

Great Northern Highway Bindoon Bypass Project: Revised Fauna Assessment (June 2019)



Banksia Woodland. Photo: W. Bancroft

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Executive Summary

Bamford Consulting Ecologists (BCE) was commissioned by Focused Vision Consulting Pty Ltd (FVC), on behalf of the Integrated Project Team (IPT) (the former Arup Jacobs Joint Venture (ASJV) with Main Roads Western Australia (Main Roads), to conduct a Level 1 fauna assessment (desktop review and site inspection) and targeted field investigations of the proposed route for the Great Northern Highway bypass of the town of Bindoon. The proposed route alignment has been adjusted since the initial studies were undertaken (Bancroft *et al.* 2017) and a re-evaluation of the impact assessment, and a synthesis of the subsequent field investigations (Bamford and Bancroft 2018; Bancroft and Bamford 2018; Bancroft *et al.* 2018) was conducted by Bancroft *et al.* (2019). Renegotiated property access in the first half of 2019 allowed for field surveys to be completed across the proposed alignment, and this report updates Bancroft *et al.* (2019) in light of these findings.

BCE uses an impact assessment process with the following components:

- The identification of **fauna values**:
 - Assemblage characteristics: uniqueness, completeness and richness;
 - Species of conservation significance;
 - Recognition of vegetation/substrate associations (VSAs) that provide habitat for fauna, particularly those that are rare, unusual and/or support significant fauna;
 - Patterns of biodiversity across the landscape; and
 - Ecological processes upon which the fauna depend.
- The review of **impacting processes** such as:
 - Habitat loss leading to population decline;
 - Habitat loss leading to population fragmentation;
 - Degradation of habitat due to weed invasion leading to population decline;
 - Ongoing mortality from operations;
 - Species interactions including feral and overabundant native species;
 - Hydrological change;
 - Altered fire regimes; and
 - Disturbance (dust, light, noise).
- The **recommendation** of actions to mitigate impacts.

The fauna investigations were based on a desktop assessment and field surveys undertaken between October 2016 and May 2019. The desktop study identified 306 vertebrate fauna species as potentially occurring in the study area (eight freshwater fish, 17 frogs, 69 reptiles, 177 birds and 35 mammals, including 11 introduced mammals). The presence of at least 77 species (one freshwater fish, five frogs, three reptiles, 52 birds and at least 14 mammals) was confirmed during the field surveys. The vertebrate assemblage includes 45 species of conservation significance.

Sampling of potential nest-trees for Forest Red-tailed Black-Cockatoo and Carnaby's Black-Cockatoo has provided potential breeding tree density estimates for these species throughout the study area. The distribution and quality of foraging habitat for these species has also been mapped. Targeted surveys also included motion-sensitive camera surveys for mammals such as Mardo, Chuditch, Brush-tailed Phascogale, Quenda, Brushtail Possum, Brush Wallaby and Rakali (Water-rat); call-playback surveys for owls (Barking Owl and, incidentally, Masked Owl); aquatic surveys for Freshwater Cobbler,

Western Mud Minnow, Nightfish and Carter's Freshwater Mussel; aural surveys for frogs (focussing on Hooting Frog, Whooping Frog and Ticking Frog); short-range endemic invertebrate collection; acoustic surveys for bats; and shield-backed trapdoor spider burrow searches.

Key fauna values are:

Fauna assemblage. Moderately intact but with a suite of mammal species and a small number of reptile and bird species locally extinct. A distinctive feature of the assemblage is that it varies north-south with declining rainfall and associated changes in vegetation, and east-west in relation to major landform changes. Thus, the assemblage includes species at the extremes of their range (both northern and southern extremities) and species associated with particular environments.

Species of conservation significance. Of the 45 species of conservation significance recorded or that may be present, those of greatest interest because they are definitely or very likely to be present, and are likely to interact with the proposal, are: Forest Red-tailed Black-Cockatoo, Carnaby's Black-Cockatoo, Chuditch, Brush-tailed Phascogale and Rakali (Water-rat).

Vegetation and Substrate Associations (VSAs). The study area passes through ten VSAs which vary north-south and east-west with rainfall and land systems. The VSAs include natural, partly degraded and almost completely degraded systems, and range from wetlands to upland forests and woodlands. Wetlands are restricted in extent but other VSAs are quite widespread regionally.

Patterns of biodiversity. Distinct patterns of biodiversity are expected due to the extent of the study area and the variety of VSAs through which it passes. Important areas include Banksia woodland on sand, southern forests on heavy soils, wetlands and areas with large Marri and/or Wandoo.

Key ecological processes. The ecological processes that currently have major effects upon the fauna assemblage include hydrology, the presence of feral species, fire, habitat degradation (due to weeds) and the partial fragmentation of the landscape due to clearing.

Processes with the potential to cause moderate or greater impact upon fauna include:

- Habitat loss leading to population fragmentation.
- Degradation of habitat due to weed invasion.
- Ongoing mortality.
- Disturbance (dust, noise, light).

Recommendations are related to impacts and include:

- Minimise the disturbance footprint within areas of native vegetation through informed route planning.
- Select a final alignment to avoid fragmenting intact native vegetation where possible.
- Avoid direct impacts upon rare features such as wetlands and large (potential nesting) trees.
- Ensure local hydrology is not affected with adequate culverts and off-road drainage management.
- Conduct black-cockatoo nest-tree surveys within the proposed disturbance footprint to minimise loss of actual or potential nest-trees.

- Conduct a survey for active black-cockatoo nests immediately prior to clearing so direct mortality can be avoided.
- Conduct a targeted fauna relocation programme for species of concern and most likely to benefit from relocation (e.g. Quenda).
- Provide a system of underpasses where fauna such as Quenda, Chuditch, Brush Wallaby and Rakali (Water-rat) might be present.
- Employ industry standards for management of dust, noise and light.
- Locate work-camps away from wetlands and native vegetation where possible.
- Rehabilitate as soon as practical and target areas where roadside rehabilitation can enhance connectivity.

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1 Introduction

1.1 Background

Main Roads Western Australia (Main Roads) plans to upgrade a 218 km section of the Great Northern Highway between Muchea and Wubin. The project includes a bypass of the town of Bindoon. Several route options for the Bindoon Bypass were proposed, and a Level 1 fauna assessment (desktop review and site inspection) of these was conducted in the latter part of 2016 by Bancroft *et al.* (2017). Subsequently, the 'Western A' route option was chosen.

Bancroft *et al.* (2018) undertook targeted (towards conservation-significant fauna species) field investigations for this route through 2017, with considerable emphasis placed on black-cockatoo habitat analysis (breeding, foraging and roosting values). Targeted surveys also included motion-sensitive camera surveys for mammals such as Mardo, Chuditch, Brush-tailed Phascogale, Quenda, Brushtail Possum, Brush Wallaby and Rakali (Water-rat); call-playback surveys for owls (Barking Owl and, incidentally, Masked Owl); aquatic surveys for Freshwater Cobbler, Western Mud Minnow, Nightfish and Carter's Freshwater Mussel; aural surveys for frogs (focussing on Hooting Frog, Whooping Frog and Ticking Frog); short-range endemic invertebrate collection; and acoustic surveys for bats.

In early 2018, at the request of the client, Bamford and Bancroft (2018) completed additional black-cockatoo habitat surveys on several properties south-west of Bindoon to provide some contextual information on the density of potential nest-trees close to the proposed bypass.

Following taxonomic revision (also in early 2018), Bancroft and Bamford (2018) conducted a review of the shield-backed trapdoor spiders of the Bindoon Bypass area and supplemented this with a site inspection and targeted burrow searches.

In mid-2018 the Bindoon Bypass route alignment was adjusted (by Main Roads) and further field surveys were required to assess the value of the amended route to black-cockatoos. Bamford Consulting Ecologists (BCE) was commissioned by Focused Vision Consulting Pty Ltd (FVC), who was in turn commissioned by the Arup Jacobs Joint Venture (ASJV), in association with Main Roads Western Australia, who together are the Integrated Project Team (IPT), to conduct the additional black-cockatoo habitat surveys of the proposed Bindoon Bypass. In addition, a re-evaluation and/or synthesis of the fauna values presented by previous studies (Bancroft *et al.* 2017; Bamford and Bancroft 2018; Bancroft and Bamford 2018; Bancroft *et al.* 2018) was requested. In early 2019, access was negotiated to a property for which tree surveys were outstanding, and this was visited in March 2019 (Bancroft *et al.* 2019). In April 2019 further revision of the proposed route was undertaken, with surveys in final 'gap' areas conducted in May 2019.

This report incorporates the findings of the most recent (March and May 2019) black-cockatoo habitat surveys, and presents the summary of the fauna assessment for the most recently proposed route (May 2019) of the Bindoon Bypass. Where applicable, information presented by the previous studies (Bancroft *et al.* 2017; Bamford and Bancroft 2018; Bancroft and Bamford 2018; Bancroft *et al.* 2018, 2019) is reiterated here.

1.2 General approach to fauna impact assessment

The purpose of impact assessment is to provide government agencies with the information they need to decide upon the significance of impacts of a proposed development. BCE uses an impact assessment process with the following components:

- The identification of **fauna values**:
 - Assemblage characteristics: uniqueness, completeness and richness;
 - Species of conservation significance;
 - Recognition of ecotypes or vegetation/substrate associations (VSAs) that provide habitat for fauna, particularly those that are rare, unusual and/or support significant fauna;
 - Patterns of biodiversity across the landscape; and
 - Ecological processes upon which the fauna depend.
- The review of **impacting processes** such as:
 - Habitat loss leading to population decline;
 - Habitat loss leading to population fragmentation;
 - Degradation of habitat due to weed invasion leading to population decline;
 - Ongoing mortality from operations;
 - Species interactions including feral and overabundant native species;
 - Hydrological change;
 - Altered fire regimes; and
 - Disturbance (dust, light, noise).
- The **recommendation** of actions to mitigate impacts.

Descriptions and background information on these values and processes can be found in Appendices 1 to 4. Based on this impact assessment process, the objectives of investigations are to: identify fauna values; review impacting processes with respect to these values and the proposed development; and provide recommendations to mitigate these impacts.

1.3 Description of survey area

1.3.1 General location

The survey area is in the general vicinity of Bindoon, north-east of Perth (Figure 1). It is bounded by the Chittering Roadhouse (on Great Northern Highway) in the south, to (approximately) Wannamal in the north-west and extends to just north of the Calingiri Road-Great Northern Highway intersection in the north-east. It is a region of mixed agriculture, farmland, hobby farms, low-density residential and conservation. Most of the environment is terrestrial with small seasonal swamps and streams. The general environment of the area was described in detail by Bancroft *et al.* (2017).

Bancroft *et al.* (2017) provided a regional description of the Bindoon Bypass area and noted that the bypass runs along the border of two IBRA Bioregions, the Jarrah Forest (JAF) and Swan Coastal Plain (SWA). Both of these bioregions are divided into subregions, with the project area passing through the Northern Jarrah Forest Subregion (JAF1) and the Dandaragan Plateau Subregion (SWA1). See Bancroft *et al.* (2017) for more information (and maps) if required.

1.3.2 *Definition of survey boundary: the 'study area'*

A number of route boundaries (and terminologies) have been used by the previous reports (Bamford 1986; Bancroft *et al.* 2017; Bamford and Bancroft 2018; Bancroft and Bamford 2018; Bancroft *et al.* 2018, 2019) and these reflected various adjustments in the route alignment (and survey scope) over time. Recent (May 2019) route refinement (to the 'development envelope') has altered the focal area of the previous report (the 'referral area', Bancroft *et al.* 2019) and, for the purposes of this revised report (at June 2019), the combined footprint of these is simplified to a single focal area, the '**study area**' (c. 3430 ha), as shown in Figure 1.

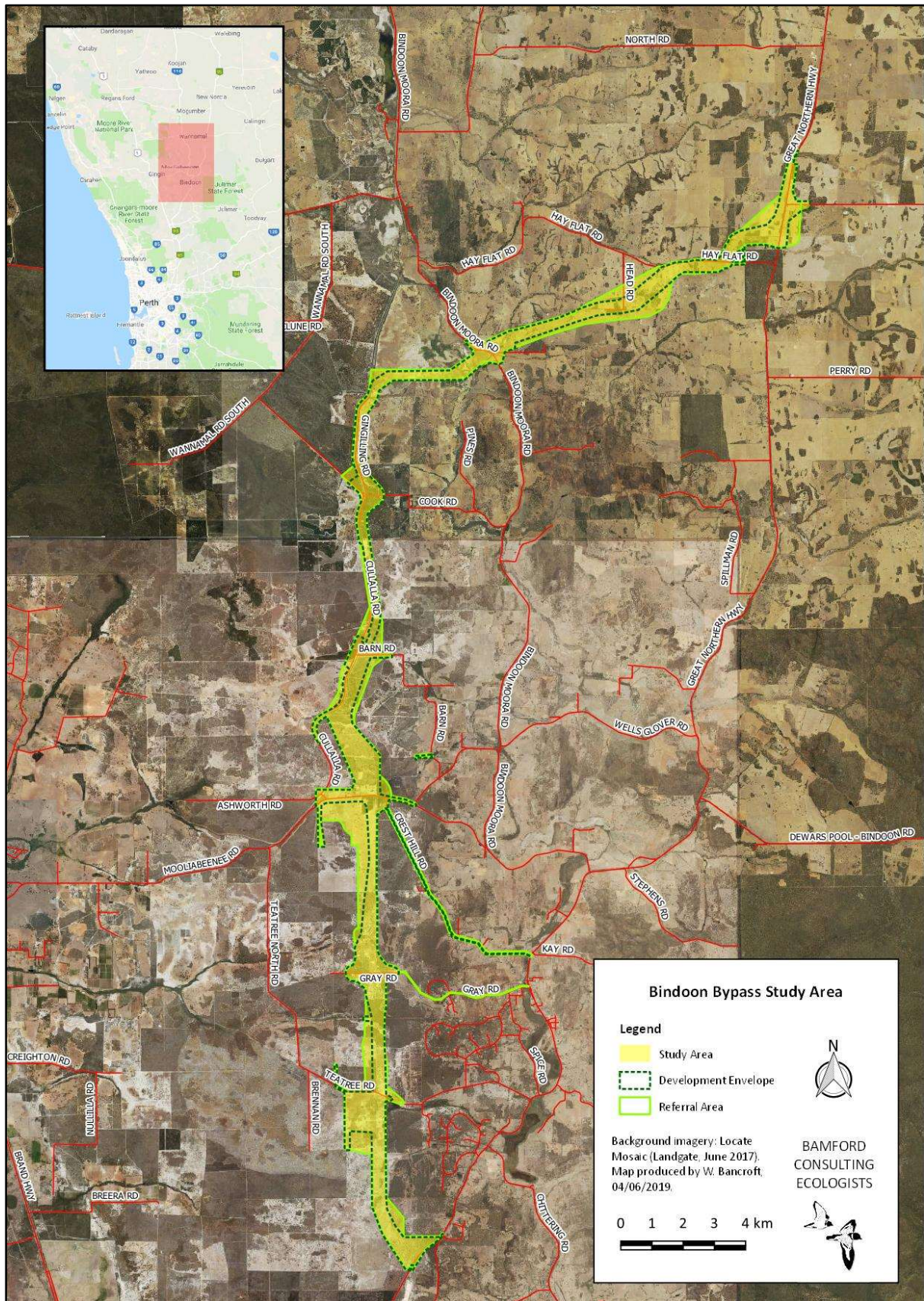


Figure 1. The Bindoon Bypass study area (at 4th June 2019).

2 Methods

The approach and sources of information used for the Level 1 assessment by Bancroft *et al.* (2017) are still considered current; and the subsequent alterations in the proposed Bindoon Bypass route alignment have not affected the interpretation. Therefore, the methodology of Bancroft *et al.* (2017) is reiterated here.

The field investigations of Bancroft *et al.* (2017, 2018, 2019), Bamford and Bancroft (2018) and Bancroft and Bamford (2018) have been synthesised in this report (see Section 3) and, as such, so too have their methods, below.

2.1 Overview

The methods used for the fauna assessment of the study area are based upon the general approach to fauna investigations for impact assessment as outlined in Section 1.2 and with reference to Appendices 1 to 4. Thus, the impact assessment process involves the identification of fauna values, review of impacting processes and preparation of mitigation recommendations.

This approach to fauna impact assessment has been developed with reference to guidelines and recommendations set out by the Western Australian Environmental Protection Authority (EPA) on fauna surveys and environmental protection, and Commonwealth biodiversity legislation (EPA 2002; EPA 2004). The EPA recommends two levels of investigation that differ in their approach for field investigations; Level 1 being a review of data and a site reconnaissance to place data into the perspective of the site, and Level 2 being a literature review and intensive field investigations (e.g. trapping and other intensive sampling). In reality, however, multiple levels of investigation exist.

The level of assessment recommended by the EPA is determined by the type, size and location of the proposed disturbance, the sensitivity of the surrounding environment in which the disturbance is planned, and the availability of pre-existing data. The consultant's familiarity with the study region is also a factor in determining the level of assessment. BCE has developed a 'Values and Impacts Approach' to determine the appropriate level of assessment, and this targets investigations to identify fauna values: the fauna assemblage, significant species, vegetation and substrate associations that provide habitat, patterns of biodiversity and ecological processes that sustain the fauna. In this case, the vertebrate fauna assemblage of the region is very well documented, including within literature from previous studies by BCE. The potential impacts of linear infrastructure upon fauna also differ from impacts from other types of clearing or development, with the footprint small and narrow in any one area, but elongated and having unique potential effects. In consideration of the above, the approach taken was a Level 1 but with additional targeted investigations focussed on significant species and environments (a Level "1.5").

The approach and methods utilised is divided into three groupings that relate to the stages and the objectives of impact assessment:

- **Desktop assessment.** The purpose of the desktop review is to produce a species list that can be considered to represent the vertebrate fauna assemblage of the study area based on unpublished and published data using a precautionary approach.

- **Field investigations.** The purpose of the field investigations is to gather information on the fauna assemblage: confirm the presence of as many species as possible (with an emphasis on species of conservation significance), place the list generated by the desktop review into the context of the environment of the study area, collect information on the distribution and abundance of this assemblage, and develop an understanding of the study area's ecological processes that maintain the fauna. Note that field investigations cannot confirm the presence of an entire assemblage, or confirm the absence of a species. This requires far more work than is possible for studies contributing to the EIA process. For example, in an intensive trapping study, How and Dell (1990) recorded in any one year only about 70% of the vertebrate species found over three years. In a study spanning over two decades, Bamford *et al.* (2010) has found that the vertebrate assemblage varies over time and space, meaning that even complete sampling at a set of sites only defines the assemblage of those sites at the time of sampling.
- **Impact assessment.** Determine how the fauna assemblage may be affected by the proposed development based on the interaction of the project with a suite of ecological and threatening processes.

2.2 Desktop assessment

2.2.1 Sources of information

Information on the fauna assemblage of the study area was drawn from a range of sources including databases, as listed in Table 1, and reports from other fauna surveys in the region, as listed in Table 2. Information from these sources was supplemented with species expected in the area based on general patterns of distribution.

Table 1. Databases searched for the desktop review; accessed October 2016.

Database	Type of records held in database	Area searched
BCE Database	Fauna recorded by BCE in vicinity of Bindoon.	Proposed routes plus c. 20 km buffer.
Atlas of Living Australia (ALA)	Fauna records from Australian museums and conservation/research bodies, including records from BirdLife Australia's Atlas Database.	Proposed routes plus c. 20 km buffer.
NatureMap (DBCA)	Records from the Western Australian Museum (WAM) and Department of Biodiversity, Conservation and Attractions (DBCA) databases, including historical data and Threatened and Priority species in WA.	Area bounded by 115° 53' 16" E, 116° 19' 56" E, 31° 35' 40" S, 31° 01' 40" S.

Database	Type of records held in database	Area searched
DBCA's Threatened and Priority Fauna Database	Records of threatened and priority fauna within Western Australia.	Proposed routes plus 20 km buffer.
EPBC Protected Matters Search Tool	Records on MNES protected under the EPBC Act.	Area bounded by 115° 53' 16" E, 116° 19' 56" E, 31° 35' 40" S, 31° 01' 40" S.

Table 2. Literature sources for the desktop review.

Author	Title
Burbidge <i>et al.</i> (1996)	A biological survey of Boonanarring nature reserve.
Owen <i>et al.</i> (2011)	Main Roads WA. Report for Great Northern Highway Upgrade: Muechea to Bindoon. Flora and Fauna Assessment.
Phoenix Environmental Sciences (2015)	Flora and fauna assessment for Muechea North and Chittering study area: Great Northern Highway, Muechea to Wubin Upgrade Stage 2 Project.

2.2.2 Previous fauna surveys in the region by BCE

There has been a number of previous comprehensive fauna investigations undertaken in the region by BCE personnel. Bamford (1986) undertook a three year, monthly fauna sampling programme on private property that is included in the study area, while Bamford *et al.* (2014) conducted a Level 2 investigation on private property and in Julimar. Bamford and Chuk (2013) conducted a fauna assessment targeting black-cockatoo nesting along road verges of the Great Northern Highway from Batty Bog Road to Walebing.

2.2.3 Nomenclature and taxonomy

As per the recommendations of the EPA (2004), 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 2018. The authorities used for each vertebrate group were: fish (Morgan *et al.* 2014), frogs (Doughty *et al.* 2018a), reptiles (Doughty *et al.* 2018b), birds (BirdLife Australia 2017), and mammals (Travouillon 2018). 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). 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.

2.2.4 Interpretation of species lists

Species lists generated from the review of sources of information are generous as they include records drawn from a large region and possibly from environments not represented in the study area. Therefore, some species that were returned by one or more of the database and literature searches have been excluded because their ecology, or the environment within the study area, determine that it is highly unlikely that these species will be present. Such species can include, for example, seabirds that might occur as extremely rare vagrants at a terrestrial, inland site, but for which the site is of no importance.

Species returned from the databases and not excluded on the basis of ecology or environment are therefore considered potentially present or expected to be present in the study area at least occasionally, whether or not they were recorded during field surveys, and whether or not the study area is likely to be important for them. This list of expected species is therefore subject to interpretation by assigning each a predicted status in the study area. The status categories used are:

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

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

2.3 Field investigations

2.3.1 Overview

The field assessments have incorporated a range of survey techniques so as to maximise sampling results but have also included methods targeted to specific species, or groups of species (Bancroft and Bamford 2018; Bancroft *et al.* 2018). Techniques utilised included:

- Identification of VSAs (Vegetation and Substrate Associations; that provide fauna habitats);

- Broad-scale targeted searches for significant fauna and an assessment of their likelihood of occurrence based on VSAs present (as part of the initial fauna assessment by Bancroft *et al.* 2017);
- Black-cockatoo habitat analysis (breeding, foraging and roosting values) for Forest Red-tailed and Carnaby's Black-Cockatoos;
- General use of motion-sensitive cameras (as part of the initial fauna assessment by Bancroft *et al.* 2017);
- Targeted motion-sensitive camera surveys for mammals: Mardo, Chuditch, Brush-tailed Phascogale, Quenda, Brushtail Possum, Brush Wallaby and Rakali (Water-rat);
- Call-playback surveys for owls: Barking Owl and, incidentally, Masked Owl (southwestern);
- Aquatic surveys for Freshwater Cobbler, Western Mud Minnow, Nightfish and Carter's Freshwater Mussel;
- Aural surveys for frogs: Hooting Frog, Whooping Frog and Ticking Frog;
- Short-range endemic invertebrate collection;
- Acoustic surveys for bats;
- Site inspection/habitat evaluation and targeted burrow searches for shield-backed trapdoor spiders; and
- Opportunistic fauna observations.

2.3.1.1 Dates of surveys

A summary of the dates of each component of the Bindoon Bypass field investigations is provided in Table 3.

Table 3. Surveys dates for each field component.

Field Component	Survey Dates
Site inspection, VSA assessment, broad-scale targeted searches for significant fauna.	6, 7, 12 & 18 October 2016; 13 December 2016.
Black-cockatoo habitat analysis	6, 7, 12 & 18 October 2016; 13 December 2016; 9 April 2017; 7, 17 & 31 May 2017; 31 July 2017; 1 to 4 August 2017; 4 to 8 September 2017; 9 to 13 & 17 October 2017; 12 November 2017; 20 & 21 February 2018; 11 & 12 September 2018; 22 & 23 November 2018; 27 March 2019; 17 May 2019.
Motion-sensitive camera surveys	7 October 2016 to 15 November 2016;

	7 July 2017 to 4 August 2017; 4 to 8 September 2017.
Call-playback surveys for owls	31 May 2017.
Aquatic surveys	7 July 2017; 3, 9 & 13 October 2017.
Aural surveys for frogs	31 May 2017.
Short-range endemic invertebrate collection	31 July 2017; 1 to 4 August 2017; 4 to 8 September 2017; 2 August 2018.
Shield-backed trapdoor spiders surveys	2 August 2018.
Opportunistic fauna observations	All surveys.

2.3.1.2 Personnel

The following personnel were involved in the field surveys:

- Mike Bamford *BSc (Biology), Hons (Biology), PhD (Biology)*;
- Mandy Bamford *BSc (Zoology), Hons (Zoology)*;
- Wes Bancroft *BSc (Zoology/Microbiology), Hons (Zoology), PhD (Zoology)*;
- Andrew Moore *BSc (Botany/Geography), BAPSc (Environmental Studies), MSc (Renewable Energy)*;
- Brenden Metcalf *BSc (Environmental Science), Hons (Biology)*;
- Peter Smith *AssDipAg*;
- Sarah Smith *BSc (Biology)*;
- Rob Browne-Cooper *BSc (Environmental Management)*;
- Simon Cherriman *BSc (Environmental Biology), Hons (Environmental Biology), MSciComm (Natural History Film)*;
- Katherine Chuk *BSc (Zoology), Hons (Zoology)*;
- Tim Gamblin *BSc (Zoology), CertEnvMngmt*;
- Barry Shepherd *BSc (Environmental Biology), Hons (Environmental Biology), PhD (Ecology)*;
- Pang Yong Kai *MSc (Zoology)*;
- Elspeth Meikle *BSc (Environmental Biology)*;
- Eliza-Joyce Mellersh *BSc (Wildlife Management)*.

Data analysis, GIS management and report preparation were by Mike Bamford, Wes Bancroft and Andrew Moore.

2.3.1.3 Licences and permits

The field surveys were conducted under Department of Parks and Wildlife (DPaW) Regulation 17 licence SF0010773 and Department of Biodiversity, Conservation and Attractions (DBCA) Regulation 17 licence SF010998.

2.3.2 Identification of vegetation and substrate associations

Vegetation and substrate associations (VSAs) combine vegetation types (provided by FVC 2017), 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. All major VSAs present within the study area were identified and sampled for fauna. Those deemed suitable to support conservation significant fauna were subject to further intensive targeted searching.

2.3.3 Targeted searching for conservation significant species

Significant species identified during the desktop assessment included several that can be found by searching for evidence of their activities (e.g. scats, tracks, diggings, burrows, nests) or listening for their call. Searching for evidence of significant fauna was therefore undertaken by walking through habitat considered suitable for such species. Species of particular interest (and the search targets) included:

- Black-cockatoos (chewed eucalypt fruits, nest hollows, scat deposits at roost sites)
- Chuditch (scats)
- Quenda (diggings and scats)
- Water-rat (foraging middens).

2.3.4 Black-cockatoo habitat analysis

2.3.4.1 Guidelines

The Commonwealth Department of the Environment and Energy (DEE; formerly the Department of Sustainability, Environment, Water, Population and Communities) provides guidelines for the study of actions that may result in impact to black-cockatoos to the DEE (for assessment under the EPBC Act). The survey and analysis reported here have been conducted with strong reference to both the existing guidelines (DSEWPaC 2012) as well as the recently revised draft guidelines (DEE 2017). In addition, survey methodology followed the recommendations listed on the DEE's Species Profile and Threats Database (DotE 2018a, c).

2.3.4.2 Breeding

The aim of the breeding surveys was to record all potential hollow-bearing trees (suitable for black-cockatoo nesting) within the proposed envelope of the Bindoon Bypass. This envelope has evolved through time (see Bancroft *et al.* 2018 for details) but the focus here is simplified to the *study area*, as shown in Figure 1. Access limitations meant that some parts of the study area could not be directly surveyed. Where possible, these areas were inspected from adjacent areas and potential nest-tree locations subsequently estimated from satellite imagery. A few locations were excluded from the survey on the advice of the client (Jacobs). Maps showing the surveyed areas are presented in Figure 2 (northern study area) and Figure 3 (southern study area). Potential nest-tree surveys have been completed in 3324 ha (97%) of the study area, with the remaining 106 ha (3%) excluded. In addition, 881 ha outside of the current study area have been mapped for potential nest-trees (see Figure 2 and Figure 3).

The following information was recorded for every suitable tree¹ (predominantly Jarrah, *Eucalyptus marginata*; Wandoo, *E. wandoo*; Marri, *Corymbia calophylla*) with a diameter at breast height (DBH) equal to or greater than 500 mm (or 300 mm for 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 4.

BCE has also developed a tree measurement protocol, based on Federal guidelines, and this is outlined in Appendix 5.

Table 4. Ranking system for the assessment of potential nest-trees for black-cockatoos.

As per DEE (2018a, c) guidance, a potential nest-tree is any tree with a diameter at breast height >500 mm (or >300 mm for *Eucalyptus salmonophloia* and *E. wandoo*).

Rank	Description of tree and hollows/activity
1	Active nest observed; adult (or immature) bird seen entering or emerging from hollow.
2	Hollow of suitable size and angle (i.e. near-vertical) visible with chew marks around entrance.
3	Potentially suitable hollow visible but no chew marks present; or potentially suitable hollow present (as suggested by structure of tree, such as large, vertical trunk broken off at a height of >10m).
4	Tree with large hollows or broken branches that might contain large hollows but hollows or potential hollows 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.
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.
x	Where a hollow that is (otherwise) potentially suitable for black-cockatoo nesting has been colonised by feral Honey Bees (<i>Apis mellifera</i>), and therefore rendered unusable, the nest-tree rank is preceded by 'x' (e.g. x2, x3, x4).

¹ the draft revised EPBC Act study guidelines (DEE 2017) stress that any tree species may provide suitable hollows.

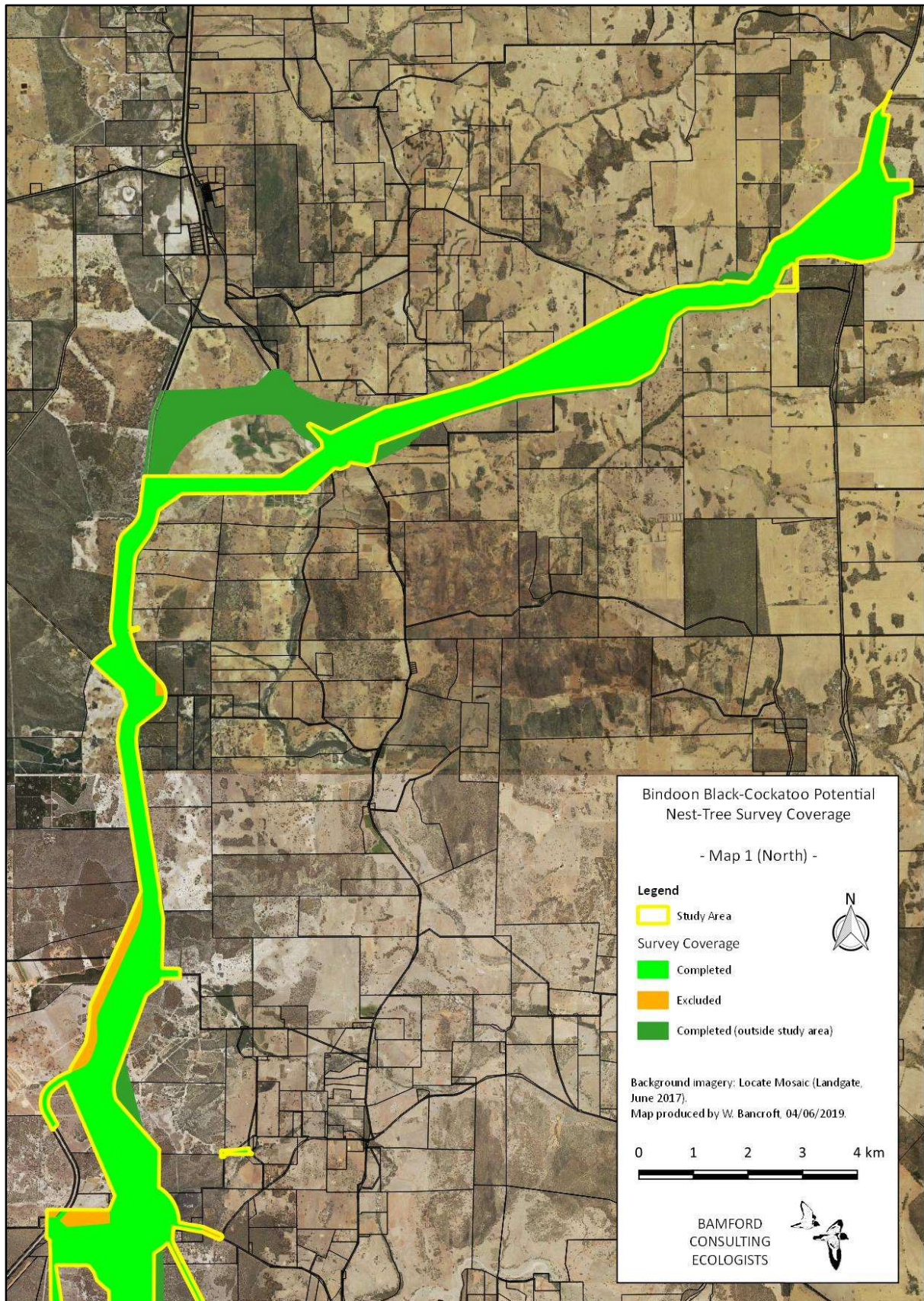


Figure 2. Map of black-cockatoo potential nest-tree survey coverage (northern study area).

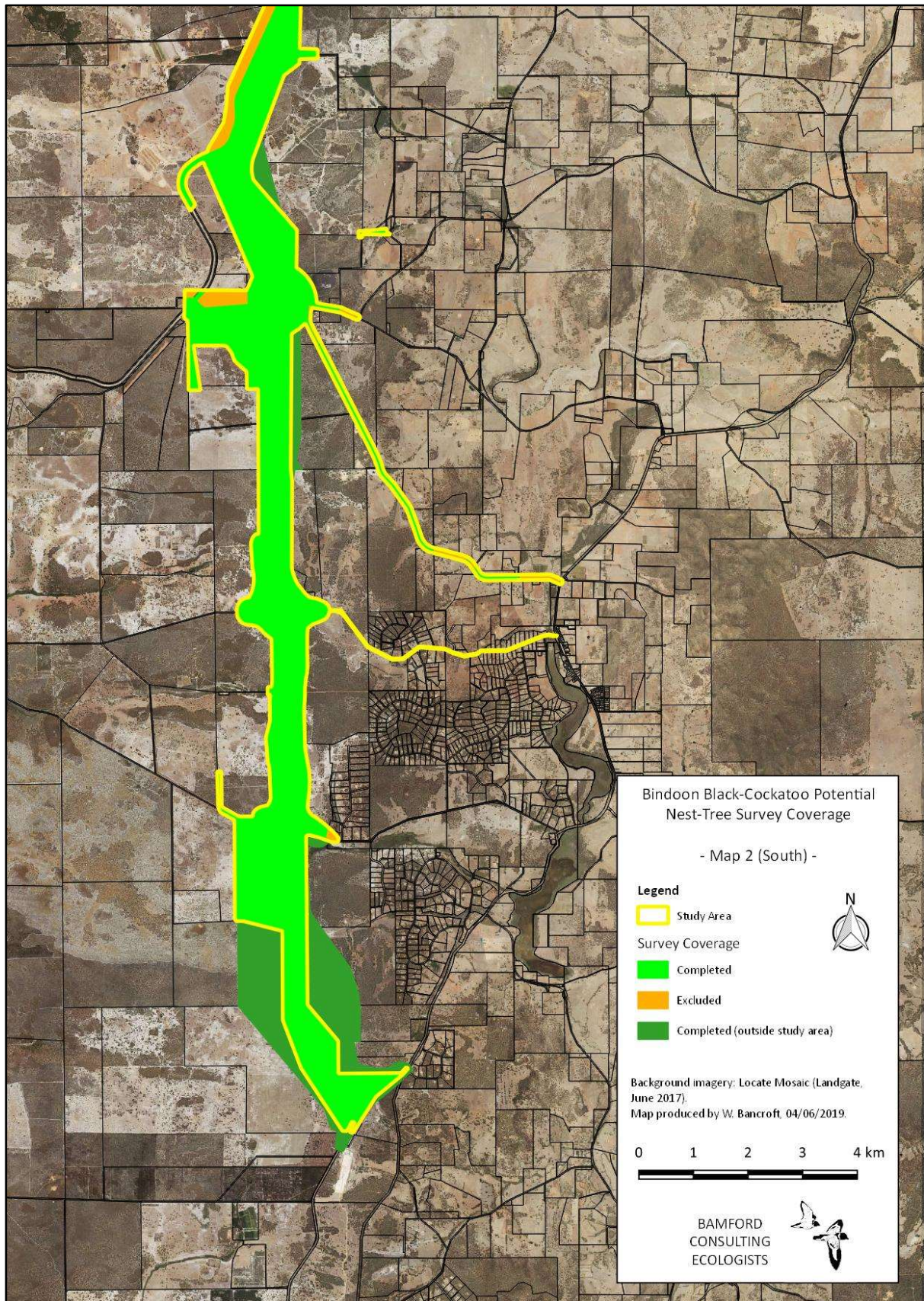


Figure 3. Map of black-cockatoo potential nest-tree survey coverage (southern study area).

2.3.4.3 Foraging

The foraging value of the study area was assessed by calculating a foraging score for areas of similar vegetation type/condition (see Appendix 6). 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 the Federal DEE 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 6. These three components are drawn from the DEE 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. In this report, a score out of six is used so that vegetation characteristics and value can be compared across the project area. A score out of 10 is presented for the purposes of aiding offset calculations. The score out of 10 is calculated only for vegetation of at least Low to Moderate foraging value (vegetation characteristics score of >3). Vegetation with No, Negligible or Low foraging value is effectively assigned context and species density scores of '0' as context and species density are of little relevance if the vegetation does not support foraging by the birds. Foraging value scores are calculated differently for the three black-cockatoo species (Appendix 6) depending upon the vegetation present.

Black-cockatoo foraging signs were also recorded in conjunction with the breeding tree surveys (see Section 2.3.4.2). 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 7 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).

2.3.4.4 Roosting

As the breeding and foraging surveys were conducted, areas likely to be used as roosting sites (e.g. sites adjacent to watercourses with large trees) or areas that had cockatoo activity in the late-afternoon were noted. These were revisited in the 30 minutes before and after sunset to watch for cockatoos moving towards their roost sites, as recommended by DEE (DotE 2018a, c). Several other locations were added to the roost surveys to ensure an even spread of sites in and around the study area. Roost survey sites and survey dates are shown in Table 5.

The Great Cocky Count (GCC) database of roost sites was also searched for relevant local records.

Table 5. Roost survey sites and survey dates.

Datum: GDA94. UTM Zone: 50J.

Site Name	Easting	Northing	6/10/2016	9/04/2017	17/05/2017	31/05/2017
Chittering Roadhouse	410140	6518531				+
Cockatoo Road 02	410720	6523329			+	+
Teatree Road Wetland	409665	6523964	+	+	+	+
Gray Road 02	409290	6528116		+		+
Mooliabeenee Road	409040	6533791		+		+
Barn Road	408558	6538295				+
Cook Road 01	408801	6543420				+
Wannamal Road West	407583	6552729				+
Head Road 02	416617	6549388		+		+
Hay Flat Road 02	420007	6550916				+
Udumung Nature Reserve 02	421687	6550439				+
Calingiri West Road	422125	6552405				+

2.3.5 Motion-sensitive cameras

Baited motion-sensitive cameras (Reconyx) were used to target species of conservation significance. Motion-sensitive camera surveys were conducted in two phases: an initial phase as part of the desktop analysis and site inspection, and a more detailed (and targeted) field investigation phase. Dates and locations of cameras used in these surveys are provided in sections 2.3.5.1 and 2.3.5.2 below.

Cameras were generally positioned on a southerly-facing angled branch or trunk (to avoid direct sun exposure into the camera lens), facing the ground, and, where appropriate, directed towards fallen logs or rock piles (potential den or exploratory sites for Chuditch). Camera locations were baited with a tethered PVC bait tube containing universal bait (a mixture of sardines, rolled oats and peanut paste) in order to attract animals.

2.3.5.1 Initial surveys

For the initial survey phases, four cameras were deployed on the 7th October 2016 and retrieved on the 15th November 2016 (c. 39 camera trap-nights per camera; a total of 156 camera trap-nights) at the locations listed in Table 6 (Camera_i01 to Camera_i04) and mapped in Figure 4. A brief habitat description of each location is also provided in Table 6.

2.3.5.2 Targeted surveys

Motion-sensitive camera surveys for most target mammals were conducted in winter 2017; timed to coincide with the breeding period of, in particular, Chuditch and Brush-tailed Phascogale (DSEWPac 2011). This is the period in which these animals are likely to be most mobile and precedes the post-breeding male die-off (DSEWPac 2011). Cameras were deployed on the 7th July 2017, and retrieved between the 31st July 2017 and the 4th August 2017.

Nineteen cameras were placed in, and adjacent to, the study area, in areas that represented the most likely habitats of the target species (denser areas of eucalypt forest; riparian vegetation; creeklines), as listed in Table 6 (Camera01 to Camera19) and mapped in Figure 4. At c. 26 camera trap-nights per camera this equated to a total of 494 camera trap-nights.

A second round of motion-sensitive camera surveys was conducted in spring 2017 to specifically target the Rakali (Water-rat). Cameras were deployed on the 4th September 2017 and retrieved on the 8th September 2017. Eleven cameras (Camera20 to Camera30) were placed along drainage lines in and around the study area as listed in Table 6 and mapped in Figure 4. At 4 camera trap-nights per camera this equated to a total of 44 camera trap-nights.

Table 6. Motion-sensitive camera survey sites.

Datum: GDA94. UTM Zone: 50J.

Camera	Easting	Northing	Notes
Camera_i01	409273	6533823	Paperbark at edge of Lake Nangar.
Camera_i02	409305	6533814	Paperbark at edge of Lake Nangar.
Camera_i03	409641	6523936	Edge of wetland on Teatree Road.
Camera_i04	409647	6523948	Edge of wetland on Teatree Road.
Camera01	421153	6550822	Wandoo Woodland.
Camera02	421098	6550835	Rock pile in Wandoo Woodland.
Camera03	418737	6550920	Paperbarks in drainage line.

Camera	Easting	Northing	Notes
Camera04	408991	6543514	Marri Woodland.
Camera05	408612	6542248	Banksia-Marri Woodland.
Camera06	409445	6533941	Paperbark at edge of Lake Nangar.
Camera07	409014	6531788	Log in Jarrah Woodland.
Camera08	409061	6530978	In Jarrah-Marri-Banksia Woodland.
Camera09	408393	6528200	Jarrah Woodland.
Camera10	409117	6528253	Looking into a hollowed-out Jarrah in Jarrah Woodland.
Camera11	409286	6527650	Open Jarrah Woodland.
Camera12	409089	6527184	Under a banksia tree in Banksia Woodland.
Camera13	409019	6524377	Jarrah Woodland at Edge of Banksia Woodland.
Camera14	409683	6523915	Paperbark and rushes/reeds at edge of wetland.
Camera15	409696	6523914	Flooded Gum and <i>Hypocalymma</i> at edge of wetland.
Camera16	409359	6522420	Jarrah Woodland - Banksia Woodland transition.
Camera17	409742	6521954	Very open Jarrah Woodland.
Camera18	409614	6521484	On Jarrah in open Jarrah Woodland.
Camera19	410691	6519675	Rock pile in paddock with Wandoo/Marri/Jarrah.
Camera20	410068	6521134	South of Corella Road.
Camera21	410093	6521154	South of Corella Road.
Camera22	420418	6550893	Hay Flat Road drainage line.
Camera23	420248	6550923	Hay Flat Road drainage line.
Camera24	420982	6550938	Udumung Nature Reserve drainage line.
Camera25	420267	6550940	Hay Flat Road drainage line.
Camera26	419094	6550973	Hay Flat Road drainage line.
Camera27	419984	6550985	Hay Flat Road drainage line.
Camera28	421222	6550989	Udumung Nature Reserve drainage line.
Camera29	419527	6551006	Hay Flat Road drainage line.
Camera30	419899	6551012	Hay Flat Road drainage line.

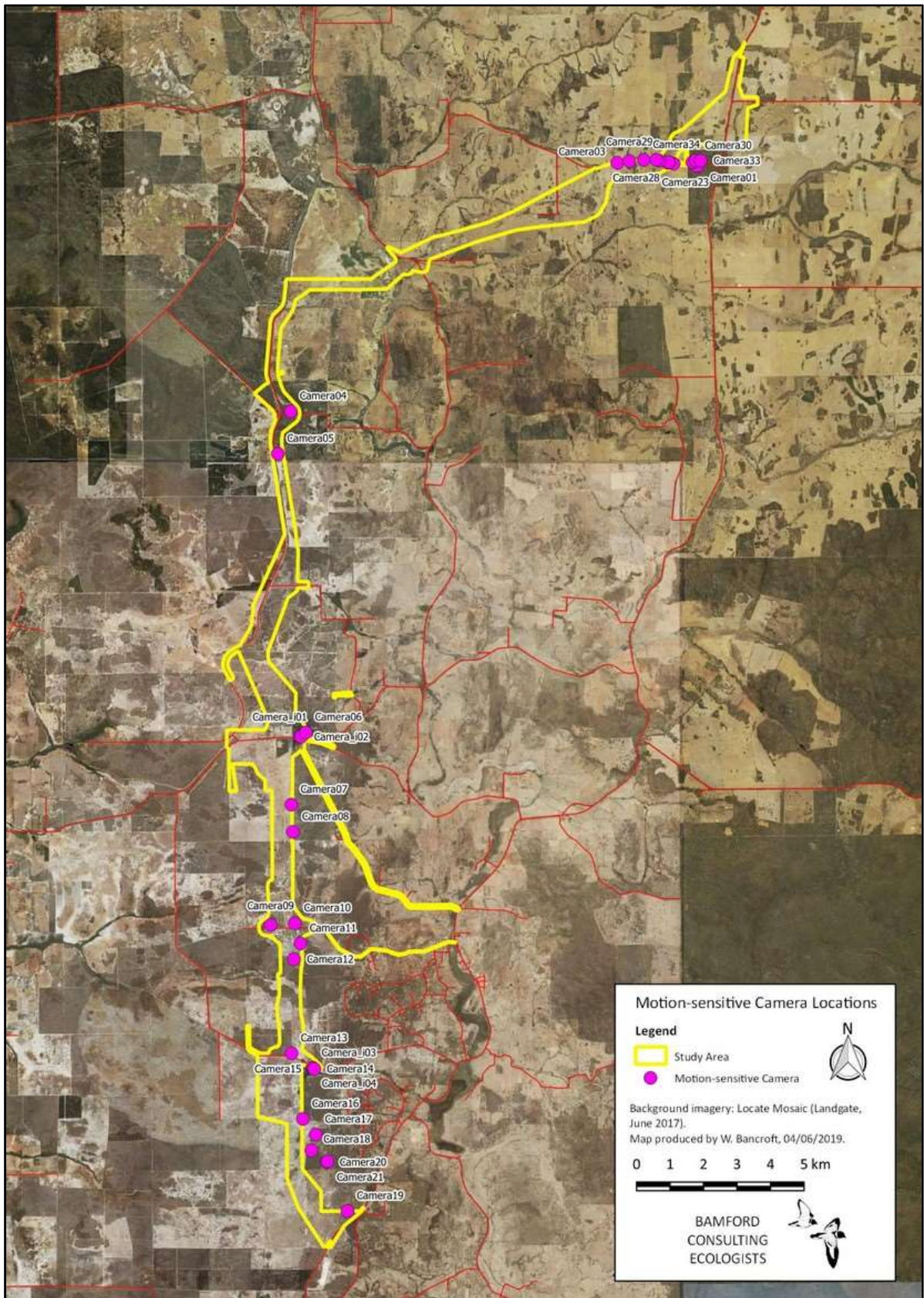


Figure 4. Location of the motion-camera survey sites.

2.3.6 Call-playback surveys for owls

The call-playback surveys for owls were conducted on the 31st May 2017; timed to coincide with the autumn period in which the two target species (see Section **Error! Reference source not found.**) are most likely to respond to playback (Liddlelow *et al.* 2002; Parker *et al.* 2007; Fulton 2017).

Fourteen sites were selected in, and adjacent to, the study area to represent the most likely habitats of the target species (denser areas of eucalypt forest), as listed in Table 7 and mapped in Figure 5. Survey protocol was based on that established by authors such as Liddlelow *et al.* (2002), Parker *et al.* (2007) and Fulton (2017). At each site, 5-15 minutes was spent listening for owl calls prior to playback. Pre-recorded calls (from the Bird Observers Club of Australia) of Barking Owl and Masked Owl were intermittently broadcast at loud volume for approximately five minutes, listening for a response in the breaks. Thereafter, surrounding perch points (e.g. trees, fencelines) were scanned with a spotlight to look for owls. As per Debus (1995) and Fulton (2017), calls were played back in the order of smallest (Barking Owl) to largest owl (Masked Owl) to avoid frightening off smaller owls with calls from the larger owls.

Table 7. Owl call-playback survey sites.

Datum: GDA94. UTM Zone: 50J.

Site Name	Easting	Northing
Maddern Road	411067	6519562
Teatree Road Wetland	409665	6523964
Gray Road 01	408523	6528121
Mooliabeenee Road	409040	6533791
Cullalla Road	408598	6543419
Kangaroo Gully Road 01	412878	6548002
Kangaroo Gully Road 02	414440	6548008
Head Road 02	416617	6549388
Wannamal South Road	407558	6550098
Hay Flat Road 01	410411	6550958
Hay Flat Road 02	420007	6550916
Hay Flat Road 03	420694	6550865
Udumung Nature Reserve 01	421084	6550951
Calingiri West Road	422125	6552405

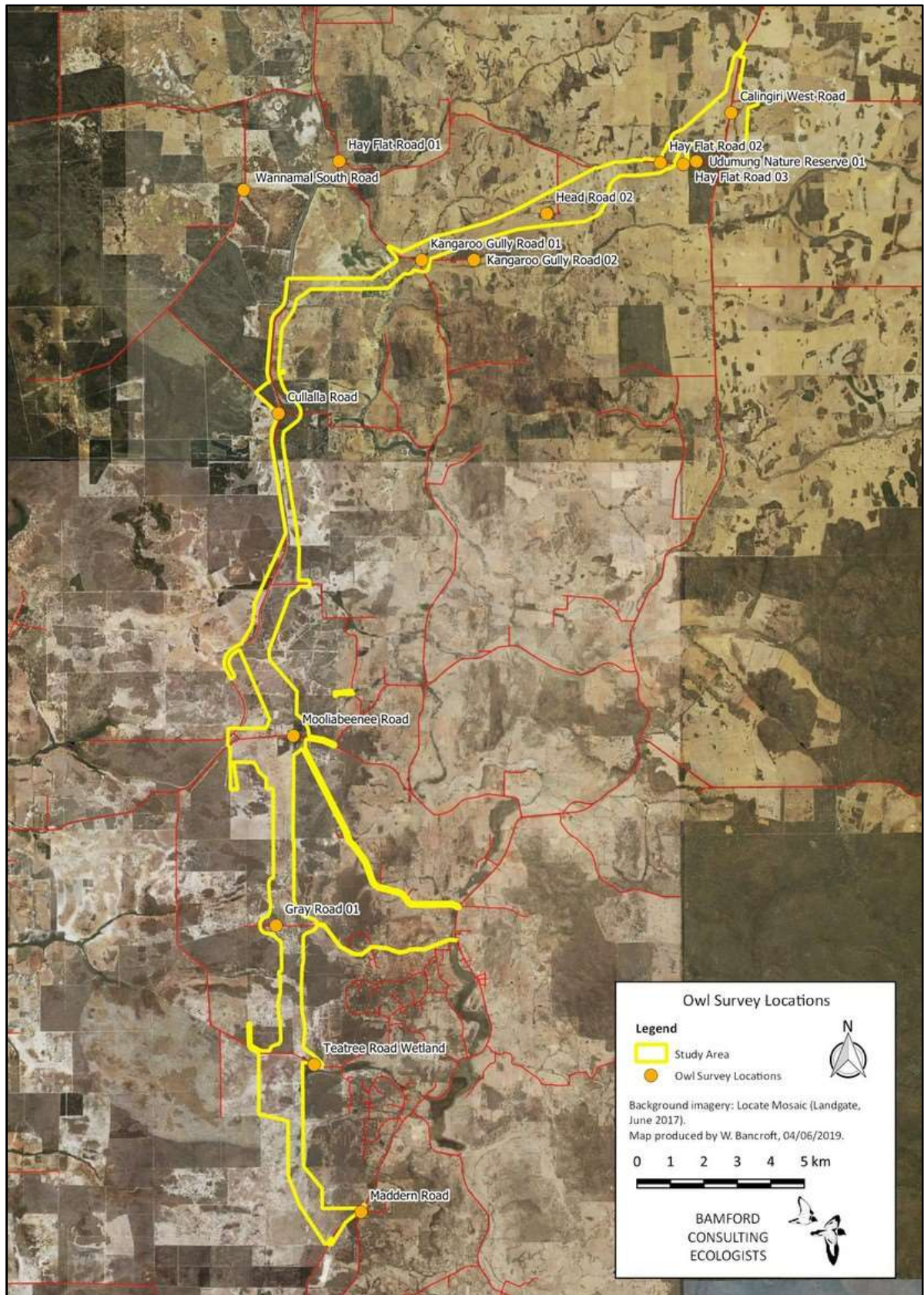


Figure 5. Location of owl call-playback survey sites.

2.3.7 *Aquatic surveys*

The aquatic surveys focused on the main wetland areas in the vicinity of the study area, as shown in Figure 6 (these wetland areas are indicative only). Surveys were by observation, as most native freshwater fish are conspicuous (except Freshwater Cobbler and Nightfish which are cryptic and tend to be most active at night), and Carter's Freshwater Mussel can be found either through dead shells, distinctive trails in soft sediment or live animals. Observational surveys were conducted at the Teatree Road wetland (7th July and 3rd October 2017) and Hay Flat drainage line (9th (observations, netting and trapping) and 13th October 2017).

Netting and deployment of a fish trap (baited, funnel-entrance trap) were carried out at the Teatree Road wetland (3rd October 2017, see Figure 6) to target the Freshwater Cobbler and Nightfish, and to target other freshwater fish as the deeply gilvin-stained water at this site limited visibility.

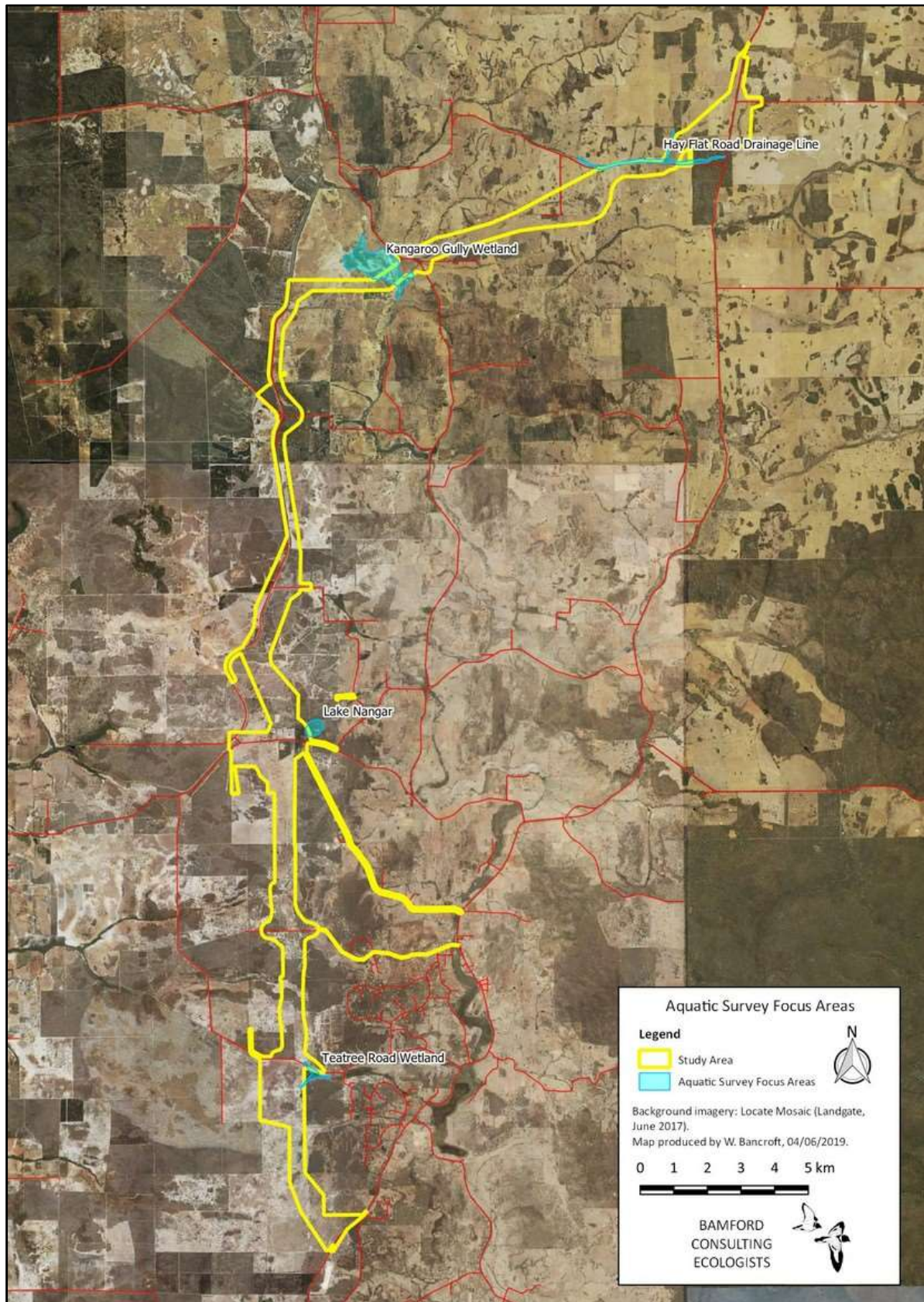


Figure 6. Location of the focus areas for the aquatic surveys.

2.3.8 Aural surveys for frogs

Aural surveys for frogs were conducted on the 31st May 2017; timed to coincide with the late autumn period in which the main target species (Hooting Frog, Whooping Frog and Ticking Frog, as noted by Bancroft *et al.* 2017) breed (and, hence, call) concurrently. It also falls within the period in which the majority of other frog species in the region can be detected aurally.

Twenty-three sites were selected in, and adjacent to, the study area to represent the favoured breeding habitats of the target species (flowing creeks and low-lying, seasonally inundated areas, in particular), as listed in Table 8 and mapped in Figure 7. Sites were visited after sunset for long enough to identify all calling species within earshot, and to determine whether the target species were present (usually c. 5-15 minutes).

Table 8. Frog aural survey sites.

Datum: GDA94. UTM Zone: 50J.

Site Name	Easting	Northing
Cockatoo Road 01	410716	6522549
Cockatoo Road 03	410500	6523761
Teatree Road Wetland	409665	6523964
Lake Needoonga Central	413900	6525507
Lake Needoonga North	413779	6527661
Gray Road 03	409754	6528109
Lake Nangar	409444	6533882
Cook Road 02	411242	6542999
Cook Road 03	412863	6542427
Cullalla Road	408598	6543419
Gingilling Road	408404	6544424
Kangaroo Gully Road 01	412878	6548002
Kangaroo Gully Road 02	414440	6548008
Bindoon-Moora Road	411498	6548742
Head Road 01	416382	6549381
Wannamal South Road	407558	6550098
Hay Flat Road 01	410411	6550958
Hay Flat Road 02	420007	6550916
Hay Flat Road 03	420694	6550865
Udumung Nature Reserve 01	421084	6550951
Wannamal West Road 01	407583	6552729
Wannamal West Road 02	408899	6553041
Calingiri West Road	422125	6552405

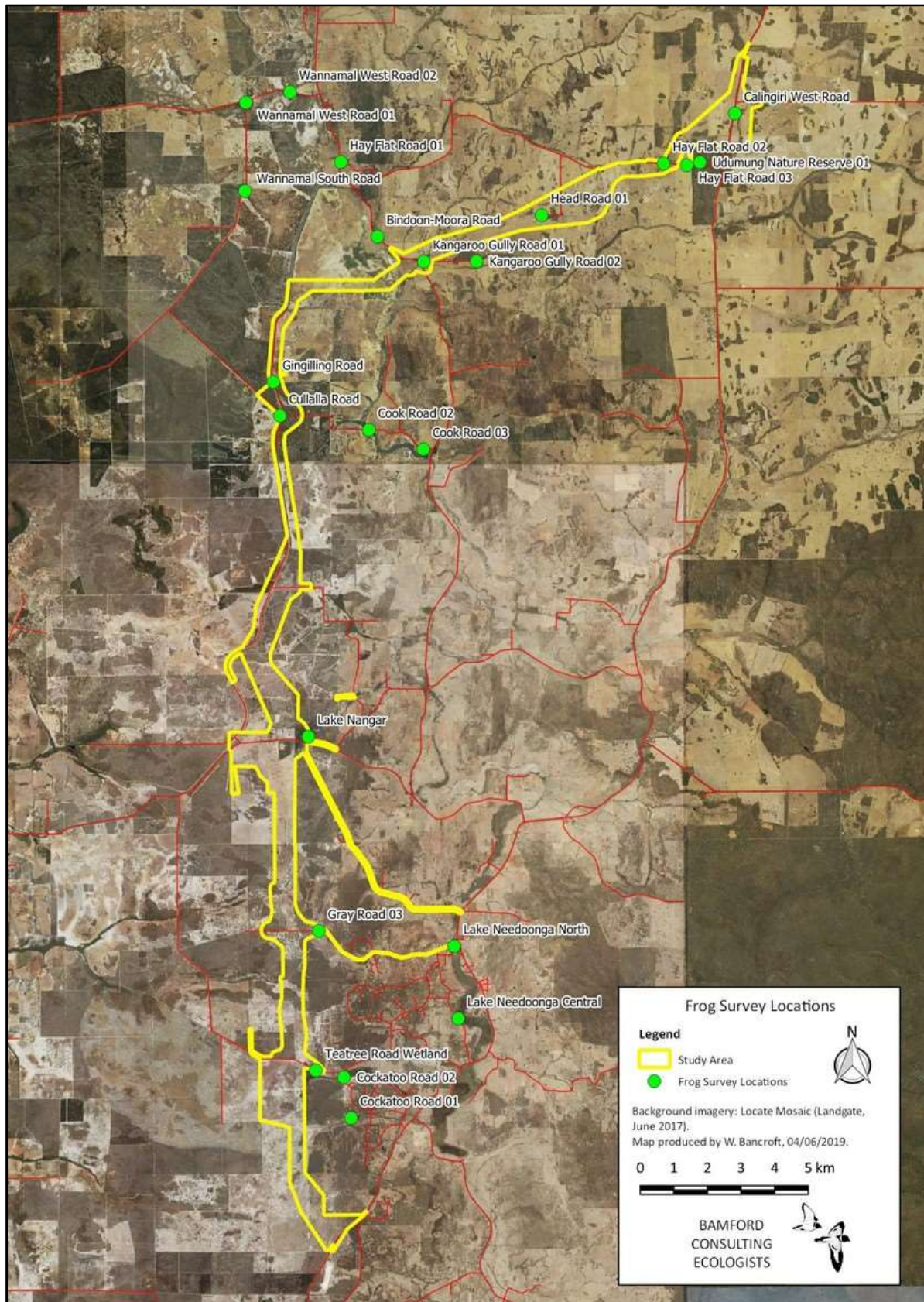


Figure 7. Locations of frog aural survey sites.

2.3.9 Short-range endemic invertebrate collection

Opportunistic searching for potential short-range endemic (SRE) invertebrates was carried during all field activity, but particularly during the 31st July to 4th August 2017, 4th to 8th September 2017 and 2nd August 2018 field trips, as target species (land snails, isopods and millipedes) are active in this season. Searching was by observation and by turning over logs and rocks, particularly in low-lying areas where conditions are seasonally damp. Specimens collected were taken to invertebrate specialists for identification.

2.3.10 Acoustic surveys for bats

In conjunction with other surveys conducted at the time, an Anabat SD1 (Titley Electronics) ultrasonic detector was deployed at two locations within the study area as listed in Table 9 and mapped in Figure 8. A brief habitat description of each location and the survey dates are also provided in Table 9.

Survey and call analysis methods followed the guidance of ABS (2006) and DSEWPac (2010). The detector was positioned approximately 25° above horizontal and pointed towards likely bat flight-paths; and set to record from 30 minutes before sunset to 30 minutes after sunrise.

Call analysis was by Dr Barry Shepherd, with reference to Fullard *et al.* (1991), Bullen and McKenzie (2002), McKenzie and Bullen (2009), and Bullen and Dunlop (2012).

Table 9. Bat survey sites.

Datum: GDA94. UTM Zone: 50J.

Site Name	Easting	Northing	Dates Surveyed	Notes
South of Corella Road	410054	6521082	4 th to 8 th September 2017	Jarrah-Marri woodland adjacent to small watercourse.
Hay Flat Road 04	420248	6550923	11 th and 12 th October 2017	Melaleuca woodland along watercourse near Udumung Nature Reserve.

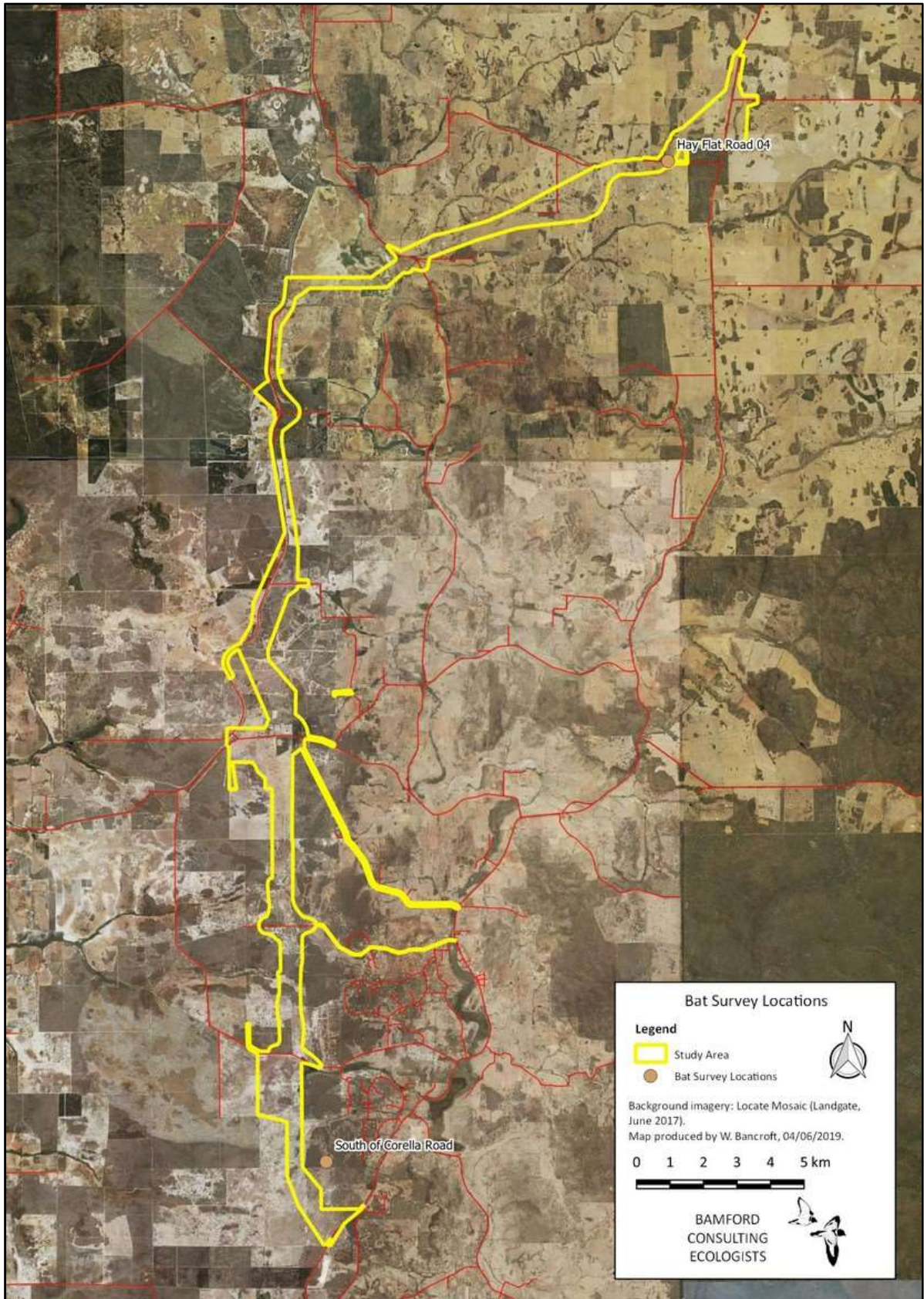


Figure 8. Location of the bat survey sites.

2.3.11 Surveys for shield-backed trapdoor spiders

In the original desktop assessment for the Bindoon Bypass, Bancroft *et al.* (2017) identified the conservation-significant Shield-backed Trapdoor Spider (*Idiosoma nigrum*) as potentially occurring within the study area. More recently, however, the systematics of the shield-backed trapdoor spiders (the “*nigrum*-group” within the *Idiosoma* genus) has been formally revised (Rix *et al.* 2017; Rix *et al.* 2018) and a group which previously contained two species (*I. nigrum* and *I. sigillatum*) has now been subdivided into seventeen separate (full) species (see Rix *et al.* 2018). As a result, the distribution of *I. nigrum*² *sensu stricto* was also revised. This taxon (now) occurs only in the central and central-western Wheatbelt of Western Australia, outside of the Bindoon Bypass study area.

Bancroft and Bamford (2018) reviewed the status of shield-backed trapdoor spiders within the study area and found that two species are likely to occur within the Bindoon Bypass study area (see Figure 9). One of these, *Idiosoma sigillatum*, is not presently listed as a conservation-significant species and was not specifically searched for in the field investigations documented here. The other species, *I. mcclementsorum*, is currently ranked as a Priority 2 species by DBCA and was the target of the spider surveys.

Field investigations to determine the likelihood of *Idiosoma mcclementsorum* occurring within the Bindoon Bypass study area comprised two components:

- (i) Ground-truthing and site inspection; and
- (ii) Targeted burrow searches.

These methods are outlined below and an *I. mcclementsorum* survey was conducted on the 2nd August 2018.

2.3.11.1 Ground-truthing and site inspection

Some of the known locations of *I. mcclementsorum* (as shown in Figure 9) were visited to familiarise the field personnel with the general habitat associations of this species. These locations included the Julimar Nature Reserve (east of the study area) and the Sevenmile Nature Reserve (north of the study area). Some searching for spider burrows was also conducted at these localities.

The on-ground habitat information was then used in conjunction with the predictive soil mapping (Figure 10) to determine likely locations within the Bindoon Bypass study area in which *I. mcclementsorum* may occur. These were then the target sites for the burrow searches.

2.3.11.2 Targeted burrow searches

Five target locations in and adjacent to the Bindoon Bypass study area were searched for *I. mcclementsorum* burrows: (1) Udumung Nature Reserve, and remnant bushland off (2) Head Road (private property), (3) Gray Road 01 (adjacent to cemetery), (4) Gray Road 02 (private property) and (5) south of Cockatoo Road (private property). These locations are mapped in Figure 10.

² The conservation status of *I. nigrum* under the WAWC Act has also been revised (upgraded) to Schedule 2 (Fauna that is rare or is likely to become extinct as endangered fauna).

Burrow searches were conducted on foot by slowly walking through the vegetation while scanning for burrows. Like all of the shield-backed trapdoor spiders, *I. mclementsorum* constructs burrows with a distinctive 'moustache-like' arrangement of twig-lines at the burrow entrance (Rix *et al.* 2018).

Location, burrow structure and a habitat description were recorded for any burrows observed. Internal inspection of the burrows was made using a milliscope.

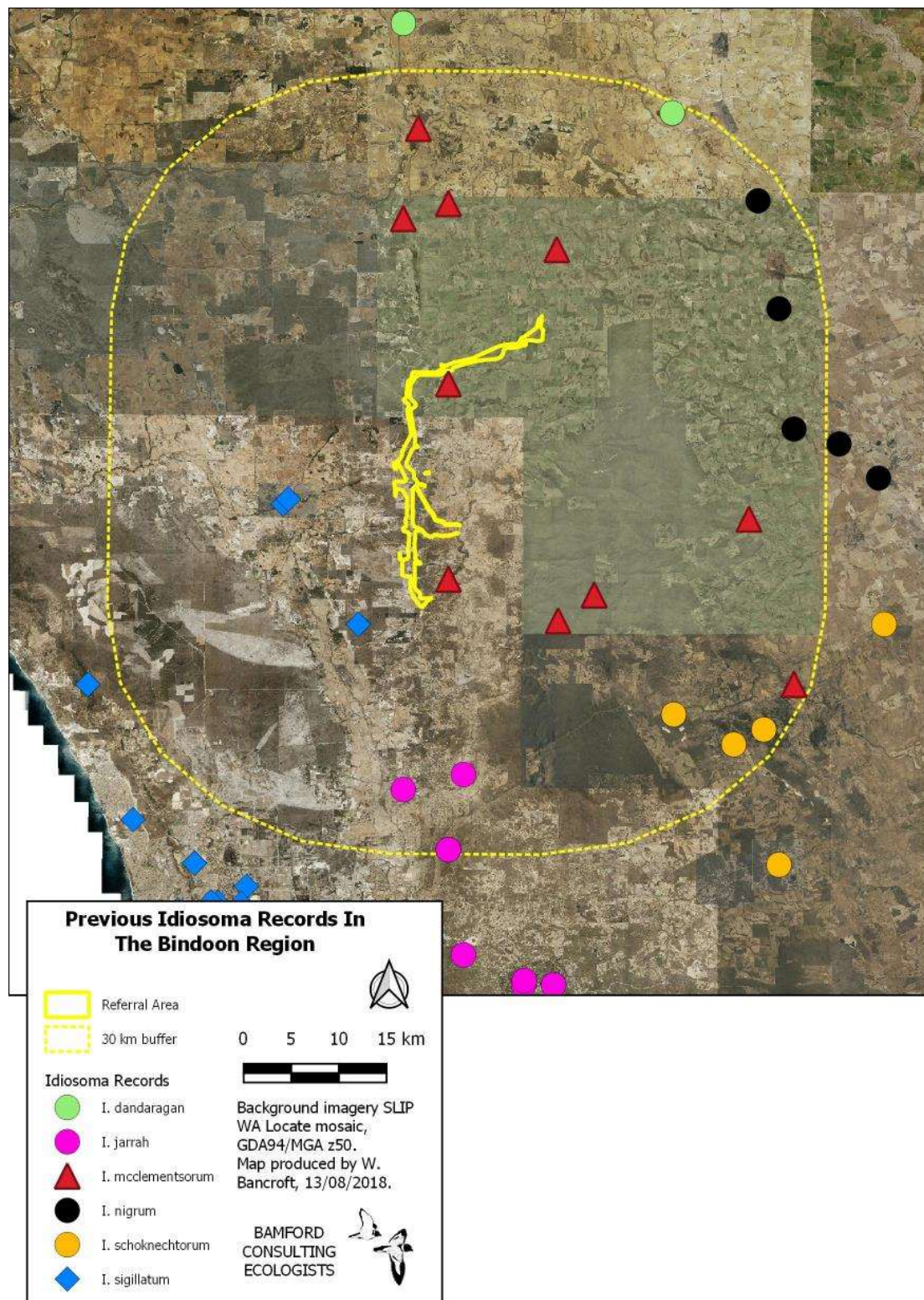


Figure 9. Shield-backed trapdoor spider (*Idiosoma* species) specimen locations in the Bindoon region.

Spider data kindly provided by Dr Mark Harvey of the Western Australian Museum. Note that this map is taken from Bancroft and Bamford (2018) and shows a previous route-alignment, the ‘referral area’, that is similar, but not an exact match, to the route of focus in this current report (at June 2019); the ‘study area’.

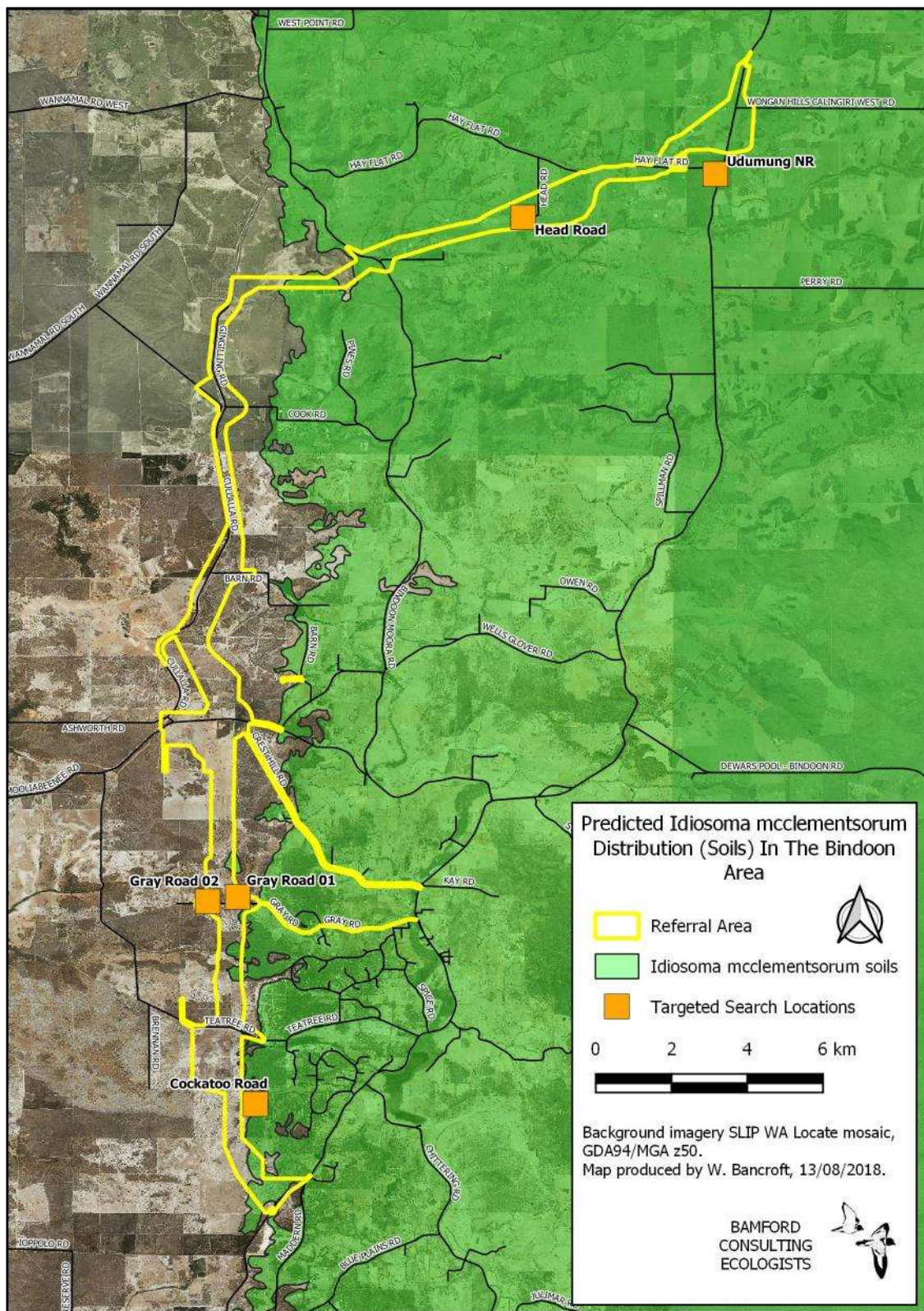


Figure 10. Map of the predicted distribution of *Idiosoma mclementsorum* in the Bindoon area.

Note that this map is taken from Bancroft and Bamford (2018) and shows a previous route-alignment, the ‘referral area’, that is similar, but not an exact match, to the route of focus in this current report (at June 2019); the ‘study area’.

2.3.12 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 birds or reptiles seen while travelling through and near the site.

2.4 Survey limitations

The EPA Guidance Statement 56 (EPA 2004) outlined a number of limitations that may arise during surveying. These survey limitations are discussed in the context of the BCE fauna survey of the study area in Table 10.

Table 10. Survey limitations as outlined by EPA (2004).

EPA Survey Limitations	BCE Comment
Level of survey.	Detailed Level 1 (desktop study and reconnaissance field survey, with targeted surveys for significant fauna). Survey intensity was deemed adequate the availability of existing information and the stage of the development project (route selection).
Competency/experience of the consultant(s) carrying out the survey.	The authors have had extensive experience in conducting desktop reviews and reconnaissance surveys for environmental impact assessment fauna studies.
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	The survey focused on terrestrial vertebrate fauna. Much of the survey effort was targeted to assessing black-cockatoo habitat.
Proportion of fauna identified, recorded and/or collected.	All fauna observed were identified.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Sources include previous fauna surveys in the area (at least six relevant studies available and reviewed) and database searches, as outlined in Section 2.2.1.
The proportion of the task achieved and further work which might be needed.	Detailed Level 1 survey and targeted investigations carried out. Exhaustive survey of all potential black-cockatoo breeding trees, and further black-cockatoo roosting surveys within chosen alignment to be carried out.
Timing/weather/season/cycle.	Surveys were conducted from October 2016 to and November 2018 across all seasons.
Disturbances (e.g. fire, flood, accidental human intervention etc.) which affected results of survey.	No disturbances affected the survey results.
Intensity (In retrospect, was the intensity adequate?)	Survey intensity was moderate (desktop study, reconnaissance survey with some targeted surveying for conservation significant fauna) to almost complete (black-cockatoo surveys) and was adequate to satisfy EPA guidance for a Level 1 survey. Targeted investigations exceeded what is often conducted for a Level 2 survey.
Completeness (e.g. was relevant area fully surveyed).	The entire study area was visually inspected and all major fauna habitats sampled. Environments likely to support conservation significant fauna were subject to further intensive sampling.

Resources (e.g. degree of expertise available in animal identification).	Personnel have a vast combined experience in fauna surveys for environmental impact assessment including multiple surveys in the general area.
Remoteness and/or access problems.	A small proportion of the study area was inaccessible (private property where permission was not granted) but this is unlikely to have a bearing on the report outcome.
Availability of contextual (e.g. biogeographic) information.	Regional information was available and was consulted, including at least six previous study reports for the local region.

2.5 Presentation of results for Impact Assessment

While some impacts are unavoidable during a development, of concern are long-term, deleterious impacts upon biodiversity. This is reflected in documents such as the Significant Impact Guidelines provided by DSEWPaC (see Appendix 4). Significant impacts may occur if:

- There is direct impact upon a VSA and the VSA is rare, a large proportion of the VSA is affected and/or the VSA supports significant fauna.
- There is direct impact upon conservation significant fauna.
- Ecological processes are altered and this affects large numbers of species or large proportions of populations, including significant species.

The impact assessment process therefore involves reviewing the fauna values identified through the desktop assessment and field investigations with respect to the project and impacting processes. The severity of impacts on the fauna assemblage and conservation significant fauna can then be quantified on the basis of predicted population change.

The presentation of this assessment follows the general approach to impact assessment as given in Section 1.2, but modified to suit the characteristics of the site. Key components to the general approach to impact assessment are addressed as follows:

Fauna values

This section presents the results of the desktop and field investigations in terms of key fauna values (described in detail in Appendix 1) and includes:

- Assemblage characteristics (uniqueness, completeness and richness);
- Species of conservation significance;
- Recognition of ecotypes or vegetation/substrate associations (VSAs);
- Patterns of biodiversity across the landscape; and
- Ecological processes upon which the fauna depend.

Impact assessment

This section reviews impacting processes (as described in detail in Appendix 3) with respect to the proposed development and examines the potential effect these impacts may have on the faunal biodiversity of the study area. It thus expands upon Section 1.2 and discusses the contribution of the project to impacting processes, and the consequences of this with respect to biodiversity. A major component of impact assessment is consideration of threats to species of conservation significance as these are a major and sensitive element of biodiversity. Therefore, the impact assessment section includes the following:

- Review of impacting processes; will the proposal result in:
 - Habitat loss leading to population decline, especially for significant species;
 - Habitat loss leading to population fragmentation, especially for significant species;
 - Weed invasion that leads to habitat degradation;
 - Ongoing mortality;
 - Species interactions that adversely affect native fauna, particularly significant species;
 - Hydrological change;
 - Altered fire regimes; or
 - Disturbance (dust, light, noise)?
- Summary of impacts upon significant species, and other fauna values.

The impact assessment concludes with recommendations for impact mitigation, based upon predicted impacts.

2.5.1 Criteria for impact assessment

Impact assessment criteria are based on the severity of impacts on the fauna assemblage and conservation significant fauna, and quantified on the basis of predicted population change (Table 11). Population change can be the result of direct habitat loss and/or impacts upon ecological processes.

The significance of population change is contextual. The EPA (2004) suggests that the availability of fauna habitats within a radius of 15 km can be used as a basis to predict low, moderate or high impacts. In this case, a high impact is where the impacted environment and its component fauna are rare (less than 5% of the landscape within a 15 km radius or within the Bioregion), whereas a low impact is where the environment is widespread (e.g. >10% of the local landscape). Under the Ramsar Convention, a wetland that regularly supports 1% of a population of a waterbird species is considered to be significant. These provide some guidance for impact assessment criteria. In the following criteria (Table 11), the significance of impacts is based upon percentage population decline within a 15 km radius (effectively local impact) and upon the effect of the decline upon the conservation status of a recognised taxon (recognisably discrete genetic population, sub-species or species). Note that percentage declines can usually only be estimated on the basis of the distribution of a species derived from the extent of available habitat.

Table 11. Assessment criteria for impacts upon fauna.

Impact Category	Observed Impact
Negligible	Effectively no population decline; at most few individuals impacted and any decline in population size within the normal range of annual variability.
Minor	Population decline temporary (recovery after end of project such as through rehabilitation) or permanent, but <1% within 15 km radius of centre-point of impact area (or within bioregion if this is smaller). No change in viability or conservation status of taxon.
Moderate	Permanent population decline 1-10% within 15 km radius. No change in viability or conservation status of taxon.
Major	Permanent population decline >10% within 15 km radius. No change in viability or conservation status of taxon.
Critical	Taxon extinction within 15 km and/or change in viability or conservation status of taxon.

3 Results

3.1 Vegetation and substrate associations (VSAs)

Ten major vegetation and substrate associations were identified in the study area:

- VSA 1.** Banksia woodland. Areas of predominantly *Banksia attenuata*, *B. menziesii*, *B. ilicifolia* and/or *B. prionotes* overstorey with diverse understorey, on sands. Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*) absent.
- VSA 2.** Banksia woodland with scattered Marri and/or Jarrah. Areas of predominantly *Banksia attenuata*, *B. menziesii*, *B. ilicifolia* and/or *B. prionotes* and Jarrah and/or Marri. Substrate sand to gravelly-sand.
- VSA 3.** Marri-Jarrah woodland. Marri and/or Jarrah woodland with relatively complete and diverse understorey, on shallow sands over gravel.
- VSA 4.** Marri-Jarrah woodland with little to no remnant understorey (e.g. grazed), on sands or gravel. Tree canopy reasonably complete/in its native form but grassy and/or herbaceous stratum mostly introduced species.
- VSA 5.** Wandoo woodland (with or without understorey). Wandoo (*E. wandoo*) at variable densities with highly variable overstorey (i.e. monoculture of Wandoo; or with Jarrah, Marri, Flooded Gum [*E. rudis*] and/or York Gum [*E. loxophleba*]). Understorey variable, ranging from cleared/grazed through weed-dominated to relatively intact native understorey. Usually on heavy soils or gravels.
- VSA 6.** Heath. Dwarf Allocasuarina (*Allocasuarina humilis*), with Balga (*Xanthorrhoea preissii*) and *Hibbertia hypericoides*, usually on stony rises. No overstorey.
- VSA 7.** Waterways or wetlands/damplands. Swamps, damplands and watercourses and immediate fringing vegetation, including Flooded Gum and/or *Melaleuca* spp.
- VSA 8.** Paddocks with large remnant trees. Cleared understorey that has been cultivated for agricultural use but that retains sparsely-spread remnant large trees (usually Jarrah, Marri or Wandoo).
- VSA 9.** Paddocks. Completely cleared lands cultivated for agricultural use.
- VSA 10.** Plantations. Cultivated lands with (usually) a monoculture of perennial trees or shrubs.

Example photographs of the VSAs were presented by Bancroft *et al.* (2017) but are not included here. VSAs are mapped for the study area in Figure 11 (northern study area) and Figure 12 (southern study area). The total areas of each VSA in the study area is presented in Table 12.

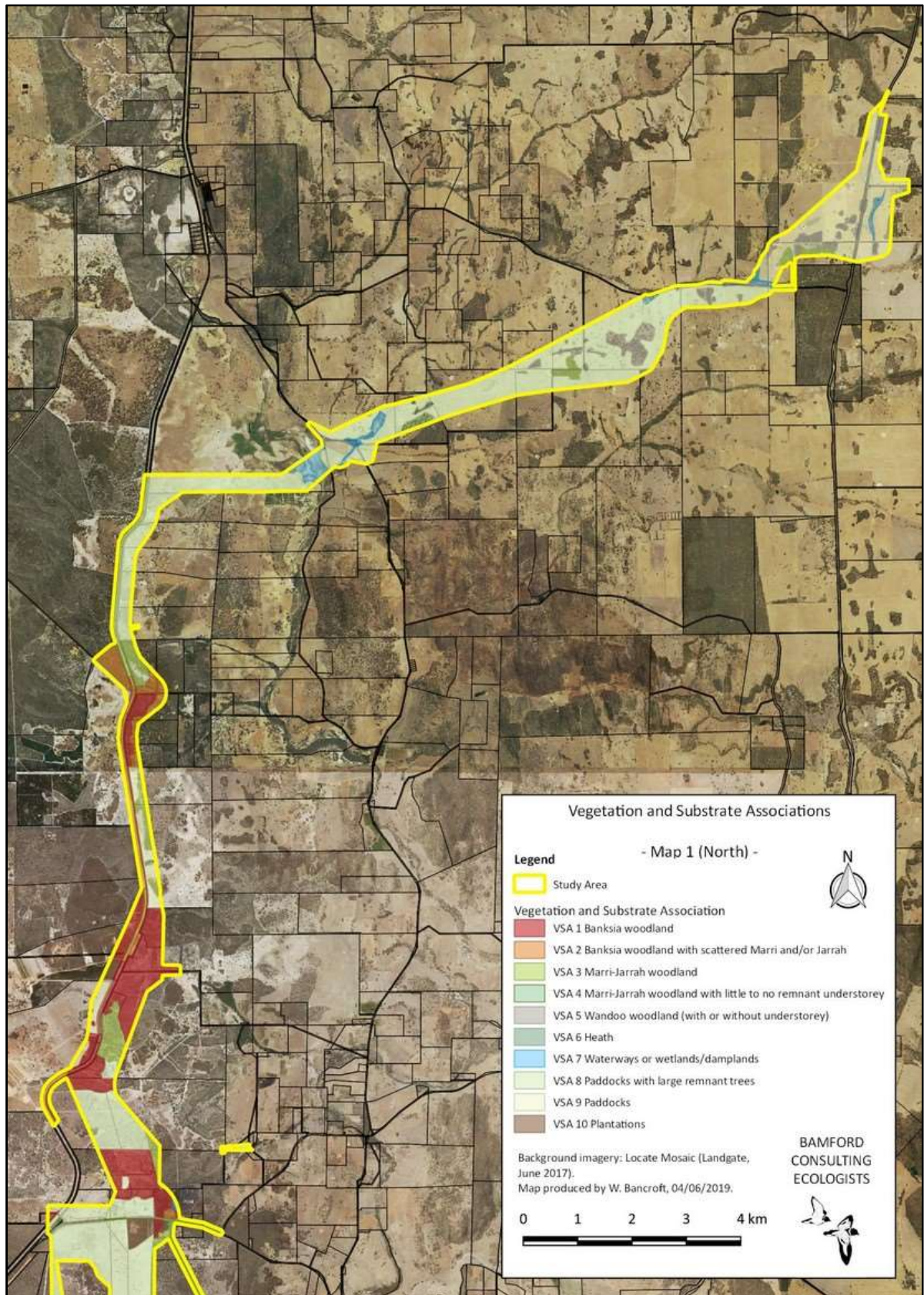


Figure 11. Vegetation and substrate associations in the study area (northern study area).

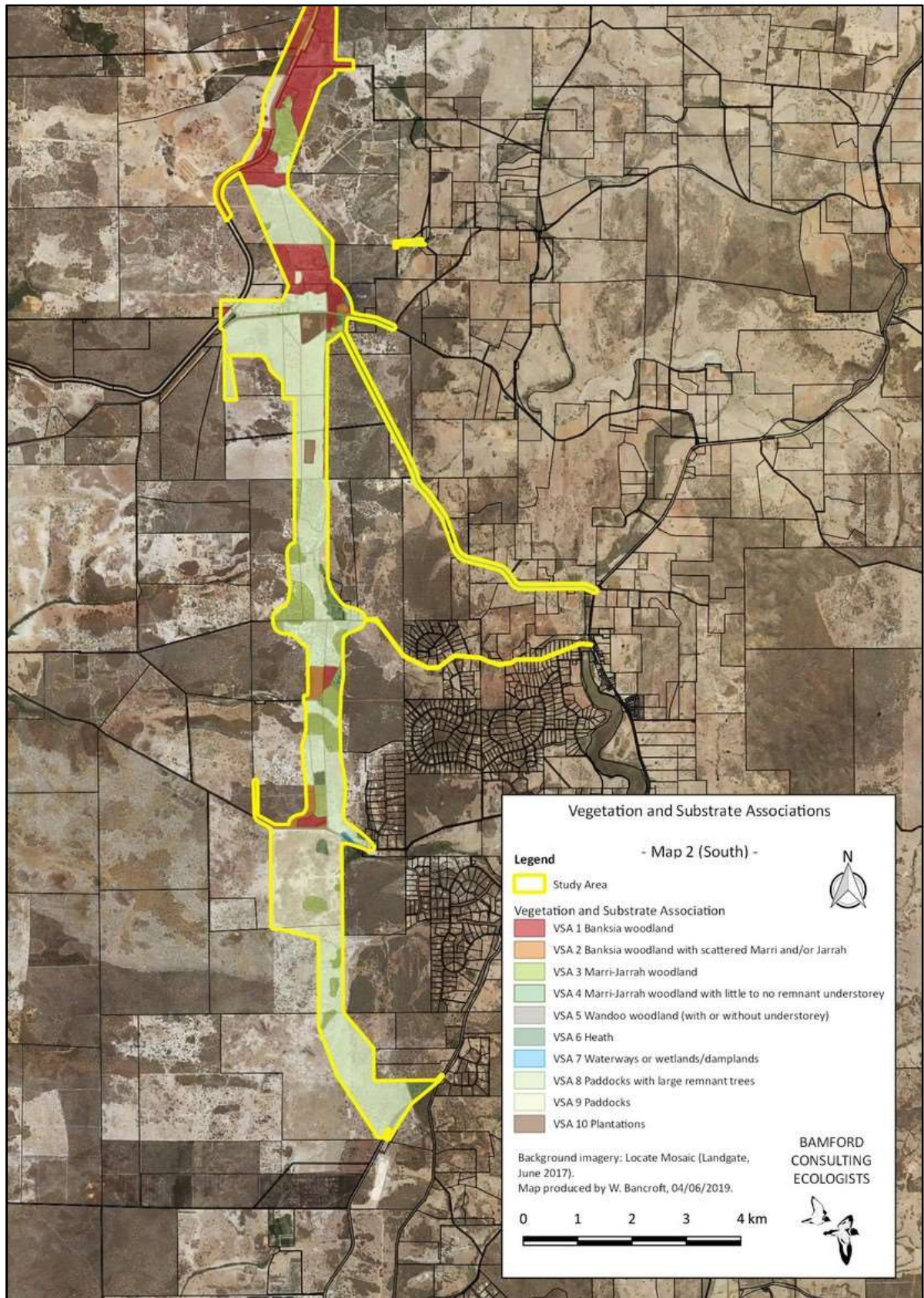


Figure 12. Vegetation and substrate associations in the study area (southern study area).

Table 12. Total area of each VSA in the study area.

VSA	Total Area (ha)	Percentage of Footprint
VSA 1. Banksia woodland.	361	10.5%
VSA 2. Banksia woodland with scattered Marri and/or Jarrah.	171	5%
VSA 3. Marri-Jarrah woodland.	353	10.3%
VSA 4. Marri-Jarrah woodland with little to no remnant understorey	87	2.5%
VSA 5. Wandoo woodland (with or without understorey).	125	3.6%
VSA 6. Heath.	0	0%
VSA 7. Waterways or wetlands/damplands.	62	1.8%
VSA 8. Paddocks with large remnant trees.	1630	47.5%
VSA 9. Paddocks.	605	17.6%
VSA 10. Plantation.	36	1%
TOTAL	3430	100%

3.2 Vertebrate fauna

3.2.1 Overview of fauna assemblage

The desktop study identified 306 vertebrate fauna species as potentially occurring in the study area: eight freshwater fish, 17 frogs, 69 reptiles, 177 birds and 35 mammals. These species are listed in Appendix 8. The presence of at least 77 species (one freshwater fish, five frogs, three reptiles, 52 birds and at least 14 mammals) was confirmed during the field surveys (as indicated in Appendix 8).

Fourteen species returned by the database searches and/or literature review are now considered to be locally extinct in the study area. These species comprise one reptile, five birds and eight mammals and are listed in Appendix 9. A further 45 species (two fish, two frogs, 21 reptiles, 14 birds and six mammals) returned by the database searches and/or literature review have been omitted from the expected species list because of habitat or range limitations. These species are listed in Appendix 10. The composition of the vertebrate fauna is summarised in Table 13.

Table 13. Composition of vertebrate fauna assemblage of the study area.

The number of non-native mammals are shown in parentheses.

Taxon	Expected Species	Recorded Species	Number of species in each status category				
			Resident	Migrant or visitor	Irregular visitor	Vagrant	Locally extinct
Fish	8	1	8				
Frogs	17	5	17				
Reptiles	69	3	69				1
Birds	177	52	109	35	26	7	5
Mammals	35 (11)	14+ (6)	35 (11)				8
Total	306	77	238	35	26	7	14

3.2.2 Expected fauna

The eight fish species expected to occur in the study area includes two introduced species, and these two species are likely to be the most widespread in permanent wetlands and drainage systems throughout the project area. The native species may be restricted to drainage systems in the south of the study area (Gingin and Ellen Brooks), where water quality is likely to be least affected by salinisation. The Mud Minnow may be restricted to the Lennard Brook tributary of Gingin Brook and around Lake Chandala along Ellen Brook, and thus may not occur within the study area.

The 17 frog species expected to occur in the study area is a rich assemblage but not all species would be sympatric (i.e. all the species would not occur throughout the study area). Because of the north-

south extent of the study area, the frog assemblage includes species at the northern limit of their range (Hooting Frog, Whooping Frog, Quacking Frog, Clicking Frog and Lea's Frog), and species whose distribution may overlap only with the northern extent of the study area (Kunupalari Frog, Humming Frog, Western Spotted Frog). Some species are also likely to be confined to particular soil types, such as the Turtle Frog on sands and the Squelching Frog on heavier soils. While some of the frogs are closely associated with wetlands, most disperse widely into terrestrial environments outside the breeding season, and the Turtle Frog is entirely terrestrial.

The 69 reptile species expected to occur in the study area also represent a rich assemblage which is not sympatric, with differences related to north-south alignment of the study area as well as to substrate and vegetation types. Distinct assemblages are likely in different VSAs, especially in relation to substrate. For example, banksia woodland on sand may be the richest VSA in term of reptile species, and may support species that do not occur on heavier loam or gravelly soils. There are also species that are at the northern limit of their range in the study area (e.g. Dell's Skink) and others near their southern limit in the north of the study area (e.g. Bicycle Dragon, Western Netted Dragon). The reptile assemblage is likely to be intact where native vegetation is in good condition, but only a subset of species will persist in degraded and cleared areas.

The 177 bird species expected to occur in the study area includes six introduced species. As with reptiles and frogs, the bird assemblage is not likely to be the same across the whole study area with some northern and southern elements. There are also species associated with and sometimes limited to particular types of VSAs, such as waterbirds limited to the wetlands, species of the eucalypt forests, species of banksia woodlands and species of heaths. Some species are even most closely associated with cleared land. Unlike other major groups, in which all or most species are expected to be residents, the bird assemblage is a complex of resident, visitor, irregular and vagrant species. The study area may only be important for resident species and those species that occur regularly, although may have a dispersal function for irregular visitors. While field investigations were not intended to document the entire bird assemblage, 43 (39%) of the 109 species expected to be resident were recorded, as were seven (22%) of the 32 species expected to be visitors or migrants.

The 35 mammal species expected to occur in the study area includes 11 introduced species, while an additional eight mammal species are considered locally extinct (Appendix 9). The status of many of the mammal species in the area is uncertain, but all listed in Appendix 8 are expected to be residents. As with other major fauna groups, the mammal assemblage is inflated by the north-south and east-west extent of the study area, with some species either limited to the south (e.g. probably Chuditch, Mardo, Quenda, Brush-tailed Phascogale and Gould's Long-eared Bat) or the north (e.g. Red-tailed Phascogale, although this species may be locally extinct). There is likely to be a strong southerly bias in the mammal assemblage, partly because of natural patterns of distribution but also due to the extent of clearing in the north. On an east-west alignment, a few species are restricted to sandy soils (some of the dunnarts and the Noodji or Ash-grey Mouse). Vegetation on sandy soils is thus likely to be richer in mammal species than forests on heavier soils.

The key features of the fauna assemblage expected in the study area are:

- **Uniqueness:** The assemblage is likely to be typical of the region but will vary north to south and to some extent east to west because of the arrangement of VSAs in relation to the

landforms present; Darling Escarpment and Dandaragan plateau, which are both aligned north-south. Because of the north-south extent that runs from typical south-west forest and woodlands into wheatbelt woodlands, the assemblage contains a lot of species at the extremes of their distribution. The assemblage is dominated by terrestrial species but includes some wetland-dependent species. While many waterbirds are expected, they are not anticipated to be abundant.

- **Completeness:** The assemblage is likely to be substantially complete but lacks at least one reptile, three bird and 11 mammal species which are all thought to be locally extinct. The number of locally extinct mammals concluded may be conservative.
- **Richness:** The assemblage is very rich but this is partly an artefact of the extent, location and shape of the study area. Parts of the study area may be richer in species than others, including woodlands on sand (rich in reptiles and small mammals), and woodlands and forests on heavy soil in the south (a suite of small and medium mammals).

As a fauna value, the most important feature of the study area's assemblage is that it contains a wide array of species across a region that is transitional from the mesic south-west into the lower rainfall region of the western wheatbelt. The assemblage is also within some large areas of a more or less intact landscape.

3.2.3 Species of conservation significance

Of the 306 species of vertebrate fauna that are expected to occur in the study area, 42³ are considered to be of conservation significance (19 CS1, seven CS2 and 16 CS3 taxa; see Appendix 1 for descriptions of these CS (conservation significance) levels). These species of conservation significance are indicated in the complete species list (Appendix 8) but are also listed in Table 14. In addition, database reviews returned three invertebrate species of conservation significance. These are:

- *Idiosoma mclementsorum*⁴, a shield-backed trapdoor spider - CS2 (P2);
- *Throscodectes xederoides*, Mogumber Bush Cricket - CS2 (P3); and
- *Westralunio carteri*, Carter's Freshwater Mussel - CS1 (S3).

Therefore, the 45 conservation significant species expected to occur in the study area comprises:

- three fish (one CS1, two CS3)
- three frogs (CS3)
- six reptiles (one CS1, two CS2, three CS3)
- 23 birds (15 CS1, two CS2, six CS3)
- seven mammals (two CS1, three CS2, two CS3)
- three invertebrates (one CS1, two CS2).

Seven conservation significant fauna species were recorded during the field investigations, as indicated in Table 14.

³ The Rainbow Bee-eater has been delisted since the assessment of Bancroft *et al.* (2017) and has been removed from the conservation significant species lists here.

⁴ Previously listed (by Bancroft *et al.* 2017) as *Idiosoma nigrum*.

Table 14. Conservation significant fauna species expected to occur within the study area.

Species are listed in taxonomic order within each level of conservation significance: CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 1 for full explanation.

EPBC Act listings: E = Endangered, V = Vulnerable, M = Migratory (see Appendix 2).

Wildlife Conservation Act 1950 listings: S1 to S7 = Schedules 1 to 7 (see Appendix 2).

DBCA Priority species: P1 to P4 = Priority 1 to 4 (see Appendix 2).

LS = considered by BCE to be of local significance (see Appendix 1).

SPECIES		STATUS	EXPECTED OCCURRENCE	RECORDED
<i>Galaxiella munda</i>	Western Mud Minnow	CS1 (S3)	Resident	
<i>Pseudemydura umbrina</i>	Western Swamp Tortoise	CS1 (C,S1)	Unlikely Resident	
<i>Apus pacificus</i>	Fork-tailed Swift	CS1 (M,S5)	Migrant	
<i>Botaurus poiciloptilus</i>	Australasian Bittern	CS1 (E,S2)	Irregular Visitor	
<i>Ardea modesta</i>	Eastern Great Egret	CS1 (S5)	Visitor	+
<i>Ardea ibis</i>	Cattle Egret	CS1 (S5)	Vagrant	
<i>Plegadis falcinellus</i>	Glossy Ibis	CS1 (M,S5)	Migrant	
<i>Falco peregrinus</i>	Peregrine Falcon	CS1 (S7)	Resident	
<i>Rostratula australis</i>	Australian Painted Snipe	CS1 (E,S2)	Vagrant	
<i>Actitis hypoleucos</i>	Common Sandpiper	CS1 (M,S5)	Migrant	
<i>Tringa nebularia</i>	Common Greenshank	CS1 (M,S5)	Migrant	
<i>Tringa glareola</i>	Wood Sandpiper	CS1 (M,S5)	Migrant	
<i>Calidris ruficollis</i>	Red-necked Stint	CS1 (M,S5)	Migrant	
<i>Calidris ferruginea</i>	Curlew Sandpiper	CS1 (C,M,S3,S5)	Migrant	
<i>Calyptorhynchus banksii naso</i>	Forest Red-tailed Black-Cockatoo	CS1 (V,S3)	Resident	+
<i>Calyptorhynchus latirostris</i>	Carnaby's Black-Cockatoo	CS1 (E,S2)	Resident	+
<i>Calyptorhynchus baudinii</i>	Baudin's Black-Cockatoo	CS1 (V,S2)	Irregular Visitor	
<i>Dasyurus geoffroii</i>	Chuditch	CS1 (V,S3)	Resident	
<i>Phascogale tapoatafa wambenger</i>	Brush-tailed Phascogale, Wambenger	CS1 (S3)	Resident	
<i>Westralunio carteri</i>	Carter's Freshwater Mussel	CS1 (S3)	Resident	
<i>Ctenotus delli</i>		CS2 (P4)	Resident	
<i>Neelaps calonotos</i>	Black-striped Snake	CS2 (P3)	Resident	
<i>Oxyura australis</i>	Blue-billed Duck	CS2 (P4)	Irregular Visitor	
<i>Ninox connivens connivens</i>	Barking Owl (southwestern)	CS2 (P2)	Resident	
<i>Isoodon fusciventer</i>	Southern Brown Bandicoot, Quenda	CS2 (P4)	Resident	
<i>Notamacropus irma</i>	Brush Wallaby	CS2 (P4)	Resident	+
<i>Hydromys chrysogaster</i>	Rakali (Water-rat)	CS2 (P4)	Resident	+

SPECIES		STATUS	EXPECTED OCCURRENCE	RECORDED
<i>Idiosoma macleodensis</i>	a shield-backed trapdoor spider	CS2 (P2)	Resident	+
<i>Throscodectes xederoides</i>	Mogumber Bush Cricket	CS2 (P3)	Resident	
<i>'Tandanus' bostocki</i>	Freshwater Cobbler	CS3 (LS)	Resident	
<i>Bostockia porosa l</i>	Nightfish	CS3 (LS)	Resident	
<i>Heleioporus barycragus</i>	Hooting Frog	CS3 (LS)	Resident	
<i>Heleioporus inornatus</i>	Whooping Frog	CS3 (LS)	Resident	
<i>Geocrinia leai</i>	Ticking Frog	CS3 (LS)	Resident	
<i>Liopholis pulchra</i>		CS3 (LS)	Resident	
<i>Anilius pinguis</i>		CS3 (LS)	Resident	
<i>Morelia spilota imbricata</i>	Carpet Python (southwest)	CS3 (LS)	Resident	
<i>Climacteris rufa</i>	Rufous Treecreeper	CS3 (LS)	Resident	
<i>Malurus elegans</i>	Red-winged Fairy-wren	CS3 (LS)	Resident	
<i>Falcunculus frontatus</i>	Crested Shrike-tit	CS3 (LS)	Resident	
<i>Myiagra inquieta</i>	Restless Flycatcher	CS3 (LS)	Irregular Visitor	
<i>Petroica multicolor</i>	Scarlet Robin	CS3 (LS)	Resident	+
<i>Eopsaltria georgiana</i>	White-breasted Robin	CS3 (LS)	Resident	
<i>Antechinus flavipes leucogaster</i>	Yellow-footed Antechinus, Mardo	CS3 (LS)	Resident	
<i>Trichosurus vulpecula</i>	Brushtail Possum	CS3 (LS)	Resident	

Relevant annotations (e.g. reasons for listing, likely occurrence in the study area and/or the likelihood/consequence/risk of impact) for each species of conservation significance are as follows:

- Western Mud Minnow, CS1 (S3) – is a stream-dwelling species that occurs in the Lennard Brook drainage system to the west of the study area. The closest record to the study area (based on the DBCA database search results) was from Gingin Brook, north-east of Gingin, approximately 11 km west of the study area. Connections between this drainage system and the wetlands within the survey appear to be intermittent; thus it is considered that the Western Mud Minnow is an unlikely resident of the southern study area.
- Western Swamp Tortoise, CS1 (C,S1) – a population of Western Swamp Tortoises has been introduced at Mogumber Nature Reserve, approximately 13 km north of the north-western edge of the study area. There is a potential corridor of suitable habitat connecting this population and wetlands along the Brockman River drainage system in the northern part of the study area. While it is unlikely that this species will naturally make this passage, it cannot be completely discounted. Therefore, the Western Swamp Tortoise is considered to be an unlikely resident in wetlands (VSA 7) in the northern-western edge of the study area.
- Fork-tailed Swift, CS1 (M,S5) – a highly aerial species that may pass over the site. Negligible impact on this species is expected.
- Australasian Bittern, CS1 (E,S2) – this species is probably locally extinct in the study area but, if present (in wetland habitats; VSA 7), would be a significant record.

- Eastern Great Egret, CS1 (S5) – recorded at a wetland along the Moora-Bindoon Road during the site inspection, this species is highly mobile and may visit the study area in small numbers when suitable conditions exist. Confined to wetland habitats (VSA 7) and likely only in small numbers. The species is widespread.
- Cattle Egret, CS1 (S5), Glossy Ibis, CS1 (M,S5) – moderate to low-likelihood of these species occurring within the study area. Both species occur infrequently on flooded paddocks and shallow wetlands on the Swan Coastal Plain. There is only a limited area of suitable wetland habitat in the study area for the Glossy Ibis.
- Peregrine Falcon, CS1 (S7) – likely to be a wide-ranging resident, in low densities, in the vicinity of the study area.
- Australian Painted Snipe, CS1 (E,S2) – possibly a vagrant to wetlands (VSA 7) in the study area.
- Common Sandpiper, Common Greenshank, Wood Sandpiper, and Red-necked Stint, CS1 (M,S5); Curlew Sandpiper, CS1 (C,M,S3,S5) – all trans-equatorial migrant waders that may intermittently use shallow wetlands (probably in small numbers) when conditions are suitable.
- Forest Red-tailed Black-Cockatoo, CS1 (V,S3) – known to be resident in Marri-Jarrah woodlands (VSAs 3 or 4) in the south of the study area. This species was recorded regularly during the field investigations but is probably limited to the southerly half of the study area (north to about Cook Road). The inland race (*C. banksii samuelii*) may occur in the north of the study area and is not of conservation significance. Impact to this species, especially to breeding trees, may be significant.
- Carnaby's Black-Cockatoo, CS1 (E,S2) – known to be a resident throughout the study area. This species was recorded regularly during the field investigations. Carnaby's Black-Cockatoo will extensively utilise the field investigations area for foraging and breeding. It will forage in areas of banksia (VSAs 1 and 2), Marri-Jarrah woodlands or similar (VSAs 3, 4, 8) and in paddocks (VSAs 8 and 9) and some plantations (VSA 10). It will breed in areas of Marri-Jarrah woodlands or similar (VSAs 3, 4, 8) and Wandoo woodland (VSA 5). It may roost in the vicinity of wetlands in the study area (VSA 7). Impact to this species, especially to breeding trees and the threat of road mortality, may be significant.
- Baudin's Black-Cockatoo, CS1 (V,S2) – unlikely to occur in the study area. Johnstone and Kirkby (2008) provided a detailed map of the distribution of Baudin's Black-Cockatoo and noted that the northern limit of its range is Gidgegannup (some 40 km to the south-east of the study area). If present at all, this species is likely to only be a visitor to the study area.
- Chuditch, CS1 (V,S3) – There are a number of DBCA database records of this species within the vicinity of the study area and there are anecdotal reports of Chuditch around Bindoon. Targeted field investigations failed to locate Chuditch and, while this does not necessarily mean the species is absent, it indicates that if it is present, it occurs at very low levels of abundance. The Chuditch is likely to be a wide-ranging resident in Marri-Jarrah woodland areas, particularly in the south. This species may be at risk of increased road mortality.
- Brush-tailed Phascogale, Wambenger, CS1 (S6) – If not locally extinct, this species is likely to be a resident in the area. Targeted field investigations failed to detect this species. The ALA database showed the core distribution of Brush-tailed Phascogale to be south of Gidgegannup (south of the study area) but included a couple of outlying records from Mooliabeenee Road and just north of Hay Flat Road (both very close to the study area) that demonstrate the

species has been historically recorded from the area. Several records of this species within 20 km of the study area were also returned from the DBCA database search.

- Carter's Freshwater Mussel, CS1 (S3) – DBCA database records showed this species to have been recorded at only three locations along the lower Ellen Brook and one location along the lower Brockman River (Marbling Brook); it is also present in Gingin Brook. Targeted field investigations failed to detect this species. Probably due to salinization, the species appears to be extinct along much of Brockman River and may thus be absent from the current study area.
- *Ctenotus delli* CS2 (P4) – this species of skink is known to occur on the Darling Scarp to the east of the study area. If present it would be at the northern extent of its range.
- Black-striped Snake, CS2 (P3) – Likely to occur in banksia woodlands on sands of the Dandaragan Plateau.
- Blue-billed Duck, CS2 (P4) – likely to occur in deep water habitats in the area but it is uncertain as to whether the wetlands (VSA 7) within the study area are sufficiently deep to support this species. Despite this, occasional visitors are possible.
- Barking Owl (south-western), CS2 (P2) – not detected in the targeted field investigations but may occur in forest in the south of the study area. It is considered to be of low concern with respect to impact during project development.
- Southern Brown Bandicoot or Quenda, CS2 (P4) – BCE has only recorded this species (previously) around the Muchea area (to the south), but the DBCA database search yielded a few records (of varying certainty) further north. Targeted field investigations failed to detect this species. If present within the study area, it seems this species is close to the northern extremity of its range. Ample suitable habitat exists throughout the study area. If present, road mortality may be an issue (in localised areas).
- Brush Wallaby, CS2 (P4) – DBCA records indicate this species to be present to the west of the study area and it was present on private property along Mooliabeenee and Cullalla Roads in the mid 1980s (Bamford 1986). Two records of this species were made by Bancroft *et al.* (2018) in this general vicinity, and a road kill was noted along Mooliabeenee Road (west of the study area) in the most recent field investigations (November 2018). There are considerable tracts of banksia woodland (VSA 1 and 2) and Marri-Jarrah woodland (VSA 3) that would support this species throughout the study area. It is probably present at low densities in these areas.
- Water-rat or Rakali, CS2 (P4) – reported from along Gingin Brook in the mid 1980s (A. Blizzard pers. comm.) and may still be present in wetlands in the study area. There were five potential records (scats, feeding remains) of the Water-rat along the Hay Flat drainage line, although intensive motion-sensitive camera surveys in this area failed to detect the species.
- *Idiosoma mccllementsorum*, CS2 (P2) – previously included as *Idiosoma nigrum*, taxonomic revision has recently redefined this species-group (Rix *et al.* 2018). *Idiosoma mccllementsorum* almost certainly occurs within the study area in remnant bushland areas with sandy-gravel soils to the east. Two burrows that were believed to be of this species were located during targeted field investigations (Bancroft and Bamford 2018).
- Mogumber Bush Cricket, CS2 (P3) – two records of this species from the DBCA database were located c. 13 km to the north of the northern edge of the study area.
- Hooting Frog, CS3 (LS) – a population of Hooting Frogs was recorded by BCE in a creek approximately 3 km north of Bindoon. This represents the northernmost record for this

species. Targeted field investigations failed to detect the Hooting Frog. Included as CS3 because the species is at the edge of its range in the study area but, given that in the region it is generally associated with the Darling Scarp (Tyler and Doughty 2009; Bush *et al.* 2010), it is probably absent the study area (which, predominately, extends much further to the west).

- Whooping Frog, Ticking Frog, *Liopholis pulchra* and *Anilius pinguis*, CS3 (LS) – if present, these species would be at the northern extremity of their range. The two frogs were not detected in targeted field investigations and have distributions that probably end south of the study area (Tyler and Doughty 2009; ALA 2018).
- Carpet Python (south-west), CS3 (LS) – the south-western sub-species of the Carpet Python was until recently listed as Priority, and it remains at risk from Foxes and land clearing, especially near Perth. There are anecdotal accounts on the species in the Bindoon area, often near rocky breakaways such as occur in eucalypt woodland on lateritic soil.
- Rufous Treecreeper, CS3 (LS) – a species that has declined dramatically across much of the wheatbelt but occurs in some Wandoo areas around Bindoon (BCE records).
- Red-winged Fairy-wren, CS3 (LS) – an isolated population of this species occurs at Gingin (along parts of Gingin Brook). Red-winged Fairy-wrens have a strong preference for dense, riparian habitats. While small sections of this habitat type do occur within the study area, it is unlikely that there is sufficient connection to Gingin to enable the wren to persist in the study area.
- Crested Shrike-tit, CS3 (LS) – a species that has declined dramatically across much of the wheatbelt but may persist in areas of Wandoo around Bindoon.
- Restless Flycatcher, CS3 (LS) – BCE has previously recorded this species from Mooliabeenee/Cullalla Road and considers it to be an irregular visitor in the study area.
- Scarlet Robin and White-breasted Robin, CS3 (LS) – the project area is at the edge of the range for these species. Scarlet Robin was recorded during the field investigations.
- Yellow-footed Antechinus, Mardo, CS3 (LS) – as for the Brush-tailed Phascogale, this species' core distribution is in the Jarrah forest south of Gidgegannup. There are, however, outlying records from the vicinity of the study area. Targeted field investigations failed to detect this species. If present, the Yellow-footed Antechinus would be at the northern limit of its range.
- Brushtail Possum, CS3 (LS) – if present, this species would be at the northern extremity of its range. Targeted field investigations failed to detect this species.

Given the above information, a number of the conservation significant species (that are expected to occur in the vicinity of the study area) are of particular interest and/or significance. These are those which are of high conservation significance, and/or are known or highly likely to occur within the study area, and/or most susceptible to the potential likely impacts. The most at-risk species are:

- Forest Red-tailed Black-Cockatoo - CS1 (V,S3)
- Carnaby's Black-Cockatoo - CS1 (E,S2)
- Chuditch - CS1 (V,S3)
- Brush-tailed Phascogale, Wambenger - CS1 (S6)
- Rakali or Water-rat - CS2 (P4).

3.3 Patterns of biodiversity

Patterns of biodiversity can be interpreted from sample data, field observations (including trapping and census results) and the characteristics of the VSAs described above. The following several patterns of biodiversity can be concluded:

- There is a higher richness of reptiles and small mammals in banksia woodland on sand, mainly on the Dandaragan Plateau.
- There is a concentration of a range of species in or close to wetlands, including several of conservation significance. Wetlands in the south are likely to be most important in this respect.
- There are several significant mammal, reptile and bird species most likely in southern forested areas on lateritic soils (VSAs 3 and 4).
- Areas of Wandoo and Marri are most likely to be important for nesting black-cockatoos. Johnstone *et al.* (2013a) recorded 84% of Forest Red-tailed Black-Cockatoo nests in Marri. Black-cockatoos will use suitable hollows even in paddock trees, and therefore, paddock with remnant trees (VSA 8) can be important, despite being classified as degraded or degraded to completely degraded from a botanical perspective.
- Paddocks without trees have very low biodiversity and therefore should be used preferentially for the alignment where possible.

3.4 Ecological processes

The nature of the landscape and the fauna assemblage indicate some of the ecological processes that may be important for ecosystem function (see Appendix 4 for descriptions and other ecological processes). These include the aspects discussed below.

Local hydrology. The study area includes a range of drainage lines and wetlands, with areas of native vegetation that are intact from low in the landscape where plants are heavily water dependent, through to upland vegetation with reduced groundwater dependence. Some of the drainage lines in the north appear to be salt-affected. Alterations to local hydrology may affect vegetation condition (discussed below under impacts) and therefore fauna habitat.

Fire. Native vegetation throughout the study area is subject to fire and while appropriate fire regimes can benefit biodiversity, inappropriate regimes can lead to a loss of biodiversity. Current fire regimes probably involve fires at regular (<10 year) intervals.

Feral species and interactions with over-abundant native species. Feral species occur throughout Western Australia and are a major component of the current mammal fauna of the study area. They have contributed to local extinction and may be affecting populations of extant species. The landscape and vegetation has also been altered through grazing by feral species, such as the Rabbit, and by livestock. The impact of the clearly abundant Black Rat around wetlands is unknown, but it may affect both Quenda and native rodents. Some native species may be over-abundant due to the provision of watering points by pastoralists, and these may also have altered the environment and affected other species. Examples of currently over-abundant native species include the Grey

Kangaroo and the Galah; the latter may compete with black-cockatoos for nesting sites. The introduced Mosquitofish may have displaced native fish species from some wetlands.

Habitat degradation due to weed invasion. Levels of weed invasion are high in cleared and partly-cleared vegetation, and weed invasion is apparent along existing roads and boundaries between paddocks and native vegetation. Weed invasion can be exacerbated by earthworks and developments (discussed further in Section 4).

Connectivity and landscape permeability. The study area lies in a region with some habitat fragmentation due mainly to clearing for agriculture. Remnant vegetation is most extensive in the south and there are important linkages along narrow reserves, drainage lines and along roads.

3.5 Summary of fauna values

The desktop study identified 306 vertebrate fauna species as potentially occurring in the study area (eight freshwater fish, 17 frogs, 69 reptiles, 177 birds and 35 mammals, including 11 introduced mammals). The presence of at least 77 species (one freshwater fish, five frogs, three reptiles, 52 birds and at least 14 mammals) was confirmed during the field surveys (see Appendix 8). The vertebrate assemblage includes 45 species of conservation significance (Table 14).

Fauna assemblage. Moderately intact but with a suite of mammal species and a small number of reptile and bird species locally extinct. A distinctive feature of the assemblage is that it varies north-south with declining rainfall and associated changes in vegetation, and east-west in relation to major landform changes. Thus, the assemblage includes species at the extremes of their range (both northern and southern extremities) and species associated with particular environments.

Species of conservation significance. Of the 45 species of conservation significance recorded or that may be present, those of greatest interest because they are definitely or very likely to be present, and are likely to interact with the proposal, are: Forest Red-tailed Black-Cockatoo, Carnaby's Black-Cockatoo, Chuditch, Brush-tailed Phascogale and Water-rat.

Vegetation and Substrate Associations (VSAs). The study area passes through ten VSAs which vary north-south and east-west with rainfall and land systems. The VSAs include natural, partly degraded and almost completely degraded systems, and range from wetlands to upland forests and woodlands. Wetlands are restricted in extent but other VSAs are quite widespread regionally.

Patterns of biodiversity. Distinct patterns of biodiversity are expected due to the extent of the study area and the variety of VSAs through which it passes. Important areas include Banksia woodland on sand, southern forests on heavy soils, wetlands and areas with large Marri and/or Wandoo.

Key ecological processes. The ecological processes that currently have major effects upon the fauna assemblage include hydrology, the presence of feral species, fire, habitat degradation (due to weeds) and the partial fragmentation of the landscape due to clearing.

3.6 Black-Cockatoo habitat analysis

3.6.1 Breeding

3.6.1.1 Overview

A total of 11,361 potential nest-trees that met the hollow-bearing criteria of DEE (2018a, c) and DEE (2017) was recorded from the 3324 ha surveyed within the study area (see Figure 1 to 3). An additional 2804 potential nest-trees have been recorded in 871 ha outside of the current study area. Note that, hereafter, the analysis and discussion refer only to those 11,361 trees recorded within the study area.

At least sixteen species of potential nest-trees were recorded, as listed in Table 15. Three species accounted for almost 96% of trees: Marri, Jarrah and Wandoo (c. 44%, 27% and 25% of all potential nest-trees, respectively, as shown in Table 15). The assessment data (species, life status, DBH and nest-tree rank) for all trees are provided in separate electronic GIS files (shapefile format).

Table 15. Species and number of potential black-cockatoo nest-trees recorded within the study area.

Tree Species		Number of Trees
<i>Banksia littoralis</i>	Swamp Banksia	3
<i>Corymbia calophylla</i>	Marri	5006
<i>Corymbia citriodora</i>	Lemon Scented Gum	15
<i>Corymbia maculata</i>	Spotted Gum	1
<i>Eucalyptus camaldulensis</i>	River Red Gum	6
<i>Eucalyptus globulus</i>	Tasmanian Blue Gum	2
<i>Eucalyptus gomphocephala</i>	Tuart	1
<i>Eucalyptus loxophleba</i>	York Gum	1
<i>Eucalyptus marginata</i>	Jarrah	3037
<i>Eucalyptus rudis</i>	Flooded Gum	121
<i>Eucalyptus tottiana</i>	Coastal Blackbutt	258
<i>Eucalyptus wandoo</i>	Wandoo	2826
<i>Eucalyptus</i> sp.	Unidentified eucalypt	36
<i>Melaleuca preissiana/rhaphiophylla</i>	Stout/Swamp Paperbark	21
<i>Nuytsia floribunda</i>	Christmas Tree	8
<i>Pinus</i> sp.	Pine species	19
TOTAL		11 361

The numbers of potential nest-trees of each species recorded in each ranking category are shown in Table 16, and the locations of these trees are mapped in Figure 13 (northern study area) and Figure 14 (southern study area). The majority (c. 74.7%) of potential nest-trees surveyed did not have hollow

entrances suited to black-cockatoos that were observable from ground level. One active nest was located (Carnaby's Black-Cockatoo) and 69 trees (c 0.6% of all potential nest-trees, see Table 16) had evidence of hollow-entrance chewing by black-cockatoos and, therefore, are highly likely to be used for breeding. A further 1,159 trees (c. 10.2%, see Table 16) had potential black-cockatoo nesting hollows (but no sign of recent use).

The potentially black-cockatoo-suitable hollows in 26 trees (0.23% of all potential nest-trees) had been colonised by feral Honey Bees and, thus, rendered the trees unusable for breeding at the time of the surveys. The number of these trees in each species in each ranking category are presented in Table 16.

The DBH profile of the potential nest-trees within the study area is presented in Figure 15. While almost 40% of the trees that were measured had a DBH between 500 and 650 mm, this probably reflects a typical profile in the remnant woodlands of the area (i.e. given considerable clearing, logging and intensive land use).

Of the 11,361 potential nest-trees, 10,626 (93.5%) were live trees.

Table 16. The number of potential nest-trees of each species in each nest-tree rank category in the study area.

See Section 2.3.4.2 for full explanation of tree categories. Parentheses indicate the number of trees in that category that were unsuitable for use because of bee hives.

† 'Other' tree species: *Banksia littoralis*, *Corymbia citriodora*, *C. maculata*, *Eucalyptus camaldulensis*, *E. globulus*, *E. gomphocephala*, *E. loxophleba*, *Eucalyptus* sp., *Melaleuca preissiana/rhaphiophylla*, *Nuytsia floribunda* and *Pinus* sp.

Category	Number of Trees						TOTAL	Percentage (of Grand Total)
	Marri	Jarrah	Wandoo	Coastal Blackbutt	Flooded Gum	Other [†]		
1 Active nest.	1	-	-	-	-	-	1	0.01
2 Potential hollow with chew-marks.	42 (1)	17	10	-	-	-	69 (1)	0.61
3 Potential hollow, no chew marks.	466 (9)	405	230 (4)	51 (1)	4	3	1159 (14)	10.20
4 Potential hollow, unsuitable orientation.	665 (3)	565 (4)	320 (4)	74	11	11	1646 (11)	14.49
5 Sufficient DBH, no observable hollows.	3832	2050	2266	133	106	99	8486	74.69
TOTAL:	5006 (13)	3037 (4)	2826 (8)	258 (1)	121	113	11 361 (26)	100.00
Percentage (of Grand Total)	44.06	26.73	24.87	2.27	1.07	0.99	100.00	

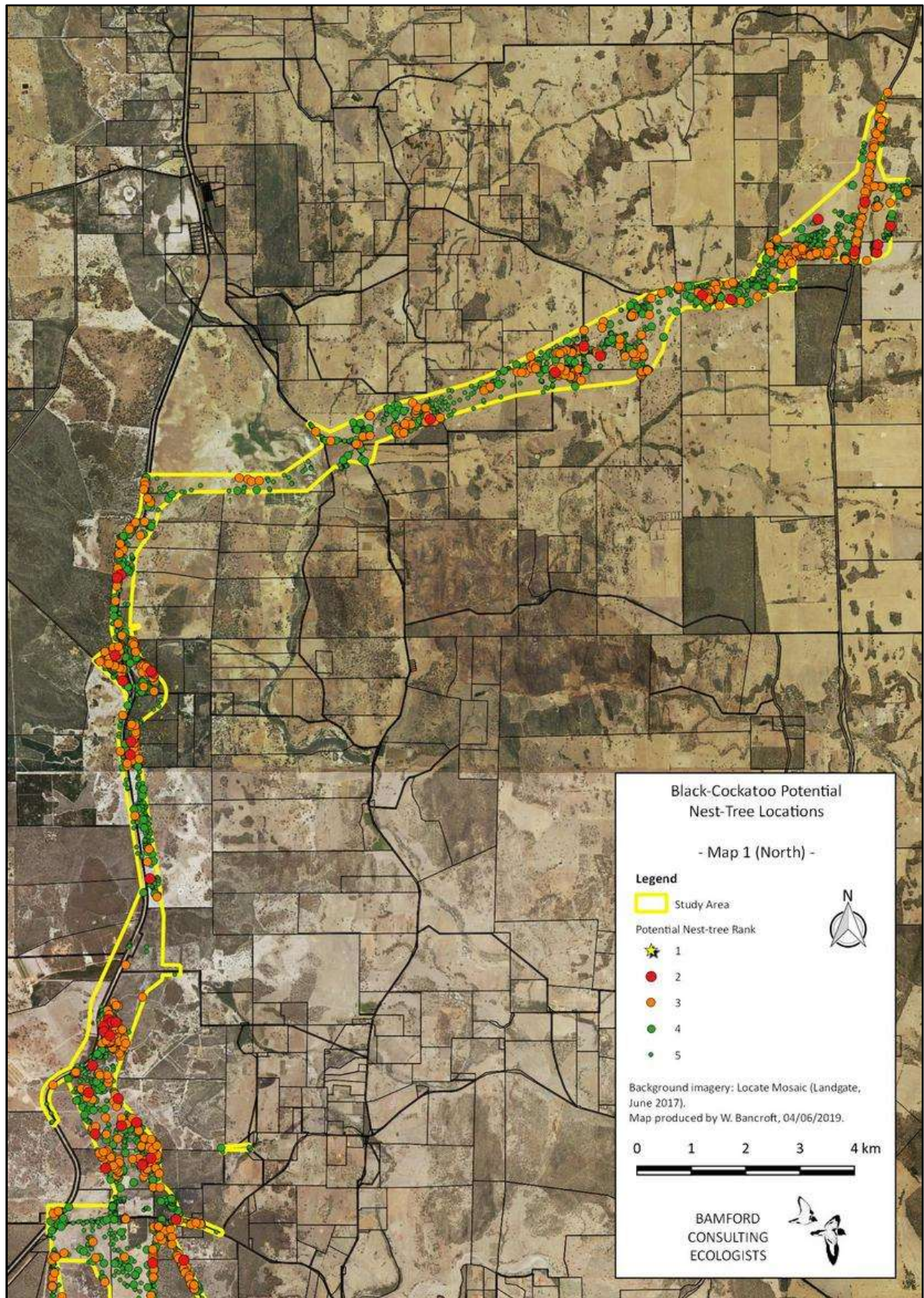


Figure 13. Location of potential nest-trees within the study area, as classified according to nest-tree rank (northern study area).

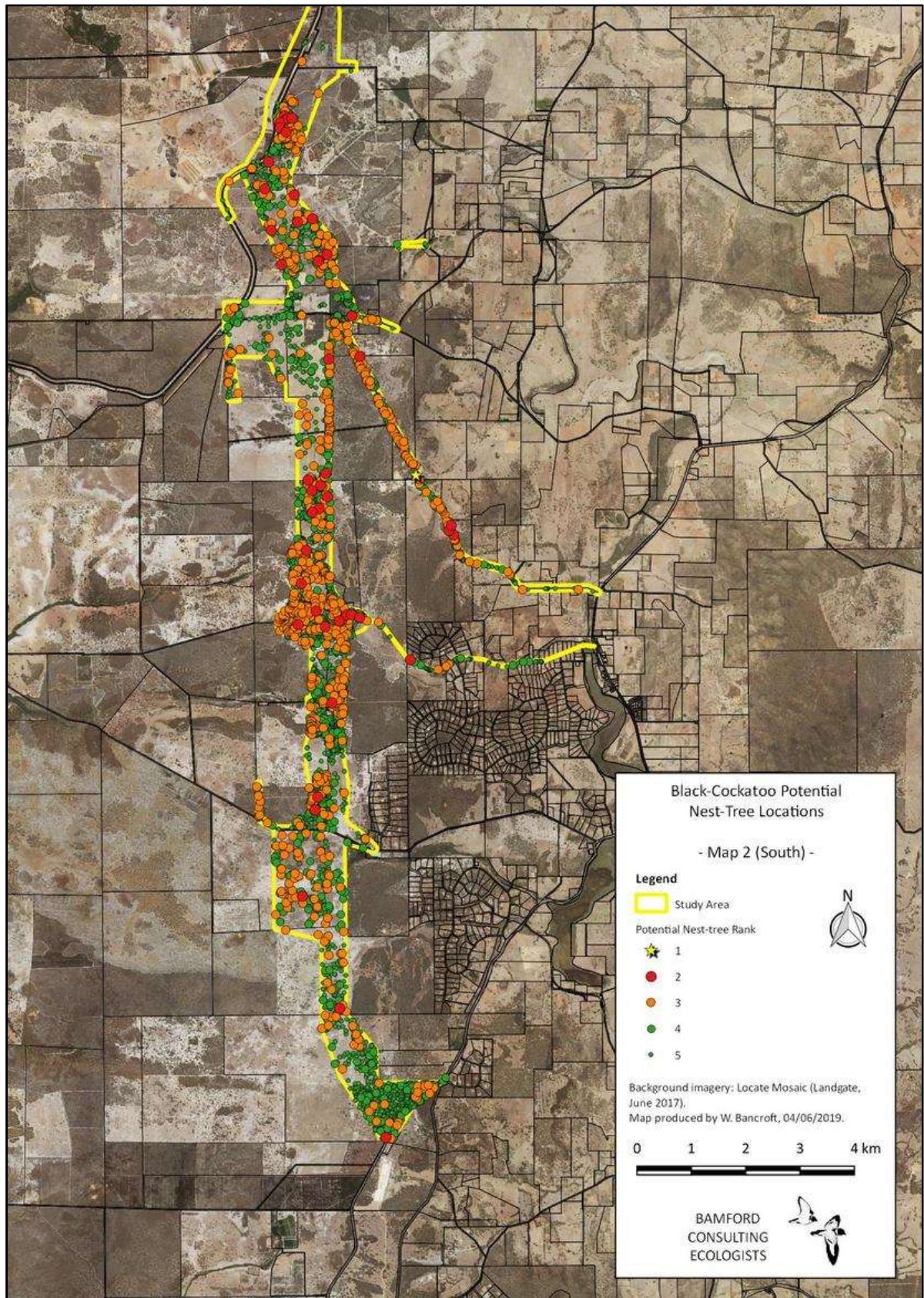


Figure 14. Location of potential nest-trees within the study area, as classified according to nest-tree rank (southern study area).

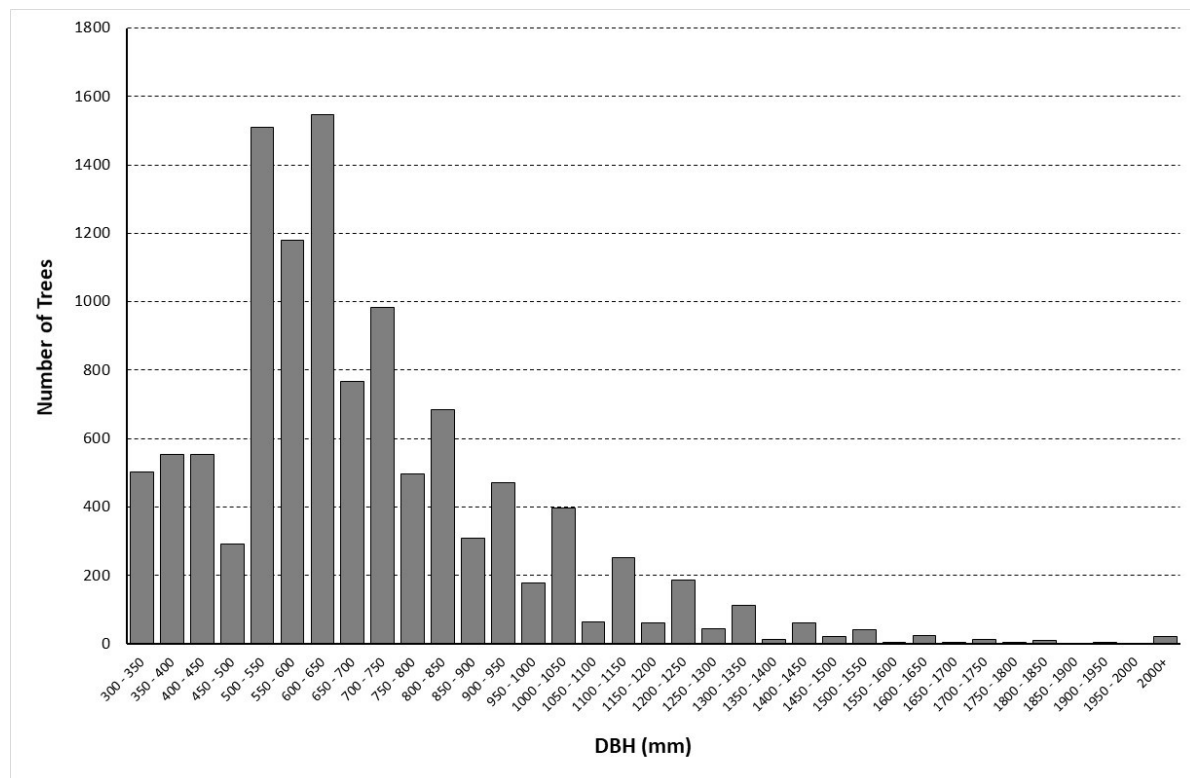


Figure 15. DBH profile of the potential black-cockatoo nest-trees within the study area.

3.6.1.2 Nest-trees and highly likely nest-trees (nest-tree rank categories 1 and 2)

The active Carnaby's Black-Cockatoo nest (Tree ID: 10,919) was a live Marri with a DBH of 1,050 mm, inspected on 10/10/2017. The female was inside the nest while the tree was inspected (mid-morning), with the male joining her at the nest-tree at a later stage. Both birds departed for a short period and, on return, the female resumed her position within the nest.

A summary of the trees that are highly likely to be nesting sites for black-cockatoos (nest-tree rank category 2) is presented in Table 17. These are trees that had evidence of chewing by black-cockatoos around the hollow entrance but which birds were not observed within the nest itself. The majority of these trees were Marri (c 61%), with the remainder Jarrah or Wandoo (see Table 17). This is a disproportionately higher representation of Marri than was observed in the general profile of potential nest-trees (c. 45% of all trees; Section 3.6.1.1 and Table 16), a similar proportion of Jarrah and a lower proportion of Wandoo.

The DBH profile of the highly likely nest-trees within the study area is presented in Figure 16. It is clear when this is compared with the general DBH profile of potential nest-trees (Figure 15) that there is a very strong preference for larger (more mature) trees. More than 70% of the highly likely nest-trees were greater than 800 mm DBH (c. 26% of all 'potential' trees).

These results strongly follow the findings of Johnstone *et al.* (2013a, b) that, for the Jarrah forest at least, large, old Marri trees are vitally important for black-cockatoo breeding biology.

Table 17. The number of trees of each species, and their life status, that were assessed as highly likely to be black-cockatoo nest sites (nest-tree rank category 2: evidence of black-cockatoo chew marks around the hollow entrance).

Percentages (of the grand total) are given in parentheses.

† one of the dead Marri trees had a hollow that had been colonised by feral Honey Bees.

Tree Species	Live	Dead	TOTAL
Marri	39 (56.5%)	3 (4.3%)†	42 (60.9%)
Jarrah	15 (21.7%)	2 (2.9%)	17 (24.6%)
Wandoo	6 (8.7%)	4 (5.8%)	10 (14.5%)
TOTAL	60 (87%)	9 (13.0%)	69 (100.0%)

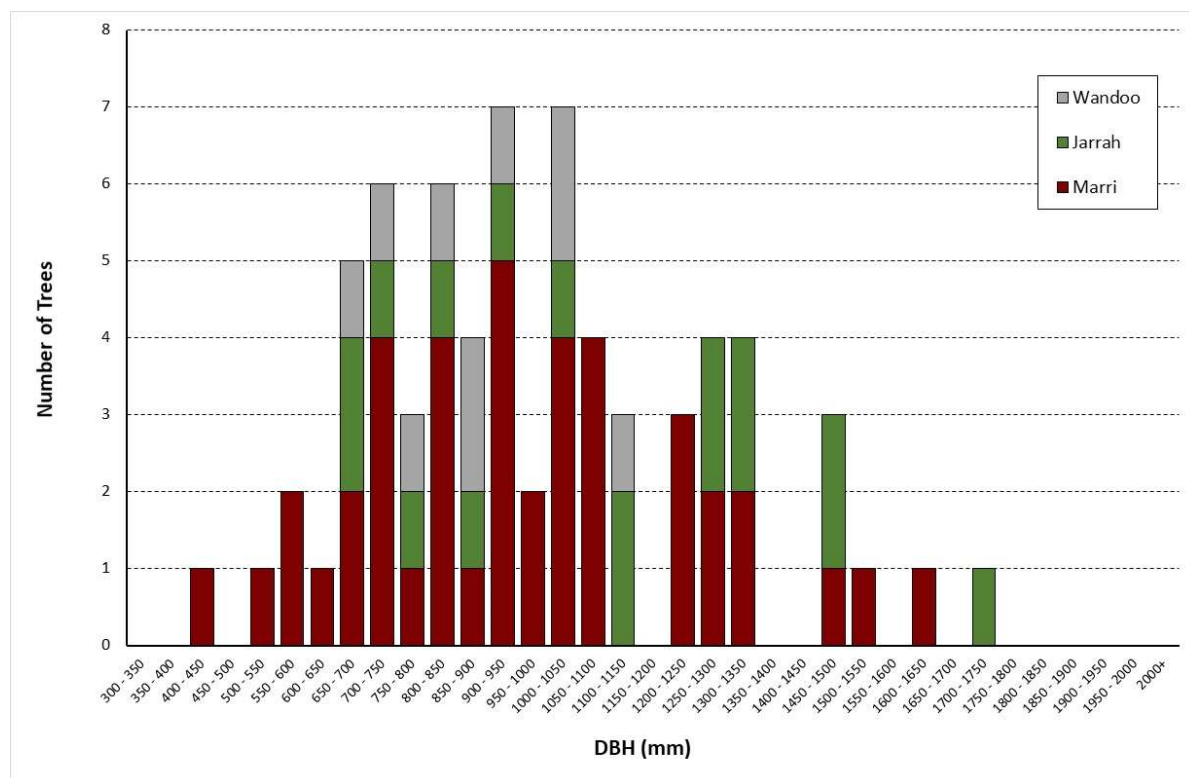


Figure 16. DBH profile of the highly likely (nest-tree rank category 2) black-cockatoo nest-trees within the study area.

3.6.2 Foraging

3.6.2.1 Forest Red-tailed Black-Cockatoo

Foraging habitat for Forest Red-tailed Black-Cockatoo was present throughout the study area. This is due to the occurrence of Marri and Jarrah, known to be mainstays of the Forest Red-tailed Black-Cockatoo diet (Johnstone and Kirkby 1999). These trees were present in variable densities (from absent to high) across the study area. Maps of vegetation scores of the study area for Forest Red-tailed Black-Cockatoo foraging are presented in Figure 17 (northern study area) and Figure 18 (southern study area). The areas (and percentages) of each vegetation score are shown in Table 18.

There are approximately 125,856 ha of remnant native vegetation within 15 km of the study area, which itself has c. 1230 ha of native vegetation (see Figure 19). Therefore, the site comprises c. 1% of the native vegetation in the 'local area' (as per the methods outlined in Section 2.3.4.3). It is almost certain that the Forest Red-tailed Black-Cockatoo breeds within the Corridor area, and as part of this study, active nests were found outside this area. Thus, a 'context' score of 2 (out of 3) has been assigned to the study area (see Section 2.3.4.3 and Appendix 6). The study area was assigned a species density score for Forest Red-tailed Black-Cockatoo of 1 (out of 1). These 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 18.

There was considerable evidence of foraging by Forest Red-tailed Black-Cockatoos throughout the southern two-thirds of the study area. A summary of the 118 foraging observations made during the nest-tree surveys is presented in Table 19 (see Appendix 11 for individual records) and mapped in Figure 20. The study area is, generally, moderate foraging habitat for Forest Red-tailed Black-Cockatoos and there was strong evidence to show that this species presently (and previously) uses the site for feeding.

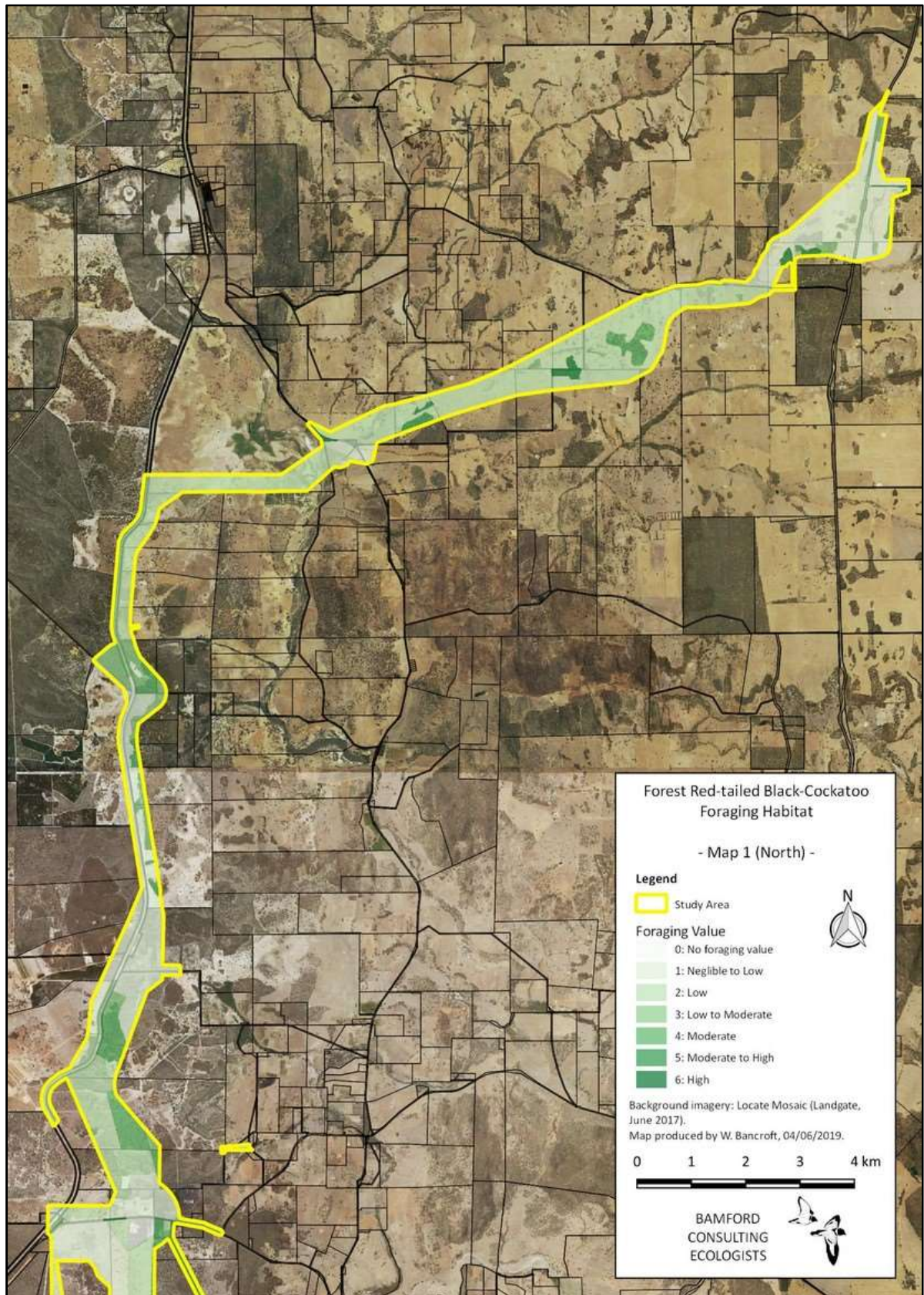


Figure 17. Distribution of Forest Red-tailed Black-Cockatoo foraging habitat (northern study area).

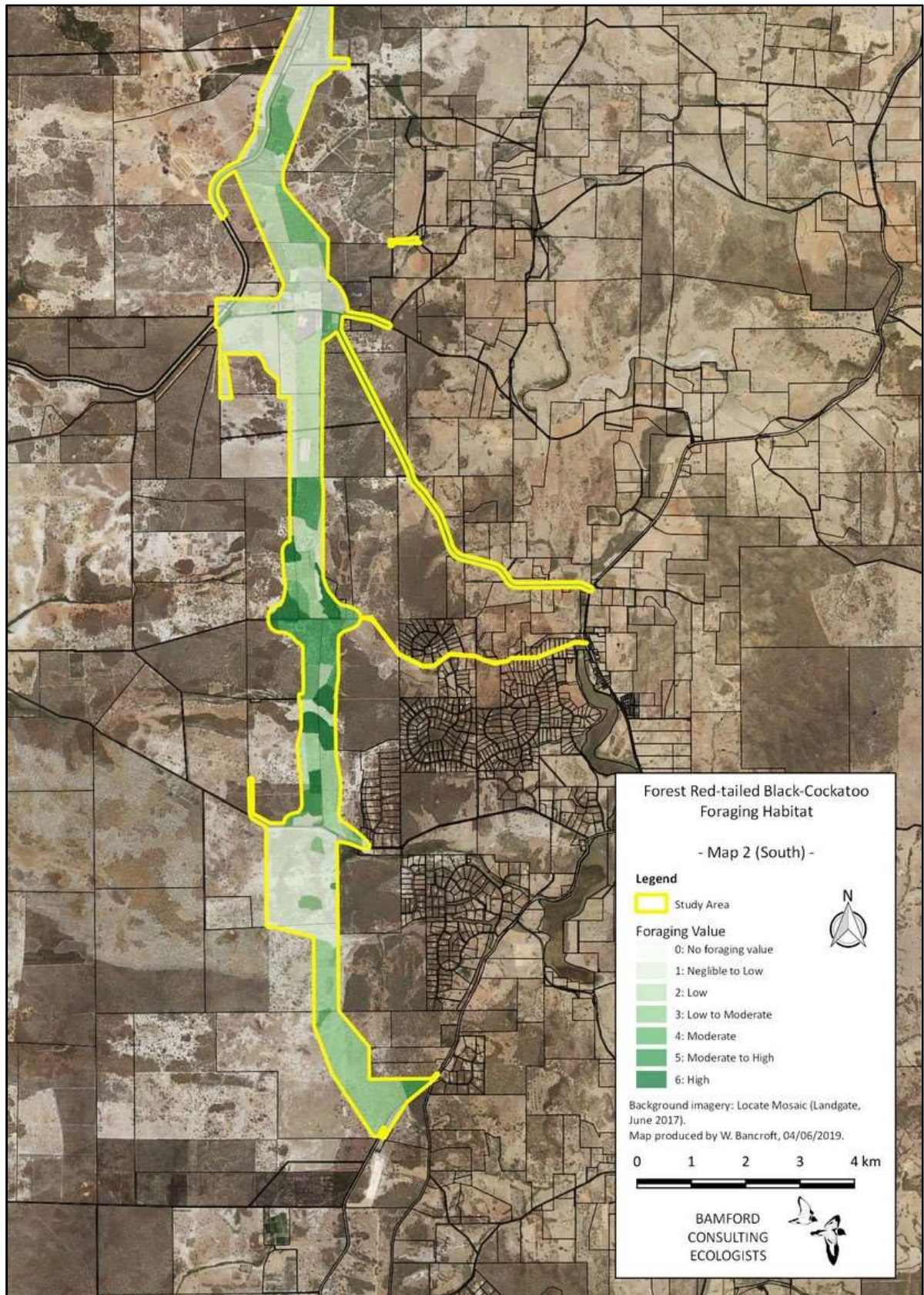


Figure 18. Distribution of Forest Red-tailed Black-Cockatoo foraging habitat (southern study area).

Table 18. Areas (ha) and proportions (%) of each category (vegetation score, combined foraging score) of foraging habitat at the study area for the three black-cockatoo species present in south-western Australia.

See Section 2.3.4.3 and Appendix 6 for explanation of vegetation, context, species density and (combined) foraging scores.

Vegetation Score/Value	Forest Red-tailed Black-Cockatoo		Carnaby's Black-Cockatoo		Baudin's Black-Cockatoo	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
6: High	112.7	3.3	183.2	5.3	-	-
5: Moderate to High	190.7	5.6	380.4	11.1	-	-
4: Moderate	275.4	8.0	580	16.9	-	-
3: Low to Moderate	540.7	15.8	323	9.4	-	-
2: Low	1153.2	33.6	1248.8	36.4	-	-
1: Negligible	1117.8	32.6	714.5	20.8	-	-
0: Nil	39.4	1.1	0	0	-	-
TOTAL	3429.9	100	3429.9	100	-	-
Context Score	2		2		-	
Species Density Score	1		1		-	
Foraging Score						
10	0	0.0	0	0.0	-	-
9	112.7	3.3	183.2	5.3	-	-
8	190.7	5.6	380.4	11.1	-	-
7	275.4	8.0	580	16.9	-	-
6	540.7	15.8	323	9.4	-	-
NA (Vegetation Score < 3)	2310.4	67.3	1963.3	57.2	-	-
TOTAL	3429.9	100	3429.9	100	-	-

Table 19. The number of black-cockatoo foraging records for each feed species (and age group).

See Table 15 for a list of feed species scientific names.

Forest Red-tailed Black-Cockatoo

Feed Species	Most Recent Age of Feed Sign				TOTAL
	Active	Recent	Intermediate	Old	
Jarrah	-	5	5	3	13
Marri	3	30	56	16	105
TOTAL	3	35	61	19	118

Carnaby's Black-Cockatoo

Feed Species	Most Recent Age of Feed Sign				TOTAL
	Active	Recent	Intermediate	Old	
Candlestick Banksia	-	1	6	9	16
Coastal Blackbutt	-	1	-	-	1
Firewood Banksia	-	-	-	1	1
Jarrah	-	4	2	-	6
Marri	1	16	50	11	78
Parrot Bush	-	2	-	-	2
Unspecified banksia	-	-	6	-	6
Unspecified	-	8	2	-	10
TOTAL	1	32	66	21	120

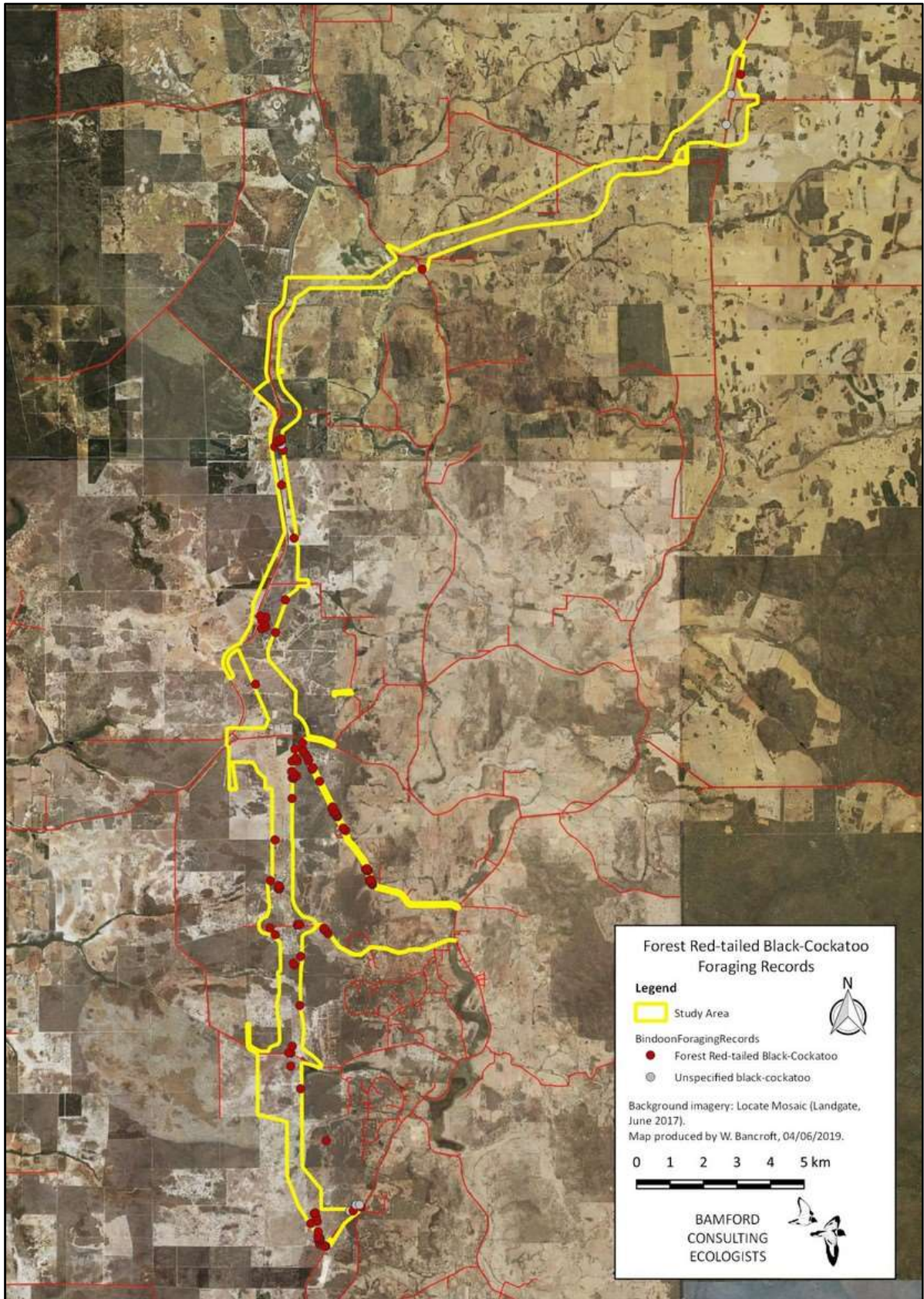


Figure 20. Distribution of Forest Red-tailed Black-Cockatoo foraging records within the study area.

3.6.2.2 Carnaby's Black-Cockatoo

Foraging habitat for Carnaby's Black-Cockatoo was present throughout the study area. This is predominantly due to the presence of several plant species known to be mainstays of the Carnaby's Black-Cockatoo diet including *Banksia attenuata*, *B. menziesii*, *B. sessilis* and Marri (Groom 2011). These trees were present in variable densities across the study area. Maps of vegetation scores of the study area for Carnaby's Black-Cockatoo foraging are presented in Figure 21 (northern study area) and Figure 22 (southern study area). The areas (and percentages) of each vegetation score are shown in Table 18.

There are approximately 125,856 ha of remnant native vegetation within 15 km of the study area, which itself has c. 1230 ha of native vegetation (see Figure 19). Therefore, the site comprises c. 1% of the native vegetation in the 'local area' (as per the methods outlined in Section 2.3.4.3). It is known that Carnaby's Black-Cockatoo breeds within the study area as evidenced by the active nest recorded during the surveys. Thus, a 'context' score of 2 (out of 3) has been assigned to the study area (see Section 2.3.4.3 and Appendix 6). The study area was assigned a species density score for Carnaby's Black-Cockatoo of 1 (out of 1). These 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 18.

There was considerable evidence of foraging by Carnaby's Black-Cockatoos throughout the study area. A summary of the 115 foraging observations made during the nest-tree surveys is presented in Table 19 (see Appendix 11 for individual records) and the observations are mapped in Figure 23. These comprised c. 65% Marri and c. 22% *Banksia* species and included most ages of evidence (recent, intermediate and old), suggesting a history of foraging activity at the site.

The study area is, generally, moderate value foraging habitat for Carnaby's Black-Cockatoos and there was strong evidence to show that this species presently (and previously) uses the site for feeding.

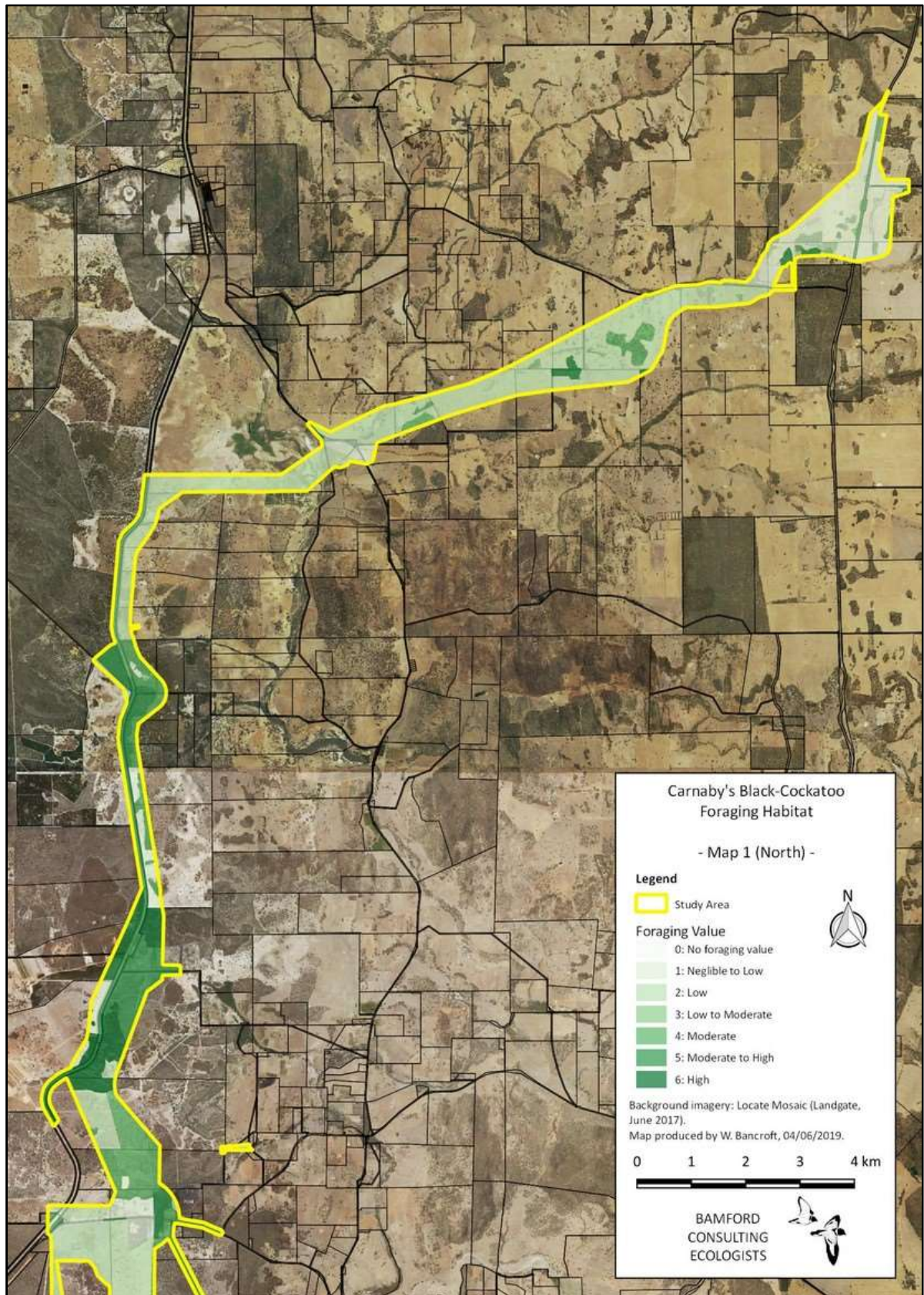


Figure 21. Distribution of Carnaby's Black-Cockatoo foraging habitat (northern study area).

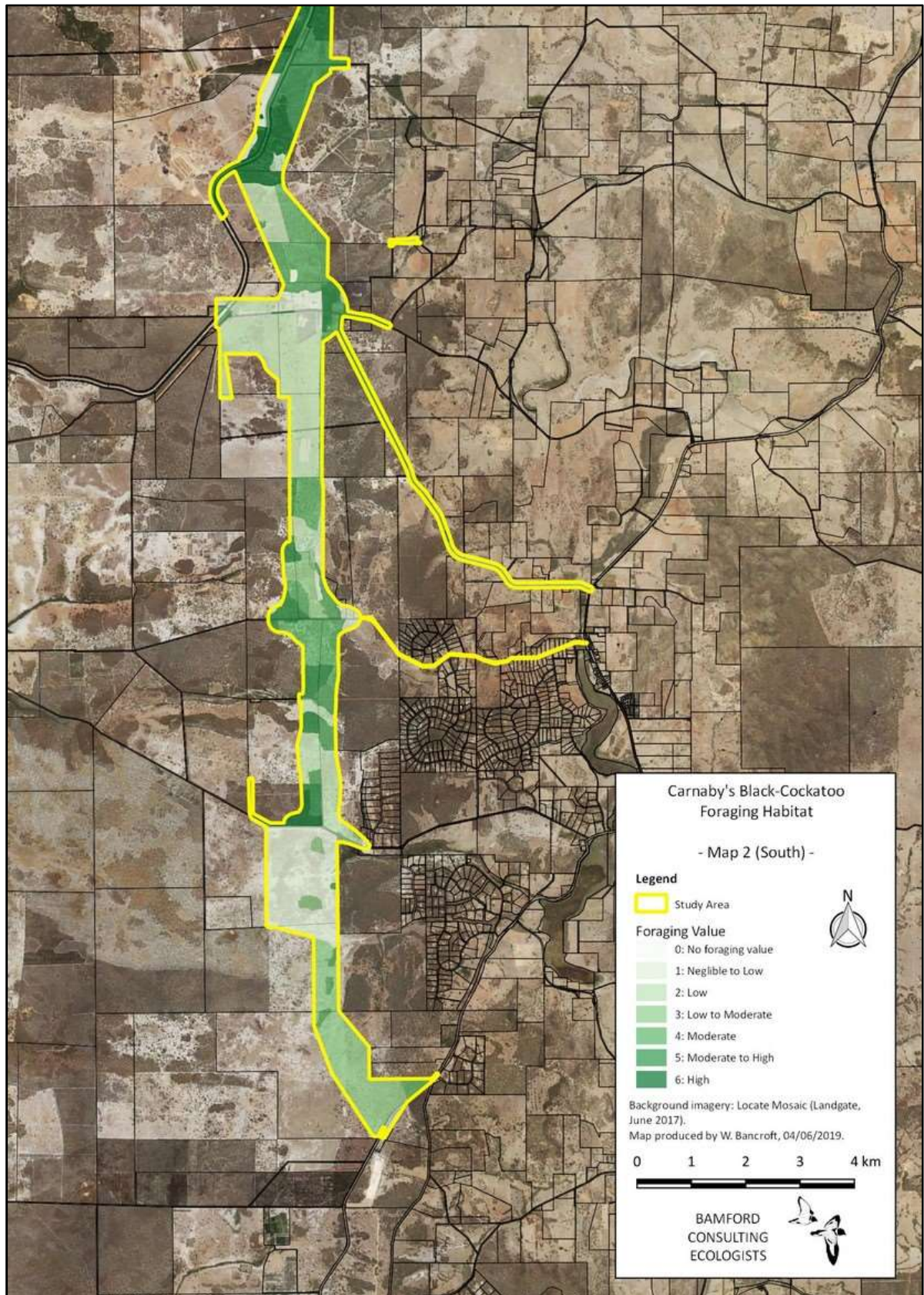


Figure 22. Distribution of Carnaby's Black-Cockatoo foraging habitat (southern study area).

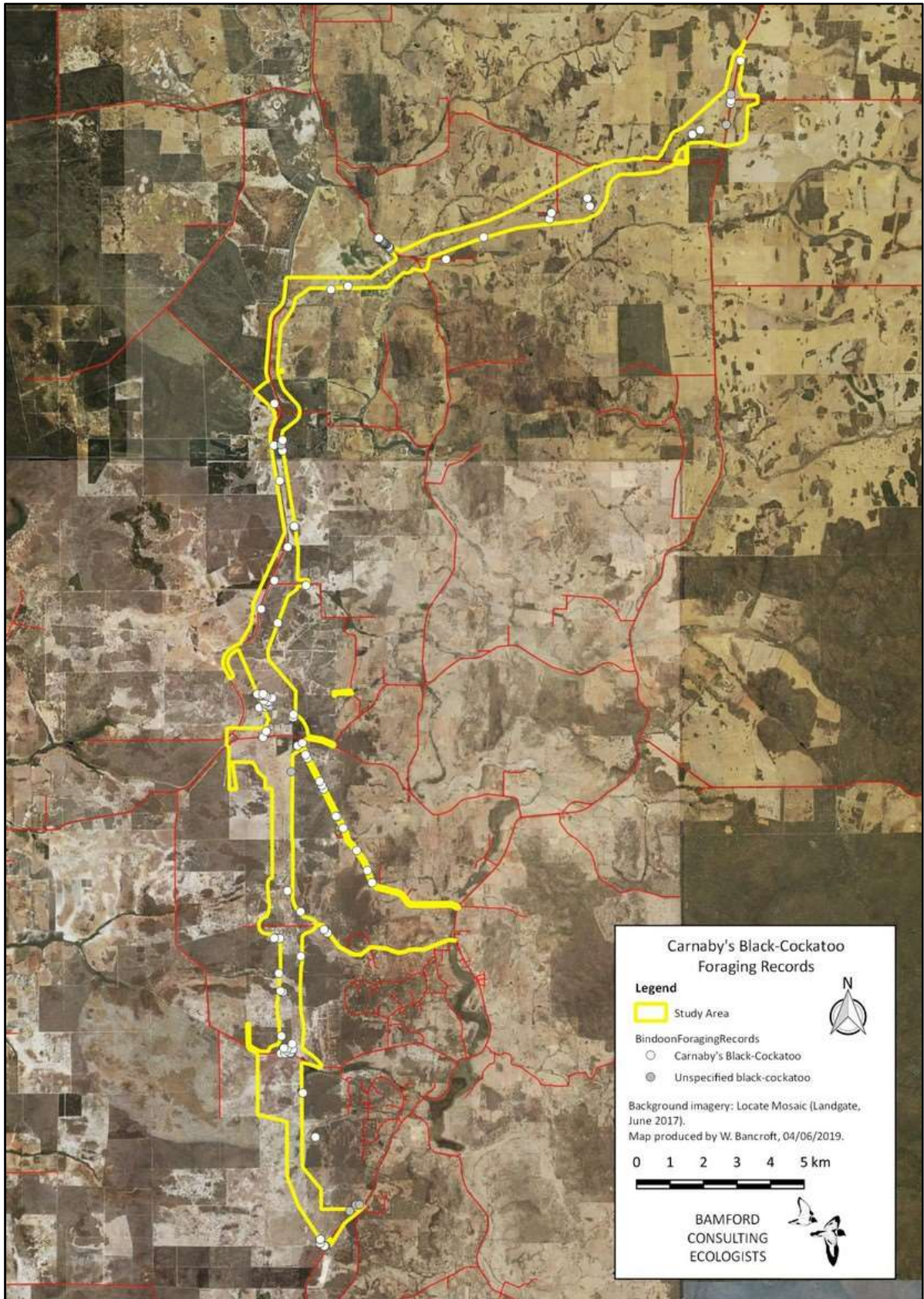


Figure 23. Distribution of Carnaby's Black-Cockatoo foraging records within the study area.

3.6.3 Roosting

The locations of the black-cockatoo roost survey sites are mapped in Figure 24. The surveys identified three black-cockatoo roost sites, all of Forest Red-tailed Black-Cockatoos, in the vicinity of the study area, as listed in Table 20. These roosts are mapped in Figure 24, along with previously known (or likely) roost locations from the Great Cocky Count database (Peck *et al.* 2016).

Table 20. Black-cockatoo roost sites located during the roosting surveys.

Datum: GDA94. UTM Zone: 50J.

Roost Name	Easting	Northing	Notes
FRTBC Roost 01	409523	6528468	Forest Red-tailed Black-Cockatoo roost site located in paddock trees and remnant woodland north-east of the cemetery on Gray Road on 09/04/2017. The location is the specific roost tree (Marri, 500 mm DBH) for three of up to 10-15 birds that roosted in this general area. The roost was revisited again on 31/05/2017 but no birds were present on this occasion.
FRTBC Roost 02	410943	6523339	Forest Red-tailed Black-Cockatoo roost site located in remnant woodland between Cockatoo Road and Warbler Court on 17/05/2017. The location is approximate, with 10-15 birds roosting in smaller parties along a c. 100 m strip of the woodland. The roost was revisited again on 31/05/2017, with at least five birds present.
FRTBC Roost 03	410137	6533310	Forest Red-tailed Black-Cockatoo roost site located in in paddock trees and remnant woodland south of the Mooliabeenee Road/Glover-Wells Road intersection. The location is approximate, with 20-30 birds (possibly more) roosting in smaller parties in this area.

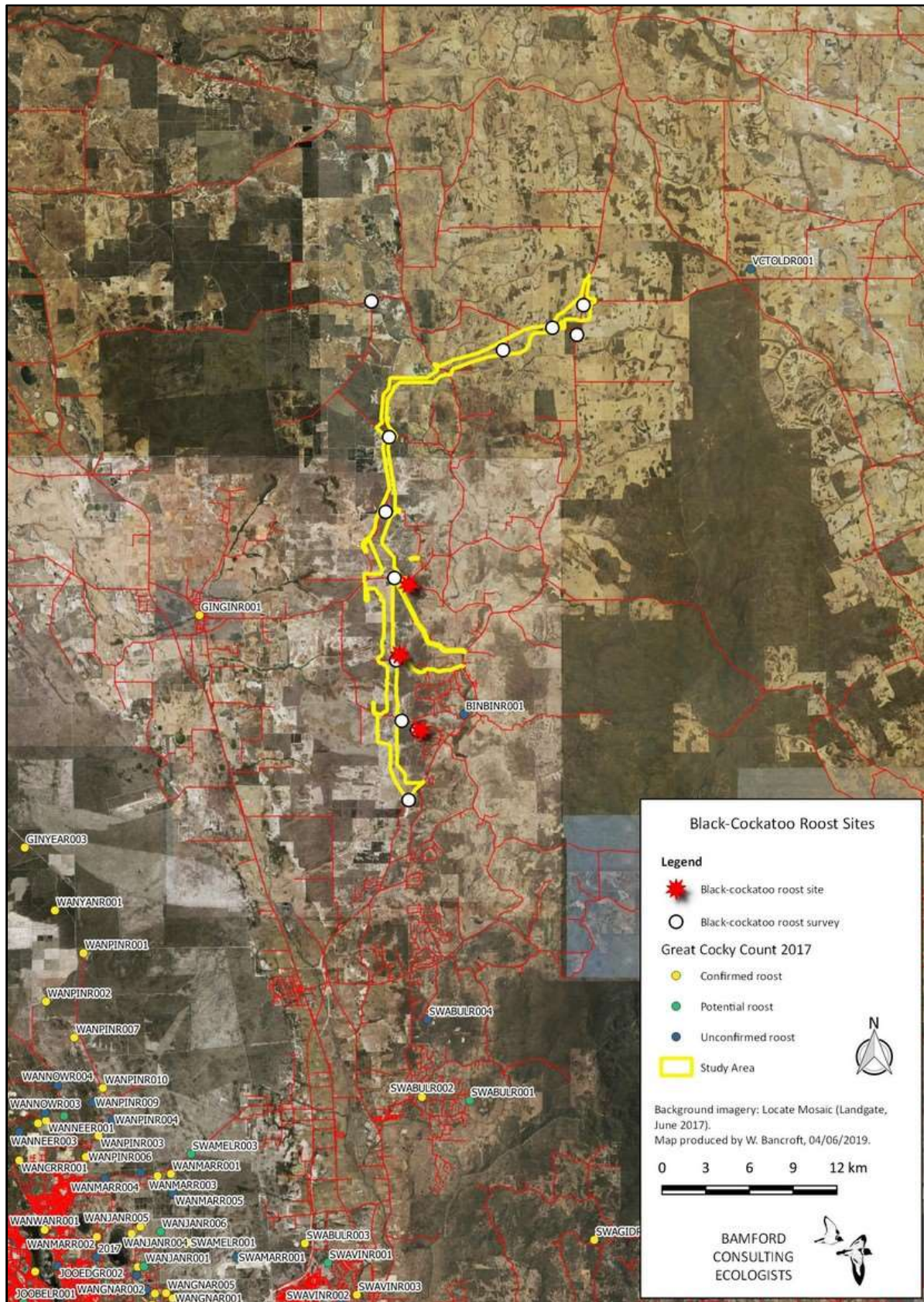


Figure 24. Black-cockatoo roost survey sites, black-cockatoo roosts (this project; green symbols) and previously known black-cockatoo roost locations in the vicinity of the study area (Great Cocky Count data; red, yellow and orange symbols).

3.7 Motion-sensitive camera surveys for mammals

None of the targeted species of mammals was recorded in the motion-sensitive camera surveys. Notably, intensive sampling of the drainage line along Hay Flat Road and into Udumung Nature Reserve (see Figure 4) failed to detect Rakali (Water-rat); although some evidence of this species was observed (as outlined in Section 3.14). Eight species of fauna were recorded from the cameras, as summarised in Table 21. Only three of these were native species (Splendid Fairy-wren, Echidna and Western Grey Kangaroo).

Table 21. Species recorded in the motion-sensitive camera surveys.

Species	Number of camera locations in which species was recorded
Splendid Fairy-wren <i>Malurus splendens</i>	4
Echidna <i>Tachyglossus aculeatus</i>	1
Western Grey Kangaroo <i>Macropus fuliginosus melanops</i>	9
House Mouse <i>Mus musculus</i>	1
Black Rat ⁵ <i>Rattus rattus</i>	9
Unidentified rodent	4
Red Fox <i>Vulpes vulpes</i>	2
Cat <i>Felis catus</i>	1
Cow <i>Bos taurus</i>	2

3.8 Call-playback surveys for owls

No owls of any species (including the targets: Barking Owl and Masked Owl) were recorded in the call-playback surveys.

It is still possible that the Barking Owl is present in the vicinity of the project area, however it was considered by Bancroft *et al.* (2017) to be of low concern with respect to impact during project development. The Masked Owl is almost certainly locally extinct (Bancroft *et al.* 2017), with the northern limit of its known range near Yanchep, some 40 km to the south-west of the project envelope (Johnstone and Storr 1998).

3.9 Aquatic surveys

The only native freshwater fish recorded was the Western Minnow (*Galaxia occidentalis*) in the Hay Flat drainage line. It was coexisting with the introduced Mosquitofish (*Gambusia holbrooki*), which

⁵ also recorded in motion-sensitive camera surveys by Bancroft *et al.* (2017).

was also present in the Teatree Road wetland and Lake Chittering. There was no evidence of Carter's Freshwater Mussel.

Beatty *et al.* (2010) conducted an extensive freshwater fish and mussel survey in the region (in the Brockman River and Ellen Brook catchments, but not the Gingin Brook catchment, but this latter has previously been sampled by BCE), with sampling sites in the project area at Udumung (Hay flat drainage), Cook Road and Bindoon. They have also sampled more extensively in the region previously. Their data, records collected in the current survey and previous studies by BCE make possible the following summary of observations relevant to the current assessment:

- Western Minnow – Widespread in the Brockman and Ellen catchments and thus through the current project area.
- Mud Minnow *Galaxiella munda* – Recorded only in Lennard Brook of the Ellen Brook Catchment (but recorded further south along Ellen Brook (Lake Chandala and constructed wetlands near Muchea by Bamford Consulting (BCE database) in 2005. These locations are well south of the current project area and thus the species is considered not to be present.
- Black-striped Minnow *Galaxiella nigrostriata* – Recorded in Lake Chandala and Melaleuca Park and thus well south of the current project area.
- Western Pygmy-perch *Edelia vittata* – Present in Ellen Brook and with few records in the lower Brockman River, probably due to salinization. Present in Gingin Brook at least as far upstream as Gingin townsite (BCE database). The species is thus present in permanent waters in the south of the current project area.
- Nightfish *Bostockia porosa* – Present in both the Brockman and Ellen catchments, although patchily distributed. More tolerant of salinity than the Pygmy-perch with records in the Brockman River as far north as Cook Road. The species is thus present in permanent waters across much of the current project area.
- Freshwater Cobbler *Tandanus bostocki* – Present in the Brockman River with historic records in Gingin Brook.
- Western Hardyhead *Leptatherina wallacei* – A mostly brackish water species present in both Ellen Brook and the Brockman River, and thus present in the current project area.
- Swan River Goby *Pseudogobius olorum* – A brackish water species present in both Ellen Brook and the Brockman River, and thus present in the current project area.
- Mosquitofish (introduced) – Throughout all catchments.
- Goldfish *Carassius auratus* (introduced) – Present in the lower reaches of Ellen Brook and some records from the Brockman River, but may not be a permanent resident.
- Carter's Freshwater Mussel – Recorded at only three locations along the lower Ellen Brook and one location along the lower Brockman River (Marbling Brook); also present in Gingin Brook just downstream of Gingin (BCE records). Probably due to salinization, the species appears to be extinct along much of Brockman River and may thus be absent from the current project area.

The native freshwater fish present in the study area are the Western Minnow (widespread), Western Pygmy-perch (limited distribution in south), Nightfish (widespread but patchy), Freshwater Cobbler, Western Hardyhead (widespread) and Swan River Goby (widespread). Carter's Freshwater Mussel

may be extinct in the project area. Of these, the Nightfish and Freshwater Cobbler are considered of CS3 (i.e. locally significant), while Carter's Freshwater Mussel is of CS1 (listed under legislation).

3.10 Aural surveys for frogs

Seven species of frog were recorded across 21 of the 23 survey sites, as shown in Table 22. The three target species (Hooting Frog, Whooping Frog and Ticking Frog) were not recorded. These species were all listed as conservation significance level CS3 by Bancroft *et al.* (2017) because, if present, would be at the extremity of their range. The results of the aural frog surveys suggest that they may not be present within the project area. The nearest record of the Hooting Frog is from about 5 km north-east (and therefore east of the existing Great Northern Highway) of the Bindoon town site in 2011 (BCE database).

A further three species (Slender Tree Frog, *Litoria adelaidensis*; Motorbike Frog, *Litoria moorei*; and Western Banjo Frog, *Limnodynastes dorsalis*) had all been recorded at the Teatree Road wetland site by Bancroft *et al.* (2017). Therefore, ten of the 17 species that are expected to occur the region (Bancroft *et al.* 2017) have now been recorded in the vicinity of the project area.

Table 22. Frog species recorded at each frog survey site.

Where recorded, the numbers (usually range or minima) of frogs heard calling are noted.

Frog Site	Species						
	Western Spotted Frog <i>Heleioporus albopunctatus</i>	Moaning Frog <i>Heleioporus eyrei</i>	Quacking Frog <i>Crinia georgiana</i>	Clicking Frog <i>Crinia glauerti</i>	Squelching Froglet <i>Crinia insignifera</i>	Bleating Froglet <i>Crinia pseudinsignifera</i>	Crawling Toadlet <i>Pseudophyrne guentheri</i>
Cockatoo Road 01	-	3-5	-	-	10-20	-	5-10
Cockatoo Road 02	-	-	10-15	5+	-	-	-
Teatree Road Wetland	-	-	10-15	5-10	-	-	-
Lake Needoonga Central	-	-	-	-	-	-	-
Lake Needoonga North	-	30+	-	-	-	-	-
Gray Road 03	-	20-40	-	-	2	-	4+
Lake Nangar	-	30+	-	-	10	-	-
Cook Road 02	-	Present	-	-	-	Present	-
Cook Road 03	-	-	Present	-	-	Present	-
Cullalla Road	-	Present	-	-	-	-	-

Frog Site	Species						
	Western Spotted Frog <i>Heleioporus albopunctatus</i>	Moaning Frog <i>Heleioporus eyrei</i>	Quacking Frog <i>Crinia georgiana</i>	Clicking Frog <i>Crinia glauerti</i>	Squelching Froglet <i>Crinia insignifera</i>	Bleating Froglet <i>Crinia pseudinsignifera</i>	Crawling Toadlet <i>Pseudophryne guentheri</i>
Gingilling Road	-	Present	-	-	-	Present	-
Kangaroo Gully Road 01	Present	-	-	-	-	-	-
Kangaroo Gully Road 02	Present	-	Present	-	-	-	-
Bindoon-Moora Road	Present	Present	Present	-	-	-	-
Head Road 01	-	-	-	-	-	-	-
Wannamal South Road	-	Present	-	-	-	-	-
Hay Flat Road 01	-	-	Present	-	-	-	-
Hay Flat Road 02	1	-	-	-	-	2	10+
Hay Flat Road 03	2	-	-	-	-	2	20+
Udumung Nature Reserve 01	-	-	-	-	-	-	5-8
Wannamal West Road 01	-	Present	Present	-	-	-	-
Wannamal West Road 02	-	Present	Present	-	-	-	-
Calingiri West Road	-	-	-	-	-	-	5-10

3.11 Short-range endemic invertebrate collection

Millipedes were collected at three locations by Bancroft *et al.* (2018) and several of the specimens represented one or more species that could not be identified and were considered to be potential SREs (V. Framenau pers. comm.). Details of locations and taxa are:

Gingilling Road, Bindoon

31°13'28.08"E; 116°02'17.52"E.

Antichiropus variabilis (widespread and not an SRE)

Antichiropus sp. (unidentified and possible SRE).

Gray Road, Bindoon

31°22'48.66"E; 116°02'19.32"E.

Antichiropus sp. (unidentified and possible SRE).

Egret Place, Chittering

31°26'34.22"E; 116°03'47.77"E.

Antichiropus sp. (possibly *A. variabilis* but could be an undescribed and possibly an SRE).

It is not clear, without further collection, if the unidentified *Antichiropus* millipedes from the three locations are the same taxon, or represent two or even three distinct taxa. Their status as SREs is also unknown and the landscapes where investigations have been carried out do not have the sorts of features usually associated with the evolution of SRE taxa. Lack of collection can give the appearance of a species having a very restricted range, and an important consideration with respect to these invertebrates is the level of risk actually presented by the proposed development.

Additionally, three millipedes were collected, opportunistically, during the field investigations of Bancroft and Bamford (2018):

One collected in Jarrah-Marri woodland near the Chittering Cemetery on Gray Road (31° 22' 36.11" S, 116° 02' 40.64" E) was identified as *Antichiropus variabilis*. This is a widespread species.

Two collected in Jarrah-Marri woodland south-west of Cockatoo Road (31° 25' 59.06" S, 116° 02' 59.85" E) were identified as *Antichiropus* 'UBS2' (UBS - Urban Bushland Survey). This species is considered to be a short-range endemic species around Perth but has been collected as far south as Bibra Lake (V. Framinau pers. comm.). It is therefore not restricted to the Bindoon Bypass study area.

3.12 Acoustic surveys for bats

At least four species of bat were recorded in the acoustic surveys, as indicated in Table 23. None of these species is of conservation significance (Bancroft *et al.* 2017). The only conservation significant bat species to occur in the Northern Jarrah Forest and Dandaragan Plateau biosubregions (see Section 1.3.1) is the Western False Pipistrelle (*Falsistrellus mackenziei*). This species was not listed as expected in the vicinity of the project area by Bancroft *et al.* (2017) because its known range is south of the Swan River (ALA 2018), and it was not detected in the acoustic surveys here. It almost certainly does not occur in the study area.

Table 23. The number of call sequences of each bat species recorded at each bat survey site.

[†] call analysis was unable to identify the *Nyctophilus* calls to species level (three species may occur in the study area: Lesser Long-eared Bat, *N. geoffroyi geoffroyi*; Gould's Long-eared Bat, *N. gouldi*; and Greater Long-eared Bat, *N. major major*).

Bat Site	Species				
	White-striped Free-tailed Bat <i>Austronomus australis</i>	Gould's Wattled Bat <i>Chalinolobus gouldii</i>	<i>Nyctophilus</i> spp. [†]	Southern Forest Bat <i>Vespadelus regulus</i>	
South of Corella Road		60	5		
Hay Flat Road 04	1	52		4	

3.13 Surveys for shield-backed trapdoor spiders

3.13.1 Field investigations

Two *Idiosoma* burrows were located within the Bindoon Bypass study area, one at the Head Road site and one at the Gray Road 02 site. While species cannot be determined on burrow architecture alone, it is almost certain that, based on the surrounding soil and vegetation type, these were *I. mcclementsorum*. The burrow locations are plotted in Figure 25 and a description of each follows.

Burrow 01. (Figure 26).

416554 E, 6549312 N (GDA94, MGA z50). Remnant bushland off Head Road. The burrow was constructed in (grey) sandy and (exposed, surface-) lateritic-gravelly soil surrounded by *Calothamnus* heath with shrub *Banksia* sp. and Balga (Grasstrees *Xanthorrhoea preissii*), and an adjacent over-storey of Marri (*Corymbia calophylla*) and/or Wandoo (*Eucalyptus wandoo*). See Figure 28 for a photograph of the surrounding vegetation and soil association.

The burrow door adornments were comprised of leaf fragments (Marri/Wandoo and shrub *Banksia* sp.) and twigs; and the twig-lines were comprised of twigs (presumably Marri/Wandoo) and the leaf-stalks of Marri/Wandoo leaves (with the leaf attached at the distal end). See Figure 26 for burrow photographs. The burrow opened to the south-east. Internal lumen diameter was c. 21mm and burrow depth (as assessed with a milliscope) was greater than 150 mm. There was a very strongly defined constriction in the burrow tube approximately 50 mm below the ground level (see bottom photograph in Figure 26).

The burrow appeared to be active. On examination with the milliscope, the base of the burrow could not be reached due to a slight bend, and no spider was observed.

Burrow 02. (Figure 27).

408366 E, 6528190 N (GDA94, MGA z50). Remnant bushland off Gray Road. The burrow was constructed in (white) sandy and (exposed, surface-) lateritic-gravelly soil (with some minor lateritic outcropping) surrounded by *Hypocalymma-Calothamnus* heath with *Banksia sessilis* shrubs and numerous Balga, and an adjacent over-storey of Marri and Jarrah (*Eucalyptus marginata*). See Figure 28 for a photograph of the surrounding vegetation and soil association.

The burrow door adornments were comprised of small (whole) leaves (from surrounding shrubs) and twigs; and the twig-lines were comprised almost entirely of twigs. See Figure 27 for burrow photographs. The burrow opened to the south-east. Internal lumen diameter was c. 15 mm. Burrow depth was not determined.

The burrow appeared to be active. Milliscope malfunction prevented the internal examination of this burrow.

3.13.2 Conclusions

Two species of shield-backed spider are likely to occur within the Bindoon Bypass study area. One of these, *Idiosoma sigillatum*, is not presently listed as a conservation-significant species and was not specifically searched for in the field investigations documented here. It is highly likely to be present

in areas of Banksia Woodland with sand as the substrate. *I. maclemeysorum* is ranked as a Priority 2 species by DBCA and almost certainly occurs within the Bindoon Bypass study area in remnant bushland areas with sandy-gravel soils. Two burrows that are believed to be of this species were located during the field investigations. While conclusive identification requires the examination of the spiders themselves, the vegetation and soil associations at these sites match habitat descriptions provided in the literature for *I. maclemeysorum* (Rix *et al.* 2018).

Spatial analysis of known *I. maclemeysorum* records (provided by the WA Museum) in conjunction with regional soil mapping (Purdie *et al.* 2004) has enabled the production of a predictive model for the likely distribution of *I. maclemeysorum* in the vicinity of the Bindoon Bypass study area. This potential distribution map is presented in Figure 10.

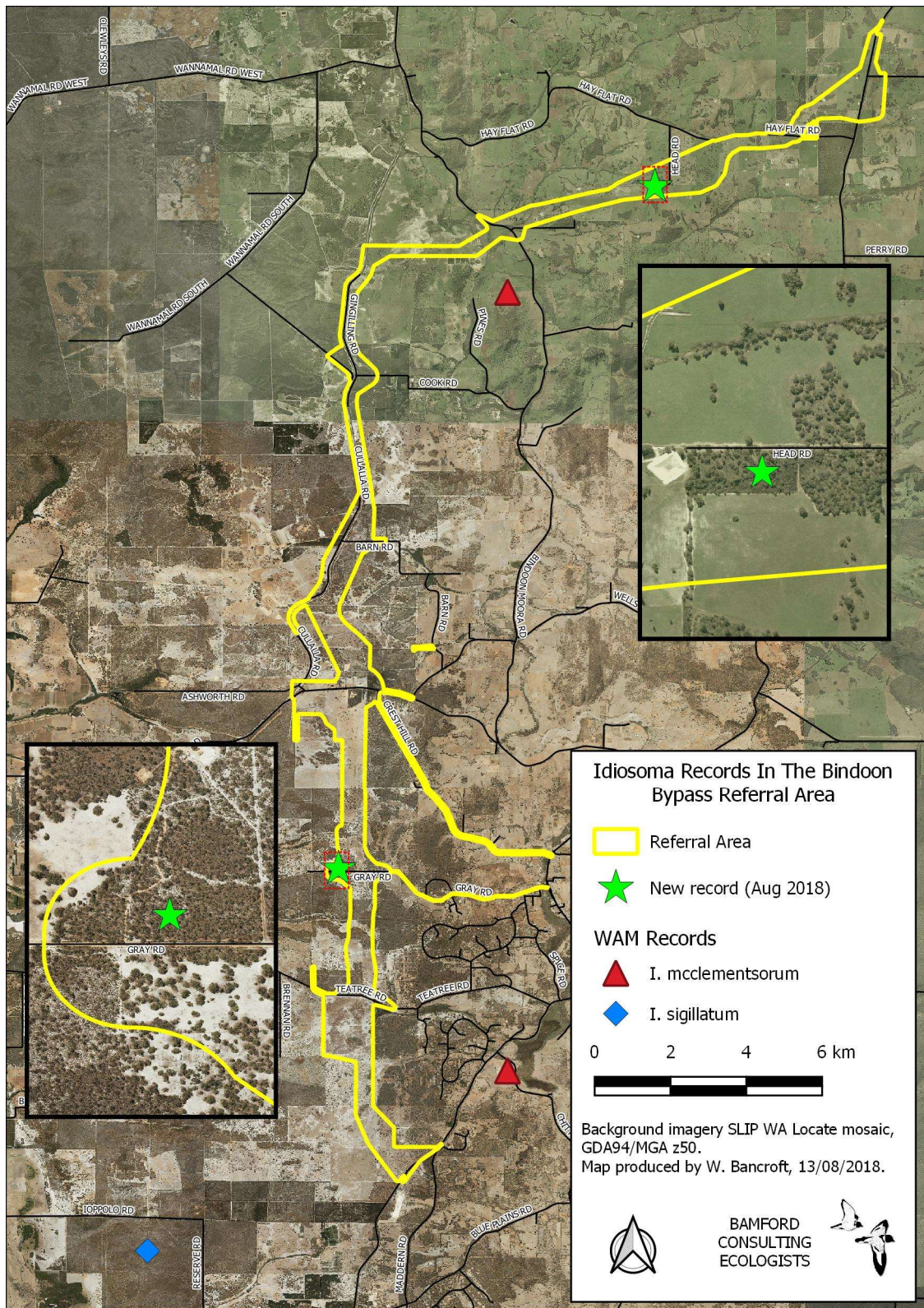


Figure 25. Location of (likely) *Idiosoma mcclementsorum* burrows (green stars) in the Bindoon Bypass study area.

Previously known *Idiosoma* locations (from the WAM) also shown. Note that this map is taken from Bancroft and Bamford (2018) and shows a previous route-alignment, the ‘referral area’, that is similar, but not an exact match, to the route of focus in this current report (at June 2019); the ‘study area’.



Figure 26. *Idiosoma (mcclementsorum)* Burrow 01, Head Road.



Figure 27. *Idiosoma (mcclementsorum)* Burrow 02, Gray Road.



Figure 28. Photographs of soil/vegetation surrounding Burrow 01 (Head Road, top) and Burrow 02 (Gray Road, bottom).

3.14 Opportunistic and indirect observations

Four of the target species were detected within the study area opportunistically, or by indirect evidence: Forest Red-tailed and Carnaby's Black-Cockatoo, Brush Wallaby and Water-rat. The details of these records are presented in Appendix 12 and they are mapped in Figure 29.

The Forest Red-tailed Black-Cockatoo was observed in the southern half of the study area, with birds not seen north of Mooliabeenee Road (see Figure 29). This largely supports the foraging observations for this species (see Figure 20), although considerable foraging evidence was noted further north in the vicinity of Cullalla Road. Thus it seems that the study area crosses over the northern boundary of this species' distribution on the Swan Coastal Plain, with the boundary somewhere between Mooliabeenee Road (observations of birds) and Cook Road (foraging records).

Carnaby's Black-Cockatoo was observed throughout the study area (see Figure 29), mostly in association with large eucalypts (especially Marri and Wandoo) or water sources (e.g. in the vicinity of the Teatree Road wetland). Curiously, few records of this species (either direct observations or foraging evidence, see Table 19 and Figure 23.) were made in Banksia Woodland within the study area (usually a major food source for this species).

The Brush Wallaby sightings were in areas of Banksia Woodland in the central part of the study area, although this species is probably present at low densities in all large areas of native vegetation in the region.

The Rakali (Water-rat) records (scats and freshwater crayfish foraging debris) were from a section of the Hay Flat Road drainage line, in the very north of the study area. While labelled as possible, the scats appeared diagnostic.

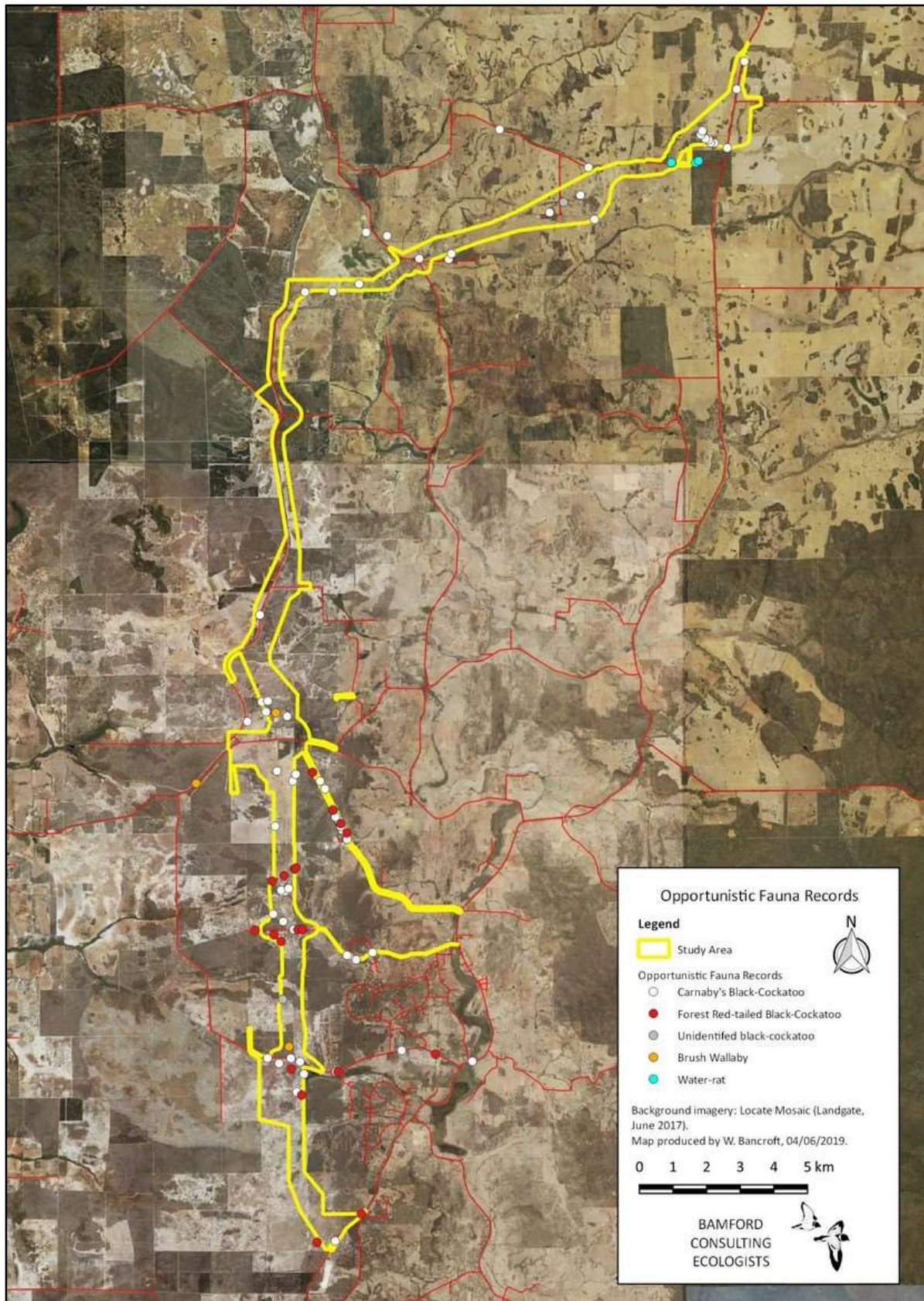


Figure 29. Opportunistic and indirect conservation significant fauna records in the study area.

4 Impact assessment

Impacting processes have to be considered in the context of fauna values and the nature of the proposed action, and are examined below. Importantly, the project is a narrow, linear feature that will result in small areas of loss at any one location, but potentially has other effects such as fragmentation. Predicted impacts need to be considered in the light of recommendations made in Section 0. Impact categories are defined in Table 11.

Habitat loss leading to population decline.

The proposed action will result in small areas of direct loss of native vegetation at any one location, so this loss would only be of concern where a location is of special significance. Assuming significant locations such as wetlands and groups of large trees that provide nesting for black-cockatoos can be avoided, the impact of direct habitat loss will be Minor.

Habitat loss leading to population fragmentation.

A linear impact footprint across an already fragmented landscape has the potential to contribute to fragmentation by increasing gaps between areas of native vegetation and even creating barriers. However, roadside revegetation may have the potential to improve connectivity where the road passes through degraded environments. Impact could be Minor to Moderate but a number of management actions are possible to mitigate impacts (see Section 5).

Degradation of habitat due to weed invasion.

The level of weed invasion is variable through the study area. Where the alignment passes through areas of native vegetation, there is a risk of weed invasion during construction and once the highway is operational. This risk will vary with final alignment selection and management (see Section 5), but the impact could be Minor to Moderate.

Mortality during construction.

This is a concern mostly on animal welfare grounds, as the footprint is small in any one location and thus inevitable mortality will generally be of low conservation significance. Exceptions might be where direct impacts upon nesting black-cockatoos could occur. Previous advice from DBCA is that direct impacts upon active black-cockatoo nests should be avoided, and removal of chicks for hand-rising is not an acceptable action as the hand-raised birds can rarely be released successfully into the wild. With appropriate management such as clearing only outside the breeding season and checking for active nests immediately prior to clearing, mortality during construction should have a Negligible to Minor impact.

Ongoing mortality.

This results mainly from roadkill and the fauna assemblage includes a number of at-risk species of conservation significance: both black-cockatoos, Chuditch and Quenda. The risk to black-cockatoos could be Moderate as the species are known to suffer high levels of road-kill and the study area passes through locations known to be used for breeding, foraging and roosting. Some actions are possible to minimise ongoing mortality (see Section 0).

Species interactions.

Some of the fauna is sensitive to feral species such as Foxes and Cats. These are present already, but during construction in particular, feral species may be attracted to work-sites and may gain improved access into native vegetation. Impacts can be kept to Minor subject to recommendations (Section 0).

Hydrological change

The alignment passes close to and even over some wetland systems, and thus drainage will need to be managed. Appropriate management during construction and along the completed roadway will be needed but should ensure the impact is Negligible.

Altered fire regimes

The vegetation of the study area is generally fire-dependent and many of the fauna species are reliant on particular fire regimes, and therefore sensitive to alterations in this. Fire risk in areas of native vegetation that are currently not readily accessed by road will increase, however, the region is already subject to regular fires so the impact of any change will probably only be Minor.

Disturbance (dust, noise, light).

The level of dust, noise and light during construction has the potential to result in significant short-term impacts. There are standard management procedures during road construction, but additional actions such as sensitive location of work-camps and directional lighting systems would avoid impacts to sensitive areas such as wetlands (see Section 0).

5 Recommendations

Section 4 (impact assessment) identified several potential adverse impacts to fauna that may result from the construction and operation of the proposed highway. Although impacts are mostly expected to be Minor or less, there is concern with impacts upon black-cockatoos, and some assessments of Minor or Negligible impacts are reliant on management actions. Recommended management strategies are listed below which would reduce the potential impacts of the proposed highway on fauna species and their habitats.

Habitat loss leading to population decline.

- Minimise the disturbance footprint in native vegetation. Figure 30 illustrates three examples of the broad alignment where final route selection could avoid native vegetation and thus greatly reduce habitat loss.
- Avoid direct impacts upon rare features such as wetlands and large (potential nesting) trees.
- Conduct black-cockatoo nest-tree surveys in detail along the proposed disturbance footprint to minimise loss of actual or potential nest-trees.
- Clearly delineate areas to be cleared to avoid accidental over-clearing.
- Rehabilitate as soon as practicable.

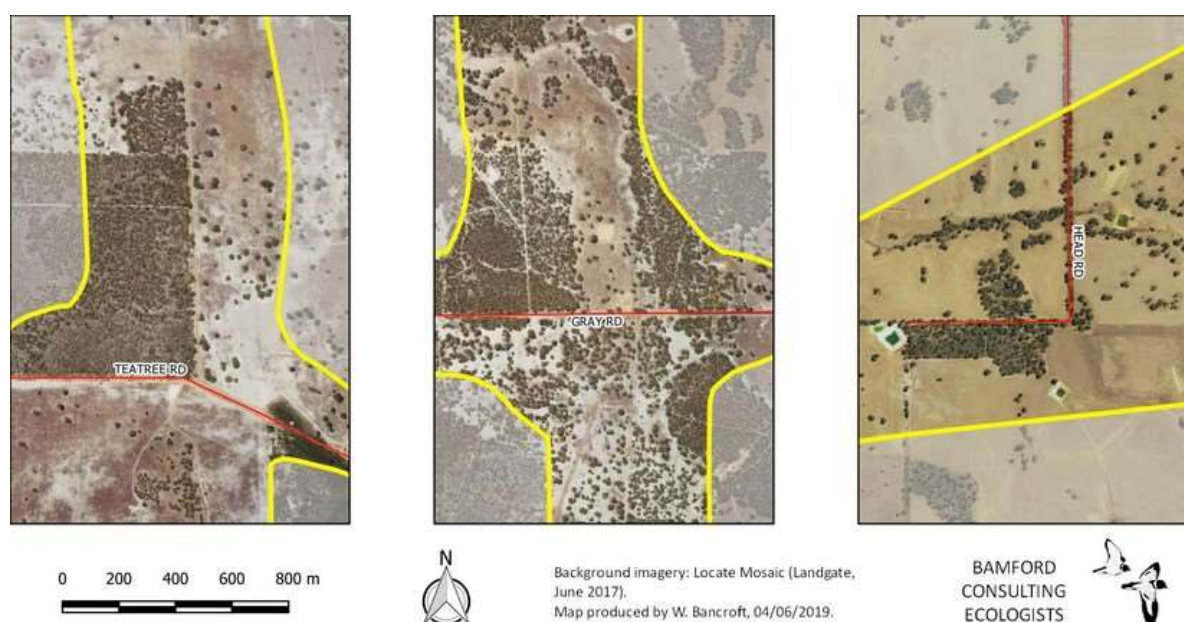


Figure 30. Examples of locations where the final alignment choice will affect the extent of habitat loss.

Habitat loss leading to population fragmentation.

- Select final alignment to avoid fragmenting intact native vegetation where possible.
- Provide a system of underpasses where fauna such as Quenda, Chuditch, Brush Wallaby and Rakali (Water-rat) might be present.
- Rehabilitate as soon as practicable and target areas where roadside rehabilitation can enhance connectivity.

Figure 31 illustrates several examples of where the final alignment could be selected to reduce the impact of habitat fragmentation.

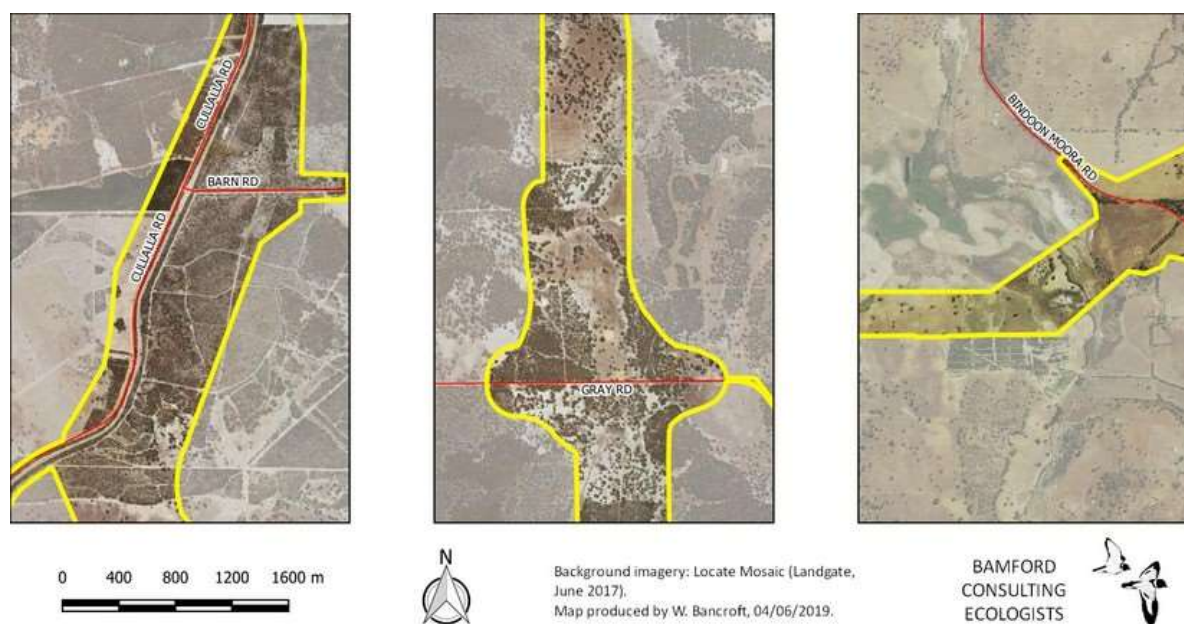


Figure 31. Examples of locations where the final alignment could be selected to reduce the impact of habitat fragmentation.

Additional area-specific notes:

- The route passes through good condition banksia woodland to the east of Cullalla Road (in the vicinity of Barn Road). Route planning options to minimise the impact of fragmentation may be to (1) keep road easement adjacent to parallel rail easement (and not fragmenting a small patch of vegetation between) or (2) to construct the road on the opposite side of the buffer zone in order to maximise the size of the remnant (between rail and highway).
- The Teatree Road to Gray Road area had several known records (from database search) of Chuditch, hence minimising fragmentation may be important in this area.
- Passage of wetland-dependant fauna (e.g. fish, frogs) along the Brockman River may be impacted without mitigating measures.

Degradation of habitat due to weed invasion.

- Employ industry standard hygiene to avoid introducing weeds and dieback during construction. Road verge management and locations of parking areas/truck bays should consider the risk of weed invasion.

Mortality during construction.

- Minimise clearing of native vegetation.
- Conduct a targeted fauna relocation programme for species of concern and most likely to benefit from relocation (e.g. Quenda).
- Conduct a survey for active black-cockatoo nests immediately prior to clearing so direct mortality can be avoided.

Ongoing mortality.

- Identify locations for underpasses and install these.
- Consider roadside fencing in locations of high fauna activity.

- Where practicable, avoid dissecting native vegetation with the road alignment.

Species interactions.

- Ensure appropriate waste disposal during construction activities to avoid attracting feral species to the area.
- Avoid unnecessary tracks through native vegetation.
- Educate personnel not to feed (deliberately or inadvertently) feral species.

Hydrological change

- Ensure local hydrology is not affected with suitable drainage features.
- Avoid turbid run-off during construction.

Altered fire regimes

- Implement a fire management plan during construction activities to ensure wildfires do not occur as a result of activities and that appropriate responses are in place should a wildfire occur.
- Discuss and plan for local fire management with DBCA and local shires, particularly with respect to the larger areas of native vegetation in the south of the study area.

Disturbance (dust, noise, light).

- Employ industry standards for management of dust, noise and light.
- Locate work-camps away from wetlands and native vegetation where possible.
- Avoid lighting that is directed into native vegetation and minimise light-spill in general.

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7 Appendices

Appendix 1. Explanation of fauna values.

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

Assemblage characteristics

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

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

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

Vegetation 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.

Patterns of biodiversity across the landscape

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

Species of conservation significance

Species of conservation significance are of special importance in impact assessment. The conservation status of fauna species in Australia is assessed under Commonwealth and State Acts such as the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Western Australian Biodiversity Conservation Act 2016* (that has replaced the *Wildlife Conservation Act 1950*). In addition, the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA) recognises priority levels, while local populations of some species may be significant even if the species as a whole has no formal recognition. Therefore, three broad levels of conservation significance can be recognised and are used for the purposes of this report, and are outlined below. A full description of the conservation significance categories, schedules and priority levels mentioned below is provided in Appendix 2.

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

Species listed under the EPBC Act are assigned to categories recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN 2012), or are listed as migratory. Migratory species are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA), the Republic of South Korea Australia Migratory Bird Agreement (ROKAMBA), and/or the Convention on the Conservation of Migratory Species of Wild Animals (CMS; also referred to as the Bonn Convention). The *Biodiversity Conservation Act 2016* uses a series of seven Schedules to classify conservation status that largely reflect the IUCN categories (IUCN 2012).

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

In Western Australia, DBCA has produced a supplementary list of Priority Fauna, being species that are not considered threatened under the *Biodiversity Conservation Act 2016* but for which DBCA feels there is cause for concern.

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

This level of significance has no legislative or published recognition and is based on interpretation of distribution information, but is used here as it may have links to preserving biodiversity at the genetic level (EPA 2002). If a population is isolated but a subset of a widespread (common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Conservation significance is applied to allow for the preservation of genetic richness at a population level, and not just at a species level. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3, as may colonies of waterbirds. The Western

Australian Department of Environmental Protection, now DBCA, used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan (DEP 2000).

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

Introduced species

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

Ecological processes upon which the fauna depend

These are the processes that affect and maintain fauna populations in an area and as such are very complex; for example, populations are maintained through the dynamic of mortality, survival and recruitment being more or less in balance, and these are affected by a myriad of factors. The dynamics of fauna populations in a project may be affected by processes such as fire regime, landscape patterns (such as fragmentation and/or linkage), the presence of feral species and hydrology. Impacts may be significant if processes are altered such that fauna populations are adversely affected, resulting in declines and even localised loss of species. Threatening processes as outlined in Appendix 3 are effectively the ecological processes that can be altered to result in impacts upon fauna.

Appendix 2. 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* and the *Western Australian Wildlife Conservation Act 1950*.

Extinct (EX)	There is no reasonable doubt that the last individual of a taxon has died.
Extinct in the Wild (EW)	A taxon is known only to survive in cultivation, in captivity or as a naturalized population (or populations) well outside the past range.
Critically Endangered (CR)	The best available evidence indicates that a taxon is facing an extremely high risk of extinction in the wild.
Endangered (EN)	The best available evidence indicates that a taxon is facing a very high risk of extinction in the wild.
Vulnerable (VU)	The best available evidence indicates that a taxon is facing a high risk of extinction in the wild.
Near Threatened (NT)	A taxon is close to qualifying as CR, EN or VU, or is likely to do so in the near future.
Least Concern (LC)	Widespread and abundant taxa; and does not qualify as CR, EN, VU or NT.
Data Deficient (DD)	There is inadequate information to make a direct, or indirect, assessment of the risk of extinction based on a taxon's distribution and/or population status.
Not Evaluated (NE)	A taxon that has not yet been evaluated against the criteria.

Schedules used in the *WA Wildlife Conservation Act 1950*

Schedule 1	Fauna that is rare or is likely to become extinct as critically endangered fauna.
Schedule 2	Fauna that is rare or is likely to become extinct as endangered fauna.
Schedule 3	Fauna that is rare or is likely to become extinct as vulnerable fauna.
Schedule 4	Fauna presumed to be extinct.
Schedule 5	Migratory birds protected under an international agreement.
Schedule 6	Fauna that is of special conservation need as conservation dependent fauna.
Schedule 7	Other specially protected fauna.

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

<p>Priority 1 (Poorly-known species)</p>	<p>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, e.g. 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 and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.</p>
<p>Priority 2 (Poorly-known species)</p>	<p>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, e.g. 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 and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.</p>
<p>Priority 3 (Poorly-known species)</p>	<p>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. Such species are in need of further survey.</p>
<p>Priority 4 (Rare, Near Threatened and other species in need of monitoring)</p>	<p>(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. (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 Conservation Dependent. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy."</p>

Appendix 3. Explanation of threatening processes.

Potential impacts of proposed developments upon fauna values can be related to threatening processes. This is recognised in the literature and under the EPBC Act, in which threatening processes are listed (see Appendix 4). Processes that may impact fauna values are discussed below. Rather than being independent of one another, processes are complex and often interrelated. They are the mechanisms by which fauna can be affected by development. Impacts may be significant if large numbers of species or large proportions of populations are affected.

Loss of habitat affecting population survival

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

Loss of habitat leading to population fragmentation

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

Degradation of habitat due to weed invasion leading to population decline

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

Increased mortality

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

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

Species interactions, including predation and competition

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

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

Hydroecology

Interruptions of hydroecological processes can have major effects because they underpin primary production in ecosystems and there are specific, generally rare habitats that are hydrology-dependent. Fauna may be impacted by potential changes to groundwater level and chemistry and altered flow regime. These changes may alter vegetation across large areas and may lead to habitat degradation or loss. Impacts upon fauna can be widespread and major.

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

Fire

The role of fire in the Australian environment and its importance to vertebrate fauna has been widely acknowledged (Gill *et al.* 1981; Fox 1982; Letnic *et al.* 2004). Fire is a natural feature of the environment but frequent, extensive fires may adversely impact some fauna, particularly mammals and short-range endemic species. Changes in fire regimes, whether to more frequent or less frequent fires, may be significant to some fauna. Impacts of severe fire may be devastating to species already occurring at low densities or to species requiring long unburnt habitats to survive. Fire management may be considered the responsibility of managers of large tracts of land.

Dust, light, noise and vibration

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

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

Appendix 4. Ecological and threatening processes identified under legislation and in the literature.

Ecological processes are processes that maintain ecosystems and biodiversity. They are important for the assessment of impacts of development proposals, because ecological processes make ecosystems sensitive to change. The issue of ecological processes, impacts and conservation of biodiversity has an extensive literature. Following are examples of the sorts of ecological processes that need to be considered.

Ecological processes relevant to the conservation of biodiversity in Australia (Soule *et al.* 2004):

- Critical species interactions (highly interactive species);
- Long distance biological movement;
- Disturbance at local and regional scales;
- Global climate change;
- Hydroecology;
- Coastal zone fluxes;
- Spatially-dependent evolutionary processes (range expansion and gene flow); and
- Geographic and temporal variation of plant productivity across Australia.

Threatening processes (EPBC Act)

Under the EPBC Act, a key threatening process is an ecological interaction that threatens or may threaten the survival, abundance or evolutionary development of a threatened species or ecological community. There are currently 20 key threatening processes listed by the federal Department of the Environment (DotE 2014b):

- Competition and land degradation by rabbits.
- Competition and land degradation by unmanaged goats.
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*).
- Incidental catch (bycatch) of Sea Turtle during coastal otter-trawling operations within Australian waters north of 28 degrees South.
- Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations.
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis.
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris.
- Invasion of northern Australia by Gamba Grass and other introduced grasses.
- Land clearance.
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants.
- Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean.
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases.
- Novel biota and their impact on biodiversity.
- Predation by European red fox.
- Predation by exotic rats on Australian offshore islands of less than 1000 km² (100,000 ha).
- Predation by feral cats.
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs.
- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species.
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (*Bufo marinus*).
- The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, *Solenopsis invicta* (fire ant).

General processes that threaten biodiversity across Australia (The National Land and Water Resources Audit):

- Vegetation clearing;
- Increasing fragmentation, loss of remnants and lack of recruitment;
- Firewood collection;
- Grazing pressure;
- Feral animals;
- Exotic weeds;
- Changed fire regimes;
- Pathogens;
- Changed hydrology—dryland salinity and salt water intrusion;
- Changed hydrology— such as altered flow regimes affecting riparian vegetation; and
- Pollution.

In addition to the above processes, DSEWPaC produced Significant Impact Guidelines that provide criteria for the assessment of the significance of impacts. These criteria provide a framework for the assessment of significant impacts. The criteria are listed below.

- Will the proposed action lead to a long-term decrease in the size of a population?
- Will the proposed action reduce the area of occupancy of the species?
- Will the proposed action fragment an existing population?
- Will the proposed action adversely affect habitat critical to the survival of a species?
- Will the proposed action disrupt the breeding cycle of a population?
- Will the proposed action modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline?
- Will the proposed action result in introducing invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat?
- Will the proposed action introduce disease that may cause the species to decline?
- Will the proposed action interfere with the recovery of the species?

Appendix 5. Bamford Consulting Ecologists black-cockatoo nesting-tree assessment protocol.

Bamford Consulting Ecologists base black-cockatoo nesting-tree assessments on Federal guidelines (DEE 2017; DotE 2018a, b, c) but also refer to the following when undertaking field surveys.

Measuring DBH

While black-cockatoos generally nest towards the crown of a tree, the diameter of a tree at breast-height (DBH) can be indicative of the likelihood of hollow-formation in the upper trunk and can be used in the assessment of the 'value' of a tree to breeding black-cockatoos. A DBH threshold of 500 mm (or 300 mm for Wandoo, *Eucalyptus wandoo*, and Salmon Gum, *E. salmonophloia*) is commonly used to delineate 'potential' nest-trees (DotE 2018a, b, c), however the tree has to be *functionally capable of supporting a nest hollow* and there are several exceptions where trees that meet a strict DBH threshold are excluded (e.g. those with low-forking into narrow-diameter trunks, or those that have been hollowed-out and 'opened' by fire). Thus some discretion needs to be used when assessing trees.

The international standard for 'breast height' is 1.3 m (James and Shugart Jr 1970).

Only occasionally are trees close to perfectly cylindrical. As such, wherever possible, DBH should be 'representative' of the tree. In cases where the tree is approximately oval in cross-section, BCE measures the diameter of the shorter axis. Note that other methods such as circumference, or the quadratic average of the long and short axes are used in some applications, but logistic constraints generally require a more pragmatic approach. DBH should be reflective of the trunk above the nesting threshold (see below). Where a tree spreads at the base along one axis, the axis that best represents the trunk above is chosen for measurement.

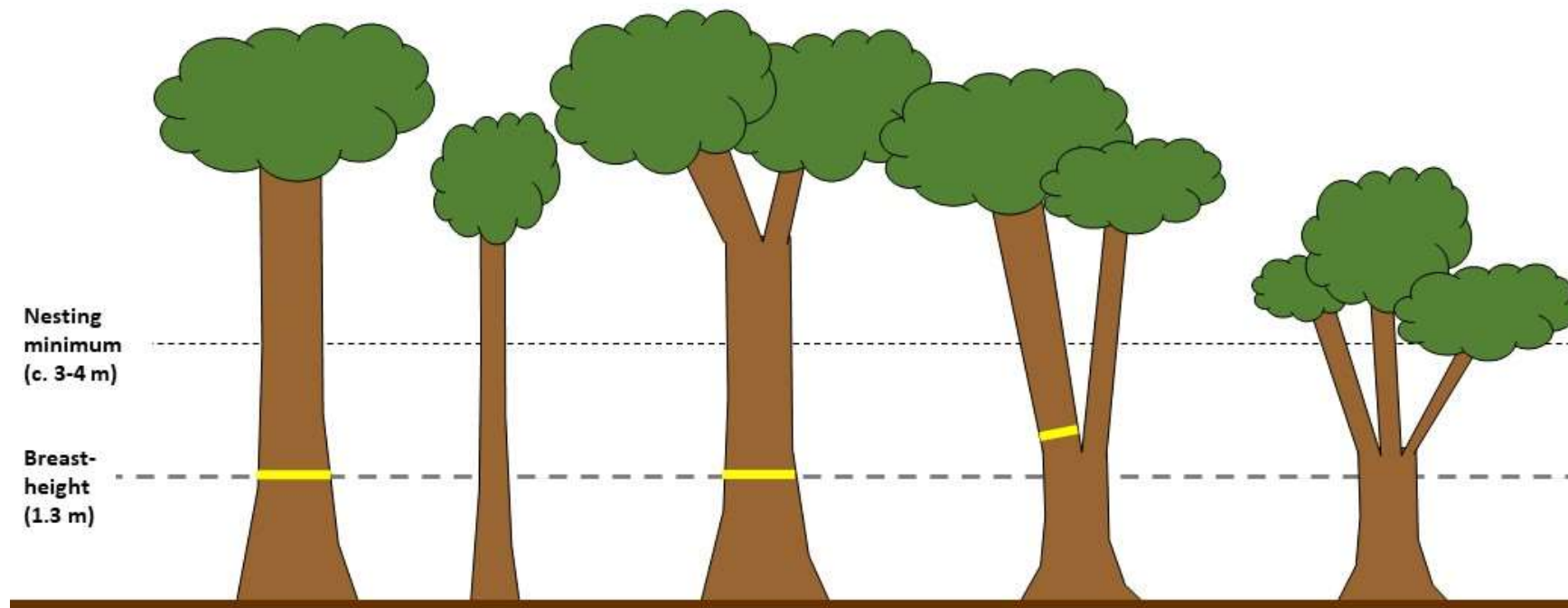
Nest height minima

For Carnaby's Black-Cockatoo, the minimum height of known nests is c. 3 m (Saunders 1979)⁶. For Forest Red-tailed Black-Cockatoo, the minimum height of a known nest is 6.5 m (Johnstone *et al.* 2013a). Thus, a 3-4 m threshold seems a pragmatic "general" one to use for the purposes of field surveys where both species are likely and multiple tree species are under consideration.

Tree forms

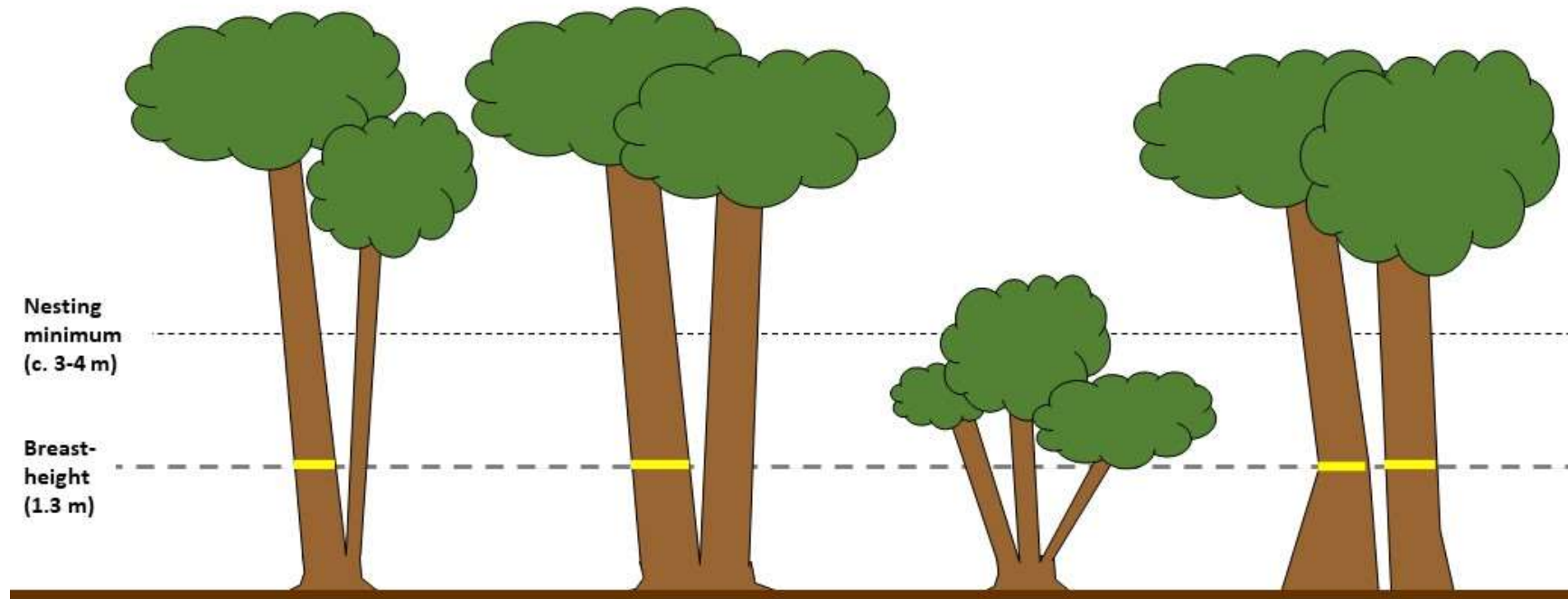
Quite obviously, trees have a range of forms and growth-habits. These can occasionally affect black-cockatoo nesting-tree surveys. As such, the following table has been developed (with reference to the information above) to guide tree assessment.

⁶ Although nests as low as 2 m (in Wandoo or Salmon Gum) were recorded, 95% of nests were above 3 m.



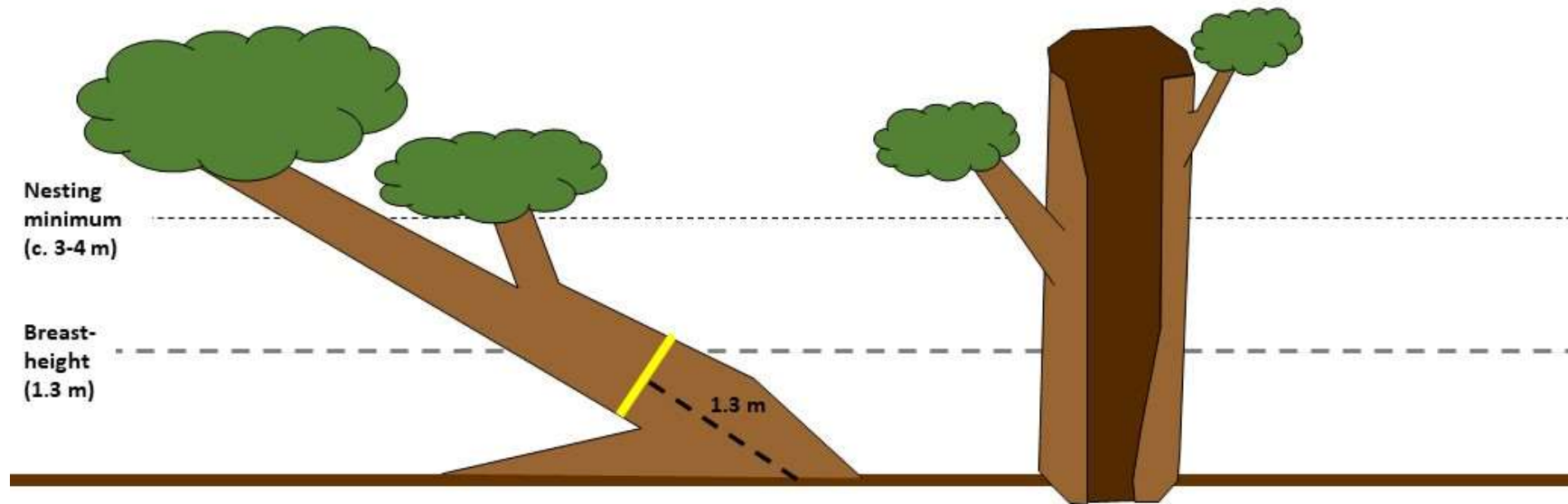
Tree Description:	Straight trunk. DBH > 500 mm*.	Straight trunk. DBH < 500 mm*.	Trunk forks above 3 m. DBH > 500 mm*.	Trunk forks between 1.3 m & 3 m. Diameter of at least one trunk above fork > c. 500 mm*.	Trunk forks between 1.3 m & 3 m. DBH > 500 mm* but <u>no</u> trunks above fork have diameter > c. 500 mm*.
Actions:	Measure DBH. Record species, life status and score for hollows. Waypoint tree.	Do not record.	Measure DBH. Record species, life status and score for hollows. Waypoint tree.	Measure/estimate diameter of <u>widest</u> trunk above fork. Note number of trunks. Record species, life status and score for hollows. Waypoint tree.	Do not record.

* Or 300 mm DBH for Wandoo, Salmon Gum.



Tree Description:	Trunk forks below 1.3 m. Diameter of <u>one</u> trunk above fork > 500 mm*.	Trunk forks below 1.3 m. Diameter of <u>multiple</u> trunks above fork > 500 mm*.	Trunk forks below 1.3 m. DBH of all trunks < 500 mm*.	Two <u>separate</u> trees in very close proximity. Both with DBH > 500 mm.
Actions:	Measure DBH of relevant trunk above fork. Note number of trunks. Record species, life status and score for hollows. Waypoint tree.	Measure DBH of <u>widest</u> trunk above fork. Note number of trunks. Record species, life status and score for hollows. Waypoint tree.	Do not record.	For <u>both</u> trees... Measure DBH. Record species, life status and score for hollows. Waypoint <u>each</u> tree (i.e. 2 separate records).

* Or 300 mm DBH for Wandoo, Salmon Gum.



Tree Description:	Trunk leans dramatically. Diameter > 500 mm* at 1.3m from centre of tree base.	Trunk has been burnt out internally to create an <u>open</u> half-pipe shape (no potential nesting sites). DBH > 500 mm*.
Actions:	Measure diameter at 1.3 m from the central base point, along the midline of the tree. Record species, life status and score for hollows. Waypoint tree.	Do not record.

* Or 300 mm DBH for Wandoo, Salmon Gum.

Appendix 6. Scoring system for the assessment of foraging value of vegetation for black-cockatoos.

Total score (out of 10) comprises:

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

These are described in detail below.

A. 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	No foraging value. No Proteaceae, eucalypts or other potential sources of food. Examples would be salt lakes and bare ground.	No foraging value. No eucalypts or other potential sources of food.	No foraging value. No eucalypts (i.e. Marri, Jarrah, Wandoo, Blackbutt or Karri) or other potential sources of food.
1	Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these <2%. Could include urban areas with scattered foraging trees. Blue Gum plantations are considered to have a score of 1 as foraging by Black-Cockatoos has been reported but appears to be unusual.	Negligible to low foraging value. Scattered specimens of known food plants (e.g. Marri and Jarrah) but projected foliage cover of these <1%. Could include urban areas with scattered foraging trees.	Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these <1%. Could include urban areas with scattered foraging trees.

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	Baudin's Black-Cockatoo	Forest Red-tailed Black-Cockatoo
2	<p>Low foraging value. Examples:</p> <ul style="list-style-type: none"> • Shrubland in which species of foraging value, such as shrubby banksias, with <10% projected foliage cover • Open eucalypt woodland/mallee of small-fruited species • Paddocks with melons or other weeds (a short-term, seasonal food source). 	<p>Low foraging value. Example:</p> <ul style="list-style-type: none"> • Woodland or forest with scattered specimens of known food plants (e.g. Marri and Jarrah) but projected foliage cover of these 1-<5%. Could include urban areas with scattered foraging trees. 	<p>Low foraging value. Examples:</p> <ul style="list-style-type: none"> • Open eucalypt woodland (i.e. Marri, Jarrah, Wandoo, Blackbutt or Karri). Projected foliage cover of these 1-<5% • Urban areas with scattered food plants such as Cape Lilac, <i>Eucalyptus caesia</i> and <i>Eucalyptus erythrocorys</i>.
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, with 10-20% projected foliage cover • Woodland with tree banksias 2-20% projected foliage cover • Eucalypt woodland/mallee of small-fruited species; Marri, if present, <10% project foliage cover. 	<p>Low to Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> • Eucalypt woodland with known food plants (and in particular Marri) with a projected foliage cover of 5-<10%. • Parkland-cleared eucalypt woodland with projected foliage cover of known food plants of 10-<20% can be considered low-to-moderate because of poor long-term viability without management. 	<p>Low to Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> • Eucalypt woodland (i.e. Marri, Jarrah, Wandoo, and Blackbutt), if present, <10% project foliage cover.

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 with tree banksias 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"> • Eucalypt woodland with known food plants (and in particular Marri) with a projected foliage cover of 10-<20% • Parkland-cleared eucalypt woodland with projected foliage cover of known food plants of 20-<40% can be considered moderate because of poor long-term viability without management • Areas of orchards and especially those with apples can be considered of moderate value. 	<p>Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> • Eucalypt woodland/forest (i.e. Marri, Jarrah, Wandoo, and Blackbutt) with 20-40% projected foliage cover.
5	<p>Moderate to High foraging value. Examples:</p> <ul style="list-style-type: none"> • Banksia Woodlands with tree banksias >40%. Vegetation condition moderate due to weed invasion and some tree deaths. • Pine plantations with trees more than 10 years old. 	<p>Moderate to High foraging value. Examples:</p> <ul style="list-style-type: none"> • Eucalypt woodland with known food plants (and in particular Marri) with a projected foliage cover of 20-<40% • Parkland-cleared eucalypt woodland with projected foliage cover of known food plants of >40% can be considered moderate because of poor long-term viability without management. 	<p>Moderate to High foraging value. Examples:</p> <ul style="list-style-type: none"> • Eucalypt woodland/forest (i.e. Marri, Jarrah, Wandoo, and Blackbutt) with >40% projected foliage cover. Vegetation condition moderate due to weed invasion and some tree deaths.

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 Woodlands of key species (e.g. <i>B. attenuata</i>, <i>B. menziesii</i>) with projected foliage cover >60%. Vegetation condition good with low weed invasion and low tree death to indicate it is robust and unlikely to decline in the medium term. 	<p>High foraging value. Example:</p> <ul style="list-style-type: none"> Eucalypt woodland/forest with a high proportion of Marri (>40% projected foliage cover). Vegetation condition good with low weed invasion and low tree death to indicate it is robust and unlikely to decline in the medium term. 	<p>High foraging value. Example:</p> <ul style="list-style-type: none"> Eucalypt woodland/forest (i.e. Marri, Jarrah, Wandoo, and Blackbutt) with >60% projected foliage cover. Vegetation condition good with low weed invasion and low tree death to indicate it is robust and unlikely to decline in the medium term.

B. Site context.

The maximum score is given in situations where foraging habitat is supporting breeding birds. It can also be given in fragmented landscapes where there is little foraging habitat remaining and thus what is left has a high contextual value. The site context score is species-specific as it depends upon factors such as the vegetation type and extent, and the presence of breeding birds, and the following table, developed by Bamford consulting in conjunction with 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):

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%	0.1 - 5%
0	< 0.1%	< 0.1%

C. Species density.

Assignment of the species density score (0 or 1) is based upon the black-cockatoo species being either abundant or not abundant, and is species specific. 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.

Appendix 7. 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 8. Vertebrate fauna expected to occur in the study area.

The list is derived from the results of database and literature searches, and from previous field surveys conducted in the local area. The sources are: 1 = Atlas of Living Australia database search; 2 = NatureMap database search; 3 = DBCA database search; 4 = EPBC Act Search (PMST); 5 = Burbidge *et al.* (1996); 6 = Owen *et al.* (2011); 7 = Leung *et al.* (2015); 8 = BCE database. CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 1 for full explanation.

EPBC Act listings: E = Endangered, V = Vulnerable, M = Migratory (see Appendix 2).

Wildlife Conservation Act 1950 listings: S1 to S7 = Schedules 1 to 7 (see Appendix 2).

DBCA Priority species: P1 to P4 = Priority 1 to 4 (see Appendix 2).

LS = considered to be of local significance by Bamford Consulting Ecologists (see Appendix 1).

Int = introduced species.

See Section 2.2.4 for explanation of expected occurrence categories.

+ = species recorded by BCE during the 2016-2018 field investigations.

Species returned from the literature review but considered to be locally extinct are listed in Appendix 9. Species returned from the literature review but omitted from the expected species list because of habitat or range limitations are listed in Appendix 10.

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
FISH					
Plotosidae (Eel-tailed catfishes)					
<i>Tandanus bostocki</i>	Freshwater Cobbler	CS3 (LS)	Resident	8	
Galaxiidae (Galaxiids)					
<i>Galaxias occidentalis</i>	Western Minnow		Resident	1, 2	
<i>Galaxiella munda</i>	Western Mud Minnow	CS1 (S3)	Resident	1, 2, 3	
Percichthyidae (Australian freshwater basses and cods)					
<i>Bostockia porosa l</i>	Nightfish	CS3 (LS)	Resident	1, 2	
<i>Nannoperca vittata l</i>	Western Pygmy Perch		Resident	1, 2, 5	
Gobiidae (Gobies)					
<i>Pseugobius olorum</i>	Blue-spot Goby		Resident	1, 2	
Cyprinidae (Cyprinids)					
<i>Carassius auratus</i>	Goldfish	Int	Resident	1	

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
Poeciliidae (Livebearers)					
<i>Gambusia holbrooki</i>	Eastern Mosquitofish	Int	Resident	1, 2	+
FROGS					
Hylidae (Tree frogs)					
<i>Litoria adelaidensis</i>	Slender Tree Frog		Resident	1, 2, 5, 6, 7	+
<i>Litoria moorei</i>	Motorbike Frog		Resident	1, 2, 6, 7	+
Limnodynastidae (Burrowing frogs)					
<i>Heleioporus albopunctatus</i>	Western Spotted Frog		Resident	1, 2	
<i>Heleioporus barycragus</i>	Hooting Frog	CS3 (LS)	Resident	1, 2	
<i>Heleioporus eyrei</i>	Moaning Frog		Resident	1, 2, 5, 7	
<i>Heleioporus inornatus</i>	Whooping Frog	CS3 (LS)	Resident	2	
<i>Heleioporus psammophilus</i>	Sand Frog		Resident	2	
<i>Limnodynastes dorsalis</i>	Western Banjo Frog		Resident	1, 2, 5, 6, 7	+
<i>Neobatrachus kunapalari</i>	Kunapalari Frog		Resident	1, 2	
<i>Neobatrachus pelobatoides</i>	Humming Frog		Resident	1, 2, 7	
Myobatrachidae (Ground frogs)					
<i>Crinia georgiana</i>	Quacking Frog		Resident	1, 2, 6, 7	+
<i>Crinia glauerti</i>	Clicking Frog		Resident	1, 2, 5, 6, 7	+
<i>Crinia insignifera</i>	Squelching Froglet		Resident	1, 2, 6, 7	
<i>Crinia pseudinsignifera</i>	Bleating Froglet		Resident	1, 2, 7	
<i>Geocrinia leai</i>	Ticking Frog	CS3 (LS)	Resident	1, 2, 7	
<i>Myobatrachus gouldii</i>	Turtle Frog		Resident	1, 2, 5	
<i>Pseudophryne guentheri</i>	Crawling Toadlet		Resident	1, 2, 7	

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
REPTILES					
Cheluidae (Side-necked freshwater tortoises/turtles)					
<i>Chelodina colliei</i>	Oblong Tortoise		Resident	1, 2, 7	
<i>Pseudemys umbrina</i>	Western Swamp Tortoise	CS1 (C,S1)	Unlikely resident	2, 3, 7	
Carphodactylidae (Carphodactylid geckos)					
<i>Underwoodisaurus milii</i>	Southern Barking Gecko		Resident	1, 2, 6, 7	
Diplodactylidae (Diplodactylid geckos)					
<i>Crenadactylus ocellatus ocellatus</i>			Resident	1, 2, 5	
<i>Diplodactylus granariensis granariensis</i>			Resident	1, 2, 7	
<i>Diplodactylus polyophthalmus</i>	Spotted Sandplain Gecko		Resident	2	
<i>Diplodactylus pulcher</i>			Resident	1, 2	
<i>Hesperoedura reticulata</i>			Resident	1	
<i>Lucasium maini</i>			Resident	2	
<i>Rhynchoedura ornata</i>	Western Beaked Gecko		Resident	2	
<i>Strophurus spinigerus</i>			Resident	1, 2	
Gekkonidae (Gekkonid geckos)					
<i>Christinus marmoratus</i>	Marbled Gecko		Resident	1, 2	
<i>Gehyra variegata</i>			Resident	1, 2, 7	
<i>Heteronotia binoei</i>	Bynoe's Gecko		Resident	2	
Pygopodidae (Legless lizards)					
<i>Aprasia pulchella</i>			Resident	1, 2, 6, 7	
<i>Aprasia repens</i>			Resident	1, 2, 5, 7	
<i>Delma concinna</i>			Resident	8	

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
<i>Delma fraseri</i>			Resident	1, 2, 5	
<i>Delma grayii</i>			Resident	1, 2	
<i>Lialis burtonis</i>			Resident	1, 2, 5, 7	
<i>Pletholax gracilis</i>	Keeled Legless Lizard		Resident	1, 2, 5	
<i>Pygopus lepidopodus</i>	Common Scaly Foot		Resident	1, 2, 5, 7	
Agamidae (Dragons)					
<i>Ctenophorus adelaidensis</i>	Western Heath Dragon		Resident	1, 2, 5, 7	
<i>Ctenophorus cristatus</i>	Bicycle Dragon		Resident	2	
<i>Ctenophorus reticulatus</i>	Western Netted Dragon		Resident	2	
<i>Pogona minor</i>	Bearded Dragon		Resident	1, 2, 5	
Scincidae (Skinks)					
<i>Acritoscincus trilineatus</i>			Resident	1, 2	
<i>Cryptoblepharus buechananii</i>	Fence Skink		Resident	1, 2, 5, 6, 7	+
<i>Ctenotus australis</i>			Resident	1, 2, 7	
<i>Ctenotus delli</i>		CS2 (P4)	Resident	1, 2	
<i>Ctenotus fallens</i>			Resident	2, 5, 6, 7	
<i>Ctenotus impar</i>			Resident	1, 2	
<i>Ctenotus pantherinus</i>	Leopard Ctenotus		Resident	1, 2	
<i>Ctenotus schomburgkii</i>			Resident	1, 2	
<i>Egernia depressa</i>	Southern Pygmy Spiny-tailed Skink		Resident	2	
<i>Egernia kingii</i>	King's Skink		Resident	1, 2	
<i>Egernia napoleonis</i>			Resident	1, 2, 7	
<i>Eremiascincus richardsonii</i>	Broad-banded Sand Swimmer		Resident	1, 2	

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
<i>Hemiergus initialis</i>			Resident	1, 2	
<i>Lerista christinae</i>			Resident	1, 2, 7	
<i>Lerista distinguenda</i>			Resident	1, 2, 5	
<i>Lerista elegans</i>			Resident	1, 2	
<i>Lerista kingi</i>			Resident	2	
<i>Liopholis multiscutata</i>			Resident	1, 2	
<i>Liopholis pulchra</i>		CS3 (LS)	Resident	1, 2	
<i>Menetia greyii</i>			Resident	1, 2, 6, 7	
<i>Morethia lineocellata</i>			Resident	1, 2	
<i>Morethia obscura</i>			Resident	1, 2, 5	
<i>Tiliqua occipitalis</i>	Western Bluetongue		Resident	2	
<i>Tiliqua rugosa</i>			Resident	1, 2, 5, 6, 7	+
Varanidae (Monitors and goannas)					
<i>Varanus gouldii</i>	Bungarra or Sand Goanna		Resident	1, 2	+
<i>Varanus tristis tristis</i>	Tree Goanna		Resident	1, 2, 7	
Typhlopidae (Blind snakes)					
<i>Anilius australis</i>			Resident	1	
<i>Anilius pinguis</i>		CS3 (LS)	Resident	1	
<i>Anilius waitii</i>			Resident	1	
Pythonidae (Pythons)					
<i>Antaresia stimsoni</i>	Stimson's Python		Resident	1, 2, 7	
<i>Morelia spilota imbricata</i>	Carpet Python (southwest)	CS3 (LS)	Resident	1, 2, 5, 7	
Elapidae (Venomous land snakes)					

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
<i>Brachyuropis semifasciatus</i>			Resident	1, 2, 5, 7	
<i>Demansia psammophis</i>	Yellow-faced Whipsnake		Resident	1, 2, 6, 7	
<i>Echiopsis curta</i>	Bardick		Resident	1, 2, 5, 7	
<i>Neelaps bimaculatus</i>	Black-naped Snake		Resident	1, 5	
<i>Neelaps calonotos</i>	Black-striped Snake	CS2 (P3)	Resident	2, 5, 7	
<i>Notechis scutatus</i>	Tiger Snake		Resident	1, 2	
<i>Parasuta gouldii</i>			Resident	1, 2, 6, 7	
<i>Parasuta nigriceps</i>			Resident	1, 2	
<i>Pseudechis australis</i>	Mulga Snake		Resident	1, 7	
<i>Pseudonaja affinis</i>	Dugite		Resident	1, 2, 5, 7	
<i>Pseudonaja mengdeni</i>	Western Brown Snake		Resident	2, 7	
<i>Simoselaps bertholdi</i>	Jan's Banded Snake		Resident	1, 2, 7	
BIRDS					
Casuariidae (Emus and Cassowaries)					
<i>Dromaius novaehollandiae</i>	Emu		Resident	1, 5, 6, 7	+
Phasianidae (Pheasants and Quail)					
<i>Coturnix pectoralis</i>	Stubble Quail		Resident	1, 7	
Anatidae (Ducks, Geese and Swans)					
<i>Biziura lobata</i>	Musk Duck		Visitor	1, 7	
<i>Stictonetta naevosa</i>	Freckled Duck		Irregular Visitor	1	
<i>Cygnus atratus</i>	Black Swan		Visitor	1, 7	
<i>Tadorna tadornoides</i>	Australian Shelduck		Visitor	1, 5, 6, 7	+
<i>Chenonetta jubata</i>	Australian Wood Duck		Visitor	1, 6, 7	+

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
<i>Malacorhynchus membranaceus</i>	Pink-eared Duck		Visitor	1, 7	
<i>Anas rhynchotis</i>	Australasian Shoveler		Visitor	7	
<i>Anas gracilis</i>	Grey Teal		Resident	1, 6, 7	
<i>Anas castanea</i>	Chestnut Teal		Visitor	1, 7	
<i>Anas superciliosa</i>	Pacific Black Duck		Resident	5, 6, 7	
<i>Aythya australis</i>	Hardhead		Visitor	1, 7	
<i>Oxyura australis</i>	Blue-billed Duck	CS2 (P4)	Irregular Visitor	1, 3, 7	
Podicipidae (Grebes)					
<i>Tachybaptus novaehollandiae</i>	Australasian Grebe		Resident	1, 7	+
<i>Poliiocephalus poliocephalus</i>	Hoary-headed Grebe		Resident	1, 7	
<i>Podiceps cristatus</i>	Great Crested Grebe		Resident	1, 7	
Columbidae (Pigeons and Doves)					
<i>Columba livia</i>	Rock Dove/Feral Pigeon	Int	Resident	1, 6, 7	
<i>Streptopelia senegalensis</i>	Laughing Dove	Int	Resident	1, 7	
<i>Streptopelia chinensis</i>	Spotted Dove	Int	Irregular Visitor	7	
<i>Phaps chalcoptera</i>	Common Bronzewing		Resident	1, 5, 6, 7	+
<i>Phaps elegans</i>	Brush Bronzewing		Resident	1	
<i>Ocyphaps lophotes</i>	Crested Pigeon		Resident	1, 5, 6, 7	
Podargidae (Frogmouths)					
<i>Podargus strigoides</i>	Tawny Frogmouth		Resident	1, 5, 7	
Aegothelidae (Owlet-nightjars)					
<i>Aegotheles cristatus</i>	Australian Owlet-nightjar		Resident	1, 5, 7	
Apodidae (Swifts and Swiftlets)					

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
<i>Apus pacificus</i>	Fork-tailed Swift	CS1 (M,S5)	Migrant	1, 4, 7	
Anhingidae (Darter)					
<i>Anhinga novaehollandiae</i>	Australasian Darter		Irregular Visitor	1, 7	
Phalacrocoracidae (Cormorants and Shags)					
<i>Microcarbo melanoleucos</i>	Little Pied Cormorant		Visitor	1, 6, 7	
<i>Phalacrocorax carbo</i>	Great Cormorant		Irregular Visitor	1, 7	
<i>Phalacrocorax sulcirostris</i>	Little Black Cormorant		Visitor	1, 7	
<i>Phalacrocorax varius</i>	Pied Cormorant		Irregular Visitor	1, 7	
Pelicanidae (Pelican)					
<i>Pelecanus conspicillatus</i>	Australian Pelican		Irregular Visitor	1, 7	
Ardeidae (Hérons, Egrets and Bitterns)					
<i>Botaurus poiciloptilus</i>	Australasian Bittern	CS1 (E,S2)	Irregular Visitor	7	
<i>Ardea pacifica</i>	White-necked Heron		Irregular Visitor	1, 7	
<i>Ardea alba</i>	Eastern Great Egret	CS1 (S5)	Visitor	1, 3, 6, 7	+
<i>Ardea ibis</i>	Cattle Egret	CS1 (S5)	Vagrant	1, 7	
<i>Egretta novaehollandiae</i>	White-faced Heron		Resident	1, 7	
<i>Egretta garzetta</i>	Little Egret		Vagrant	7	
<i>Nycticorax caledonicus</i>	Nankeen Night-Heron		Visitor	1, 7	
Threskiornithidae (Ibis and Spoonbills)					
<i>Plegadis falcinellus</i>	Glossy Ibis	CS1 (M,S5)	Migrant	1, 3, 7	
<i>Threskiornis moluccus</i>	Australian White Ibis		Resident	1, 6, 7	+
<i>Threskiornis spinicollis</i>	Straw-necked Ibis		Resident	1, 6, 7	+
<i>Platalea regia</i>	Royal Spoonbill		Vagrant	1	

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
<i>Platalea flavipes</i>	Yellow-billed Spoonbill		Visitor	1, 7	+
Accipitridae (Eagles, Kites, Goshawks and Osprey)					
<i>Elanus axillaris</i>	Black-shouldered Kite		Resident	1, 5, 7	+
<i>Lophoictinia isura</i>	Square-tailed Kite		Migrant	1, 7	
<i>Haliastur sphenurus</i>	Whistling Kite		Resident	1, 5, 7	
<i>Accipiter fasciatus</i>	Brown Goshawk		Resident	1, 5, 6, 7	
<i>Accipiter cirrocephalus</i>	Collared Sparrowhawk		Resident	1, 5, 7	
<i>Circus approximans</i>	Swamp Harrier		Resident	1, 7	
<i>Aquila audax</i>	Wedge-tailed Eagle		Resident	1, 5, 6, 7	
<i>Hieraetus morphnoides</i>	Little Eagle		Resident	1, 5, 7	
Falconidae (Falcons)					
<i>Falco cenchroides</i>	Nankeen Kestrel		Resident	1, 5, 7	+
<i>Falco berigora</i>	Brown Falcon		Resident	5, 7	
<i>Falco longipennis</i>	Australian Hobby		Resident	5, 6, 7	
<i>Falco peregrinus</i>	Peregrine Falcon	CS1 (S7)	Resident	1, 3, 7	
Rallidae (Crakes, Rails and Swamphens)					
<i>Porphyrio porphyrio</i>	Purple Swamphen		Resident	1, 7	
<i>Gallirallus philippensis</i>	Buff-banded Rail		Resident	1	
<i>Porzana tabuensis</i>	Spotless Crake		Resident	1	
<i>Tribonyx ventralis</i>	Black-tailed Native-hen		Resident	1	
<i>Gallinula tenebrosa</i>	Dusky Moorhen		Resident	7	
<i>Fulica atra</i>	Eurasian Coot		Resident	1, 7	+
Otididae (Bustards)					

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
<i>Ardeotis australis</i>	Australian Bustard		Irregular Visitor	1, 7	
Recurvirostridae (Stilts and Avocets)					
<i>Himantopus leucocephalus</i>	Black-winged Stilt		Visitor	1, 7	+
<i>Recurvirostra novaehollandiae</i>	Red-necked Avocet		Irregular Visitor	1, 7	
<i>Cladorhynchus leucocephalus</i>	Banded Stilt		Vagrant	1	
Charadriidae (Plovers, Dotterel and Lapwings)					
<i>Charadrius ruficapillus</i>	Red-capped Plover		Visitor	1	
<i>Eseyornis melanops</i>	Black-fronted Dotterel		Visitor	1, 7	
<i>Erythronyx cinctus</i>	Red-kneed Dotterel		Visitor	1	
<i>Vanellus tricolor</i>	Banded Lapwing		Visitor	1, 7	
Rostratulidae (Painted Snipe)					
<i>Rostratula australis</i>	Australian Painted Snipe	CS1 (E,S2)	Vagrant	4, 7	
Scolopacidae (Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes)					
<i>Actitis hypoleucos</i>	Common Sandpiper	CS1 (M,S5)	Migrant	1, 7	
<i>Tringa nebularia</i>	Common Greenshank	CS1 (M,S5)	Migrant	7	
<i>Tringa glareola</i>	Wood Sandpiper	CS1 (M,S5)	Migrant	1	
<i>Calidris ruficollis</i>	Red-necked Stint	CS1 (M,S5)	Migrant	1, 3	
<i>Calidris ferruginea</i>	Curlew Sandpiper	CS1 (C,M,S3,S5)	Migrant	4	
Turnicidae (Button-quail)					
<i>Turnix varius</i>	Painted Button-quail		Resident	1, 5	
<i>Turnix velox</i>	Little Button-quail		Irregular Visitor	1, 7	
Laridae (Gulls, Terns and Noddies)					
<i>Chroicocephalus novaehollandiae</i>	Silver Gull		Vagrant	1, 7	

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
Cacatuidae (Cockatoos and Corellas)					
<i>Calyptorhynchus banksii naso</i>	Forest Red-tailed Black-Cockatoo	CS1 (V,S3)	Resident	1, 3, 4, 7	+
<i>Calyptorhynchus latirostris</i>	Carnaby's Black-Cockatoo	CS1 (E,S2)	Resident	1, 3, 4, 5, 6, 7	+
<i>Calyptorhynchus baudinii</i>	Baudin's Black-Cockatoo	CS1 (V,S2)	Irregular Visitor	1, 3, 7	
<i>Eolophus roseicapillus</i>	Galah		Resident	1, 5, 6, 7	+
<i>Cacatua tenuirostris</i>	Long-billed Corella	Int	Resident	1, 7	
<i>Cacatua pastinator</i>	Western Corella		Resident	1, 7	+
<i>Cacatua sanguinea</i>	Little Corella		Resident	6, 7	
Psittacidae (Parrots, Lorikeets and Rosellas)					
<i>Trichoglossus haematodus</i>	Rainbow Lorikeet	Int	Resident	1	
<i>Glossopsitta porphyrocephala</i>	Purple-crowned Lorikeet		Irregular Visitor	1, 5, 7	
<i>Polytelis anthopeplus</i>	Regent Parrot		Irregular Visitor	1	
<i>Platycercus icterotis</i>	Western Rosella		Irregular Visitor	1, 7	
<i>Barnardius zonarius</i>	Australian Ringneck		Resident	1, 5, 6, 7	+
<i>Purpureicephalus spurius</i>	Red-capped Parrot		Resident	1, 5, 6, 7	+
<i>Psephotus varius</i>	Mulga Parrot		Irregular Visitor	7	
<i>Melopsittacus undulatus</i>	Budgerigar		Vagrant	1, 7	
<i>Neophema elegans</i>	Elegant Parrot		Resident	1, 7	+
Cuculidae (Cuckoos)					
<i>Chalcites basalus</i>	Horsfield's Bronze-Cuckoo		Migrant	1, 5, 6, 7	
<i>Chalcites lucidus</i>	Shining Bronze-Cuckoo		Migrant	1, 5, 7	
<i>Cacomantis pallidus</i>	Pallid Cuckoo		Migrant	1, 5, 7	
<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo		Migrant	1, 5, 7	

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
Strigidae (Hawk-Owls)					
<i>Ninox connivens connivens</i>	Barking Owl (southwestern)	CS2 (P2)	Resident	1, 5, 7	
<i>Ninox novaeseelandiae</i>	Southern Boobook		Resident	1, 5, 7	
Tytonidae (Masked Owls)					
<i>Tyto alba</i>	Eastern Barn Owl		Resident	1	
Halcyonidae (Tree Kingfishers)					
<i>Dacelo novaeguineae</i>	Laughing Kookaburra	Int	Resident	1, 5, 6, 7	+
<i>Todiramphus sanctus</i>	Sacred Kingfisher		Resident	1, 5, 7	+
Meropidae (Bee-eaters)					
<i>Merops ornatus</i>	Rainbow Bee-eater		Migrant	1, 3, 5, 7	+
Climacteridae (Trecreepers)					
<i>Climacteris rufa</i>	Rufous Trecreeper	CS3 (LS)	Resident	1	
Maluridae (Fairy-wrens, Emu-wrens and Grasswrens)					
<i>Malurus splendens</i>	Splendid Fairy-wren		Resident	1, 5, 6, 7	+
<i>Malurus leucopterus</i>	White-winged Fairy-wren		Resident	5, 7	
<i>Malurus lamberti</i>	Variegated Fairy-wren		Resident	7	
<i>Malurus pulcherrimus</i>	Blue-breasted Fairy-wren		Resident	1, 7	
<i>Malurus elegans</i>	Red-winged Fairy-wren	CS3 (LS)	Resident	1	
Acanthizidae (Thornbills and Gerygones)					
<i>Sericornis frontalis</i>	White-browed Scrubwren		Resident	1, 7	
<i>Smicornis brevirostris</i>	Weebill		Resident	1, 5, 6, 7	+
<i>Gerygone fusca</i>	Western Gerygone		Resident	1, 5, 7	+
<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill		Resident	1, 5, 7	+

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
<i>Acanthiza uropygialis</i>	Chestnut-rumped Thornbill		Resident	1, 7	
<i>Acanthiza inornata</i>	Western Thornbill		Resident	1, 5, 7	+
<i>Acanthiza apicalis</i>	Inland Thornbill		Resident	5, 7	
Pardalotidae (Pardalotes)					
<i>Pardalotus punctatus</i>	Spotted Pardalote		Resident	1, 7	
<i>Pardalotus striatus</i>	Striated Pardalote		Resident	1, 5, 6, 7	+
Meliphagidae (Honeyeaters and Chats)					
<i>Acanthorhynchus superciliosus</i>	Western Spinebill		Resident	1, 5, 6, 7	+
<i>Lichenostomus virescens</i>	Singing Honeyeater		Resident	1, 5, 6, 7	+
<i>Lichenostomus leucotis</i>	White-eared Honeyeater		Resident	1, 7	
<i>Lichenostomus ornatus</i>	Yellow-plumed Honeyeater		Resident	1, 5	
<i>Purnella albifrons</i>	White-fronted Honeyeater		Irregular Visitor	1	
<i>Manorina flavigula</i>	Yellow-throated Miner		Resident	1, 5, 7	
<i>Acanthagenys rufogularis</i>	Spiny-cheeked Honeyeater		Resident	1, 7	
<i>Anthochaera lunulata</i>	Western Wattlebird		Resident	1, 5, 7	+
<i>Anthochaera carunculata</i>	Red Wattlebird		Resident	1, 5, 6, 7	+
<i>Epthianura tricolor</i>	Crimson Chat		Irregular Visitor	1	
<i>Epthianura albifrons</i>	White-fronted Chat		Resident	1, 5, 7	
<i>Glyciphila melanops</i>	Tawny-crowned Honeyeater		Migrant	1, 5	
<i>Lichmera indistincta</i>	Brown Honeyeater		Resident	1, 5, 6, 7	+
<i>Phylidonyris novaehollandiae</i>	New Holland Honeyeater		Resident	1, 5, 6, 7	+
<i>Phylidonyris niger</i>	White-cheeked Honeyeater		Resident	1	
<i>Melithreptus brevirostris</i>	Brown-headed Honeyeater		Resident	1, 5, 7	

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
<i>Melithreptus chloropsis</i>	Gilbert's Honeyeater		Resident	1	
Pomatostomidae (Australian Babblers)					
<i>Pomatostomus superciliosus</i>	White-browed Babbler		Resident	1, 7	
Neosittidae (Sittellas)					
<i>Daphoenositta chrysoptera</i>	Varied Sittella		Resident	1, 5, 7	+
Campephagidae (Cuckoo-shrikes and Trillers)					
<i>Coracina maxima</i>	Ground Cuckoo-shrike		Irregular Visitor	1	
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike		Resident	1, 5, 6, 7	+
<i>Lalage tricolor</i>	White-winged Triller		Migrant	1, 5	+
Pachycephalidae (Whistlers, Shrike-thrushes and allies)					
<i>Falcunculus frontatus</i>	Crested Shrike-tit	CS3 (LS)	Resident	1	
<i>Pachycephala occidentalis</i>	Western Whistler		Resident	1, 5, 7	
<i>Pachycephala rufiventris</i>	Rufous Whistler		Resident	1, 5, 6, 7	+
<i>Colluricincla harmonica</i>	Grey Shrike-thrush		Resident	1, 5, 7	+
<i>Oreoica gutturalis</i>	Crested Bellbird		Resident	1, 7	
Artamidae (Woodswallows, Currawongs, Butcherbirds and Magpie)					
<i>Artamus personatus</i>	Masked Woodswallow		Irregular Visitor	7	
<i>Artamus cinereus</i>	Black-faced Woodswallow		Resident	5, 6, 7	
<i>Artamus cyanopterus</i>	Dusky Woodswallow		Resident	1, 5, 7	
<i>Cracticus torquatus</i>	Grey Butcherbird		Resident	1, 5, 6, 7	+
<i>Cracticus nigrogularis</i>	Pied Butcherbird		Resident	1, 7	
<i>Cracticus tibicen</i>	Australian Magpie		Resident	1, 5, 6, 7	+
<i>Strepera versicolor</i>	Grey Currawong		Resident	1, 7	

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
Rhipiduridae (Fantails)					
<i>Rhipidura fuliginosa</i>	Grey Fantail		Resident	5, 6, 7	+
<i>Rhipidura leucophrys</i>	Willie Wagtail		Resident	1, 5, 6, 7	+
Corvidae (Crows and Ravens)					
<i>Corvus coronoides</i>	Australian Raven		Resident	5, 6, 7	+
<i>Corvus bennetti</i>	Little Crow		Irregular Visitor	1, 7	
Monarchidae (Monarch and Flycatchers)					
<i>Myiagra inquieta</i>	Restless Flycatcher	CS3 (LS)	Irregular Visitor	1, 7	
<i>Grallina cyanoleuca</i>	Magpie-lark		Resident	1, 5, 6, 7	+
Petroicidae (Australian Robins)					
<i>Microeca fascinans</i>	Jacky Winter		Irregular Visitor	1	
<i>Petroica multicolor</i>	Scarlet Robin	CS3 (LS)	Resident	1, 5	+
<i>Petroica goodenovii</i>	Red-capped Robin		Resident	1, 5, 6, 7	+
<i>Melanodryas cucullata</i>	Hooded Robin		Resident	1, 5	
<i>Eopsaltria georgiana</i>	White-breasted Robin	CS3 (LS)	Resident	1	
Acrocephalidae (Reed-Warblers)					
<i>Acrocephalus australis</i>	Australian Reed-Warbler		Resident	1, 7	
Megaluridae (Grassbirds)					
<i>Megalurus gramineus</i>	Little Grassbird		Resident	1, 7	
<i>Cincloramphus mathewsi</i>	Rufous Songlark		Migrant	1, 5, 7	+
<i>Cincloramphus cruralis</i>	Brown Songlark		Migrant	1, 7	
Timaliidae (True Babblers)					
<i>Zosterops lateralis</i>	Silveryeye		Resident	1, 5, 6, 7	

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
Hirundinidae (Swallows and Martins)					
<i>Cheramoeca leucosterna</i>	White-backed Swallow		Resident	1, 5	
<i>Hirundo neoxena</i>	Welcome Swallow		Resident	1, 5, 6, 7	
<i>Petrochelidon ariel</i>	Fairy Martin		Irregular Visitor	1	
<i>Petrochelidon nigricans</i>	Tree Martin		Resident	1, 5, 6, 7	+
Nectariniidae (Sunbirds and Flowerpeckers)					
<i>Dicaeum hirundinaceum</i>	Mistletoebird		Resident	1, 5, 7	+
Estrildidae (Weaver Finches)					
<i>Taeniopygia guttata</i>	Zebra Finch		Irregular Visitor	7	
Motacillidae (Pipits and Wagtails)					
<i>Anthus novaeseelandiae</i>	Australasian Pipit		Resident	1, 5, 7	+
MAMMALS					
Tachyglossidae (Echidnas)					
<i>Tachyglossus aculeatus</i>	Short-beaked Echidna		Resident	1, 2, 5, 7	+
Dasyuridae (Dasyurids)					
<i>Antechinus flavipes leucogaster</i>	Yellow-footed Antechinus, Mardo	CS3 (LS)	Resident	1, 2	
<i>Dasyurus geoffroii</i>	Chuditch	CS1 (V,S3)	Resident	1, 2, 3, 4, 7	
<i>Phascogale tapoatafa wambenger</i>	Brush-tailed Phascogale, Wambenger	CS1 (S6)	Resident	1, 2, 3	
<i>Sminthopsis crassicaudata</i>	Fat-tailed Dunnart		Resident	2	
<i>Sminthopsis dolichura</i>	Little long-tailed Dunnart		Resident	1, 2	
<i>Sminthopsis fuliginosus fuliginosus</i>	Grey-bellied Dunnart		Resident	1, 5	
<i>Sminthopsis gilberti</i>	Gilbert's Dunnart		Resident	1, 2, 7	
<i>Sminthopsis granulipes</i>	White-tailed Dunnart		Resident	2	

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
Peramelidae (Bandicoots)					
<i>Isodon obesulus fusciventer</i>	Southern Brown Bandicoot, Quenda	CS2 (P4)	Resident	1, 2, 3, 7	
Burramyidae (Pygmy possums)					
<i>Cercartetus concinnus</i>	Western Pygmy-possum, Mundarda		Resident	1, 2, 7	
Tarsipedidae (Honey Possum)					
<i>Tarsipes rostratus</i>	Honey Possum, Noolbenger		Resident	1, 2, 5	
Phalangeridae (Brushtail possums)					
<i>Trichosurus vulpecula</i>	Brushtail Possum	CS3 (LS)	Resident	6, 7	
Macropodidae (Kangaroos)					
<i>Macropus fuliginosus melanops</i>	Western Grey Kangaroo		Resident	1, 2, 5, 6, 7	+
<i>Notamacropus irma</i>	Brush Wallaby	CS2 (P4)	Resident	1, 2, 3, 5, 7	+
<i>Osphranter robustus erubescens</i>	Euro, Biggada		Resident	1, 2, 7	
Muridae (Rats and mice)					
<i>Hydromys chrysogaster</i>	Water-rat, Rakali	CS2 (P4)	Resident	1, 2	(i)
<i>Mus musculus</i>	House Mouse	Int	Resident	1, 2, 5, 6, 7	+
<i>Pseudomys albocinereus albocinereus</i>	Ash-grey Mouse, Noodji		Resident	1, 2, 5	
<i>Rattus norvegicus</i>	Brown Rat	Int	Resident	7	
<i>Rattus rattus</i>	Black Rat	Int	Resident	1, 2, 7	+
Leporidae (Rabbits and hares)					
<i>Oryctolagus cuniculus</i>	Rabbit	Int	Resident	1, 2, 5, 6, 7	+
Molossidae (Freetail bats)					
<i>Austronomus australis</i>	White-striped Free-tailed Bat		Resident	2, 5	+
Vespertilionidae (Vespertilionid bats)					

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat		Resident	1, 2, 5	+
<i>Nyctophilus geoffroyi geoffroyi</i>	Lesser Long-eared Bat		Resident	1, 2, 5, 7	(+)
<i>Nyctophilus gouldi</i>	Gould's Long-eared Bat		Resident	1, 2, 5, 7	(+)
<i>Nyctophilus major major</i>	Greater Long-eared Bat		Resident	2	(+)
<i>Vespadelus regulus</i>	Southern Forest Bat		Resident	1, 2, 5	+
Canidae (Dogs)					
<i>Canis lupus</i>	Dog	Int	Resident	1, 5, 7	
<i>Vulpes vulpes</i>	Red Fox	Int	Resident	1, 2, 5, 6, 7	+
Felidae (Cats)					
<i>Felis catus</i>	Cat	Int	Resident	1, 2, 5, 7	+
Suidae (Pigs)					
<i>Sus scrofa</i>	Pig	Int	Resident	6, 7	
Bovidae (Horned ruminants)					
<i>Bos taurus</i>	European Cattle	Int	Resident	6, 7	+
<i>Capra hircus</i>	Goat	Int	Resident	7	
Cervidae (Deer)					
<i>Cervus elaphus</i>	Red Deer	Int	Resident	8	

Appendix 9. Species returned from the literature review that may once have occurred in the vicinity of the study area but that are now considered locally extinct.

Data sources: 1 = Atlas of Living Australia database search; 2 = NatureMap database search; 3 = DBCA database search; 4 = EPBC Act Search (PMST); 5 = Burbidge *et al.* (1996); 6 = Owen *et al.* (2011); 7 = Leung *et al.* (2015); 8 = BCE database.

CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 1 for full explanation.

EPBC Act listings: E = Endangered, V = Vulnerable, M = Migratory (see Appendix 2).

Wildlife Conservation Act 1950 listings: S1 to S7 = Schedules 1 to 7 (see Appendix 2).

DBCA Priority species: P1 to P4 = Priority 1 to 4 (see Appendix 2).

LS = considered to be of local significance by Bamford Consulting Ecologists (see Appendix 1).

Int = introduced species.

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE
Pythonidae (Pythons)				
<i>Aspidites ramsayi</i>	Woma	CS2 (P1)	Locally Extinct	7
Megapodiidae (Megapodes)				
<i>Leipoa ocellata</i>	Malleefowl	CS1 (V,S3)	Locally Extinct	4, 7
Burhinidae (Stone-curlews)				
<i>Burhinus grallarius</i>	Bush Stone-curlew		Locally Extinct	1, 7
Tytonidae (Masked Owls)				
<i>Tyto novaehollandiae novaehollandiae</i>	Masked Owl (southwestern)	CS2 (P3)	Locally Extinct	8
Psophodidae (Whipbirds and Wedgebills)				
<i>Psophodes nigrogularis</i>	Western Whipbird		Locally Extinct	8
Petroicidae (Australian Robins)				
<i>Drymodes brunneopygia</i>	Southern Scrub-robin		Locally Extinct	7
Dasyuridae (Dasyurids)				
<i>Parantechinus apicalis</i>	Dibbler	CS1 (E,S2)	Locally Extinct	7
<i>Phascogale calura</i>	Red-tailed Phascogale	CS1 (E,S6)	Locally Extinct	4

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE
Thylacomyidae (Bilbies)				
<i>Macrotis lagotis</i>	Bilby, Dalgyte	CS1 (V,S3)	Locally Extinct	1, 2, 3
Pseudocheiridae (Ringtail possums)				
<i>Pseudocheirus occidentalis</i>	Western Ringtail Possum	CS1 (V,S1)	Locally Extinct	2
Potoroidae (Potoroos and bettongs)				
<i>Bettongia lesueur graii</i>	Burrowing Bettong, Boodie	CS1 (Ex,S4)	Locally Extinct	2
<i>Bettongia penicillata ogilbyi</i>	Brush-tailed Bettong, Woylie	CS1 (E,S1)	Locally Extinct	4
Macropodidae (Kangaroos)				
<i>Petrogale lateralis lateralis</i>	Black-footed Rock-Wallaby	CS1 (V,S2)	Locally Extinct	2, 4
Muridae (Rats and mice)				
<i>Pseudomys shortridgei</i>	Heath Mouse	CS1 (V,S3)	Locally Extinct	2

Appendix 10. Species returned from the literature review that have been omitted from the expected species list because of habitat or range limitations.

Data sources: 1 = Atlas of Living Australia database search; 2 = NatureMap database search; 3 = DBCA database search; 4 = EPBC Act Search (PMST); 5 = Burbidge *et al.* (1996); 6 = Owen *et al.* (2011); 7 = Leung *et al.* (2015).

CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 1 for full explanation.

EPBC Act listings: E = Endangered, V = Vulnerable, M = Migratory (see Appendix 2).

Wildlife Conservation Act 1950 listings: S1 to S7 = Schedules 1 to 7 (see Appendix 2).

DBCA Priority species: P1 to P4 = Priority 1 to 4 (see Appendix 2).

LS = considered to be of local significance by Bamford Consulting Ecologists (see Appendix 1).

Int = introduced species.

SPECIES	COMMON NAME	STATUS	DATA SOURCE	REASON FOR OMISSION
Percichthyidae (Australian freshwater basses and cods)				
<i>Nannatherina balstoni</i>	Balston's Pygmy Perch	CS1 (V,S3)	4	Outside of usual range.
Gobiidae (Gobies)				
<i>Glossogobius giuris</i>	Flathead Goby		2	Outside of usual range.
Limnodynastidae (Burrowing frogs)				
<i>Neobatrachus sutor</i>	Shoemaker Frog		1, 2	Outside of usual range.
<i>Neobatrachus wilsmorei</i>	Plonking Frog		2	Outside of usual range.
Diplodactylidae (Diplodactylid geckos)				
<i>Diplodactylus calcicolus</i>	South Coast Gecko		1	Outside of usual range.
<i>Strophurus assimilis</i>	Goldfields Spiny-tailed Gecko		2	Outside of usual range.
Gekkonidae (Gekkonid geckos)				
<i>Hemidactylus frenatus</i>	Asian House Gecko	Int	1	Outside of usual range.
Pygopodidae (Legless lizards)				
<i>Delma australis</i>			2	Outside of usual range.
<i>Delma butleri</i>			2	Outside of usual range.

SPECIES	COMMON NAME	STATUS	DATA SOURCE	REASON FOR OMISSION
<i>Pygopus nigriceps</i>			2	Outside of usual range.
Agamidae (Dragons)				
<i>Ctenophorus scutulatus</i>			2	Outside of usual range.
<i>Moloch horridus</i>	Thorny Devil		2	Outside of usual range.
Scincidae (Skinks)				
<i>Ctenotus inornatus</i>			1	Outside of usual range.
<i>Ctenotus mimetes</i>			2	Outside of usual range.
<i>Ctenotus uber</i>			2	Outside of usual range.
<i>Egernia stokesii badia</i>	Spiny-tailed Skink	CS1 (E,S3)	2, 3, 7	Outside of usual range.
<i>Lerista gerrardii</i>			2	Outside of usual range.
<i>Lerista lineopunctulata</i>			1, 2, 7	Outside of usual range.
<i>Lerista praefrontalis</i>		CS1 (S3)	1, 2, 5	Outside of usual range.
<i>Liopholis inornata</i>			2	Outside of usual range.
<i>Morethia butleri</i>			2	Outside of usual range.
Varanidae (Monitors and goannas)				
<i>Varanus caudolineatus</i>			2	Outside of usual range.
Elapidae (Venomous land snakes)				
<i>Elapognathus coronatus</i>	Crowned Snake		1, 2, 7	Outside of usual range.
<i>Parasuta monachus</i>			2	Outside of usual range.
<i>Pseudonaja nuchalis</i>	Gwardar; Northern Brown Snake		1, 2	Outside of usual range.
Anatidae (Ducks, Geese and Swans)				
<i>Cygnus olor</i>	Mute Swan	Int	1	Outside of usual range.
<i>Anas platyrhynchos</i>	Northern Mallard		7	Outside of usual range.

SPECIES	COMMON NAME	STATUS	DATA SOURCE	REASON FOR OMISSION
Columbidae (Pigeons and Doves)				
<i>Geopelia cuneata</i>	Diamond Dove		1	Outside of usual range.
Accipitridae (Eagles, Kites, Goshawks and Osprey)				
<i>Pandion haliaetus</i>	Eastern Osprey	CS1 (M,S5)	4, 7	Insufficient suitable habitat.
<i>Haliaeetus leucogaster</i>	White-bellied Sea-Eagle		7	Insufficient suitable habitat.
Charadriidae (Plovers, Dotterel and Lapwings)				
<i>Thinornis rubricollis</i>	Hooded Plover	CS2 (P4)	3	Insufficient suitable habitat.
Scolopacidae (Snipe, Sandpipers, Godwits, Curlew, Stints and Phalaropes)				
<i>Numenius madagascariensis</i>	Eastern Curlew	CS1 (C,M,S3,S5)	4	Insufficient suitable habitat.
Laridae (Gulls, Terns and Noddies)				
<i>Thalasseus bergii</i>	Crested Tern		1	Insufficient suitable habitat.
Cacatuidae (Cockatoos and Corellas)				
<i>Cacatua galerita</i>	Sulphur-crested Cockatoo	Int	1, 7	Outside of usual range.
<i>Nymphicus hollandicus</i>	Cockatiel		1	Outside of usual range.
Sturnidae (Starlings)				
<i>Sturnus vulgaris</i>	Common Starling		7	Outside of usual range.
Passeridae (Weaver Finches)				
<i>Passer domesticus</i>	House Sparrow	Int	7	Outside of usual range.
<i>Passer montanus</i>	Eurasian Tree Sparrow	Int	7	Outside of usual range.
Fringillidae (Old World Finches)				
<i>Carduelis carduelis</i>	European Goldfinch	Int	7	Outside of usual range.
Macropodidae (Kangaroos)				
<i>Notamacropus eugenii derbianus</i>	Tammar	CS2 (P4)	1, 2	Outside of usual (modern) range.

SPECIES	COMMON NAME	STATUS	DATA SOURCE	REASON FOR OMISSION
Muridae (Rats and mice)				
<i>Leporillus conditor</i>	Greater Stick-nest Rat	CS1 (V,S6)	2, 3, 7	Outside of usual range.
<i>Notomys mitchellii</i>	Mitchell's Hopping-mouse		2	Outside of usual range.
<i>Pseudomys hermannsburgensis</i>	Sandy Inland Mouse		2	Outside of usual range.
<i>Rattus fuscipes fuscipes</i>	Western Bush Rat		2	Outside of usual range.
Sciuridae (Rats and mice)				
<i>Funambulus pennanti</i>	Indian Palm Squirrel	Int	7	Outside of usual range.

Appendix 11. Black-cockatoo foraging records from within the study area.

See Section 2.3.4.3 and Appendix 7 for description of age classes.

Foraging Record	Date	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
1	6/10/2016	408668	6541392	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Unspecified
2	7/10/2016	409195	6528144	Forest Red-tailed Black-Cockatoo	<i>Eucalyptus marginata</i>	Old
3	7/10/2016	409219	6528151	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Old
4	7/10/2016	409259	6528152	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + old
5	12/10/2016	409102	6526950	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Old
6	18/10/2016	409988	6528005	Carnaby's Black-Cockatoo	<i>Eucalyptus marginata</i>	Recent + intermediate
7	18/10/2016	409988	6528005	Forest Red-tailed Black-Cockatoo	<i>Eucalyptus marginata</i>	Recent + intermediate
8	18/10/2016	409982	6528048	Forest Red-tailed Black-Cockatoo	<i>Eucalyptus marginata</i>	Intermediate
9	18/10/2016	411958	6548321	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
10	18/10/2016	411933	6548329	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
11	18/10/2016	411927	6548366	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
12	18/10/2016	411913	6548375	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
13	18/10/2016	411855	6548430	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
14	18/10/2016	411812	6548441	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
15	18/10/2016	411846	6548444	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
16	18/10/2016	411806	6548446	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
17	18/10/2016	411829	6548449	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
18	18/10/2016	411798	6548451	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
19	18/10/2016	411790	6548461	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate

Foraging Record	Date	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
20	18/10/2016	411784	6548465	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
21	18/10/2016	411789	6548478	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
22	18/10/2016	411767	6548480	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
23	18/10/2016	411760	6548482	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
24	18/10/2016	411749	6548491	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
25	18/10/2016	411754	6548507	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
26	18/10/2016	411724	6548510	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
27	18/10/2016	411719	6548537	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
28	18/10/2016	411691	6548541	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
29	18/10/2016	411682	6548542	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
30	18/10/2016	411700	6548551	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
31	18/10/2016	411670	6548577	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
32	18/10/2016	411637	6548581	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
33	18/10/2016	411624	6548598	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
34	18/10/2016	411612	6548608	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
35	18/10/2016	411594	6548619	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
36	18/10/2016	411598	6548622	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
37	18/10/2016	411629	6548626	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
38	18/10/2016	416712	6549199	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate + old
39	18/10/2016	416775	6549381	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
40	18/10/2016	422111	6552626	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Old
41	18/10/2016	422114	6552651	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Old

Foraging Record	Date	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
42	18/10/2016	422127	6552731	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Old
43	31/07/2017	411100.997	6519730.13	Forest Red-tailed Black-Cockatoo	<i>Eucalyptus marginata</i>	Intermediate
44	31/07/2017	410945.307	6519795.726	Unspecified black-cockatoo	<i>Eucalyptus marginata</i>	Intermediate
45	31/07/2017	411048.915	6519800.224	Unspecified black-cockatoo	<i>Corymbia calophylla</i>	Intermediate
46	1/08/2017	408262.306	6533922.11	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
47	1/08/2017	408506	6538415	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Old
48	1/08/2017	408905	6539413	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Old
49	1/08/2017	409093	6539681	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Old
50	1/08/2017	409125	6540015	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Old
51	1/08/2017	409100	6540039	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Old
52	1/08/2017	408722	6541264	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate
53	1/08/2017	408745	6542286	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
54	1/08/2017	408760	6542298	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
55	1/08/2017	408760	6542305	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
56	1/08/2017	408515	6542407	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate
57	1/08/2017	408494	6542448	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
58	1/08/2017	408682	6542459	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
59	1/08/2017	408709	6542466	Unspecified black-cockatoo	<i>Corymbia calophylla</i>	Old
60	2/08/2017	410035	6518565	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
61	2/08/2017	410035	6518565	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
62	2/08/2017	410031	6518568	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
63	2/08/2017	410031	6518568	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate

Foraging Record	Date	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
64	2/08/2017	410031	6518568	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
65	2/08/2017	410031	6518568	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
66	2/08/2017	410005	6518569	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
67	2/08/2017	410005	6518569	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
68	2/08/2017	410000	6518571	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
69	2/08/2017	410000	6518571	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
70	2/08/2017	410759	6519616	Unspecified black-cockatoo	<i>Eucalyptus marginata</i>	Recent
71	2/08/2017	410858	6519621	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
72	2/08/2017	410051	6521707	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
73	2/08/2017	409731	6521820	Carnaby's Black-Cockatoo	<i>Eucalyptus marginata</i>	Recent + intermediate
74	2/08/2017	408995	6524320	Carnaby's Black-Cockatoo	<i>Eucalyptus marginata</i>	Intermediate
75	2/08/2017	408997	6524324	Forest Red-tailed Black-Cockatoo	<i>Eucalyptus marginata</i>	Intermediate
76	2/08/2017	408932	6524331	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
77	2/08/2017	408879	6524394	Carnaby's Black-Cockatoo	<i>Banksia sp.</i>	Intermediate
78	2/08/2017	408891	6524464	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
79	2/08/2017	409040	6524526	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
80	2/08/2017	408616	6542534	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
81	2/08/2017	408686	6542569	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
82	2/08/2017	408583	6542571	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
83	2/08/2017	408681	6542573	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
84	2/08/2017	408594	6542582	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
85	2/08/2017	408750.8	6542602.2	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Old

Foraging Record	Date	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
86	2/08/2017	408706.5	6542639.7	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Old
87	3/08/2017	408697	6524312	Carnaby's Black-Cockatoo	<i>Banksia sp.</i>	Intermediate
88	3/08/2017	408823	6524314	Carnaby's Black-Cockatoo	<i>Banksia sp.</i>	Intermediate
89	3/08/2017	408734	6526135	Carnaby's Black-Cockatoo	<i>Eucalyptus marginata</i>	Intermediate
90	3/08/2017	408757	6526147	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
91	3/08/2017	408530	6527854	Forest Red-tailed Black-Cockatoo	<i>Eucalyptus marginata</i>	Recent + intermediate
92	3/08/2017	408370	6528057	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
93	3/08/2017	409036	6532536	Forest Red-tailed Black-Cockatoo	<i>Eucalyptus marginata</i>	Old
94	3/08/2017	409009	6532718	Unspecified black-cockatoo	<i>Corymbia calophylla</i>	Intermediate
95	3/08/2017	409038	6532722	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
96	3/08/2017	409035	6533028	Forest Red-tailed Black-Cockatoo	<i>Eucalyptus marginata</i>	Intermediate
97	3/08/2017	409193.911	6533039.564	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
98	3/08/2017	409137.585	6533123.067	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Old
99	3/08/2017	409118.88	6533392.939	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
100	3/08/2017	409203	6533488	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
101	3/08/2017	409345	6533572	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate + old
102	3/08/2017	409345	6533572	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate + old
103	3/08/2017	408126	6536978	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate
104	3/08/2017	408255	6537032	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Old
105	3/08/2017	408206	6537136	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
106	3/08/2017	408133	6537231	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
107	3/08/2017	408256	6537325	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate + old

Foraging Record	Date	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
108	3/08/2017	408082	6537356	Forest Red-tailed Black-Cockatoo	<i>Eucalyptus marginata</i>	Recent + intermediate
109	3/08/2017	408112	6537566	Carnaby's Black-Cockatoo	<i>Banksia menziesii</i>	Old
110	4/08/2017	409355.2	6523137.5	Carnaby's Black-Cockatoo	<i>Eucalyptus marginata</i>	Recent
111	4/08/2017	409076	6527008	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
112	4/08/2017	409292	6527208	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
113	4/09/2017	408996.6	6523932.3	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
114	4/09/2017	408656.74	6529219.2	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
115	4/09/2017	408621.64	6529222.51	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Old
116	4/09/2017	408661.6	6529237.6	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
117	4/09/2017	408660.14	6529299.03	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
118	4/09/2017	408637.74	6529319.54	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
119	5/09/2017	409288.3	6523259.8	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
120	5/09/2017	408387.8231	6529464.525	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
121	5/09/2017	409170.24	6532586.88	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
122	6/09/2017	409032.7	6531918	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
123	6/09/2017	409072.96	6532515.18	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
124	6/09/2017	409091.33	6532558.93	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
125	6/09/2017	409096.29	6532616.71	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
126	6/09/2017	414750	6548656	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate
127	6/09/2017	417919.4	6549576.4	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Old
128	6/09/2017	421212.1902	6551856.093	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Old
129	6/09/2017	422124.6926	6552916.505	Unspecified black-cockatoo	<i>Corymbia calophylla</i>	Old

Foraging Record	Date	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
130	7/09/2017	420978	6551723	Carnaby's Black-Cockatoo	<i>Banksia sessilis</i>	Recent + intermediate
131	8/09/2017	412913	6547701	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
132	8/09/2017	412913	6547701	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
133	8/09/2017	421988	6552012	Unspecified black-cockatoo	<i>Corymbia calophylla</i>	Old
134	8/09/2017	421988	6552012	Unspecified black-cockatoo	<i>Corymbia calophylla</i>	Old
135	9/10/2017	411430	6529348	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate + old
136	9/10/2017	411416	6529387	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate
137	9/10/2017	411413	6529395	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Active + intermediate
138	9/10/2017	411425	6529405	Carnaby's Black-Cockatoo	<i>Unspecified sp.</i>	Intermediate
139	9/10/2017	411391	6529495	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate
140	9/10/2017	411283	6529758	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate + old
141	9/10/2017	411283	6529769	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
142	9/10/2017	411270	6529794	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
143	9/10/2017	411265	6529823	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate + old
144	9/10/2017	410371	6531377	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
145	9/10/2017	410346	6531385	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Recent
146	9/10/2017	410374	6531409	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate
147	9/10/2017	410365	6531426	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate
148	9/10/2017	410277	6531479	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate + old
149	9/10/2017	410315	6531517	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
150	9/10/2017	410314	6531521	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
151	9/10/2017	410219	6531598	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate

Foraging Record	Date	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
152	9/10/2017	410244	6531665	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
153	10/10/2017	409007	6524309	Carnaby's Black-Cockatoo	<i>Unspecified sp.</i>	Recent + intermediate
154	10/10/2017	408981	6524336	Carnaby's Black-Cockatoo	<i>Unspecified sp.</i>	Recent + intermediate
155	10/10/2017	409052	6524437	Carnaby's Black-Cockatoo	<i>Unspecified sp.</i>	Recent
156	10/10/2017	409043	6524602	Carnaby's Black-Cockatoo	<i>Unspecified sp.</i>	Recent
157	10/10/2017	408690	6526172	Carnaby's Black-Cockatoo	<i>Unspecified sp.</i>	Recent
158	10/10/2017	410109	6527886	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
159	10/10/2017	410091	6527910	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
160	10/10/2017	410064	6527946	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
161	10/10/2017	411400	6529396	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Active
162	10/10/2017	411353	6529445	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
163	10/10/2017	411339	6529470	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Old
164	10/10/2017	411227	6529801	Forest Red-tailed Black-Cockatoo	<i>Eucalyptus marginata</i>	Recent
165	10/10/2017	411238	6529801	Forest Red-tailed Black-Cockatoo	<i>Eucalyptus marginata</i>	Intermediate
166	10/10/2017	410965	6530364	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
167	10/10/2017	410633	6530957	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
168	10/10/2017	410566	6531024	Forest Red-tailed Black-Cockatoo	<i>Eucalyptus marginata</i>	Recent
169	10/10/2017	410560	6531032	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
170	10/10/2017	410560	6531032	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
171	10/10/2017	410391	6531379	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
172	10/10/2017	410391	6531379	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
173	10/10/2017	410327	6531517	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate

Foraging Record	Date	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
174	10/10/2017	413629.1	6547996.5	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
175	10/10/2017	417845	6549821	Carnaby's Black-Cockatoo	<i>Unspecified sp.</i>	Recent
176	11/10/2017	409853.8	6518622.8	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
177	11/10/2017	409874	6518655	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
178	11/10/2017	409861.5	6518716.1	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Old
179	11/10/2017	409825.2	6518720	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
180	11/10/2017	409874.8	6518765.6	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
181	11/10/2017	409874.8	6518765.6	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
182	11/10/2017	409827	6518768	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate + old
183	11/10/2017	409877	6518770	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
184	11/10/2017	409867.9	6518789	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
185	11/10/2017	409817	6518806	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
186	11/10/2017	409856	6518824	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate
187	11/10/2017	409806	6518847	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate + old
188	11/10/2017	409814	6518996	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Old
189	11/10/2017	409592.9	6519243.9	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
190	11/10/2017	409784	6519305.3	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
191	11/10/2017	409754	6519445	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
192	11/10/2017	409694	6519542	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
193	11/10/2017	409727.8	6519560.2	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
194	11/10/2017	408789	6524470	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Intermediate
195	11/10/2017	408716	6524831	Carnaby's Black-Cockatoo	<i>Eucalyptus marginata</i>	Recent

Foraging Record	Date	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
196	11/10/2017	409261.3	6525742.7	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Old
197	11/10/2017	409293.4	6527206.3	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Old
198	11/10/2017	409290	6528542	Carnaby's Black-Cockatoo	<i>Unspecified sp.</i>	Intermediate
199	11/10/2017	408900	6529162	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Old
200	11/10/2017	408170	6533742	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Old
201	12/10/2017	408640	6526702	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Intermediate
202	12/10/2017	408667	6527743	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
203	12/10/2017	408500	6527752	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
204	12/10/2017	409976	6532196	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
205	12/10/2017	409921	6532310	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Intermediate
206	12/10/2017	409858	6532429	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
207	12/10/2017	409858	6532429	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
208	12/10/2017	409631	6532787	Forest Red-tailed Black-Cockatoo	<i>Eucalyptus marginata</i>	Old
209	12/10/2017	409658	6532831	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
210	12/10/2017	409513	6533117	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
211	12/10/2017	409492	6533119	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Old
212	12/10/2017	409439	6533219	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Old
213	12/10/2017	409439	6533219	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Old
214	17/10/2017	409035	6534331	Carnaby's Black-Cockatoo	<i>Eucalyptus todtiana</i>	Recent
215	17/10/2017	409072	6534334	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Old
216	17/10/2017	409079	6534422	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Old
217	17/10/2017	408057	6534631	Carnaby's Black-Cockatoo	<i>Unspecified sp.</i>	Recent + intermediate

Foraging Record	Date	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
218	17/10/2017	408264	6534637	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Old
219	17/10/2017	408353	6534665	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
220	17/10/2017	408319	6534693	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
221	17/10/2017	408238	6534729	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Old
222	17/10/2017	408221	6534781	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Old
223	17/10/2017	408345	6534797	Carnaby's Black-Cockatoo	<i>Banksia sp.</i>	Intermediate
224	17/10/2017	408307	6534812	Carnaby's Black-Cockatoo	<i>Banksia sp.</i>	Intermediate
225	17/10/2017	408190	6534840	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Old
226	17/10/2017	408439	6534912	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate
227	17/10/2017	408271	6534968	Carnaby's Black-Cockatoo	<i>Banksia sp.</i>	Intermediate
228	17/10/2017	408119	6534978	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Intermediate + old
229	17/10/2017	408111	6534992	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate
230	17/10/2017	408226	6535003	Carnaby's Black-Cockatoo	<i>Unspecified sp.</i>	Recent + intermediate
231	17/10/2017	407999	6535031	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate
232	17/10/2017	408171	6535038	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
233	15/11/2017	411316	6529770	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Active
234	15/11/2017	409523	6533029	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Old
235	15/11/2017	409383	6533292	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Old
236	15/11/2017	409348	6533376	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Old
237	15/11/2017	408508.01	6543693.32	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
238	11/09/2018	408525.28	6530681.94	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate

Foraging Record	Date	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
239	12/09/2018	410196.69	6547094.71	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Active + recent + intermediate
240	12/09/2018	410702.02	6547194.33	Carnaby's Black-Cockatoo	<i>Corymbia calophylla</i>	Recent + intermediate
241	12/09/2018	422416.5	6553508	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
242	12/09/2018	422414.9	6553918.3	Carnaby's Black-Cockatoo	<i>Dryandra sp.</i>	Recent
243	22/11/2018	407945	6535324	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
244	22/11/2018	408542	6536865	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Intermediate
245	22/11/2018	408608	6537152	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Intermediate
246	22/11/2018	408828	6537838	Forest Red-tailed Black-Cockatoo	<i>Corymbia calophylla</i>	Recent
247	22/11/2018	409453	6538272	Carnaby's Black-Cockatoo	<i>Banksia attenuata</i>	Intermediate

Appendix 12. Opportunistic and indirect observations of target species.

Datum: GDA94. UTM Zone: 50J.

Species	Date	Easting	Northing	Count	Notes
Brush Wallaby	10/10/2017	408892	6524645	1	Seen in Jarrah-Marri Woodland north of Teatree Road.
Brush Wallaby	17/10/2017	408501	6534576	1	Seen in Banksia Woodland, north of Mooliabeenee Road (west of Lake Nangar).
Brush Wallaby	23/11/2018	406133	6532475	1	Road kill on Mooliabeenee Road.
Carnaby's Black-Cockatoo	1/08/2017	410269	6518867	2	
Carnaby's Black-Cockatoo	3/08/2017	409005	6532542	6	
Carnaby's Black-Cockatoo	3/08/2017	411184	6548864	2	Flying west.
Carnaby's Black-Cockatoo	4/08/2017	414343	6524211	1	
Carnaby's Black-Cockatoo	4/09/2017	409125	6523297	5	
Carnaby's Black-Cockatoo	4/09/2017	408596	6524149	2	
Carnaby's Black-Cockatoo	4/09/2017	409033	6528131	10	
Carnaby's Black-Cockatoo	4/09/2017	408719	6528369	4	Flying south.
Carnaby's Black-Cockatoo	4/09/2017	408705	6529237	2	Flying west.
Carnaby's Black-Cockatoo	4/09/2017	408768	6529260	5	Flying west.
Carnaby's Black-Cockatoo	4/09/2017	408661	6529297	10	Flying west.
Carnaby's Black-Cockatoo	5/09/2017	409336	6523834	5	Flying west.
Carnaby's Black-Cockatoo	5/09/2017	408423	6528593	6	Flying north.
Carnaby's Black-Cockatoo	6/09/2017	409093	6532747	2	Chewing on hollow entrance.
Carnaby's Black-Cockatoo	6/09/2017	411809	6548761	3	Flying north.
Carnaby's Black-Cockatoo	6/09/2017	416641	6549454	2	Flying to north-east.
Carnaby's Black-Cockatoo	6/09/2017	421133	6551766	2	Flying to dam.

Species	Date	Easting	Northing	Count	Notes
Carnaby's Black-Cockatoo	6/09/2017	421184	6551882	4	
Carnaby's Black-Cockatoo	7/09/2017	408257	6524305	3	Pair plus juvenile, feeding on Banksia menziesii.
Carnaby's Black-Cockatoo	7/09/2017	417975	6549249	2	Flying west.
Carnaby's Black-Cockatoo	7/09/2017	421534	6551523	2	Flying east.
Carnaby's Black-Cockatoo	7/09/2017	421424	6551536	3	Flying south.
Carnaby's Black-Cockatoo	7/09/2017	421363	6551615	3	Flying south.
Carnaby's Black-Cockatoo	7/09/2017	421270	6551650	6	
Carnaby's Black-Cockatoo	8/09/2017	412765	6548082	2	
Carnaby's Black-Cockatoo	8/09/2017	421922	6551377	2	Flying east.
Carnaby's Black-Cockatoo	9/10/2017	410370	6531378	2	Pair mating in Dead Marri.
Carnaby's Black-Cockatoo	9/10/2017	410274	6531476	2	Flying east.
Carnaby's Black-Cockatoo	9/10/2017	413642	6548066	3	Feeding on the ground to east.
Carnaby's Black-Cockatoo	9/10/2017	413723	6548228	2	
Carnaby's Black-Cockatoo	9/10/2017	417796	6550795	9	Flying west.
Carnaby's Black-Cockatoo	9/10/2017	422203	6553123	1	
Carnaby's Black-Cockatoo	10/10/2017	410291	6523905	4	
Carnaby's Black-Cockatoo	10/10/2017	412240	6524535	6	Flying north.
Carnaby's Black-Cockatoo	10/10/2017	410619	6530814	1	Male inspecting nest hollow in Marri.
Carnaby's Black-Cockatoo	10/10/2017	410619	6530814	2	Inspecting tree hollow.
Carnaby's Black-Cockatoo	10/10/2017	410569	6531013	2	Inspecting tree hollows to east.
Carnaby's Black-Cockatoo	10/10/2017	410488	6531080	1	
Carnaby's Black-Cockatoo	10/10/2017	410427	6531201	2	Feeding on Marri.
Carnaby's Black-Cockatoo	10/10/2017	410396	6531297	13	Flying south.

Species	Date	Easting	Northing	Count	Notes
Carnaby's Black-Cockatoo	10/10/2017	410375	6531342	1	
Carnaby's Black-Cockatoo	10/10/2017	410375	6531342	2	Entering nest hollow 500m away.
Carnaby's Black-Cockatoo	10/10/2017	410375	6531342	3	To east.
Carnaby's Black-Cockatoo	10/10/2017	410363	6531368	2	
Carnaby's Black-Cockatoo	10/10/2017	410367	6531375	1	To east.
Carnaby's Black-Cockatoo	10/10/2017	417556	6549970		
Carnaby's Black-Cockatoo	10/10/2017	415155	6551926	2	Flying north.
Carnaby's Black-Cockatoo	11/10/2017	409222	6524198	1	
Carnaby's Black-Cockatoo	11/10/2017	408947	6524302		
Carnaby's Black-Cockatoo	11/10/2017	410887	6527231	1	
Carnaby's Black-Cockatoo	11/10/2017	410664	6527351	2	Flying west.
Carnaby's Black-Cockatoo	11/10/2017	410615	6527366	3	Flying east.
Carnaby's Black-Cockatoo	11/10/2017	411378	6527448	1	Flying north.
Carnaby's Black-Cockatoo	11/10/2017	408881	6529350	8	
Carnaby's Black-Cockatoo	12/10/2017	410553	6531019	2	
Carnaby's Black-Cockatoo	12/10/2017	410200	6531679	1	
Carnaby's Black-Cockatoo	12/10/2017	409964	6532310	1	Flying north.
Carnaby's Black-Cockatoo	12/10/2017	409816	6532546	3	Flying north-west.
Carnaby's Black-Cockatoo	17/10/2017	407656	6534312		
Carnaby's Black-Cockatoo	17/10/2017	408838	6534470	2	One parent and one young.
Carnaby's Black-Cockatoo	17/10/2017	408210	6534605	2	
Carnaby's Black-Cockatoo	17/10/2017	408083	6534900	2	
Carnaby's Black-Cockatoo	17/10/2017	408263	6534924	3	Flying east.

Species	Date	Easting	Northing	Count	Notes
Carnaby's Black-Cockatoo	11/09/2018	408481	6531202	2	Well to the south.
Carnaby's Black-Cockatoo	11/09/2018	408536	6532844.4	3	Flew in, landed and then flew off.
Carnaby's Black-Cockatoo	11/09/2018	409369	6547088	10	Perched/feeding in Xanthorrhoea.
Carnaby's Black-Cockatoo	12/09/2018	410196	6547094	12	Feeding in Marri.
Carnaby's Black-Cockatoo	12/09/2018	410974	6547332	2	Flying west.
Carnaby's Black-Cockatoo	12/09/2018	422433	6553949	2	Flying past.
Carnaby's Black-Cockatoo	23/11/2018	408025	6537486	3	Feeding in Banksia along Cullalla Road.
Forest Red-tailed Black-Cockatoo	31/07/2017	411042	6519674	3	
Forest Red-tailed Black-Cockatoo	2/08/2017	408743	6529731	3	
Forest Red-tailed Black-Cockatoo	4/09/2017	408961	6523988	3	
Forest Red-tailed Black-Cockatoo	4/09/2017	409157	6528126	1	
Forest Red-tailed Black-Cockatoo	5/09/2017	409270	6523208		
Forest Red-tailed Black-Cockatoo	5/09/2017	408390	6529571	2	Female in hollow. Male nearby.
Forest Red-tailed Black-Cockatoo	5/09/2017	410193	6531690	3	
Forest Red-tailed Black-Cockatoo	7/09/2017	410348	6523904	2	
Forest Red-tailed Black-Cockatoo	7/09/2017	413247	6524425	6	Feeding on Marri.
Forest Red-tailed Black-Cockatoo	10/10/2017	410614	6531002	2	
Forest Red-tailed Black-Cockatoo	10/10/2017	410436	6531283	2	Feeding on Marri.
Forest Red-tailed Black-Cockatoo	11/10/2017	409728	6518830	5	
Forest Red-tailed Black-Cockatoo	11/10/2017	409292	6528132	3	
Forest Red-tailed Black-Cockatoo	11/10/2017	409054	6529929		Feeding.
Forest Red-tailed Black-Cockatoo	11/10/2017	409097	6529961	3	Two adults and one juvenile.
Forest Red-tailed Black-Cockatoo	12/10/2017	408656	6527778		

Species	Date	Easting	Northing	Count	Notes
Forest Red-tailed Black-Cockatoo	12/10/2017	408447	6527969	2	Pair in probable nest-tree.
Forest Red-tailed Black-Cockatoo	12/10/2017	407884	6528113		
Forest Red-tailed Black-Cockatoo	12/10/2017	409594	6532804	2	Flying east.
Rakali (Water-rat)	8/09/2017	420278	6550935		Possible foraging signs (freshwater crayfish remains) or scats.
Rakali (Water-rat)	8/09/2017	420982	6550938		Possible foraging signs (freshwater crayfish remains) or scats.
Rakali (Water-rat)	8/09/2017	420264	6550939		Possible foraging signs (freshwater crayfish remains) or scats.
Rakali (Water-rat)	8/09/2017	421077	6550982		Possible foraging signs (freshwater crayfish remains) or scats.
Rakali (Water-rat)	8/09/2017	421071	6550989		Possible foraging signs (freshwater crayfish remains) or scats.
Unidentified black-cockatoo	10/10/2017	408704	6526054		Potential roost site in Marri tree; lots of fresh droppings on ground.
Unidentified black-cockatoo	10/10/2017	417058	6549762		Potential roost site in Marri tree; lots of fresh droppings on ground.

