of remnant native vegetation (as assessed by DPIRD 2022) within 15 km of the survey area, which itself has c. 378 ha of native vegetation. Therefore, the site comprises c. 1.2% of the native vegetation in the 'local area' (as per the methods outlined in Appendix 4). It is likely that the Carnaby's Black-Cockatoo breeds within the local area, given the proximity to Jarrah/Marri and Wandoo forests in the region. Thus, a 'context' score of 2 (out of 3) has been assigned to the survey area for this species (see Appendix 4).

There was evidence of foraging by the Carnaby's Black-Cockatoo within the survey area. This was foraging on Parrot Bush and Pingle (with intermediate and old-aged signs noted). The locations of these records are shown in Figure 5. It is expected that Carnaby's Black-Cockatoo will occur regularly (including foraging) within the survey area. Therefore, the survey area was assigned a species 'density' score for Carnaby's Black-Cockatoo of 1 (out of 1; see Appendix 4).

The context and density values have been added on to the vegetation scores to yield the overall foraging value scores (with areas and percentages) that are also presented in Table 4. A map of foraging scores for Carnaby's Black-Cockatoo foraging within the survey area is presented in Figure 4.

The survey area is, generally, of moderate to high value for foraging by the Carnaby's Black-Cockatoo and there was evidence to show that this species has previously used the site for feeding.

Table 4. Areas (ha) and proportions (%) of each category (vegetation score, combined foraging score) of foraging habitat at the survey area for Carnaby's Black-Cockatoo, Forest Red-tailed Black-Cockatoo and Baudin's Black-Cockatoo.

See Section 2.4.3.3 and Appendix 4 for explanation of vegetation, context, species density and (combined) foraging scores.

Vegetation Score/Value	Carnaby's Black-Cockatoo		Forest Red-tailed Black-Cockatoo		Baudin's Black-Cockatoo	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
6: High	0	0.0	0	0.0	0	0.0
5: Moderate to High	152	39.2	0	0.0	0	0.0
4: Moderate	220	56.5	169	43.3	152	39.2
3: Low to Moderate	0	0.0	220	56.5	220	56.5
2: Low	17	4.4	1	0.2	1	0.2
1: Negligible	0	0.0	0	0.0	16	4.2
0: Nil	0	0.0	0	0.0	0	0.0
TOTAL	389	100.0	389	100.0	389	100.0
Context Score	2		2		2	
Species Density Score	1		1		1	
Foraging Score						
10	-	-	-	-	-	-
9	-	-	-	-	-	-
8	152	39.2	0	0.0	0	0.0
7	220	56.5	169	43.3	152	39.2
6	0	0.0	220	56.5	220	56.5
NA (Vegetation Score < 3)	17	4.4	1	0.2	17	4.4
TOTAL	389	100.0	389	100.0	389	100.0

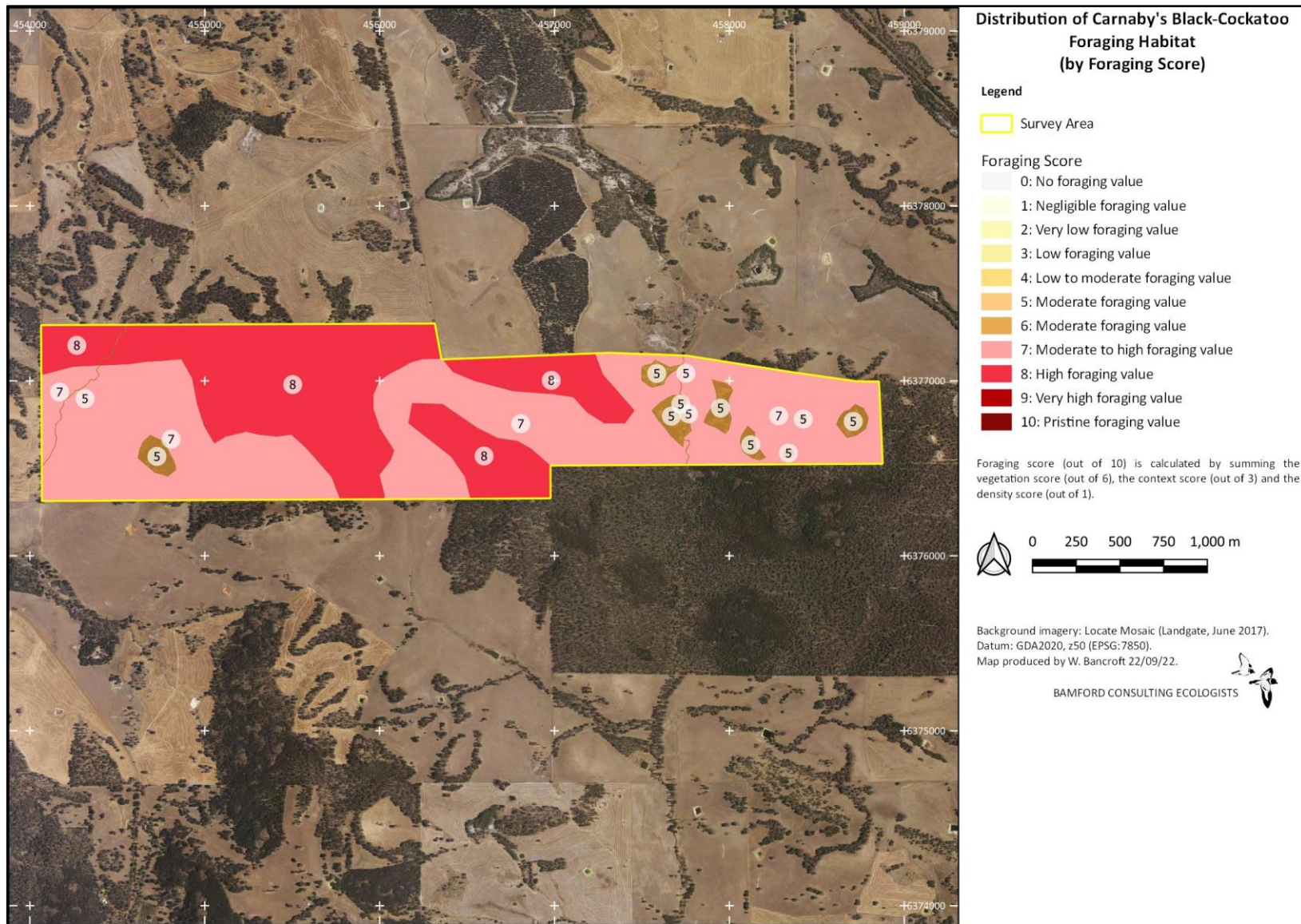


Figure 4. Distribution of Carnaby's Black-Cockatoo foraging habitat in the survey area.

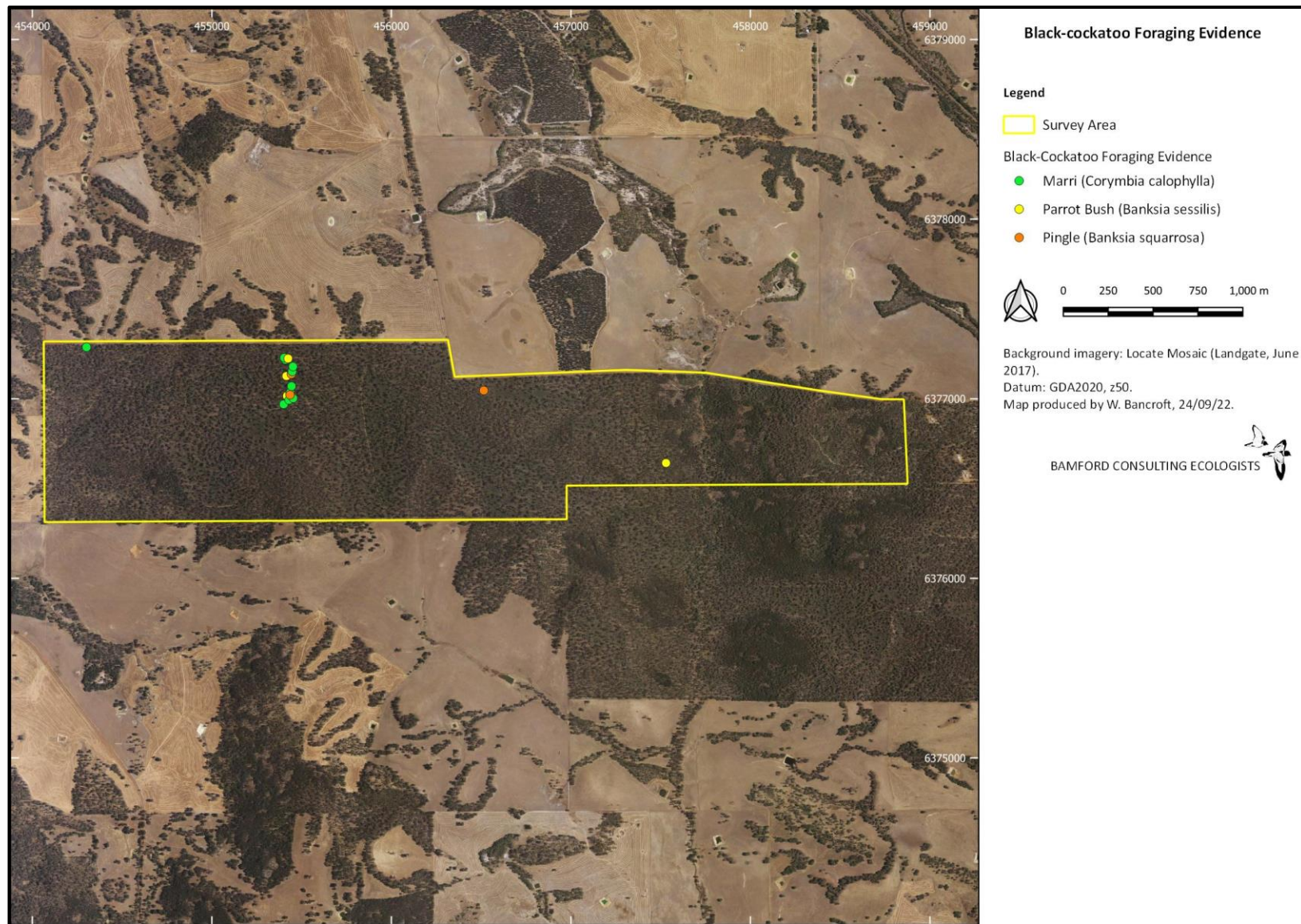


Figure 5. Location of black-cockatoo foraging records (from the September 2022 inspection) within the survey area.

3.3.3.2 Forest Red-tailed Black-Cockatoo

Foraging habitat for the Forest Red-tailed Black-Cockatoo was present throughout the survey area. This is predominantly due to the presence of two tree species known to be mainstays of the Forest Red-tailed Black-Cockatoo diet: Jarrah, *Eucalyptus marginata*; and Marri (Johnstone and Kirkby 1999; Johnstone *et al.* 2013b). The presence of Rock Sheoak, *Allocasuarina huegeliana* may also afford this species some foraging opportunity, although little mention of this food source is provided in the literature (Johnstone and Kirkby 1999; Johnstone *et al.* 2013b). There is no strong evidence to suggest that this species will feed on wandoo (Johnstone and Storr 1998; Higgins 1999; Johnstone and Kirkby 1999; Johnstone *et al.* 2013b). The forage tree species that were present occurred in varying densities, across the site, but nowhere were they notably high density. The areas (and percentages) of each vegetation score are shown for the Forest Red-tailed Black-Cockatoo in Table 4.

There are approximately 31,325 ha of remnant native vegetation (as assessed by DPIRD 2022) within 15 km of the survey area, which itself has c. 378 ha of native vegetation. Therefore, the site comprises c. 1.2% of the native vegetation in the 'local area' (as per the methods outlined in Appendix 4). It is likely that the Forest Red-tailed Black-Cockatoo breeds within the local area, given the proximity to Jarrah/Marri forests in the region. Thus, a 'context' score of 2 (out of 3) has been assigned to the survey area for this species (see Appendix 4).

There was evidence of foraging by the Forest Red-tailed Black-Cockatoo within the survey area. This was entirely foraging on Marri (with intermediate and old-aged signs noted). The locations of these records are shown in Figure 5, and a representative photo of foraging evidence is provided in Plate 6. It is expected that the Forest Red-tailed Black-Cockatoo will occur regularly (including foraging) within the survey area. Therefore, the survey area was assigned a species 'density' score for Forest Red-tailed Black-Cockatoo of 1 (out of 1; see Appendix 4).

The context and density values have been added on to the vegetation scores to yield the overall foraging value scores (with areas and percentages) that are also presented in Table 4. A map of foraging scores for Forest Red-tailed Black-Cockatoo foraging within the survey area is presented in Figure 6.

The survey area is, generally, of moderate value for foraging by the Forest Red-tailed Black-Cockatoo and there was evidence to suggest that this species has previously used the site for feeding.



Plate 6. Marri nuts foraged by Forest Red-tailed Black-Cockatoos ('intermediate' aged foraging).

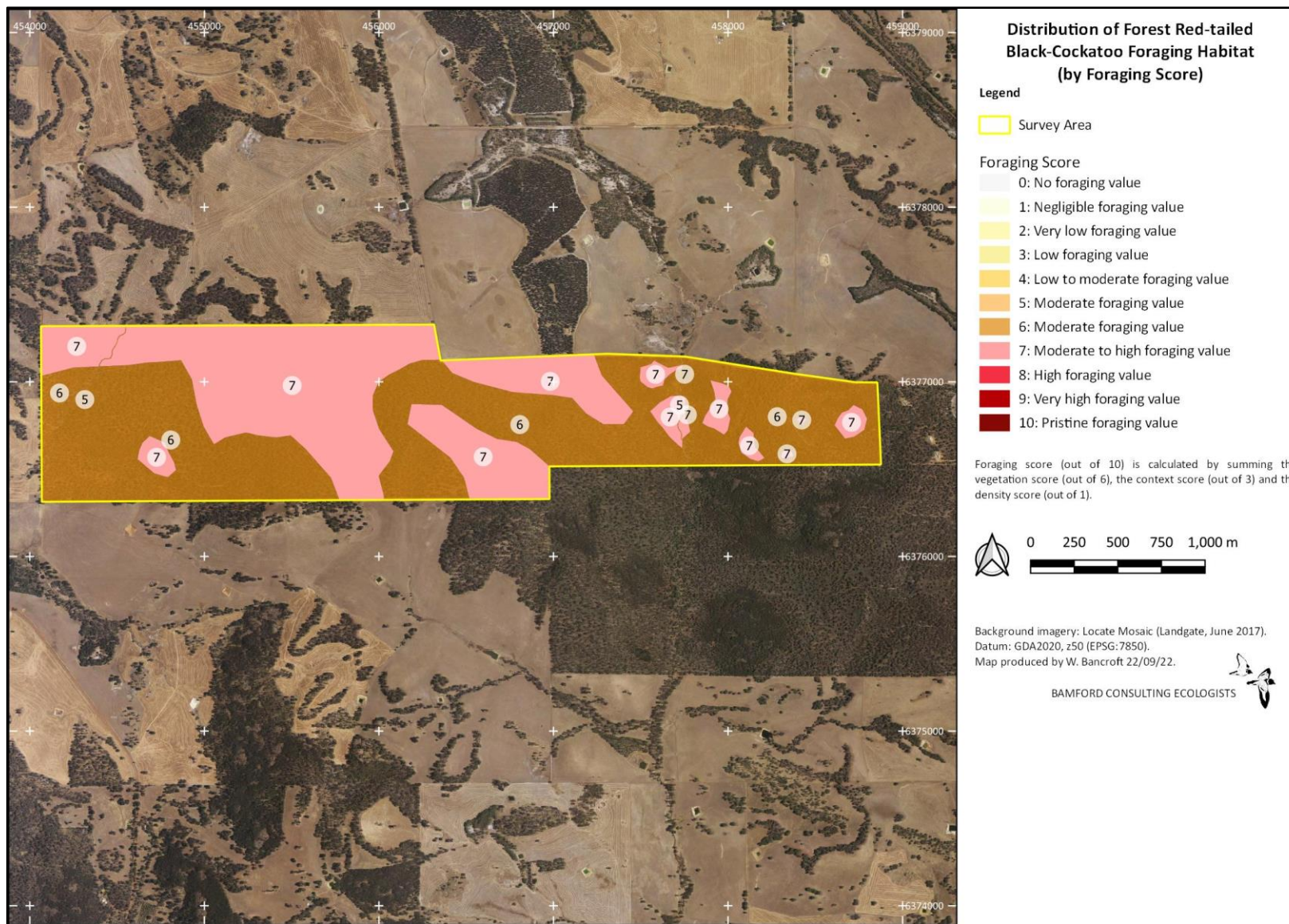


Figure 6. Distribution of Forest Red-tailed Black-Cockatoo foraging habitat in the survey area.

3.3.3.3 *Baudin's Black-Cockatoo*

Foraging habitat for the Baudin's Black-Cockatoo was present throughout most of the survey area. This is predominantly due to the presence of two tree species known to be mainstays of the Baudin's Black-Cockatoo diet (Jarrah and Marri) and also the presence of proteaceous shrubs (e.g. *Banksia* and *Hakea* spp.) that are also known to be supplementary food sources for this species (Johnstone and Storr 1998; Higgins 1999; Johnstone and Johnstone 2001; Lee *et al.* 2013). The forage tree species that were present occurred in varying densities, across the site, but nowhere were they notably high density. The areas (and percentages) of each vegetation score are shown for the Baudin's Black-Cockatoo in Table 4.

There are approximately 31,325 ha of remnant native vegetation (as assessed by DPIRD 2022) within 15 km of the survey area, which itself has c. 378 ha of native vegetation. Therefore, the site comprises c. 1.2% of the native vegetation in the 'local area' (as per the methods outlined in Appendix 4). It is possible that the Baudin's Black-Cockatoo breeds within the local area, given the proximity to Jarrah/Marri and Wandoo forests in the region. Thus, a 'context' score of 2 (out of 3) has been assigned to the survey area for this species (see Appendix 4).

There was no evidence of foraging by the Baudin's Black-Cockatoo within the survey area. It is expected, however, that the Baudin's Black-Cockatoo will occur regularly (including foraging) within the survey area as it is located along the main southern migration corridor (Johnstone and Kirkby 2008; DAWE 2022b). Therefore, the survey area was assigned a species 'density' score for Baudin's Black-Cockatoo of 1 (out of 1; see Appendix 4).

The context and density values have been added on to the vegetation scores to yield the overall foraging value scores (with areas and percentages) that are also presented in Table 4. A map of foraging scores for Baudin's Black-Cockatoo foraging within the survey area is presented in Figure 7.

The survey area is, generally, of moderate value for foraging by the Baudin's Black-Cockatoo.

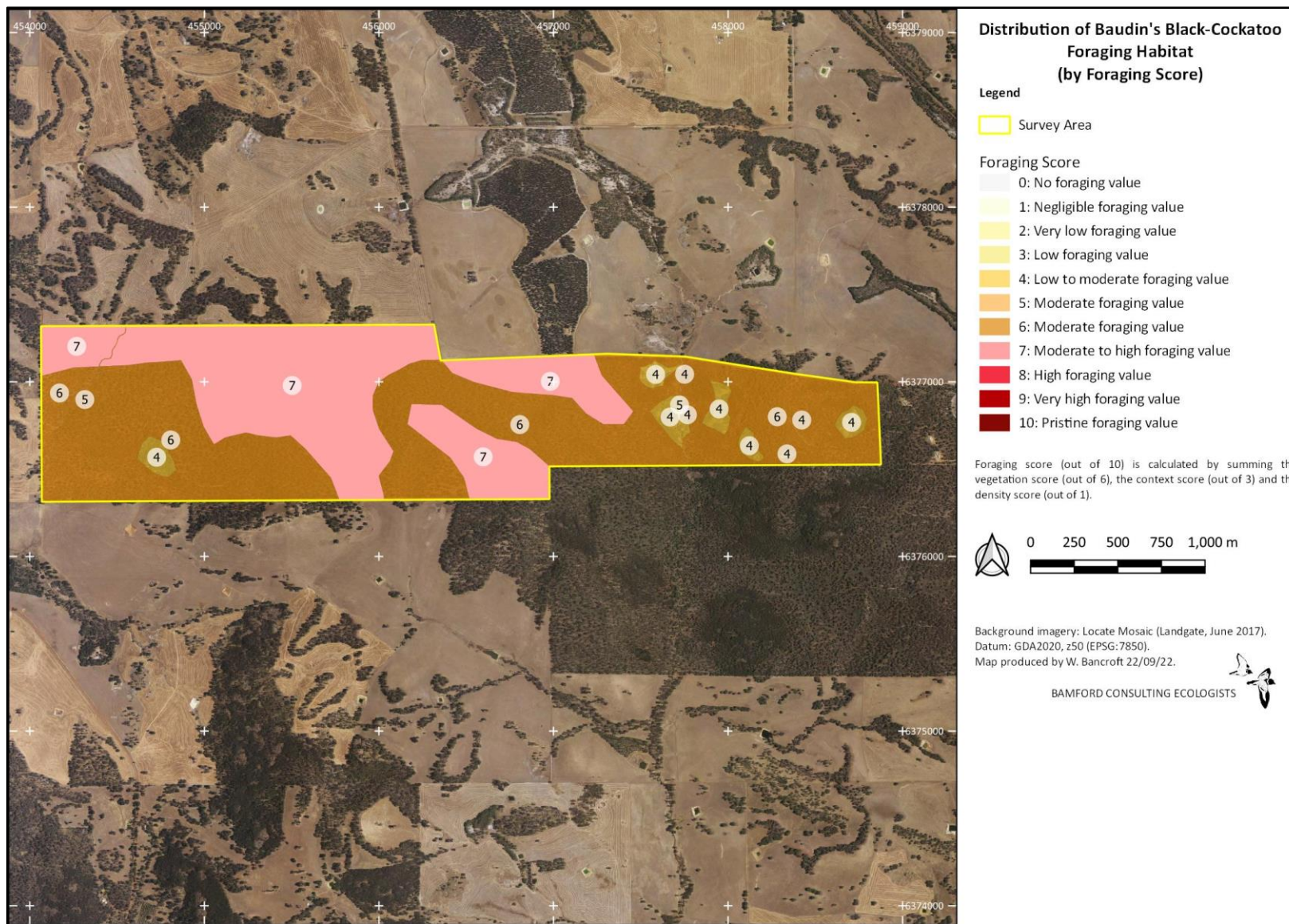


Figure 7. Distribution of Baudin’s Black-Cockatoo foraging habitat in the survey area.

3.3.3.4 DCCEEW foraging quality scoring tool

The DCCEEW foraging quality scoring tool (provided by DAWE 2022b) was used to assess the site as a whole. The calculations are presented in Table 5 and these generated a total score (out of 10) for each species of black-cockatoo. The survey area scored 10 (out of 10) for both Carnaby's and Forest Red-tailed Black-cockatoos, and 8 (out of 10) for Baudin's Black-Cockatoo.

Table 5. DCCEEW foraging quality scoring tool calculations for the survey area.

Attribute	Baudin's Black-Cockatoo	Carnaby's Black-Cockatoo	Forest Red-tailed Black-Cockatoo
Starting score	10	10	10
Foraging potential	-2 (No evidence of foraging debris.)	0 (Foraging debris present.)	0 (Foraging debris present.)
Connectivity	0 (Foraging habitat within 12 km.)	0 (Foraging habitat within 12 km.)	0 (Foraging habitat within 12 km.)
Proximity to breeding	0 (Breeding habitat within 12 km.)	0 (Breeding habitat within 12 km.)	0 (Breeding habitat within 12 km.)
Proximity to roosting	0 (Known night roosting habitat within 20 km.)	0 (Known night roosting habitat within 20 km.)	0 (Known night roosting habitat within 20 km.)
Impact from significant plant disease	0 (<i>Phytophthora</i> spp. or Marri canker affects less than 50% of preferred food plants.)	0 (<i>Phytophthora</i> spp. or Marri canker affects less than 50% of preferred food plants.)	0 (<i>Phytophthora</i> spp. or Marri canker affects less than 50% of preferred food plants.)
Total Score	8	10	10

3.3.4 Black-cockatoo night roosting habitat

No black-cockatoos were recorded coming in to roost within, or in the vicinity of, the survey area from the single roost-watch location (on the northern boundary of the site) on the evening of 16th September 2022. The current landholder provided anecdotal evidence that at some times of the year black-cockatoos have been known to move into the survey area around dusk.

The area around the survey area has been known to support black-cockatoo roosting, however there are no known records of roost sites within the survey area itself. Previously known roost locations (provided by DBCA 2022a and that reflect data collected in BirdLife Australia's Great Cocky Counts) within 15 km of the survey area are mapped in Figure 8. The nearest of these known roosts is within c. 3 km of the survey area boundary. Further details on these roosts can be provided, if required, by requesting data from BirdLife Australia.

Given the established roosts within the region, anecdotal evidence and the availability of taller trees (e.g. eucalypts) preferred by black-cockatoos as roost locations within the survey area, there is very strong potential that black-cockatoos use the site for roosting for at least some times of the year.

3.3.5 Black-cockatoo watering points

Several potential water sources for black-cockatoos were noted. These included seasonal drainages through the site (including an area on one which is believed to be a perennial spring), and a number of farm dams in paddocks that surround the survey area (and would likely provide at least some water for most of the year).

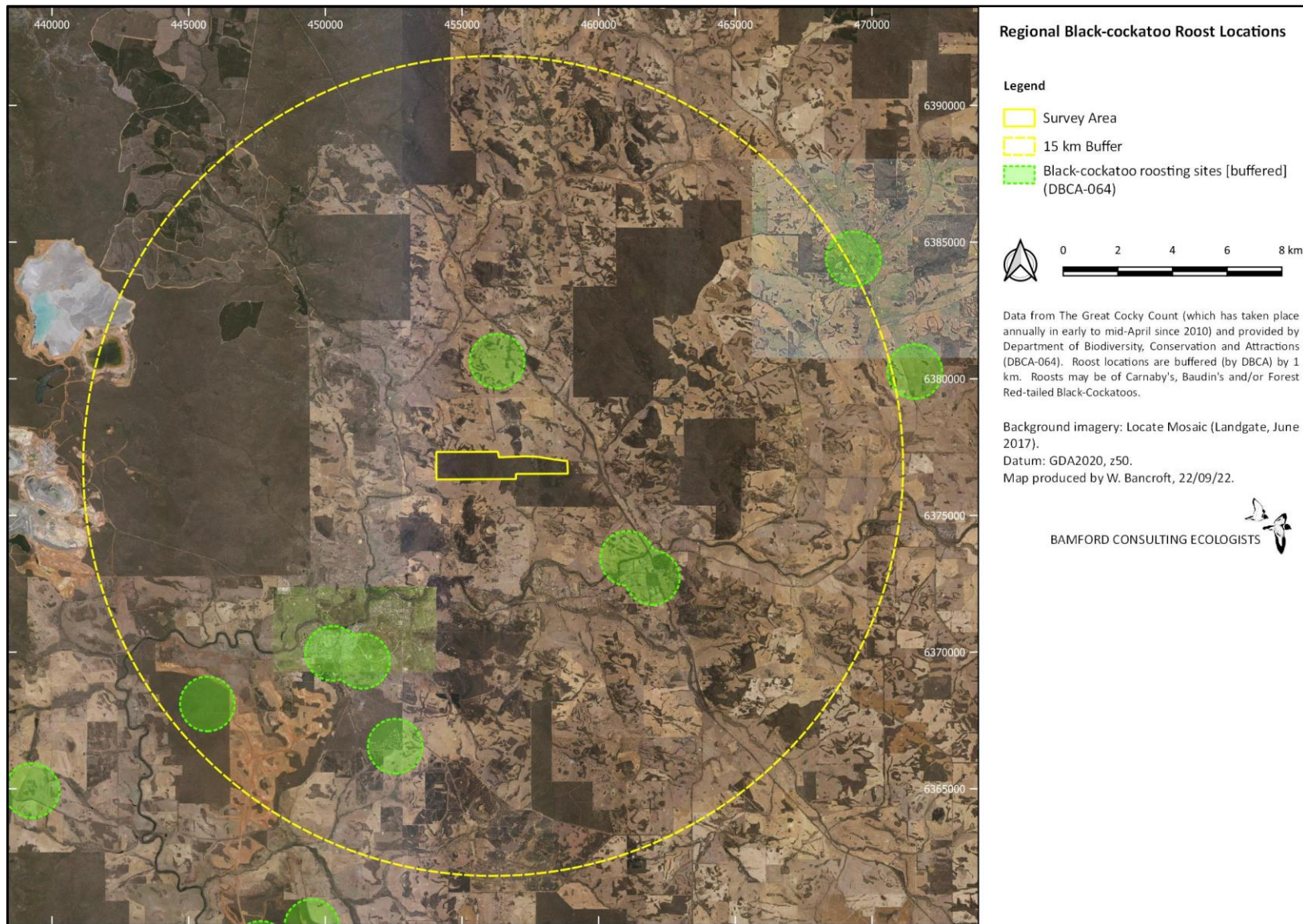


Figure 8. Known black-cockatoo roost locations within the region.

3.4 MNES Vertebrate Fauna

A number of vertebrate species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and that could be considered Matters of National Environmental Significance (MNES), have the potential to occur within the study area. Using a 20 km buffer around the survey area, a search of the EPBC database (using the EPBC Protected Matters Search Tool provided by DCCEEW 2022b) yielded 12 listed threatened vertebrate species that may occur in the region. These are discussed briefly below, in relation to their likely occurrence within the survey area:

- i. Malleefowl (*Leipoa ocellata*). Not expected to occur. Habitat probably unsuitable. Probably out of range.
- ii. Curlew Sandpiper (*Calidris ferruginea*). Not expected to occur. Habitat unsuitable.
- iii. Eastern Curlew (*Numenius madagascariensis*). Not expected to occur. Habitat unsuitable.
- iv. Australian Painted-snipe (*Rostratula australis*). Not expected to occur. Habitat unsuitable. Probably out of range.
- v. Carnaby's Black-Cockatoo (*Zanda latirostris*). Known to occur. See Section 3.3 above.
- vi. Baudin's Black-Cockatoo (*Zanda baudinii*). Expected to occur. See Section 3.3 above.
- vii. Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*). Known to occur. See Section 3.3 above.
- viii. Grey Falcon (*Falco hypoleucos*). Not expected to occur. Habitat unsuitable. Out of range.
- ix. Woylie (*Bettongia penicillata ogilbyi*). Unlikely to currently occur but habitat is well suited to this species. While the Woylie is probably locally extinct there is an extant population in very similar habitat at Dryandra Woodland National Park to the east (connectively to the study area is tenuous, however). With additional management (e.g. feral predator control and/or fencing), the site could be a strong potential for reintroduction of this species.
- x. Chuditch (*Dasyurus geoffroii*). Expected to occur. The woodlands within the survey area would provide ideal habitat for this species although competition with/predation by feral predators may be of some concern. A number of fallen, hollowed logs are present throughout the site and these would provide excellent dens for Chuditch. While these are very wide ranging animals, the overall health of the ecosystem within the survey area (and surrounds) should be able to support a resident population of Chuditch.
- xi. Red-tailed Phascogale (*Phascogale calura*). Expected to occur. The Rock Sheoak patches within the survey area provide excellent habitat for this species (Kitchener 1981; Short and Hide 2012; Cannella *et al.* 2018). While not extensive, there should be enough resources within the site to support resident Red-tailed Phascogales.
- xii. Quokka (*Setonix brachyurus*). Not expected to occur. Habitat unsuitable (lack of preferred Swamp Peppermint thickets).

In addition to the above, it should also be noted that the site would be ideal for the EPBC-listed Numbat (*Myrmecobius fasciatus*) and that, while low likelihood, the presence of this species should not be completely discounted. This species was not returned in the EPBC search however a recent, unexpected, sighting (in 2021) in nearby Boddington gives some hope that numbats may be persisting locally (Loney 2021).

3.5 Priority Vertebrate Fauna

In addition to the threatened species listed under the EPBC Act, the survey area may also support (or be capable of supporting) a range of DBCA-ranked Priority species (see Appendix 1 for definitions of DBCA priority rankings). Brief comments are provided for some of these species below:

- i. Dells' Skink (*Ctenotus delli*). Ranked as P4. This species may persist in the heaths and woodlands surrounding granite outcrops within the site where it often prefers sandier soils.
- ii. Peregrine Falcon (*Falco peregrinus*). Listed as OS. It is likely that this species would presently use the site, at least in part (these birds have large home ranges).
- iii. Masked Owl – southwest (*Tyto novaehollandiae novaehollandiae*). Ranked as P3. Could occur in forested areas and surrounding farmland may also provide some foraging opportunities.
- iv. Barking Owl – southwest (*Ninox connivens connivens*). While presently ranked as P3, a recent publication (Davis *et al.* 2022) suggested that this taxon may be in a dire situation. It is probably locally extinct but there is a slim possibility of it persisting.
- v. South-western Brush-tailed Phascogale (*Phascogale tapoatafa wambenger*). Ranked as CD. It is expected that this species would be present and the numerous tree-hollows observed within the survey area provide ideal refugia, as noted by Van der Ree *et al.* (2006). In a highly modified agricultural landscape (within which the survey area sits), the 'dry forested slopes' present throughout the site have been previously found to be a favoured habitat for this species (Lawton *et al.* 2021). Cannella *et al.* (2018) found both of species of phascogale to be present, in sympatry, in the broader region.
- vi. Quenda (*Isoodon fusciventer*). Ranked as P4. Expected to be present. Known to occur in similar habitats within the region. The presence of feral predators may inhibit this species.
- vii. Brush Wallaby (*Notamacropus irma*). Ranked as P4. Possibly present. Brush Wallabies are common in the Jarrah, Marri and Wandoo forests to the north of the survey area (W. Bancroft, pers. obs) and are likely to be similarly common in forests to the west.
- viii. Tammar Wallaby (*Notamacropus eugenii derbianus*). Ranked as P4. Probably locally extinct but this species has persisted further east, around Narrogin.
- ix. Rakali/Water-rat (*Hydromys chrysogaster*). Ranked as P4. Likely to occur along drainages within the survey area at least irregularly (if not resident). These water courses connect to the Hotham River (to the south of the site) and it is likely that Rakali persist along this system.
- x. Western False Pipistrelle (*Falsistrellus mackenziei*). Ranked as P4. Occurs in dry sclerophyll forest, such as is present across the survey area, in the south-west of Western Australia and, as such, could be expected to be present within the site, at least as a regular visitor (if not resident).

3.6 Other Fauna

A number of threatened and priority *invertebrate* species may occur in the vicinity of the survey area. Further details and desktop assessment of these species could be provided, if required.

At least 47 vertebrate species were recorded during the site inspection. A list of these species is provided in Appendix 7.

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5 Appendices

Appendix 1. Categories used in the assessment of conservation status.

IUCN (International Union for the Conservation of Nature) categories, as outlined by IUCN (2012), and as used for the *Environment Protection and Biodiversity Conservation Act 1999*:

EX	Extinct	Taxa not definitely located in the wild during the past 50 years.
EW	Extinct in the Wild	Taxa known to survive only in captivity.
CR	Critically Endangered	Taxa facing an extremely high risk of extinction in the wild in the immediate future.
EN	Endangered	Taxa facing a very high risk of extinction in the wild in the near future.
VU	Vulnerable	Taxa facing a high risk of extinction in the wild in the medium-term future.
NT	Near Threatened	Taxa that risk becoming Vulnerable in the wild.
CD	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.
DD	Data Deficient (Insufficiently Known)	Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.
LC	Least Concern	Taxa that are not Threatened.

Categories used in the *WA Biodiversity Conservation Act 2016*:

<i>THREATENED SPECIES</i>		
CR	Critically Endangered	Threatened species considered to be “facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines”.
EN	Endangered	Threatened species considered to be “facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines”.
VU	Vulnerable	Threatened species considered to be “facing a high risk of extinction in the wild in the medium term future, as determined in accordance with criteria set out in the ministerial guidelines”.
<i>EXTINCT SPECIES</i>		
EX	Extinct	Species where “there is no reasonable doubt that the last member of the species has died”, and listing is otherwise in accordance with the ministerial guidelines (section 24 of the BC Act).
EW	Extinct in the Wild	Species that “is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere in its past range, despite surveys over a time frame appropriate to its life cycle and form”, and listing is otherwise in accordance with the ministerial guidelines (section 25 of the BC Act).

SPECIALLY PROTECTED SPECIES

MI	Migratory	Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and listing is otherwise in accordance with the ministerial guidelines (section 15 of the BC Act).
CD	Conservation Dependent	Species of special conservation need that are dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened, and listing is otherwise in accordance with the ministerial guidelines (section 14 of the BC Act).
OS	Other Specially Protected	Species otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18 of the BC Act).

WA DBCA Priority species (species not listed under the *WA Biodiversity Conservation Act 2016*, but for which there is some concern).

		Poorly-known species.
P1	Priority 1	Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, for example, agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements for threatened listing and appear to be under immediate threat from known threatening processes. These species are in urgent need of further survey.
		Poorly-known species.
P2	Priority 2	Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, for example, national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements for threatened listing and appear to be under threat from known threatening processes. These species are in urgent need of further survey.
		Poorly-known species.
P3	Priority 3	Species that are known from several locations and the species does not appear to be under imminent threat or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. These species need further survey.

Rare, Near Threatened and other species in need of monitoring.

(a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands.

P4 Priority 4

(b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as a conservation dependent specially protected species.

(c) Species that have been removed from the list of threatened species or lists of conservation dependent or other specially protected species, during the past five years for reasons other than taxonomy.

(d) Other species in need of monitoring.

Appendix 2. Plants known to be used for foraging, roosting and nesting by black-cockatoos in south-western Western Australia.

Data compiled from the literature (Davies 1966; Saunders 1974, 1979a, b, 1980; Saunders *et al.* 1982; Saunders 1986; Johnstone and Storr 1998; Higgins 1999; Johnstone and Kirkby 1999, 2008; Groom 2011; Johnstone *et al.* 2011; DotE 2017a, b, c).

FRTBC = Forest Red-tailed Black-Cockatoo, CBC = Carnaby's Black-Cockatoo, BBC = Baudin's Black-Cockatoo.

Plant status: blank = Western Australian native, AN = Australian native (but not naturally occurring in Western Australia), E = exotic (i.e. not native to Australia).

F = foraging, R = roosting, N or n = nesting (main and less commonly used species, respectively).

Plant Species	Plant Status	FRTBC	CBC	BBC
<i>Acacia baileyana</i> (Cootamundra Wattle)	AN		F	
<i>Acacia pentadenia</i> (Karri Wattle)			F	
<i>Acacia saligna</i> (Orange Wattle)			F	
<i>Agonis flexuosa</i> (Peppermint Tree)			F	
<i>Allocasuarina fraseriana</i> (Sheoak)		F		F
<i>Anigozanthos flavidus</i> (Tall Kangaroo Paw)				F
<i>Araucaria heterophylla</i> (Norfolk Island Pine)	E		F	
<i>Banksia ashbyi</i> (Ashby's Banksia)			F	
<i>Banksia attenuata</i> (Slender Banksia)			F	
<i>Banksia baxteri</i> (Baxter's Banksia)			F	
<i>Banksia carlinoides</i> (Pink Dryandra)			F	
<i>Banksia coccinea</i> (Scarlet Banksia)			F	
<i>Banksia dallanneyi</i> (Couch Honey-pot Dryandra)			F	
<i>Banksia ericifolia</i> (Heath-leaved Banksia)	AN		F	
<i>Banksia fraseri</i> (Dryandra)			F	
<i>Banksia gardneri</i> (Prostrate Banksia)			F	
<i>Banksia grandis</i> (Bull Banksia)			F	F
<i>Banksia hookeriana</i> (Hooker's Banksia)			F	
<i>Banksia ilicifolia</i> (Holly Banksia)			F	F
<i>Banksia kippistiana</i> (Dryandra)			F	
<i>Banksia leptophylla</i>			F	
<i>Banksia lindleyana</i> (Porcupine Banksia)				F
<i>Banksia littoralis</i> (Swamp Banksia)			F	F
<i>Banksia menziesii</i> (Firewood or Menzie's Banksia)			F	
<i>Banksia mucronulata</i> (Swordfish Dryandra)			F	
<i>Banksia nivea</i> (Honey-pot Dryandra)			F	
<i>Banksia nobilis</i> (Golden Dryandra)			F	
<i>Banksia praemorsa</i> (Cut-leaf Banksia)			F	F
<i>Banksia prionotes</i> (Acorn Banksia)			F	
<i>Banksia quercifolia</i> (Oak-leaved Banksia)			F	F
<i>Banksia sessilis</i> (Parrot Bush)			F	F
<i>Banksia speciosa</i> (Showy Banksia)			F	
<i>Banksia squarrosa</i> (Pingle)			F	F

Plant Species	Plant Status	FRTBC	CBC	BBC
<i>Banksia tricuspis</i> (Lesueur Banksia or Pine Banksia)			F	
<i>Banksia undata</i> (Urchin or Cut-leaf Dryandra)			F	
<i>Banksia verticillata</i> (Granite Banksia)			F	
<i>Brassica campestris</i> (Canola, Rape)	E		F	
<i>Callistemon</i> spp.				F
<i>Callistemon viminalis</i> (Captain Cook Bottlebrush)	AN		F	
<i>Callitris</i> sp.			F	
<i>Carya illinoensis</i> (Pecan)	E		F	F
<i>Casuarina cunninghamiana</i> (River Sheoak)	AN		F	
<i>Citrullus lanatus</i> (Pie or Afghan Melon)	E		F	
<i>Corymbia calophylla</i> (Marri)		F,N	F,n,R	F,n
<i>Corymbia ficifolia</i> (Red Flowering Gum)			F	
<i>Corymbia haematoxylon</i> (Mountain Marri)			F	
<i>Corymbia maculata</i> (Spotted Gum)			R	
<i>Darwinia citriodora</i> (Lemon-scented Darwinia)	AN		F	F
<i>Diospyros</i> sp. (Sweet Persimmon)	E		F	F
<i>Eremophila glabra</i> (Tarbush)			F	
<i>Erodium aureum</i> (Corkscrew Grass or Storksbill)	E		F	
<i>Erodium botrys</i> (Corkscrew Grass or Storksbill)	E		F	F
<i>Eucalyptus caesia</i> (Silver Princess)			F	
<i>Eucalyptus camaldulensis</i> (River Red Gum)	AN		R	
<i>Eucalyptus citriodora</i> (Lemon Scented Gum)	AN	F	F,R	F
<i>Eucalyptus diversicolor</i> (Karri)		n	n	N
<i>Eucalyptus globulus</i> (Tasmanian Blue Gum)	AN		R	
<i>Eucalyptus gomphocephala</i> (Tuart)		n	F,n,R	
<i>Eucalyptus grandis</i> (Flooded Gum, Rose Gum)	AN		R	
<i>Eucalyptus longicornis</i> (Red Morrell)			n	
<i>Eucalyptus loxophleba</i> (York Gum)			F,n	
<i>Eucalyptus marginata</i> (Jarrah)		F,N	F,n,R	F
<i>Eucalyptus megacapa</i> (Bullich)		n		n
<i>Eucalyptus occidentalis</i> (Swamp Yate)			n	
<i>Eucalyptus patens</i> (Blackbutt)		F	F,R	
<i>Eucalyptus pleurocarpa</i> (Tallerack)			F	
<i>Eucalyptus preissiana</i> (Bell-fruited Mallee)			F	
<i>Eucalyptus robusta</i> (Swamp Mahogany)			F,R	
<i>Eucalyptus rudis</i> (Flooded Gum)			R	
<i>Eucalyptus salmonophloia</i> (Salmon Gum)			F,N	
<i>Eucalyptus salubris</i> (Gimlet)			n	
<i>Eucalyptus todtiana</i> (Coastal Blackbutt or Prickley Bark)			F	
<i>Eucalyptus wandoo</i> (Wandoo)			F,N,R	F,n
<i>Ficus</i> sp. (Fig)			F	
<i>Grevillea armigera</i> (Prickly Toothbrushes)			F	
<i>Grevillea bipinnatifida</i> (Fuschia Grevillea)			F	
<i>Grevillea hookeriana</i> (Red Toothbrushes)			F	

Plant Species	Plant Status	FRTBC	CBC	BBC
<i>Grevillea hookeriana</i> subsp. <i>apiculoba</i> (Black Toothbrushes)			F	
<i>Grevillea paniculata</i> (Kerosene Bush)			F	
<i>Grevillea paradoxa</i> (Bottlebrush Grevillea)			F	
<i>Grevillea petrophiloides</i> (Pink Poker)			F	
<i>Grevillea robusta</i> (Silky Oak)			F	
<i>Grevillea wilsonii</i> (Native Fuchsia)				F
<i>Hakea auriculata</i>			F	
<i>Hakea candolleana</i>			F	
<i>Hakea circumalata</i> (Coastal Hakea)			F	
<i>Hakea commutata</i>			F	
<i>Hakea conchifolia</i>			F	
<i>Hakea costata</i> (Ribbed Hakea)			F	
<i>Hakea cristata</i> (Snail Hakea)			F	F
<i>Hakea cucullata</i> (Snail Hakea)			F	
<i>Hakea cyclocarpa</i> (Ramshorn)			F	
<i>Hakea eneabba</i>			F	
<i>Hakea erinacea</i> (Hedgehog Hakea)			F	F
<i>Hakea falcata</i> (Sickle Hakea)			F	
<i>Hakea flabellifolia</i> (Fan-leaved Hakea)			F	
<i>Hakea gilbertii</i>			F	
<i>Hakea incrassata</i> (Golfball or Marble Hakea)			F	
<i>Hakea lasiantha</i> (Woolly Flowered Hakea)			F	
<i>Hakea lasianthoides</i>			F	F
<i>Hakea laurina</i> (Pin-cushion hakea)			F	
<i>Hakea lissocarpha</i> (Honeybush)			F	F
<i>Hakea marginata</i>				F
<i>Hakea megalosperma</i> (Lesueur Hakea)			F	
<i>Hakea multilineata</i> (Grass Leaf Hakea)			F	
<i>Hakea obliqua</i> (Needles and Corks)			F	
<i>Hakea oleifolia</i> (Dungyn or Olive-leaved Hakea)			F	
<i>Hakea pandanicarpa</i> subsp. <i>crassifolia</i> (Thick-leaved Hakea)			F	
<i>Hakea petiolaris</i> (Sea Urchin Hakea)			F	
<i>Hakea polyanthema</i>			F	
<i>Hakea preissii</i> (Needle Tree)			F	
<i>Hakea prostrata</i> (Harsh Hakea)			F	F
<i>Hakea psilorrhyncha</i>			F	
<i>Hakea ruscifolia</i> (Candle Hakea)			F	F
<i>Hakea scoparia</i> (Kangaroo Bush)			F	
<i>Hakea smilacifolia</i>			F	
<i>Hakea spathulata</i>			F	
<i>Hakea stenocarpa</i> (Narrow-fruited Hakea)			F	F
<i>Hakea sulcata</i> (Furrowed Hakea)			F	

Plant Species	Plant Status	FRTBC	CBC	BBC
<i>Hakea trifurcata</i> (Two-leaved Hakea)			F	F
<i>Hakea undulata</i> (Wavy-leaved Hakea)			F	
<i>Hakea varia</i> (Variable-leaved Hakea)			F	F
<i>Helianthus annuus</i> (Sunflower)	E		F	
<i>Hibiscus</i> sp. (Hibiscus)	E		F	
<i>Isopogon scabriusculus</i>			F	
<i>Jacaranda mimosifolia</i> (Jacaranda)	E		F	F
<i>Jacksonia furcellata</i> (Grey Stinkwood)			F	
<i>Kingia australis</i> (Kingia)				F
<i>Lambertia inermis</i> (Chittick)			F	
<i>Lambertia multiflora</i> (Many-flowered Honeysuckle)			F	
<i>Liquidamber styraciflua</i> (Liquid Amber)	E		F	
<i>Lupinus</i> sp. (Lupin)	E		F	
<i>Macadamia integrifolia</i> (Macadamia)	E		F	F
<i>Malus domestica</i> (Apple)	E		F	F
<i>Melaleuca leuropoma</i>			F	
<i>Melia azedarach</i> (Cape Lilac or White Cedar)	E	F	F	
<i>Mesomeleana</i> sp.			F	
<i>Persoonia longifolia</i> (Snottygobble)		F		
<i>Pinus canariensis</i> (Canary Island Pine)	E		F	
<i>Pinus caribea</i> (Caribbean Pine)	E		F	
<i>Pinus pinaster</i> (Pinaster or Maritime Pine)	E		F,R	
<i>Pinus radiata</i> (Radiata Pine)	E		F,R	F
<i>Protea</i> 'Pink Ice'	E		F	
<i>Protea repens</i>	E		F	
<i>Prunus amygdalus</i> (Almond Tree)	E		F	
<i>Pyrus communis</i> (European Pear)	E			F
<i>Quercus</i> spp. (Oak spp.)	E			F
<i>Raphanus raphanistrum</i> (Wild Radish)	E		F	
<i>Reedia spathacea</i>				F
<i>Tipuana tipu</i> (Tipu or Rosewood Tree)	E		F	
<i>Xanthorrhoea preissii</i> (Grass Tree)			F	F

Appendix 3. Extended rationale for chosen methodology.

Vegetation and 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, relictual 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.

VSA assessment was made with reference to the key attributes provided by (EPA 2020):

- soil type and characteristics
- extent and type of ground surfaces and landforms
- height, cover and dominant flora within each vegetation stratum
- presence of specific flora or vegetation of known importance to fauna
- evidence of fire history including, where possible, estimates of time since fire
- evidence and degree of other disturbance or threats, e.g. feral species
- presence of microhabitats and significant habitat features, such as coarse woody debris, rocky
- outcrops, tree hollows, water sources and caves
- evidence of potential to support significant fauna
- function of the habitat as a fauna refuge or part of an ecological linkage.

Appendix 4. Scoring system for the assessment of foraging value of vegetation for Black-Cockatoos.

Bamford Consulting Ecologists

Revised 4th April 2021

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. Site condition. Vegetation composition, condition and structure scoring

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	Baudin's Black-Cockatoo	Forest Red-tailed Black-Cockatoo
0	<p>No foraging value. No Proteaceae, eucalypts or other potential sources of food. Examples:</p> <ul style="list-style-type: none"> • 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 	<p>No foraging value. No eucalypts or other potential sources of food. Examples:</p> <ul style="list-style-type: none"> • Water bodies (e.g. dams, rivers); • Bare ground; • Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits). 	<p>No foraging value. No eucalypts or other potential sources of food. Examples:</p> <ul style="list-style-type: none"> • Water bodies (e.g. dams, rivers); • Bare ground; • Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits).
1	<p>Negligible to low foraging value. Examples:</p> <ul style="list-style-type: none"> • 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. <i>Erodium</i> 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). 	<p>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.</p>	<p>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.</p>

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	Baudin's Black-Cockatoo	Forest Red-tailed Black-Cockatoo
2	<p>Low foraging value. Examples:</p> <ul style="list-style-type: none"> • 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 <i>B. attenuata</i> and <i>B. menziesii</i>) 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. <i>Erodium</i> spp.) that represent a short-term and/or seasonal food source. 	<p>Low foraging value. Examples:</p> <ul style="list-style-type: none"> • 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. 	<p>Low foraging value. Examples:</p> <ul style="list-style-type: none"> • 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, <i>Eucalyptus caesia</i> and <i>E. erythrocorys</i>.

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	Baudin's Black-Cockatoo	Forest Red-tailed Black-Cockatoo
3	<p>Low to Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> • 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 <i>B. attenuata</i> and <i>B. menziesii</i>) 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. 	<p>Low to Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> • 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). 	<p>Low to Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> • 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	<p>Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> Woodland/low forest with tree banksias (of key species <i>B. attenuata</i> and <i>B. menziesii</i>) 20-40% projected foliage cover; Woodland/low forest with tree banksias (of key species <i>B. attenuata</i> and <i>B. menziesii</i>) 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. 	<p>Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> 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). 	<p>Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> 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	<p>Moderate to High foraging value. Examples:</p> <ul style="list-style-type: none"> • Banksia Low Forest (of key species <i>B. attenuata</i> and <i>B. menziesii</i>) with 40-60% projected foliage cover; • Banksia Low Forest (of key species <i>B. attenuata</i> and <i>B. menziesii</i>) 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). 	<p>Moderate to High foraging value. Examples:</p> <ul style="list-style-type: none"> • 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). 	<p>Moderate to High foraging value. Examples:</p> <ul style="list-style-type: none"> • 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	<p>High foraging value. Example:</p> <ul style="list-style-type: none"> Banksia Low Forest (of key species <i>B. attenuata</i> and <i>B. menziesii</i>) 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-Jarra 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). 	<p>High foraging value. Example:</p> <ul style="list-style-type: none"> Marri-Jarra 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). 	<p>High foraging value. Example:</p> <ul style="list-style-type: none"> Marri-Jarra 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 assignment 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. Assignment 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 (≥ 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 5. The foraging quality scoring tool template from DAWE (2022b).

Table A1 Foraging quality scoring tool template

Starting score		Baudin's Cockatoo	Camaby's Cockatoo	Forest Red-tailed Black-Cockatoo
10		Start at a score of 10 if your site is native eucalypt woodlands and forest, and proteaceous woodland and heath, particularly Marri, within the range of the species, including along roadsides and parkland cleared areas. Can include planted vegetation. This tool only applies to sites equal to or larger than 1 hectare in size.	Start at a score of 10 if your site is native shrubland, kwongan heathland or woodland, dominated by proteaceous plant species such as <i>Banksia</i> spp. (including <i>Dryandra</i> spp.), <i>Hakea</i> spp. and <i>Grevillea</i> spp., as well as native eucalypt woodland and forest that contains foraging species, within the range of the species, including along roadsides and parkland cleared areas. Also includes planted native vegetation. This tool only applies to sites equal to or larger than 1 hectare in size.	Start at a score of 10 if your site is Jarrah or Marri woodland and/or forest, or if it is on the edge of Karri forest, or if Wandoo and Blackbutt occur on the site, within the range of the subspecies, including along roadsides and parkland cleared areas. This tool only applies to sites equal to or larger than 1 hectare in size.
Attribute	Sub-tractions	Context adjustor (attributes reducing functionality of foraging habitat)		
Foraging potential	-2	Subtract 2 from your score if there is no evidence of feeding debris on your site.	Subtract 2 from your score if there is no evidence of feeding debris on your site.	Subtract 2 from your score if there is no evidence of feeding debris on your site.
Connectivity	-2	Subtract 2 from your score if you have evidence to conclude that there is no other foraging habitat within 12 km of your site.	Subtract 2 from your score if you have evidence to conclude that there is no other foraging habitat within 12 km of your site.	Subtract 2 from your score if you have evidence to conclude that there is no other foraging habitat within 12 km of your site.
Proximity to breeding	-2	Subtract 2 if you have evidence to conclude that your site is more than 12 km from breeding habitat	Subtract 2 if you have evidence to conclude that your site is more than 12 km from breeding habitat.	Subtract 2 if you have evidence to conclude that your site is more than 12 km from breeding habitat.
Proximity to roosting	-1	Subtract 1 if you have evidence to conclude that your site is more than 20 km from a known night roosting habitat.	Subtract 1 if you have evidence to conclude that your site is more than 20 km from a known night roosting habitat.	Subtract 1 if you have evidence to conclude that your site is more than 20 km from a known night roosting habitat.
Impact from significant plant disease	-1	Subtract 1 if your site has disease present (e.g. <i>Phytophthora</i> spp. or Marri canker) and the disease is affecting more than 50% of the preferred food plants present.	Subtract 1 if your site has disease present (e.g. <i>Phytophthora</i> spp. or Marri canker) and the disease is affecting more than 50% of the preferred food plants present.	Subtract 1 if your site has disease present (e.g. <i>Phytophthora</i> spp. or Marri canker) and the disease is affecting more than 50% of the preferred food plants present.
Total score		<i>Enter score</i>	<i>Enter score</i>	<i>Enter score</i>
Appraisal		To support your habitat score, you should provide an overall appraisal of the habitat on the impact site and within 20km of the impact area to clearly explain and justify the score. It should include discussion on the foraging habitat's proximity to other resources (e.g. exact distance to proximate resources), frequency of use of proximate sites, the degree of evidence and description of vegetation type and condition.		

Appendix 6. Examples of Forest Red-tailed Black-Cockatoo foraging signs across the range of age categories used in this study.

Active/Recent



Intermediate



Old

Jarrah nuts



Jarrah leaves



Marri nuts



Appendix 7. Species recorded in the field investigations.

Species	Notes
Myobatrachidae (Ground frogs)	
<i>Crinia pseudinsignifera</i>	Bleating Froglet
Columbidae (Pigeons and Doves)	
<i>Phaps chalcoptera</i>	Common Bronzewing
Cuculidae (Cuckoos)	
<i>Chalcites lucidus</i>	Shining Bronze-Cuckoo
<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo
Turnicidae (Button-quail)	
<i>Turnix varius</i>	Painted Button-quail
Accipitridae (Eagles, Kites, Goshawks)	
<i>Lophoictinia isura</i>	Square-tailed Kite
<i>Aquila audax</i>	Wedge-tailed Eagle
<i>Accipiter fasciatus</i>	Brown Goshawk
Alcedinidae (Kingfishers)	
<i>Dacelo novaeguineae</i>	Laughing Kookaburra
Cacatuidae (Cockatoos and Corellas)	
<i>Calyptorhynchus banksii naso</i>	Forest Red-tailed Black-Cockatoo
<i>Calyptorhynchus latirostris</i>	Carnaby's Black-Cockatoo
<i>Eolophus roseicapilla</i>	Galah
Psittaculidae (Parrots, Lorikeets and Rosellas)	
<i>Purpureicephalus spurius</i>	Red-capped Parrot
<i>Barnardius zonarius</i>	Australian Ringneck
<i>Neophema elegans</i>	Elegant Parrot
<i>Glossopsitta porphyrocephala</i>	Purple-crowned Lorikeet
Climacteridae (Trecreepers)	
<i>Climacteris rufus</i>	Rufous Trecreeper
Maluridae (Fairy-wrens, Emu-wrens and Grasswrens)	
<i>Malurus splendens</i>	Splendid Fairy-wren
Meliphagidae (Honeyeaters and Chats)	

Species	Notes
<i>Lichmera indistincta</i>	Brown Honeyeater
<i>Melithreptus chloropsis</i>	Gilbert's Honeyeater
<i>Acanthorhynchus superciliosus</i>	Western Spinebill
<i>Anthochaera carunculata</i>	Red Wattlebird
Pardalotidae (Pardalotes)	
<i>Pardalotus punctatus</i>	Spotted Pardalote
<i>Pardalotus striatus</i>	Striated Pardalote
Acanthizidae (Thornbills and Gerygones)	
<i>Gerygone fusca</i>	Western Gerygone
<i>Smicronis brevirostris</i>	Weebill
<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill
Campephagidae (Cuckoo-shrikes and Trillers)	
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike
Pachycephalidae (Whistlers, Shrike-thrushes and allies)	
<i>Pachycephala rufiventris</i>	Rufous Whistler
<i>Colluricincla harmonica</i>	Grey Shrike-thrush
Artamidae (Woodswallows, Currawongs, Butcherbirds and Magpie)	
<i>Gymnorhina tibicen</i>	Australian Magpie
Rhipiduridae (Fantails)	
<i>Rhipidura leucophrys</i>	Willie Wagtail
<i>Rhipidura albiscapa</i>	Grey Fantail
Corvidae (Crows and Ravens)	
<i>Corvus coronoides</i>	Australian Raven
Monarchidae (Monarch and Flycatchers)	
<i>Grallina cyanoleuca</i>	Magpie-lark
Petroicidae (Australian Robins)	
<i>Petroica boodang</i>	Scarlet Robin
<i>Eopsaltria griseogularis</i>	Western Yellow Robin
Dicaeidae (Flowerpeckers)	
<i>Dicaeum hirundinaceum</i>	Mistletoebird
Hirundinidae (Swallows and Martins)	

Species	Notes
<i>Petrochelidon nigricans</i>	Tree Martin
Zosteropidae (White-eyes)	
<i>Zosterops lateralis</i>	Silvereye
Tachyglossidae (Echidnas)	
<i>Tachyglossus aculeatus acanthion</i>	Short-beaked Echidna Diggings
Peramelidae (Bandicoots)	
<i>Isoodon fusciventer</i>	Quenda (Possible diggings)
Phalangeridae (Brush-tail possums)	
<i>Trichosurus vulpecula hypoleucus</i>	Brush-tail Possum Tree scratches
Macropodidae (Kangaroos)	
<i>Macropus fuliginosus melanops</i>	Western Grey Kangaroo
Leporidae (Rabbits and hares)	
<i>Oryctolagus cuniculus</i>	Rabbit Diggings, scats
Canidae (Dogs)	
<i>Vulpes vulpes</i>	Red Fox
Suidae (Pigs)	
<i>Sus scrofa</i>	Pig Diggings

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