

Great Northern Highway: Bindoon Bypass Fauna Assessment



Carnaby's Black-Cockatoo feeding signs on Marri fruits. Photo: W. Bancroft

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In association with:



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Executive Summary

Bamford Consulting Ecologists (BCE) was commissioned by Focused Vision consulting Pty Ltd (FVC), on behalf of Arup Jacobs Joint Venture (ASJV), to conduct a Level 1 fauna assessment (desktop review and site inspection) of three proposed route options for the Great Northern Highway to bypass the town of Bindoon. 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 in October and December 2016. The desktop study identified 306 vertebrate fauna species as potentially occurring in the survey area (eight freshwater fish, 17 frogs, 69 reptiles, 177 birds and 35 mammals, including 11 introduced mammals). The presence of 66 species (one freshwater fish, five frogs, three reptiles, 52 birds and five mammals) was confirmed during the 2016 field surveys. The vertebrate assemblage includes up to 46 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 survey area. The distribution and quality of foraging habitat for these species has also been mapped.

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 46 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, Rainbow Bee-eater, Chuditch, Brush-tailed Phascogale, Carter's Freshwater Mussel, Quenda and Water-rat.

Vegetation and Substrate Associations (VSAs). The survey area passes through nine VSAs which vary north-south and east-west with rainfall and land system. 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 survey 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 (and therefore may become threatening processes if altered) 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 (roadkill).
- 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 which avoids 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 and adjust the final alignment where practicable 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.

Comparison of options

The three options are greatly different in area and extent, and this primarily determines the relative values and impacts upon fauna. Western bypass A (including the common area) is by far the greatest in area and extent, as it extends for over 30 km north to south, and therefore supports more species and a greater variety of environments than the other options. For example, it encompasses forested areas in the south, banksia woodlands on the Dandaragan Plateau and Wandoo woodland in the north, so interacts with different fauna assemblages with these differences in the environment. In contrast, Western bypass B (including the common area), has a length of about 10 km and affects only forested areas in the south (and some farmland; as do all options). The Eastern bypass is narrower than the other two options and only about 5 km long. It affects forested areas and is aligned closer to a large wetland (Lake Chittering) than the other two options. Western bypass A has the greatest implications in terms of impacts upon fauna because of its area and extent.

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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. At the time of conducting the study that this report documents, there were three route options for the Great Northern Highway to bypass the town of Bindoon, as shown in Figure 1. Two routes pass through a common area in the south (Area 1 in Figure 1), with two western options, Western A and Western B (Areas 2 and 3 in Figure 1, respectively), and an eastern option (Area 4 in Figure 1).

As part of the Environmental Impact Assessment for the project, Bamford Consulting Ecologists (BCE) was commissioned by Focused Vision Consulting Pty Ltd (FVC), who were in turn commissioned by the Arup Jacobs Joint Venture (ASJV), working on behalf of Main Roads, to conduct a Level 1 fauna assessment of the proposed routes (referred to hereafter as the “survey area”). The function of the fauna assessment, consistent with Environmental Protection Agency (EPA) Guidance (desktop review and reconnaissance survey), is to identify the fauna values of the target sites so that impacts upon these from any proposed development can be assessed and, where possible, minimised.

The purpose of this report is to provide information on the fauna values, particularly for significant species, an overview of the ecological function of the site within the local and regional context, and to provide discussion on the interaction of the proposal on these fauna values and functions.

1.2 General approach to fauna impact assessment

The purpose of impact assessment is to provide information required 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 Project scope

A scope of works was provided to BCE by FVC, as received from ASJV, which outlined the requirement for the following fauna assessment aspects for the survey area:

- A spring Level 1 and Level 2 fauna survey, including targeted surveys of conservation significant fauna (if identified as potentially present in the desktop review); and
- Surveys for black-cockatoos, including potential breeding trees, roosting and breeding sites and mapping of breeding and foraging habitat.

In reference to EPA Guidance Statement No.56 (EPA 2004), BCE determined that the specific scope of the project therefore required the following actions to be undertaken:

- complete a desktop assessment of the study area prior to a field assessment to identify all fauna constraints which may be in or near the survey area;
- identify and review any existing and relevant fauna reports;
- identify significant fauna values and potential sensitivity to impact;
- identify broad vegetation and Substrate Associations (VSAs) present within the survey area;
- conduct field surveys to verify / ground truth the desktop assessment findings;
- undertake relevant fauna constraints mapping using GIS mapping software;
- assess all fauna aspects likely to require referral of the project to the EPA;
- assess Matters of National Environmental Significance (MNES) and indicate whether potential impacts on MNES as protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) are likely to require referral of the project to the Commonwealth Department of the Environment and Energy (DEE), providing justification of a decision as to whether referral is likely to be required, and ensuring reference to relevant Commonwealth significant impact guidelines;
- determine the legislative context of fauna aspects required for the assessment; and
- provide a concise report on the findings of the fauna assessment.

1.4 Description of survey area

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 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. Broad environmental characteristics of the survey area are outlined in the following section.

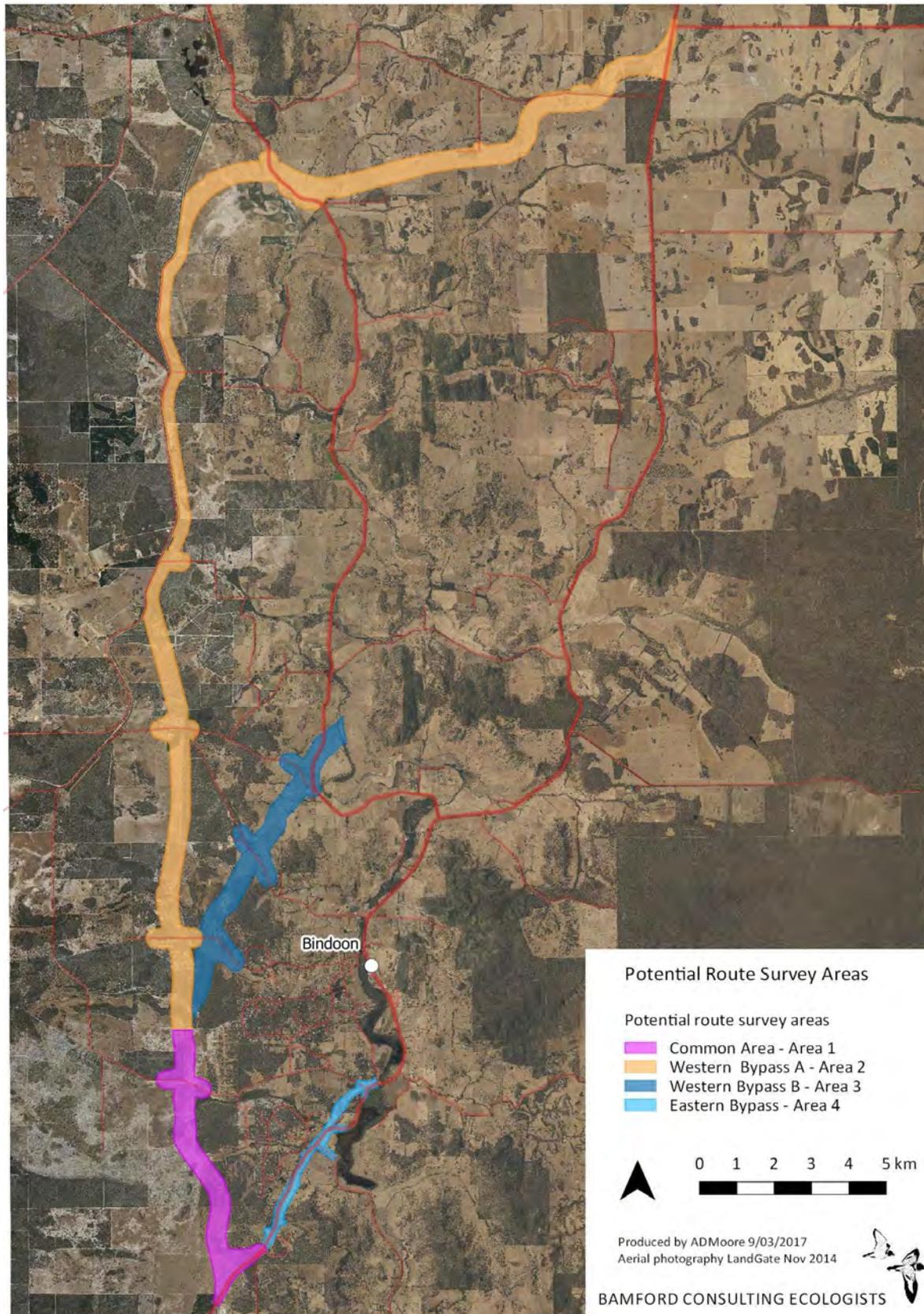


Figure 1. Surveys areas for the proposed Bindoon Bypass routes.

2 Regional description

The Interim Biogeographic Regionalisation of Australia (IBRA v7) (DEE 2016) has identified 26 bioregions in Western Australia. These main regions are further subdivided into 55 sub-regions, as shown in Figure 2. The bioregions (including subregions) are classified on the basis of climate, geology, landforms, vegetation and fauna (Thackway and Cresswell 1995). IBRA regions and subregions are affected by a range of different threatening processes and have varying levels of sensitivity to impact (EPA 2004). The Bindoon bypass survey area 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 survey area passing through the Northern Jarrah Forest Subregion (JAF1) and the Dandaragan Plateau Subregion (SWA1), as shown in Figure 3. The subregions are summarised below.

Northern Jarrah Forest Subregion

Characterised by Jarrah-Marri forest on lateritic gravels and, in the eastern part, by woodlands of Wandoo - Marri on clayey soils. Eluvial and alluvial deposits support *Agonis* shrublands. In areas of Mesozoic sediments, Jarrah forests occur in a mosaic with a variety of species-rich shrublands. The climate is Warm Mediterranean. The subregion incorporates the area east of the Darling Scarp, overlying Archaean granite and metamorphic rocks of an average elevation of 300 m, capped by an extensive lateritic duricrust, dissected by later drainage and broken by occasional granite hills. Rainfall is from 1300 mm on the scarp to approximately 700 mm in the east and north. Vegetation comprises Jarrah - Marri forest in the west with Bullich and Blackbutt in the valleys grading to Wandoo and Marri woodlands in the east with Powderbark on breakaways. There are extensive but localised sand sheets with Banksia low woodlands. Heath is found on granite rocks and as a common understorey of forests and woodlands in the north and east. Dominant land uses mainly include forestry (native forests), conservation, grazing (improved pastures), cultivation (dry land agriculture), forestry (plantations), and mining (Williams and Mitchell 2001). In the Bindoon area, there is increasing low-density residential.

Dandaragan Plateau Subregion

Characterised by Banksia low woodland, Jarrah - Marri woodland, Marri woodland, and by scrub-heaths on laterite pavement and on gravelly sandplains. The climate is Warm Mediterranean and annual rainfall is 700 mm. The dominant land use is dry-land agriculture (Desmond 2001).

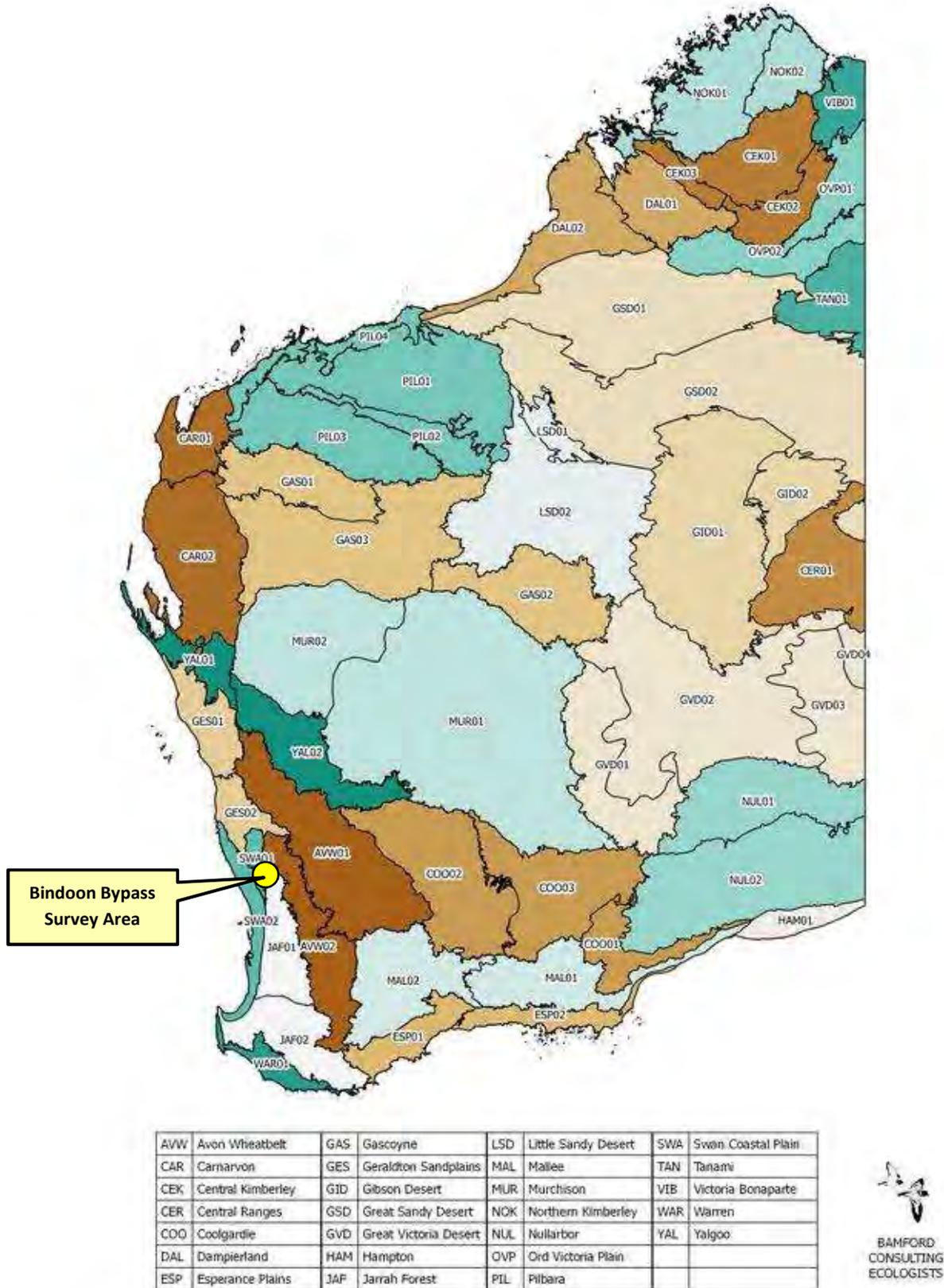


Figure 2. IBRA7 (Interim Biogeographic Regionalisation of Australia, version 7) subregions in Western Australia.

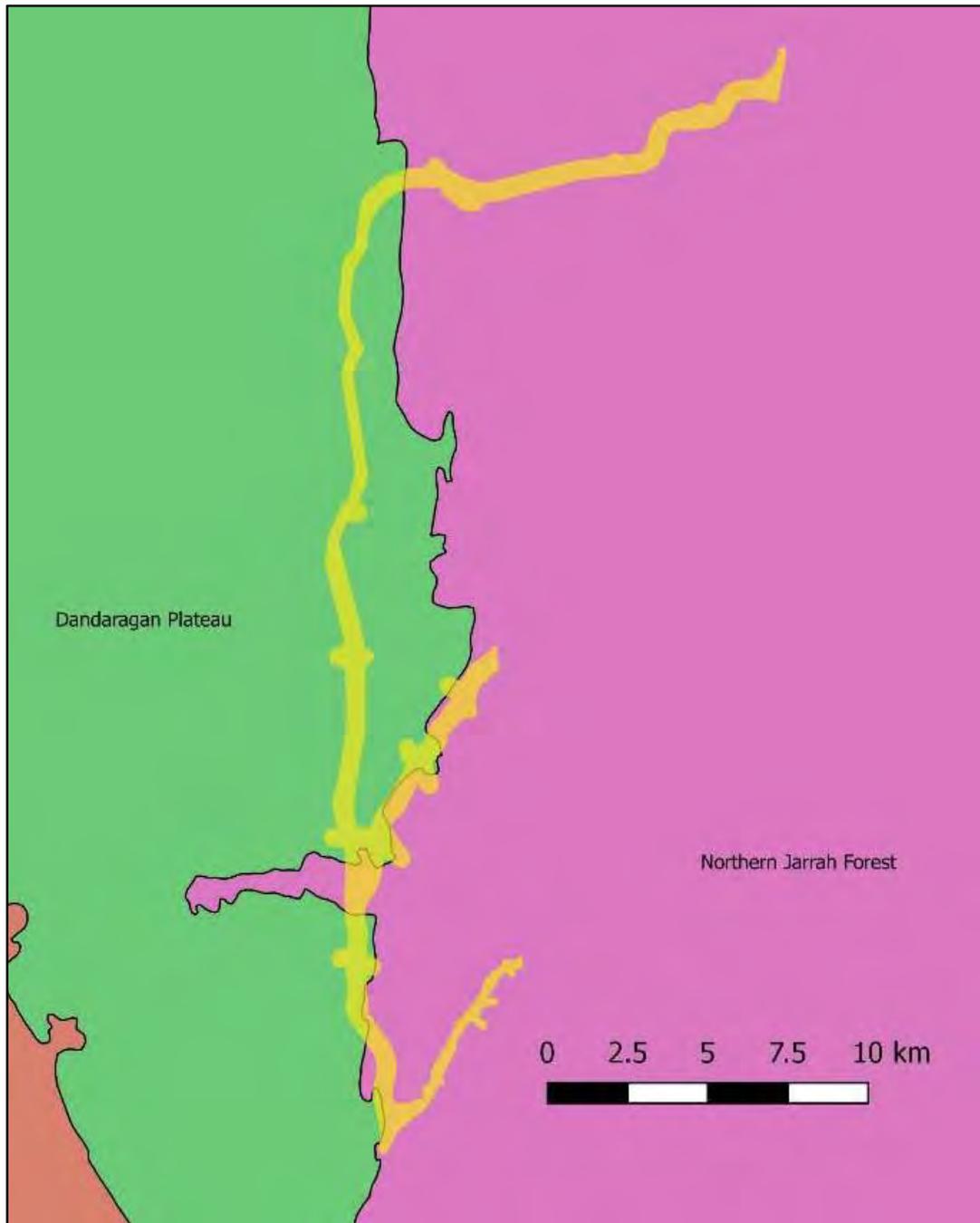


Figure 3. Proposed Bindoon Bypass routes (yellow) overlain on IBRA subregions.

See Figure 1 for route details

3 Methods

3.1 Overview

The methods used for the fauna assessment of the survey 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 survey 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 or likelihood 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 survey area, collect information on the distribution and abundance of this assemblage, and develop an understanding of the survey 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.

3.2 Desktop assessment

3.2.1 Sources of information

Information on the fauna assemblage of the survey 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 (DPaW)	Records from the Western Australian Museum (WAM) and Department of Parks and Wildlife (DPaW) 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.
DPaW's Threatened and Priority Fauna Database	Records of threatened and priority fauna within Western Australia.	Proposed routes plus 20 km buffer.
EPBC Protected Matters database via the online 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: Muchea to Bindoon. Flora and Fauna Assessment.
<i>Phoenix Environmental Sciences.</i> (2015)	Flora and fauna assessment for Muchea North and Chittering study area: Great Northern Highway, Muchea to Wubin Upgrade Stage 2 Project.

3.2.2 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 option Western A, 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.

3.2.3 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 2016. The authorities used for each vertebrate group were: fish (Morgan *et al.* 2014), frogs (Doughty *et al.* 2016a), reptiles (Doughty *et al.* 2016b), birds (BirdLife Australia 2014), and mammals (Travouillon 2016). 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.

3.2.4 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 survey 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 survey 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 survey area at least occasionally, whether or not they were recorded during field surveys, and whether or not the survey

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 survey area. The status categories used are:

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

These status categories make it possible to distinguish between vagrant species, which may be recorded at any time but for which the site is not important in a conservation sense, and species which use the site in other ways but for which the site is important at least occasionally. This is particularly useful for birds that may naturally be migratory or nomadic, and for some mammals that can also be mobile or irruptive, and further recognises that even the most detailed field survey can fail to record species which will be present at times. 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.

3.3 Field survey

3.3.1 Overview

The field assessment incorporated a range of survey techniques so as to maximise sampling results. Techniques utilised included:

- Identification of VSAs (that provide fauna habitats);
- Targeted searches for significant fauna and an assessment of their likelihood of occurrence based on VSAs present;
- Continuous recording of bird species encountered opportunistically;
- Use of motion-sensitive cameras;
- Stratified surveys of black-cockatoo breeding and foraging trees; and
- Opportunistic fauna observations.

3.3.2 Dates of surveys

The survey area was assessed on the 6th, 7th, 12th and 18th October 2016, and 13th December 2016.

3.3.3 Personnel

The following personnel were involved in the 2016 field surveys, data analysis and report preparation:

- Dr Mike Bamford *BSc (Biol.), Hons (Biol.), PhD (Biol.)*;
- Dr Wes Bancroft *BSc (Zool./Microbiol.), Hons (Zool.), PhD (Zool.)*; and
- Mr Andrew Moore *BSc, BApSc, MSc*.

3.3.4 Licences and permits

The field survey was conducted under Department of Parks and Wildlife (DPaW) Regulation 17 licence SF0010773.

3.3.5 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 survey area were identified and sampled for fauna. Those deemed suitable to support conservation significant fauna were subject to further intensive targeted searching.

3.3.6 Targeted searching for conservation significant species

Significant species identified during the desktop assessment include 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 method) included:

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

3.3.7 Motion-sensitive cameras

Baited motion-sensitive cameras (Reconyx) were set at two sites targeting species of conservation significance. Details for camera locations are provided below:

- two cameras located in the wetland on Mooliabeenee Road: at 409273 E, 6533823 N; and 409305 E, 6533814 N.
- two cameras located in the wetland on Teatree Road: at 409641 E, 6523936 N; and at 409647 N, 6523948 N.

Cameras were deployed on the 7th October 2016 and retrieved on the 15th November 2016 (c. 39 camera trap-nights per camera; 156 total trap-nights).

3.3.8 *Black-cockatoo habitat analysis*

3.3.8.1 *Breeding*

The Bindoon bypass route options survey area is approximately 3200 ha (c. 480, 1890, 664 and 181 ha for Areas 1 to 4, respectively). Given the large area, that a preferred route option had not been chosen when field investigations were undertaken, and that that final road footprint will be less than the buffered corridors, BCE sub-sampled trees within the survey area in order to provide contextual information on black-cockatoo nesting habitat. The aim of these tree surveys was to provide detailed data such that a quantitative comparison of the nesting potential of habitat zones within the project area could be made.

The survey area was inspected and VSAs (see Section 3.3.5) determined, and the VSAs most likely to support nesting trees for black-cockatoos were identified. A number of survey 'belt transects' were then stratified in these VSAs throughout the project area. It is considered that the benefits (e.g. time efficiencies, representative coverage) of this approach outweigh a random sampling design. Belt transects varied considerably in shape and size, depending on the most suitable on-ground approach and/or on-ground conditions. In most cases the boundary of a belt transect was defined by physical features (e.g. roads, tracks, fence lines, edge of remnants) or a VSA change. Field personnel generally traversed using a zig-zag approach (and GPS tracking and/or way-pointing to record coverage) within the belt transects to ensure all trees within the transect boundary were assessed. Belt transect areas were calculated using GIS software (QGIS) and these areas were used to standardise tree data (e.g. as tree density) for comparisons.

Survey methodology followed the recommendations of the Department of Sustainability, Environment, Water, Populations and Communities (DSEWPaC) (2010, 2012, 2013a, b, c). Within the belt transects, the following information was recorded for every suitable tree (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;
- alive/dead status;
- DBH; and
- nest hollows visible from the ground or those considered potentially present, with the quality of these nest-hollows scored as per Table 3.

Table 3. Scoring system for the assessment of potential nest trees for black-cockatoos.

As per DotE (2016c) 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*).

Score	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.

3.3.8.2 Foraging

During the site inspection, the foraging value of the survey area was assessed by calculating a foraging score for areas of similar vegetation type/condition (see Table 4). The foraging score provides a numerical value that reflects the significance of vegetation as foraging habitat for black-cockatoos, and this numerical value is designed to provide the sort of information needed by 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 Table 4. 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. 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 (Table 4) depending upon the vegetation present.

Black-cockatoo foraging signs were also recorded in conjunction with the breeding tree surveys (see Section 3.3.8.1). 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, Figure 4 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).

3.3.8.3 Roosting

During the site inspection, 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. Where possible, these were revisited in the 30 minutes before and after sunset to watch for birds moving towards their roost sites, as recommended by DSEWPaC (2013a, b, c). The Great Cocky Count (GCC) database of roost sites was also searched for relevant local records.

3.3.9 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 direct sightings of birds or reptiles seen while travelling through and near the site.

Table 4. 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 2-10% 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.

C. A score out of one for species density.

The maximum score is allocated where the density of black-cockatoos is high, such as the birds being seen regularly and/or abundant foraging debris. The species density score is species-specific.

Active/Recent



Intermediate



Old

Jarrah nuts



Jarrah leaves



Marri nuts



Figure 4. Examples of Forest Red-tailed Black-Cockatoo foraging signs across the range of age categories used in this study.

3.4 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 survey area in Table 5.

Table 5. 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 in Western Australia, with a combined experience of 60+ years.
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 3.2.1.
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. Some seasonal surveys (Barking Owl, frogs, SRE invertebrates) to be completed.
Timing/weather/season/cycle.	Survey was conducted in October and December 2016 during mild/warm and dry conditions. This is a suitable season for breeding activity (including black-cockatoos), migrant bird species and high reptile activity.
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) 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 survey 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 combined 60+ years' experience in fauna surveys for environmental impact assessment including multiple surveys in the general area.
Remoteness and/or access problems.	Some of the survey area was inaccessible (private property where permission was not granted) but this is unlikely to have a strong bearing on the report outcome. A large property to which access was not granted was

	the site of Bamford's (1986) three-year study, and therefore the fauna of this area is well-known.
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.

3.5 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 (now the Department of the Environment and Energy; 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 survey 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.

3.5.1 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 6). 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 6), 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 6. 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.

4 Fauna values

4.1 Vegetation and substrate associations (VSAs)

Nine major vegetation and substrate associations were identified in the survey 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 Grasstrees (*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.

Example photographs of the VSAs are presented in Figure 5. VSAs are mapped for the survey area in Figure 6.

The total area of each VSA in the survey area (i.e. all four areas combined) is presented in Table 7.

Figure 5. Example photographs of the VSAs within the survey area.

VSA 1. Banksia woodland.



VSA 2. Banksia woodland with scattered Marri and/or Jarrah.



VSA 3. Marri-Jarrah woodland.



VSA 4. Marri-Jarrah woodland with little to no remnant understorey (e.g. grazed).



VSA 5. Wandoo woodland (with or without understorey).



VSA 6. Heath. (Photographs courtesy of Kellie Bauer-Simpson)



VSA 7. Waterways or wetlands/damplands.



VSA 8. Paddocks with large remnant trees.



VSA 9. Paddocks.



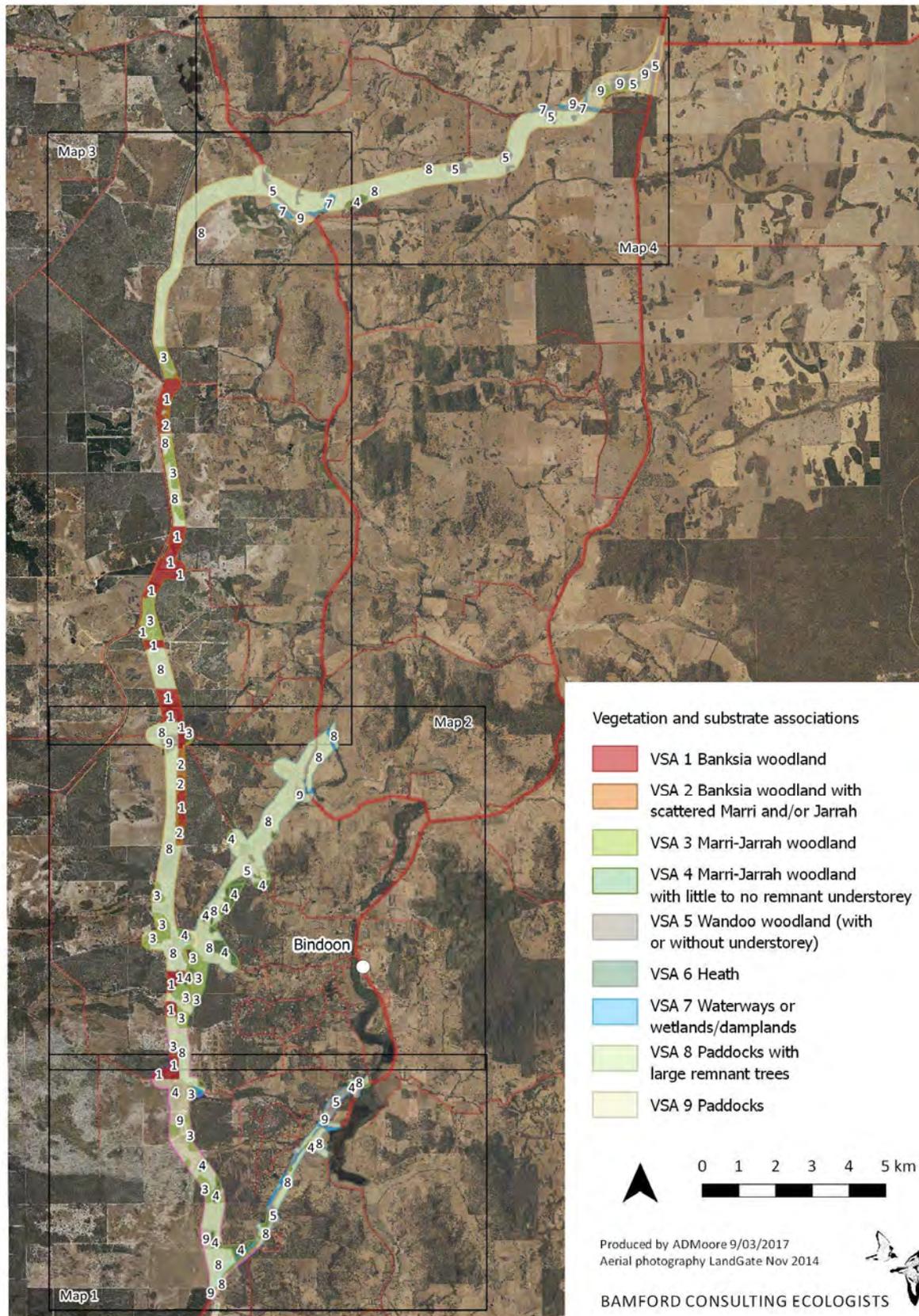


Figure 6. Vegetation and substrate associations in the survey area.

See Appendix 5 for four finer-scale maps.

Table 7. Total area of each VSA in the survey area.

VSA	Total Area (ha)	Percentage of Footprint
VSA 1. Banksia woodland.	256	8%
VSA 2. Banksia woodland with scattered Marri and/or Jarrah.	61	2%
VSA 3. Marri-Jarrah woodland.	301	10%
VSA 4. Marri-Jarrah woodland with little to no remnant understorey	198	6%
VSA 5. Wandoo woodland (with or without understorey).	139	4%
VSA 6. Heath.	2	0%
VSA 7. Waterways or wetlands/damplands.	54	2%
VSA 8. Paddocks with large remnant trees.	1808	58%
VSA 9. Paddocks.	296	9%
TOTAL	3116	100%

4.2 Vertebrate fauna

4.2.1 Overview of fauna assemblage

The desktop study identified 306 vertebrate fauna species as potentially occurring in the survey area: eight freshwater fish, 17 frogs, 69 reptiles, 177 birds and 35 mammals. These species are listed in Appendix 6. The presence of 66 species (one freshwater fish, five frogs, three reptiles, 52 birds and five mammals) was confirmed during the 2016 field surveys (as indicated in Appendix 6). Only the introduced Black Rat was recorded by camera trapping.

Fourteen species returned by the database searches and/or literature review are now considered to be locally extinct in the survey area. These species comprise one reptile, five birds and eight mammals and are listed in Appendix 7.

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 8.

The composition of the vertebrate fauna is summarised in Table 8.

Table 8. Composition of vertebrate fauna assemblage of the survey 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)	5 (3)	35 (11)				8
Total	306	66	238	35	26	7	14

4.2.2 *Expected fauna*

The eight fish species expected to occur in the survey area includes two introduced species (Goldfish and Mosquitofish), 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 survey 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 survey area.

The 17 frog species expected to occur in the survey area is a rich assemblage but not all species would be sympatric (ie all the species would not occur in the same areas or throughout the survey area). Because of the north-south extent of the survey 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 survey 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 survey area also represent a rich assemblage which is not sympatric, with differences related to north-south alignment of the survey 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 survey area (e.g. Dell's Skink) and others near their southern limit in the north of the survey 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 survey area includes six introduced species. As with reptiles and frogs, the bird assemblage is not likely to be the same across the whole survey 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 survey area may only be important for resident species and those species that occur regularly, although the area 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 survey area includes 11 introduced species, while an additional eight mammal species are considered locally extinct (Appendix 7). The status of many of the mammal species in the area is uncertain, but all listed in Appendix 6 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 survey 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 survey 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 survey area. Parts of the survey 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 survey 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. Western bypass A will be the richest in species as a result of its size and north-south extent.

4.2.3 Species of conservation significance

Of the 307 species of vertebrate fauna that are expected to occur in the survey area, 43 are considered to be of conservation significance (20 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 6) but are also listed in Table 9. In addition, database reviews returned three invertebrate species of conservation significance. These are:

- *Idiosoma nigrum*, Shield-backed Trapdoor Spider - CS1 (V, S3)
- *Throscodectes xederoides*, Mogumber Bush Cricket - CS2 (P3)
- *Westralunio carteri*, Carter's Freshwater Mussel - CS1 (S3).

Therefore, the 46 conservation significant species expected to occur in the survey area comprises:

- three fish (one CS1, two CS3)
- three frogs (CS3)
- six reptiles (one CS1, two CS2, three CS3)
- 24 birds (16 CS1, two CS2, six CS3)
- seven mammals (two CS1, three CS2, two CS3)
- three invertebrates (two CS1, one CS2).

Five conservation significant fauna species were recorded during the 2016 field surveys, as indicated in Table 9.

Table 9. Conservation significant fauna species expected to occur within the survey 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).

DPaW 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>Merops ornatus</i>	Rainbow Bee-eater	CS1 (S5)	Migrant	+
<i>Dasyurus geoffroii</i>	Chuditch	CS1 (V,S3)	Resident	
<i>Phascogale tapoatafa wambenger</i>	Brush-tailed Phascogale, Wambenger	CS1 (S3)	Resident	

SPECIES		STATUS	EXPECTED OCCURRENCE	RECORDED
<i>Idiosoma nigrum</i>	Shield-backed Trapdoor Spider	CS1 (V,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>Isodon obesulus fusciventer</i>	Southern Brown Bandicoot, Quenda	CS2 (P4)	Resident	
<i>Notamacropus irma</i>	Brush Wallaby	CS2 (P4)	Resident	
<i>Hydromys chrysogaster</i>	Water-rat	CS2 (P4)	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 survey 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 survey area (based on the DPaW database search results) is from Gingin Brook, north-east of Gingin, approximately 11 km west of the survey 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 survey areas.

- 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 survey 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 survey 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 survey 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 project 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 survey 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 survey 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 survey area for the Glossy Ibis.
- Peregrine Falcon, CS1 (S7) – likely to be a wide-ranging resident, in low densities, in the vicinity of the survey area.
- Australian Painted Snipe, CS1 (E,S2) – possibly a vagrant to wetlands (VSA 7) in the survey 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 survey area. This species was recorded regularly during the site inspections but is probably limited to the southerly sections; the inland race (*C. banksii samuelii*) may occur in the north of the survey 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 survey area. This species was recorded regularly during the site inspections. Carnaby's Black-Cockatoo will extensively utilise the survey 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). 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 survey 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 survey 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 survey area). If present at all, this species is likely to only be a visitor to the survey area.

- Rainbow Bee-eater, CS1 (S5) – recorded and almost certainly a regular, breeding migrant to the survey area. The Rainbow Bee-eater is widespread across southern Australia from mid spring to late summer, and therefore individual records are of low significance.
- Chuditch, CS1 (V,S3) – There are a number of DPaW database records of this species within the vicinity of the project area. 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. The ALA database shows the core distribution of Brush-tailed Phascogale to be south of Gidgegannup (south of the study area) but includes a couple of outlying records from Mooliabeenee Road and just north of Hay Flat Road (both very close to the survey area) that demonstrate the species has been historically recorded from the area. Several records of this species within 20 km of the survey area were also returned from the DPaW database search.
- Shield-backed Trapdoor Spider, CS1 (V,S3) – the distribution map on the ALA database shows the study area to be just outside the south-western edge of the species' range. If present, the north-eastern section of Area 2 is most likely to support this species.
- Carter's Freshwater Mussel, CS1 (S3) – DPaW database records show this species to have been recorded from east and west of the survey area, including two records within a few hundred metres of the Area 2 envelope. Thus it is likely to be present in suitable freshwater sediments (in VSA 7) throughout the site.
- *Ctenotus delli* CS2 (P4) – this species of skink is known to occur on the Darling Scarp to the east of the survey 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 survey area are sufficiently deep to support this species. Despite this, occasional visitors are possible.
- Barking Owl (south-western), CS2 (P2) – may occur in forest in the south of the survey area.
- Southern Brown Bandicoot or Quenda, CS2 (P4) – BCE has only recorded this species (previously) around the Muchea area (to the south), but the DPaW database search yielded a few records (of varying certainty) further north. If present within the survey area, it seems this species is close to the northern extremity of its range. Ample suitable habitat exists throughout the survey area. If present, road mortality may be an issue (in localised areas).
- Brush Wallaby, CS2 (P4) – DPaW records indicate this species to be present to the west of the survey area and it was present on private property along Mooliabeenee and Cullalla Roads in the mid 1980s (Bamford 1986). There are considerable tracts of banksia woodland (VSA 1 and 2) and Marri-Jarrah woodland (VSA 3) that would support this species.
- 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 south of the survey area. Not detected on cameras set near wetlands in spring 2016.
- Mogumber Bush Cricket, CS2 (P3) – two records of this species from the DPaW database were located c. 13 km to the north of the northern edge of the survey 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. Included as CS3 because the species is at the edge of its range in the survey area.
- Whooping Frog, Ticking Frog, *Liopholis pulchra* and *Anilios pinguis*, CS3 (LS) – if present, these species would be at the northern extremity of their range.
- 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 survey area, it is unlikely that there is sufficient connection to Gingin to enable the wren to persist in the survey 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 survey area.
- Scarlet Robin and White-breasted Robin, CS3 (LS) – the project area is at the edge of the range for these species.
- 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 survey area. 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.

Given the above information, a number of the conservation significant species (that are expected to occur in the vicinity of the survey 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 survey 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)
- Rainbow Bee-eater - CS1 (S5)
- Chuditch - CS1 (V,S3)
- Brush-tailed Phascogale, Wambenger - CS1 (S6)
- Carter's Freshwater Mussel - CS1 (S3)
- Quenda - CS2 (P4)
- Rakali or Water-rat - CS2 (P4).

Some of these are widespread through the overall area, but the Forest Red-tailed Black-Cockatoo, Chuditch, Quenda and Brush-tailed Phascogale are most likely restricted or largely restricted to the southern areas, including the common area of Western bypass A and B, while the Carter's Freshwater

Mussel and Rakali are most likely restricted to freshwater wetlands in the south, including Lake Chittering (Near the Eastern bypass).

4.3 Black-Cockatoo habitat analysis

The desktop analysis highlighted that the Forest Red-tailed Black-Cockatoo and Carnaby's Black-Cockatoo are conservation significant species at likely risk of impact from the proposed road development. Additional information on the breeding, foraging and roosting value of the survey area was collected in order to place the potential impacts in context and/or guide mitigation planning/measures.

4.3.1 Breeding

Following the site inspection and determination of VSAs, four were considered the most likely to support hollow-bearing trees suitable for black-cockatoo breeding: VSA 3, 4, 5 and 8 (see Table 10). Nineteen belt transects were stratified and surveyed within these VSAs across the survey area, as shown in Figure 7, and a summary of the survey effort is presented in Table 10.

Table 10. Survey effort for black-cockatoo habitat analysis.

Vegetation and Substrate Association	Number of Transects	Total Area Searched (ha)
VSA 3. Marri-Jarraah woodland.	6	25.43
VSA 4. Marri-Jarraah woodland with little to no remnant understorey (e.g. grazed).	3	12.93
VSA 5. Wandoo woodland (with or without understorey).	4	9.97
VSA 8. Paddocks with large remnant trees.	6	59.54
Total	19	107.87

A total of 846 trees that met the hollow-bearing criteria of DotE (2016a, b, c) was recorded from the 108 hectares surveyed. The assessment data (species, life status, DBH and hollow score) for each of these trees are listed in Appendix 9.

The average number of potential hollow-bearing trees per hectare is shown for each major tree species in each VSA in Table 11. Areas of wandoo woodland (VSA 5) had the highest density of potential nest trees, with approximately 25 potential trees/ha in this VSA.

The numbers of trees recorded in each hollow-score category are shown in Table 12, and the locations of these trees are mapped in Figure 8. The vast majority (c. 84%) of trees surveyed in the study did not have hollow entrances suited to black-cockatoos that were observable from ground level. Three trees had evidence of chewing by black-cockatoos and, therefore, are highly likely to be used for breeding. No active nests were located.

The DBH profile of the surveyed area is presented in Figure 9. While almost half 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).

Table 11. Mean density (\pm SE; trees/ha) of potential each species of hollow-bearing trees (considered suitable for black-cockatoo breeding) in the four VSAs surveyed.

DBH = diameter at breast height

Vegetation and Substrate Association	Jarrah $\geq 500\text{mm DBH}$	Marri $\geq 500\text{mm DBH}$	Wandoo $\geq 300\text{mm DBH}$	Total
VSA 3. Marri-Jarrah woodland.	5.53 \pm 0.86	4.54 \pm 1.09	0	10.06 \pm 1.34
VSA 4. Marri-Jarrah woodland with little to no remnant understorey (e.g. grazed).	8.59 \pm 0.94	4.62 \pm 0.23	0	13.22 \pm 0.73
VSA 5. Wandoo woodland (with or without understorey).	0.18 \pm 0.18	7.26 \pm 4.43	17.96 \pm 5.04	25.41 \pm 1.54 ¹
VSA 8. Paddocks with large remnant trees.	2.51 \pm 1.86	1.88 \pm 0.65	0.51 \pm 0.51	4.9 \pm 2.59
Overall	3.93 \pm 0.91	4.29 \pm 1.02	3.94 \pm 1.96	12.16 \pm 1.98

Table 12. The number of trees in each hollow-score category.

See Section 3.3.8 for full explanation of tree categories. Parentheses indicate the number of trees in that category that were unsuitable for use because of bee hives.

Category	Number of Trees	Percentage
1 Active nest.	0	0.0
2 Potential hollow with chew-marks.	3	0.4
3 Potential hollow, no chew marks.	94 (1)	11.1
4 Potential hollow, unsuitable orientation.	35 (4)	4.1
5 Sufficient DBH, no observable hollows.	714	84.4
Total:	846	

¹ An additional 16 trees from two other species (14 Flooded Gum, *E. rudis*, and two York Gum, *E. loxophleba*) were located in this VSA but are not included in the calculations here.

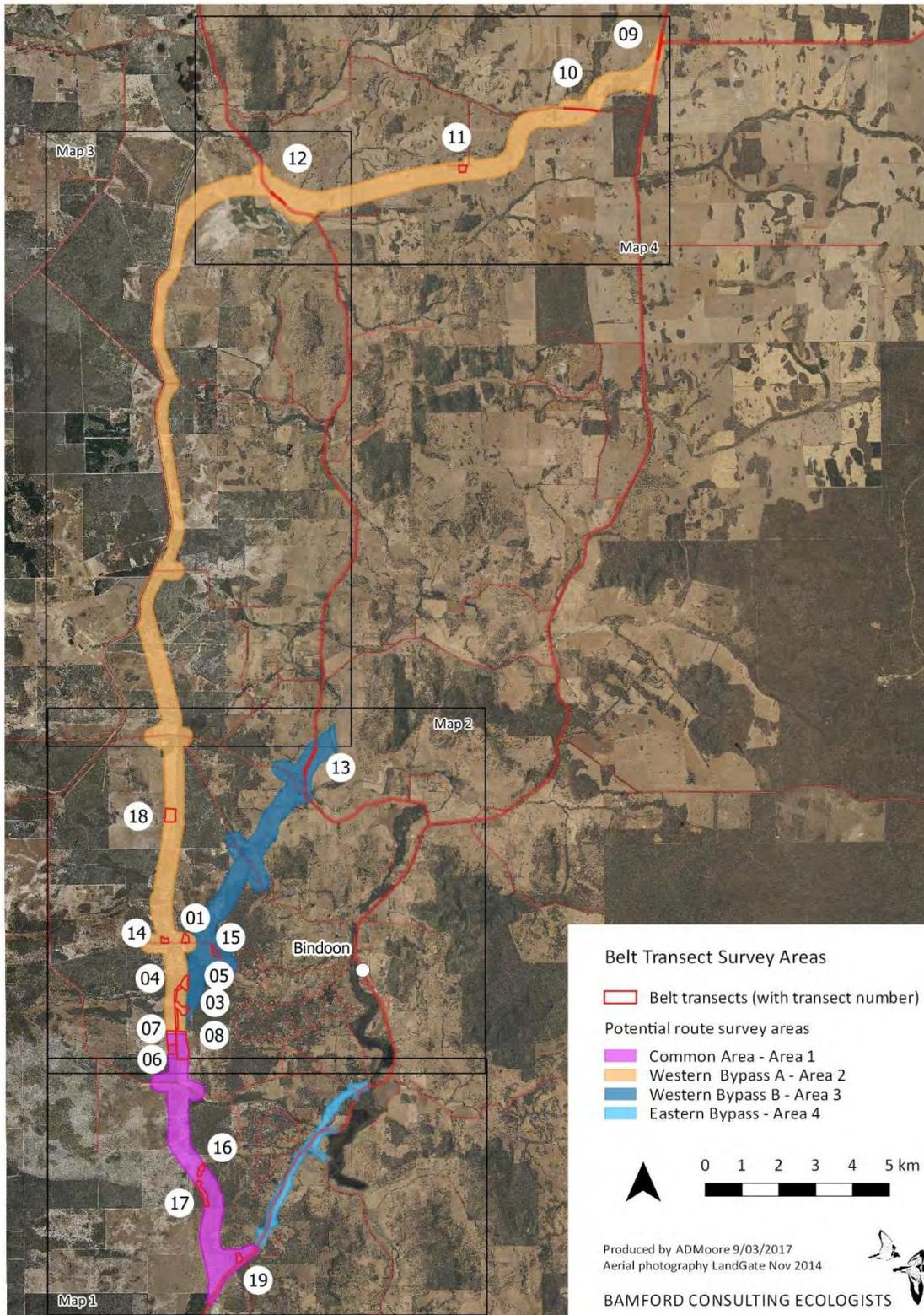


Figure 7. Location of belt transects (for black-cockatoo habitat analysis) within the survey area.

See Appendix 10 for four finer scale maps.

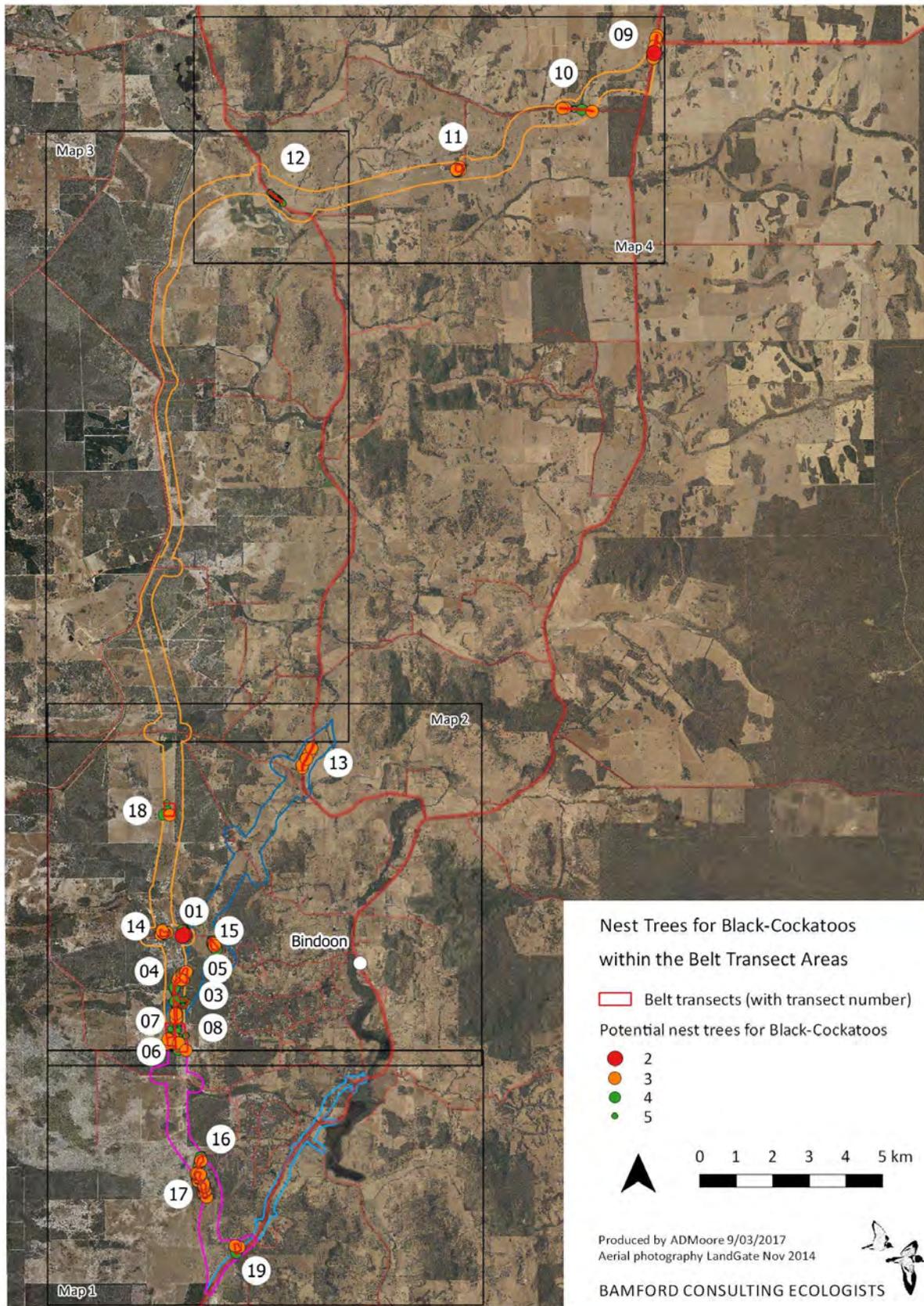


Figure 8. Location of potential nest trees as classified according to hollow-score.

See Appendix 11 for four finer scale maps.

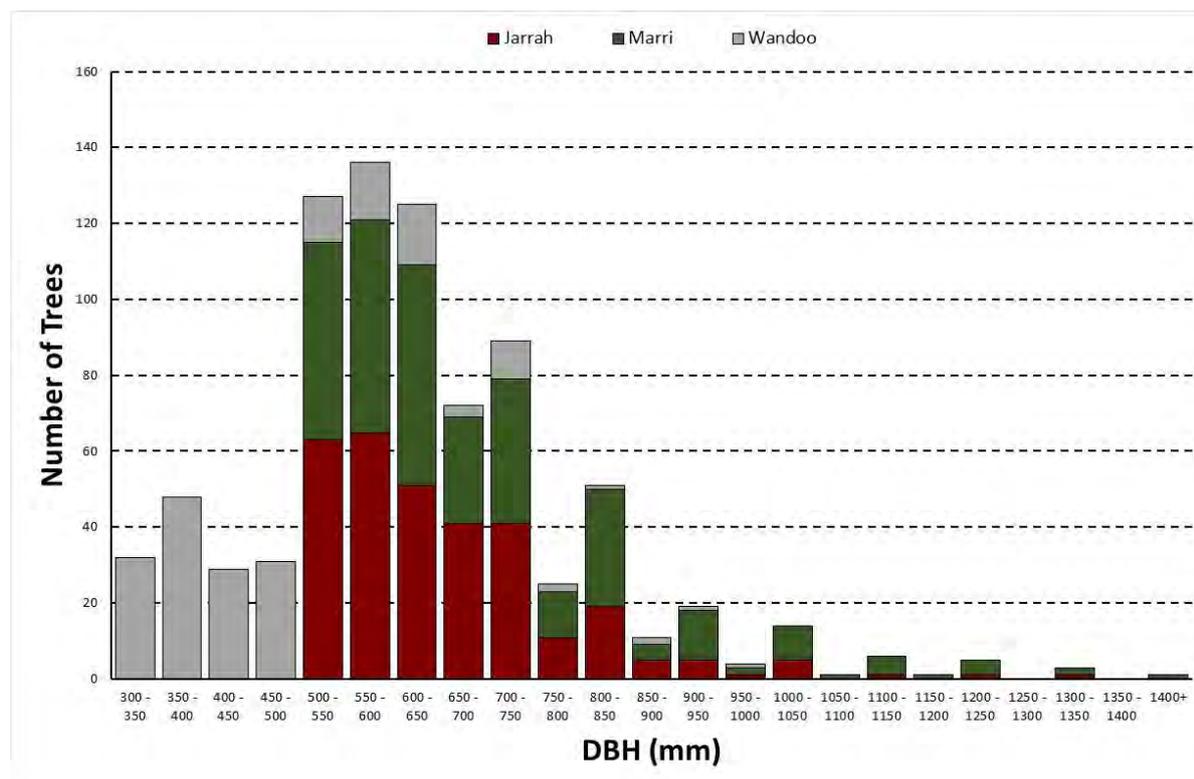


Figure 9. DBH profile of the potential black-cockatoo nesting trees surveyed.

4.3.1.1 Extrapolation of tree data

The VSA areas presented in Table 7 were multiplied by the mean tree densities (Table 11) to estimate the total numbers of each (major) hollow-bearing tree species in the survey area. These values are presented in Table 13. Approximately 18 000 trees may support black-cockatoo nests within the entire survey area.

Table 13. The estimated number of potential hollow-bearing trees (± SE) in the survey area.

Note that not all VSAs were sampled.

Vegetation and Substrate Association	Jarrah > 500mm DBH	Marri > 500mm DBH	Wandoo >300mm DBH	Total
VSA 3. Marri-Jarrah woodland.	1664 ± 260	1366 ± 327	0	3030 ± 587
VSA 4. Marri-Jarrah woodland with little to no remnant understorey (e.g. grazed).	1702 ± 187	915 ± 46	0	2617 ± 233
VSA 5. Wandoo woodland (with or without understorey).	26 ± 26	1010 ± 616	2497 ± 700	3533 ± 1342
VSA 8. Paddocks with large remnant trees.	4535 ± 3354	3402 ± 1174	916 ± 916	8853 ± 5444
Overall	7927 ± 3827	6693 ± 2163	3413 ± 1616	18033 ± 7606

4.3.2 *Foraging*

The distribution of foraging habitat is mapped for Carnaby's Black-Cockatoo and Forest Red-tailed Black-Cockatoo in Figure 10 and Figure 11 respectively (with finer scale maps presented in Appendix 12 and Appendix 13 respectively).

The total area (and proportions) of each foraging score is presented in Figure 12 for Carnaby's Black-Cockatoo and in Figure 13 for Forest Red-tailed Black-Cockatoo. Approximately one quarter of the survey area was found to support 'moderate' or better foraging habitat for Carnaby's Black-Cockatoo (a foraging score of four or greater). Less than 10% of the survey area was found to support 'moderate' or better foraging habitat for the Forest Red-tailed Black-Cockatoo.

Forty-two records of foraging by black-cockatoos were made during the site inspections and targeted tree surveys. These records are listed in Appendix 14. Of these records, 86% were from Carnaby's Black-Cockatoos, with the remaining 14% from Forest Red-tailed Black-Cockatoos. Foraging by Carnaby's Black-Cockatoo was noted, broadly, across the entire study area, with 94% on Marri, and c. 3% on each of Jarrah and Banksia. Foraging by Forest Red-tailed Black-cockatoo was restricted to the area approximately south of Gray Road, with half of the records from Marri and half from Jarrah.

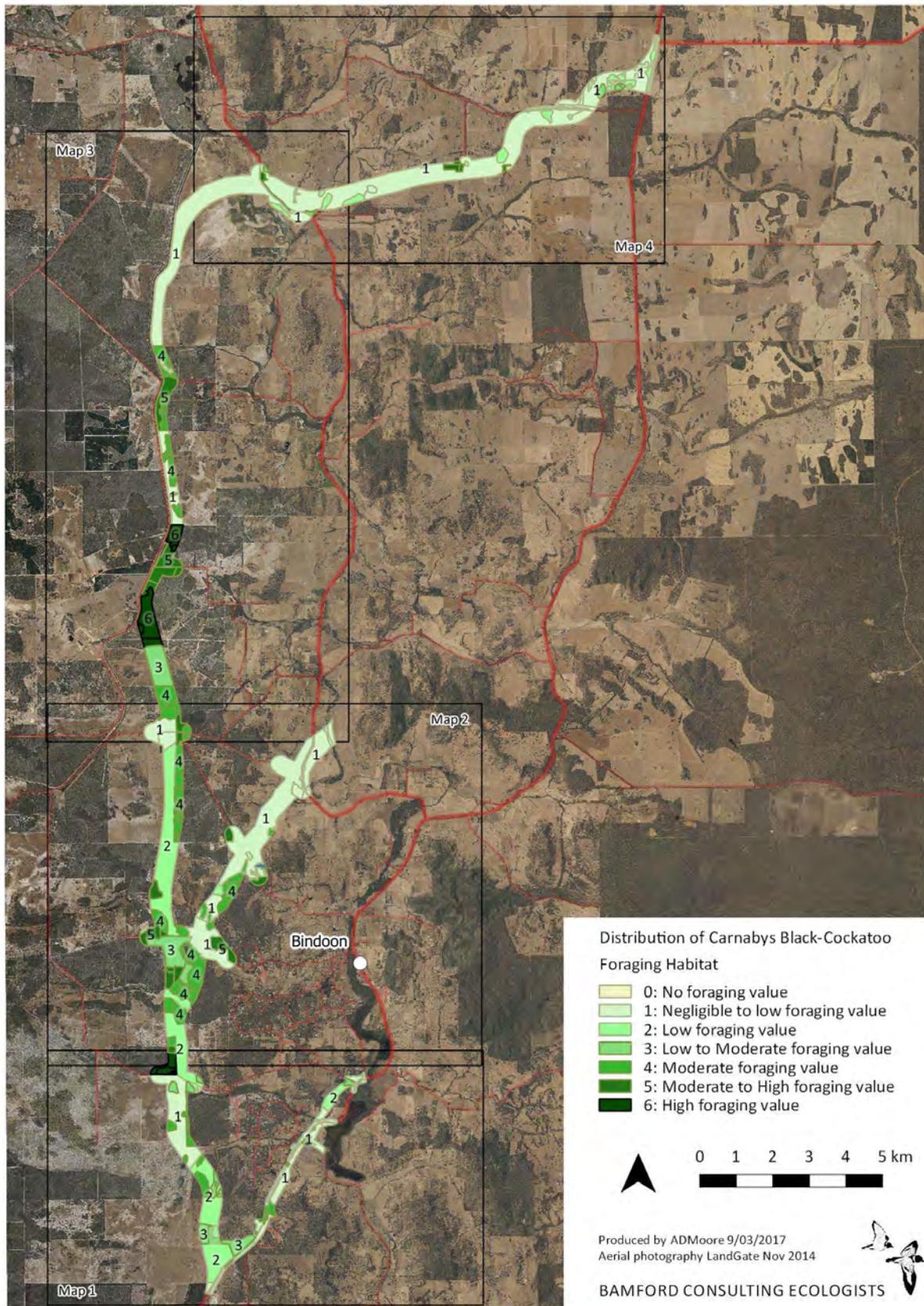


Figure 10. Distribution of Carnaby's Black-Cockatoo foraging habitat within the survey area.

See Appendix 12 for four finer scale maps.

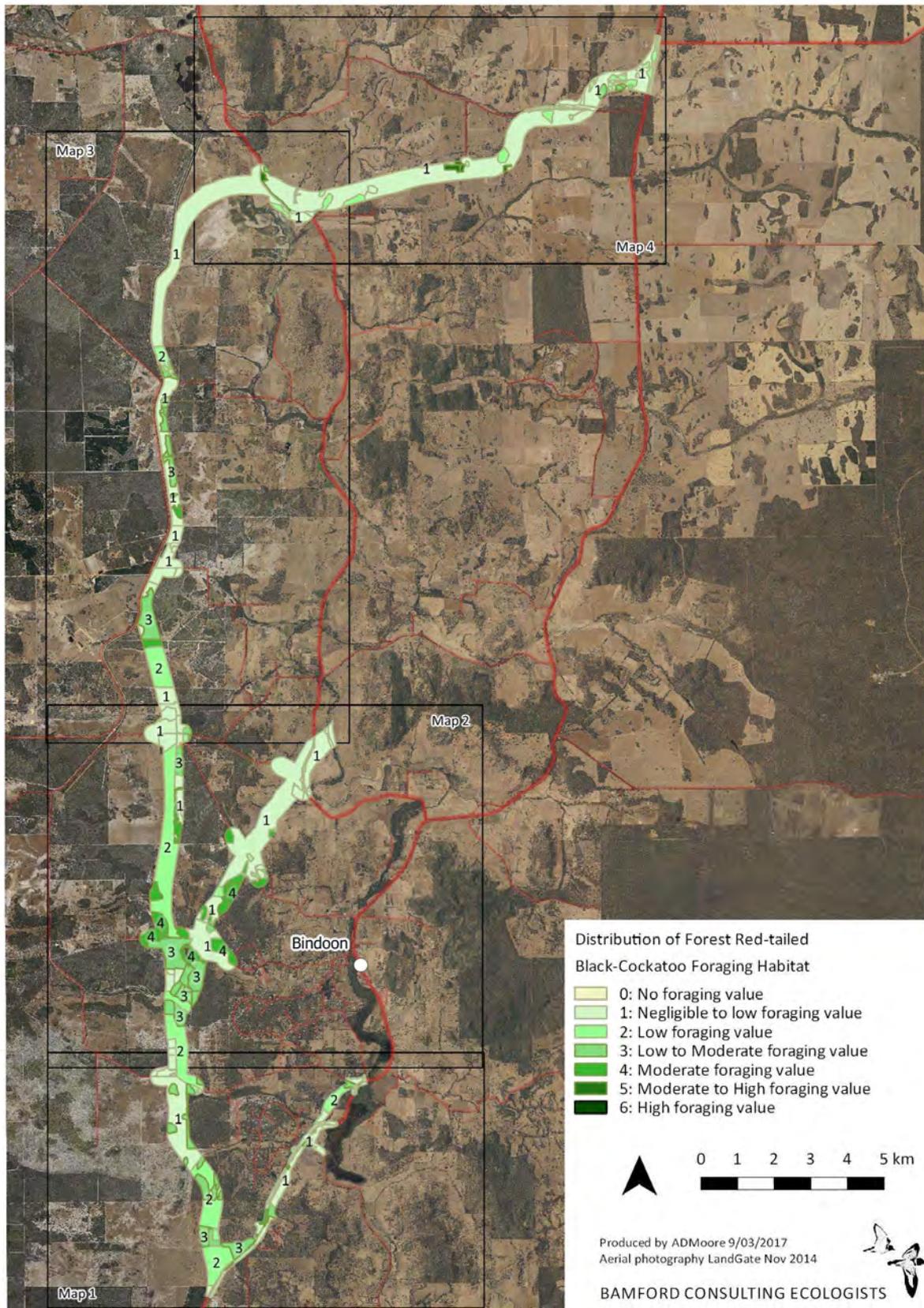


Figure 11. Distribution of Forest Red-tailed Black-Cockatoo foraging habitat within the survey area.

See Appendix 13 for four finer scale maps.

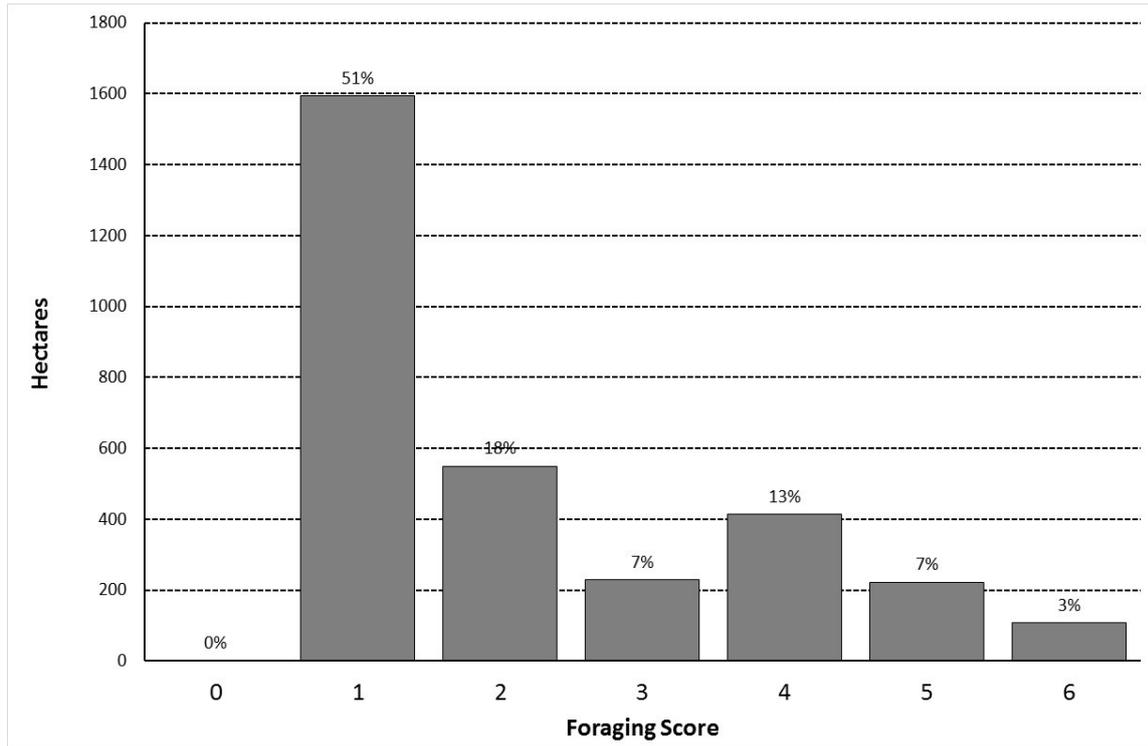


Figure 12. Area (hectares) of each foraging score category for Carnaby's Black-Cockatoo.

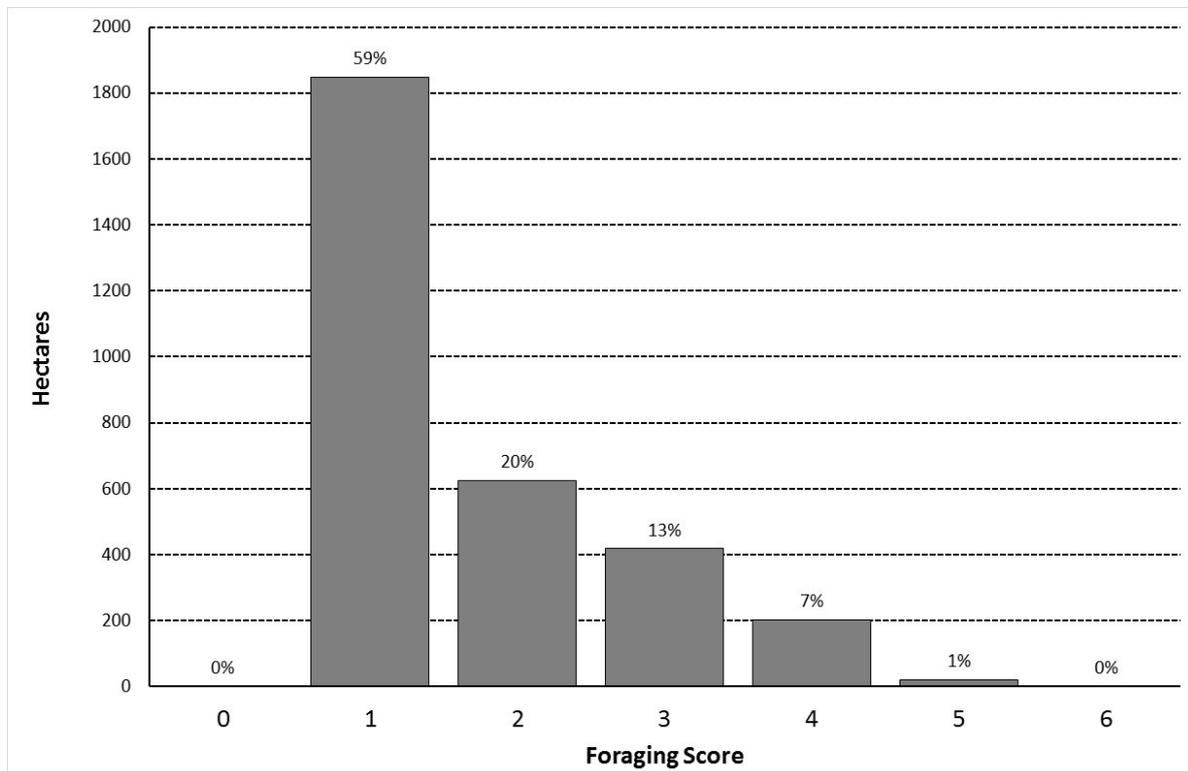


Figure 13. Area (hectares) of each foraging score category for Forest Red-tailed Black-Cockatoo.

4.3.3 Roosting

A roost-watch was conducted adjacent to the wetland on Teatree Road on the 6th October (409584 E, 6524027 N). This wetland was visited by 70-100 Carnaby's Black-Cockatoos in the later afternoon, where the birds drank, and fed on grass seeds (probably *Erodium*) and Marri fruits. No roosting activity was observed. Peck *et al.* (2016) have recorded a roost site just south of the Bindoon town site, and one at Gingin, so further work to assess these locations, and identify others, may be warranted.

4.4 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.* 2013) 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.

4.5 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). It is through alterations to these key ecological processes that development can adversely impact upon ecosystems, and the ecological processes may become threatening processes. These processes include the aspects discussed below.

Local hydrology. The survey 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 survey 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 survey 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 5).

Connectivity and landscape permeability. The survey 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.

4.6 Summary of fauna values

The desktop study identified 306 vertebrate fauna species as potentially occurring in the survey area (eight freshwater fish, 17 frogs, 69 reptiles, 177 birds and 35 mammals, including 11 introduced mammals). The presence of 66 species (one freshwater fish, five frogs, three reptiles, 52 birds and five mammals) was confirmed during the 2016 field surveys (see Appendix 6). The vertebrate assemblage includes 46 species of conservation significance (Table 9).

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. Because of its area and extent, Western bypass A can be expected to have the richest fauna assemblage.

Species of conservation significance. Of the 46 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, Rainbow Bee-eater, Chuditch, Brush-tailed Phascogale, Carter's Freshwater Mussel, Quenda and Rakali or Water-rat. There is a southerly bias in the distribution of these key significant species such that they are likely in all options and especially the common area of Western bypasses A and B.

Vegetation and Substrate Associations (VSAs). The survey area passes through nine 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. Because of its north-south extent, Western bypass A supports the most VSAs.

Patterns of biodiversity. Distinct patterns of biodiversity are expected due to the extent of the survey 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.

Comparison of options

The three options are greatly different in area and extent, and this primarily determines the relative values and impacts upon fauna. Western bypass A (including the common area) is by far the greatest in area and extent, as it extends for over 30 km north to south, and therefore supports more species and a greater variety of environments than the other options. For example, it encompasses forested areas in the south, banksia woodlands on the Dandaragan Plateau and Wandoo woodland in the north, so interacts with different fauna assemblages with these differences in the environment. In contrast, Western bypass B (including the common area), has a length of about 10 km and affects only forested areas in the south (and some farmland; as do all options). The Eastern bypass is narrower than the other two options and only about 5 km long. It affects forested areas and is aligned closer to a large wetland (Lake Chittering) than the other two options. Western bypass A has the greatest implications in terms of impacts upon fauna because of its area and extent. However, it is the common area in the south that supports or may support the most species of conservation significance.

5 Impact assessment

Impacting processes have to be considered in the context of fauna values present and the nature of the proposed action. 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 environmental fragmentation. Predicted impacts need to be considered in the light of recommendations made in Section 6. Impact categories are defined in Table 6.

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 6).

Degradation of habitat due to weed invasion.

The level of weed invasion is variable through the survey area. Where the alignment passes through areas of native vegetation, there is a risk of weed invasion during construction (including spread of existing weed species or introduction of new species) and once the highway is operational. This risk will vary with final alignment selection and effectiveness of management processes (see Section 6), 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, while mortality will generally affect species of low conservation significance. Exceptions might be where direct impacts upon nesting black-cockatoos could occur. Previous advice from DPaW 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 once the road is operational 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 survey area passes through locations known to be used for breeding, foraging and roosting. Some actions are possible to minimise ongoing mortality (see Section 6).

Species interactions.

Some of the fauna present 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 with effective management practices (Section 6).

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 survey 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 6).

6 Recommendations

Section 5 (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 14 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 progressively and as soon as practicable.



Teatree Road area



Crest Hill Road area



Head Road area

Figure 14. Examples of locations where the final alignment choice will affect the extent of habitat loss.

The blue line indicates the survey area. Varied scales.

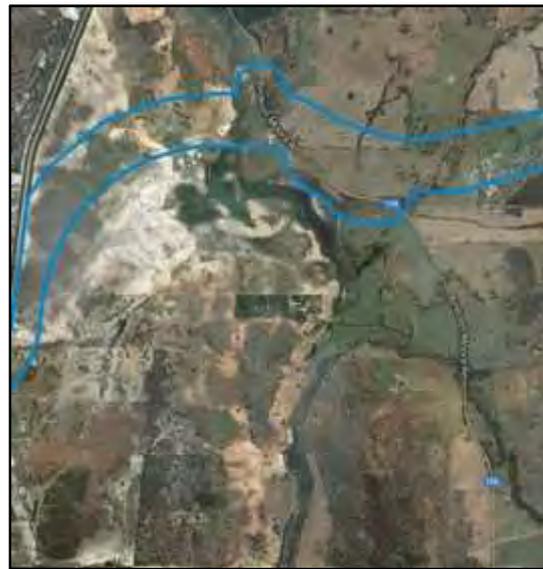
Habitat loss leading to population fragmentation.

- 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.

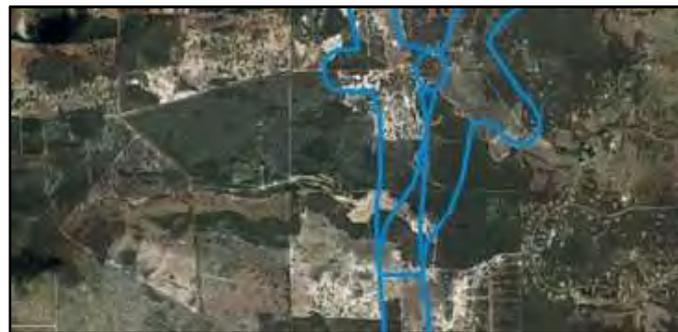
Figure 15 illustrates several examples of where the final alignment could be selected to reduce the impact of habitat fragmentation.



Cullalla Road area



Brockman River area near Wannamal



Teatree Road to Gray Road area

Figure 15. Examples of locations where the final alignment could be selected to reduce the impact of habitat fragmentation.

The blue line indicates the survey area. Varied scales.

Additional area-specific notes:

- Passage of wetland-dependant fauna (e.g. fish, frogs) along the Brockman River may be impacted without mitigating measures.
- 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.

Degradation of habitat due to weed invasion.

- Employ industry standard hygiene to avoid introducing weeds or spread existing weed species 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.
- Fauna spotters/handlers should be present during vegetation clearing to carry out local relocations and to minimise direct mortality where possible, and to be able to rescue injured fauna.
- Risks to fauna should be included in site inductions so that all personnel are aware of what fauna might be present and how direct impacts are to be managed.

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 DPaW and local shires, particularly with respect to the larger areas of native vegetation in the south of the survey 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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8 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 Parks and Wildlife (DPaW) 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 DPaW but not listed under State or Commonwealth Acts.

In Western Australia, DPaW has produced a supplementary list of Priority Fauna, being species that are not considered threatened under the *Biodiversity Conservation Act 2016* but for which DPaW 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 DPaW, 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):

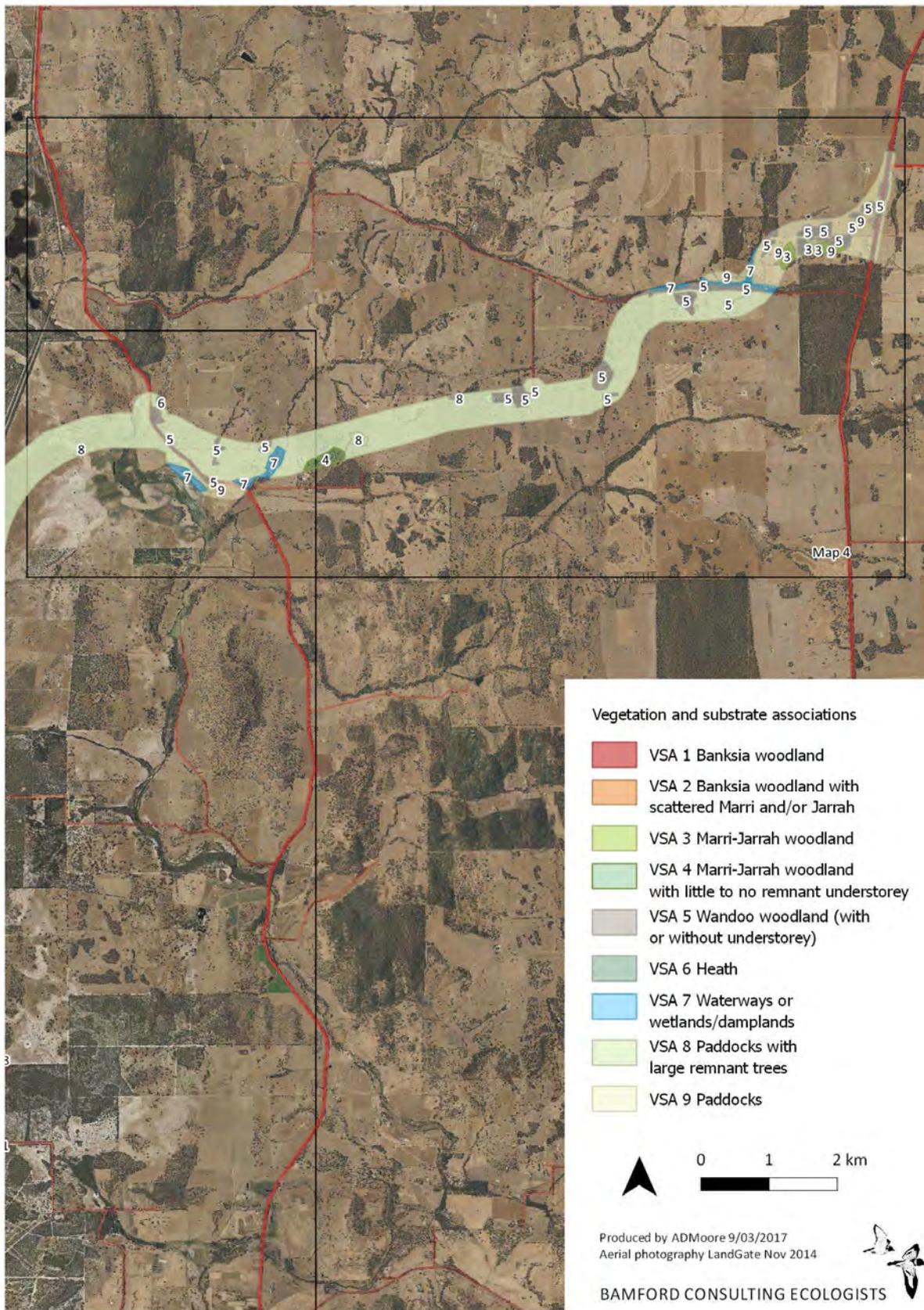
- Vegetation clearing;
- Increasing fragmentation, loss of remnants and lack of recruitment;
- Firewood collection;
- Grazing pressure;
- Feral animals;
- Exotic weeds;
- Changed fire regimes;
- Pathogens;
- Changed hydrology—dryland salinity and salt water intrusion;
- Changed hydrology— such as altered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

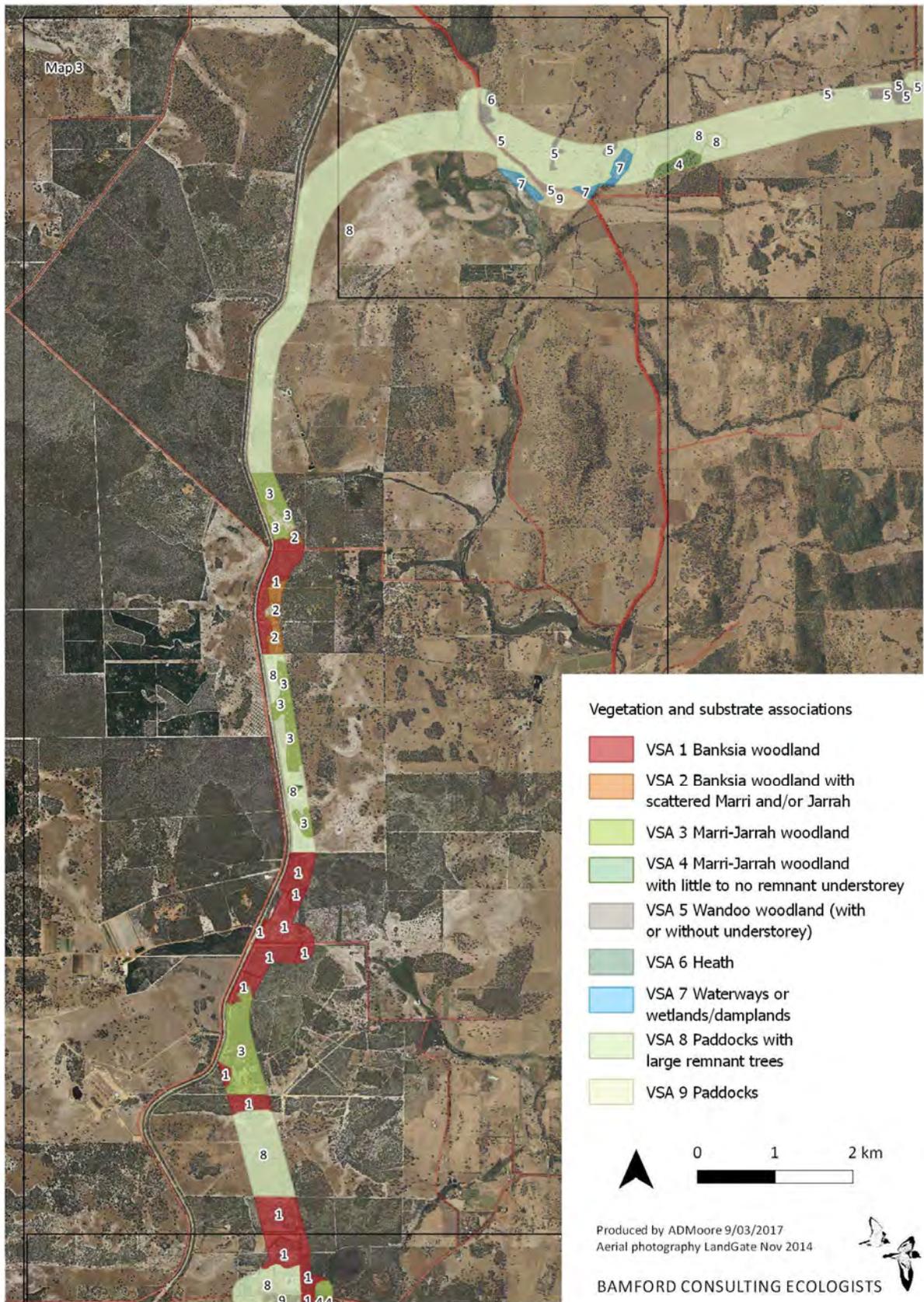
In addition to the above processes, DSEWPaC produced Significant Impact Guidelines that provide criteria for the assessment of the significance of impacts. These criteria provide a framework for the assessment of significant impacts. The criteria are listed below.

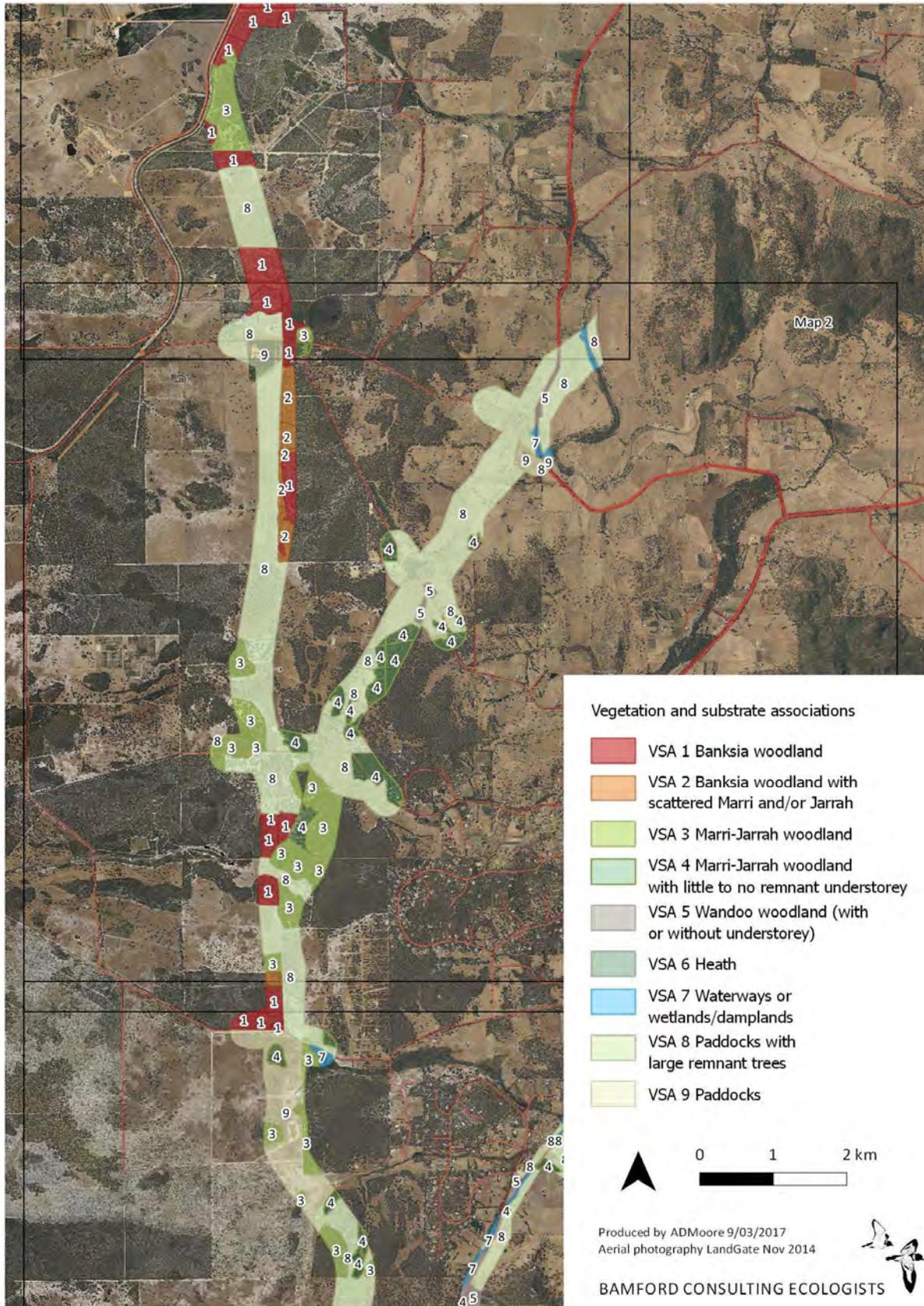
- Will the proposed action lead to a long-term decrease in the size of a population?
- Will the proposed action reduce the area of occupancy of the species?
- Will the proposed action fragment an existing population?
- Will the proposed action adversely affect habitat critical to the survival of a species?
- 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?

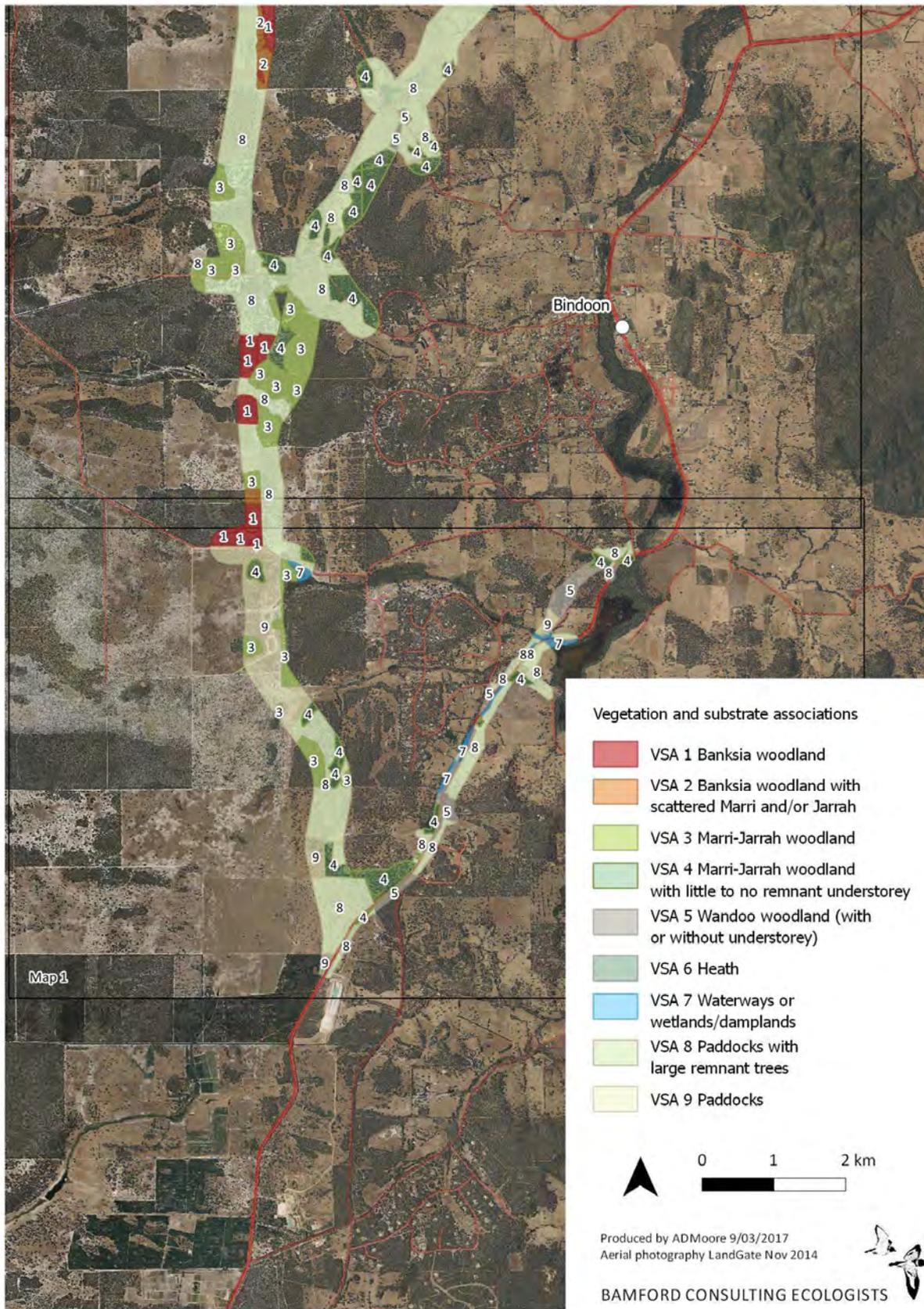
Appendix 5. Finer-scale maps of the vegetation and substrate associations in the survey area.

An overview map is presented in Figure 6.









Appendix 6. Vertebrate fauna expected to occur in the survey 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 = DPaW 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).

DPaW 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 3.2.4 for explanation of expected occurrence categories.

+ = species recorded by BCE during the 2016 surveys.

Species returned from the literature review but considered to be locally extinct are listed in Appendix 7. Species returned from the literature review but omitted from the expected species list because of habitat or range limitations are listed in Appendix 8.

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED IN 2016
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 IN 2016
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 IN 2016
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 IN 2016
<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>Remiascincus richardsonii</i>	Broad-banded Sand Swimmer		Resident	1, 2	

SPECIES	COMMON NAME	STATUS	EXPECTED OCCURRENCE	DATA SOURCE	RECORDED IN 2016
<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 IN 2016
<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 IN 2016
<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 IN 2016
<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	

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<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 IN 2016
<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	

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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	

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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	CS1 (S5)	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>Smicronis 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 IN 2016
<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 IN 2016
<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 IN 2016
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 fascians</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 IN 2016
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 IN 2016
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>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 IN 2016
<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 7. Species returned from the literature review that may once have occurred in the vicinity of the survey area but that are now considered locally extinct.

Data sources: 1 = Atlas of Living Australia database search; 2 = NatureMap database search; 3 = DPaW 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).

DPaW 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 8. 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 = DPaW 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).

DPaW 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 wilmorei</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 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 9. Potential hollow-bearing trees.

See Section 4.1 for VSA details: VSA 3 (Marri-Jarrah woodland); VSA 4 (Marri-Jarrah woodland with little to no remnant understorey); VSA 5 (Wandoo woodland); VSA 8 (Paddocks with large remnant trees).

WGS84, Zone 50J.

Jarrah = *Eucalyptus marginata*; Flooded Gum = *E. rudis*; Wandoo = *E. wandoo*; York Gum = *E. loxopheba*; Marri = *Corymbia calophylla*.

DBH = diameter at breast height.

See Section 3.3.8 for hollow category details: 1 (Active nest); 2 (Potential hollow with chew-marks); 3 (Potential hollow, no chew marks); 4 (Potential hollow, unsuitable orientation); 5 (Sufficient DBH, no observable hollows).

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
1	1	4	409341	6528130	Jarrah	Live	780	5	
2	1	4	409342	6528149	Jarrah	Live	630	5	
3	1	4	409343	6528195	Jarrah	Live	640	5	
4	1	4	409332	6528201	Jarrah	Live	590	5	
5	1	4	409324	6528219	Jarrah	Live	680	5	Twin trunks.
6	1	4	409320	6528251	Jarrah	Live	630	5	
7	1	4	409338	6528251	Jarrah	Live	560	5	
8	1	4	409340	6528260	Marri	Live	520	5	
9	1	4	409336	6528303	Jarrah	Live	570	5	
10	1	4	409314	6528290	Jarrah	Live	510	5	
11	1	4	409311	6528298	Jarrah	Live	520	5	
12	1	4	409298	6528302	Marri	Live	620	5	
13	1	4	409290	6528311	Jarrah	Live	580	5	
14	1	4	409285	6528260	Jarrah	Live	500	5	
15	1	4	409273	6528230	Jarrah	Live	660	5	
16	1	4	409245	6528241	Jarrah	Live	790	5	
17	1	4	409227	6528215	Jarrah	Live	760	5	Twin trunks.
18	1	4	409241	6528200	Jarrah	Live	500	5	
19	1	4	409235	6528194	Jarrah	Live	500	5	
20	1	4	409249	6528196	Jarrah	Live	580	5	
21	1	4	409285	6528194	Marri	Live	520	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
22	1	4	409294	6528184	Jarrah	Live	560	5	Twin trunks.
23	1	4	409310	6528163	Jarrah	Live	590	5	
24	1	4	409323	6528139	Jarrah	Live	700	5	
25	1	4	409310	6528136	Jarrah	Live	670	5	
26	1	4	409299	6528134	Marri	Live	510	5	
27	1	4	409288	6528129	Jarrah	Live	590	5	
28	1	4	409284	6528142	Marri	Live	570	5	
29	1	4	409286	6528146	Marri	Live	520	5	
30	1	4	409296	6528156	Jarrah	Live	550	5	
31	1	4	409294	6528160	Jarrah	Live	520	5	
32	1	4	409259	6528152	Marri	Live	640	2	
33	1	4	409264	6528126	Marri	Live	790	5	
34	1	4	409244	6528128	Marri	Live	880	5	
35	1	4	409252	6528180	Jarrah	Live	840	5	
36	1	4	409242	6528273	Jarrah	Live	640	5	
37	1	4	409247	6528294	Jarrah	Live	600	5	
38	1	4	409212	6528210	Marri	Live	560	5	
39	1	4	409213	6528196	Jarrah	Live	570	5	
40	1	4	409208	6528184	Jarrah	Live	680	5	
41	1	4	409220	6528177	Marri	Live	580	5	
42	1	4	409219	6528151	Marri	Dead	580	3	
43	1	4	409218	6528127	Jarrah	Live	750	5	
44	1	4	409209	6528136	Marri	Live	670	2	
45	1	4	409188	6528152	Jarrah	Live	740	5	
46	1	4	409178	6528147	Marri	Live	580	5	
47	1	4	409205	6528276	Jarrah	Live	770	4	
48	1	4	409216	6528309	Marri	Live	590	5	
49	1	4	409228	6528313	Jarrah	Live	530	5	
50	1	4	409235	6528306	Jarrah	Live	670	5	
51	1	4	409236	6528319	Jarrah	Live	520	5	
52	1	4	409232	6528343	Jarrah	Live	560	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
53	1	4	409224	6528353	Jarrah	Live	540	5	
54	1	4	409271	6528365	Jarrah	Live	700	5	
55	1	4	409263	6528346	Marri	Live	660	5	
56	1	4	409251	6528355	Jarrah	Live	520	5	
57	2	3	409036	6525805	Marri	Live	550	5	
58	2	3	409038	6525810	Marri	Live	550	5	
59	2	3	409017	6525811	Jarrah	Live	500	5	
60	2	3	409014	6525810	Marri	Live	900	5	
61	2	3	409028	6525826	Jarrah	Live	500	5	
62	2	3	409033	6525835	Marri	Live	600	5	
63	2	3	409041	6525850	Jarrah	Live	550	5	
64	2	3	409036	6525860	Jarrah	Live	550	3	
65	2	3	409017	6525862	Marri	Live	500	5	
66	2	3	409002	6525867	Jarrah	Live	750	5	
67	2	3	409006	6525877	Jarrah	Live	550	5	
68	2	3	409013	6525886	Jarrah	Live	550	5	
69	2	3	409022	6525937	Jarrah	Live	650	5	
70	2	3	409025	6525949	Jarrah	Live	500	5	
71	2	3	409027	6525977	Marri	Live	650	3	
72	2	3	409046	6525991	Jarrah	Live	650	4	
73	2	3	409043	6526056	Jarrah	Live	600	5	
74	2	3	409033	6526087	Jarrah	Live	500	5	
75	2	3	409031	6526092	Jarrah	Live	600	5	
76	2	3	409022	6526118	Jarrah	Live	900	x4	Bees in hollow.
77	2	3	408996	6526161	Marri	Live	500	5	
78	2	3	409001	6526186	Marri	Live	600	5	
79	2	3	408992	6526204	Jarrah	Live	600	5	
80	2	3	408992	6526215	Jarrah	Live	750	5	
81	2	3	409004	6526230	Marri	Live	500	5	
82	2	3	409008	6526244	Jarrah	Live	700	5	
83	2	3	409019	6526243	Jarrah	Live	550	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
84	2	3	409033	6526266	Jarrah	Live	550	5	
85	2	3	409032	6526284	Marri	Live	600	5	
86	2	3	408996	6526330	Jarrah	Live	1300	4	
87	2	3	408994	6526330	Marri	Live	700	5	
88	2	3	408987	6526324	Marri	Live	550	5	Triple trunk.
89	3	8	409052	6526363	Jarrah	Live	550	5	Multi trunk.
90	3	8	409050	6526346	Marri	Live	600	5	
91	3	8	409068	6526334	Marri	Live	900	5	Multi trunk.
92	3	8	409141	6526315	Marri	Live	550	5	
93	3	8	409146	6526315	Marri	Live	550	5	
94	3	8	409126	6526282	Jarrah	Live	700	5	
95	3	8	409107	6526269	Jarrah	Dead	850	5	
96	3	8	409193	6526213	Marri	Live	550	5	Multi trunk.
97	3	8	409215	6526189	Marri	Live	900	5	
98	3	8	409238	6526185	Marri	Live	800	5	
99	3	8	409246	6526255	Marri	Live	900	5	
100	3	8	409280	6526281	Marri	Live	600	5	
101	3	8	409331	6526315	Marri	Live	650	5	
102	3	8	409348	6526315	Jarrah	Live	550	5	
103	3	8	409275	6526372	Marri	Live	650	5	
104	3	8	409269	6526371	Marri	Live	750	5	
105	3	8	409207	6526363	Marri	Dead	600	5	
106	3	8	409139	6526356	Marri	Live	600	5	
107	3	8	409049	6526367	Jarrah	Live	650	5	
108	4	3	408990	6526529	Marri	Live	500	5	
109	4	3	408982	6526539	Marri	Live	750	5	
110	4	3	408982	6526550	Marri	Live	750	5	
111	4	3	408983	6526557	Marri	Live	500	5	
112	4	3	408988	6526671	Marri	Live	600	4	
113	4	3	408973	6526687	Marri	Live	650	5	
114	4	3	408969	6526711	Jarrah	Live	700	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
115	4	3	408991	6526711	Jarrah	Live	650	4	
116	4	3	409001	6526747	Jarrah	Live	600	5	
117	4	3	409014	6526772	Marri	Live	550	5	
118	4	3	409008	6526797	Marri	Live	550	5	
119	4	3	409012	6526816	Marri	Live	600	5	
120	4	3	409096	6526901	Marri	Live	500	5	
121	4	3	409088	6526911	Jarrah	Live	600	5	
122	4	3	409077	6526913	Marri	Live	1200	3	
123	4	3	409068	6526912	Jarrah	Live	800	5	
124	4	3	409084	6526934	Marri	Live	650	5	
125	4	3	409088	6526956	Marri	Live	500	5	
126	4	3	409102	6526950	Marri	Live	800	5	
127	4	3	409110	6526970	Marri	Live	700	3	
128	4	3	409118	6526978	Marri	Live	500	5	
129	4	3	409125	6526954	Marri	Live	600	5	
130	4	3	409127	6526922	Jarrah	Live	900	5	
131	4	3	409129	6526909	Marri	Live	1200	5	
132	4	3	409126	6526881	Marri	Live	500	5	
133	4	3	409135	6526886	Jarrah	Live	550	5	
134	5	8	409166	6526993	Marri	Live	950	5	
135	5	8	409162	6527010	Jarrah	Live	800	5	
136	5	8	409186	6526993	Jarrah	Live	600	5	
137	5	8	409172	6526963	Jarrah	Live	700	5	
138	5	8	409173	6526954	Jarrah	Live	600	5	
139	5	8	409176	6526956	Marri	Live	750	5	
140	5	8	409208	6526969	Marri	Live	1000	5	
141	5	8	409218	6526983	Marri	Live	900	5	
142	5	8	409226	6526992	Jarrah	Live	800	5	
143	5	8	409227	6526995	Jarrah	Live	600	5	
144	5	8	409229	6527004	Marri	Live	900	5	
145	5	8	409236	6527006	Jarrah	Live	800	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
146	5	8	409242	6527004	Jarrah	Live	650	5	
147	5	8	409238	6526981	Marri	Live	800	3	
148	5	8	409264	6526966	Marri	Dead	700	5	
149	5	8	409289	6526975	Marri	Live	1100	5	
150	5	8	409274	6526994	Marri	Live	700	5	
151	5	8	409263	6527016	Marri	Live	1400	3	
152	5	8	409250	6527045	Marri	Live	800	5	
153	5	8	409240	6527083	Marri	Live	1000	5	
154	5	8	409231	6527104	Marri	Live	850	5	
155	5	8	409245	6527109	Marri	Live	1000	5	
156	5	8	409216	6527102	Marri	Live	800	3	
157	5	8	409202	6527074	Marri	Live	800	5	
158	5	8	409198	6527054	Marri	Live	1000	5	
159	5	8	409209	6527049	Marri	Live	1200	3	
160	5	8	409278	6527109	Marri	Live	700	3	
161	5	8	409268	6527103	Marri	Live	800	5	
162	5	8	409293	6527113	Marri	Live	900	5	
163	5	8	409307	6527129	Marri	Live	800	5	
164	5	8	409312	6527138	Marri	Dead	600	3	
165	5	8	409318	6527137	Marri	Live	700	5	
166	5	8	409298	6527171	Marri	Live	900	5	
167	5	8	409289	6527188	Jarrah	Live	700	5	
168	5	8	409290	6527202	Marri	Live	800	5	
169	5	8	409306	6527210	Jarrah	Live	1000	5	
170	5	8	409225	6526908	Jarrah	Live	1000	5	
171	5	8	409221	6526910	Marri	Dead	800	3	
172	5	8	409210	6526922	Jarrah	Live	800	5	
173	5	8	409211	6526939	Marri	Dead	800	5	
174	5	8	409207	6526940	Jarrah	Live	600	5	
175	5	8	409183	6526915	Jarrah	Live	900	3	
176	6	4	409012	6525193	Marri	Live	770	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
177	6	4	408999	6525242	Marri	Live	610	5	
178	6	4	408994	6525254	Marri	Live	570	5	
179	6	4	409001	6525276	Marri	Live	540	5	
180	6	4	409007	6525281	Marri	Live	530	5	
181	6	4	408996	6525319	Marri	Live	510	5	
182	6	4	408993	6525333	Marri	Live	690	5	
183	6	4	408976	6525338	Jarraah	Live	570	5	
184	6	4	408971	6525324	Jarraah	Live	550	5	
185	6	4	408971	6525317	Jarraah	Live	800	5	
186	6	4	408971	6525312	Jarraah	Dead	700	3	
187	6	4	408955	6525311	Marri	Live	600	5	
188	6	4	408946	6525313	Marri	Live	800	5	
189	6	4	408948	6525334	Marri	Live	800	5	
190	6	4	408934	6525305	Jarraah	Live	700	5	
191	6	4	408955	6525282	Jarraah	Live	650	5	
192	6	4	408972	6525280	Jarraah	Live	1000	3	
193	6	4	408985	6525210	Jarraah	Live	500	3	
194	6	4	408975	6525164	Marri	Live	650	3	Galahs nesting?
195	6	4	408975	6525151	Jarraah	Live	500	5	
196	6	4	408962	6525155	Jarraah	Live	600	5	
197	6	4	408967	6525175	Jarraah	Live	650	x4	Bees in hollow.
198	6	4	408945	6525171	Jarraah	Live	700	3	
199	6	4	408944	6525171	Jarraah	Live	650	3	
200	6	4	408947	6525186	Jarraah	Live	600	5	
201	6	4	408938	6525195	Jarraah	Live	500	5	
202	6	4	408934	6525200	Jarraah	Live	550	5	
203	6	4	408918	6525229	Jarraah	Live	900	3	
204	6	4	408921	6525242	Jarraah	Live	800	3	
205	6	4	408893	6525283	Jarraah	Live	600	5	
206	6	4	408884	6525309	Jarraah	Live	700	5	
207	6	4	408890	6525311	Marri	Live	650	x3	Bees in hollow.

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
208	6	4	408897	6525323	Marri	Live	600	5	
209	6	4	408859	6525321	Marri	Live	500	5	
210	6	4	408847	6525308	Marri	Live	700	5	
211	6	4	408834	6525270	Jarraah	Live	650	3	
212	6	4	408841	6525264	Jarraah	Live	650	3	
213	6	4	408895	6525206	Jarraah	Live	600	5	
214	6	4	408902	6525203	Jarraah	Live	650	4	
215	6	4	408912	6525186	Jarraah	Live	700	5	
216	6	4	408912	6525145	Jarraah	Live	600	5	
217	6	4	408928	6525126	Jarraah	Live	550	5	
218	6	4	408925	6525115	Jarraah	Live	550	5	
219	6	4	408830	6525107	Marri	Live	550	5	
220	6	4	408825	6525118	Marri	Live	500	5	
221	6	4	408825	6525126	Marri	Live	700	5	
222	6	4	408818	6525141	Jarraah	Live	500	5	
223	6	4	408805	6525149	Marri	Dead	800	3	
224	6	4	408803	6525151	Marri	Live	500	5	
225	6	4	408802	6525184	Marri	Live	550	5	
226	6	4	408810	6525192	Marri	Live	550	5	
227	6	4	408828	6525170	Jarraah	Live	550	5	
228	6	4	408853	6525185	Jarraah	Live	550	5	
229	6	4	408862	6525186	Jarraah	Live	550	3	
230	6	4	408844	6525229	Jarraah	Live	550	5	
231	6	4	408834	6525225	Jarraah	Live	550	5	
232	6	4	408823	6525215	Marri	Live	550	5	
233	6	4	408822	6525227	Marri	Live	500	5	
234	6	4	408815	6525259	Jarraah	Live	500	5	
235	6	4	408807	6525261	Jarraah	Live	550	5	
236	6	4	408810	6525276	Jarraah	Live	800	3	
237	6	4	408806	6525284	Marri	Live	500	5	
238	6	4	408793	6525309	Jarraah	Live	600	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
239	6	4	408789	6525297	Marri	Live	600	5	
240	6	4	408789	6525289	Jarraah	Live	600	5	
241	7	8	408786	6525350	Marri	Live	550	5	
242	7	8	408877	6525562	Marri	Live	700	5	
243	7	8	408840	6525400	Jarraah	Live	650	5	
244	7	8	408886	6525363	Marri	Live	700	5	
245	7	8	408969	6525356	Jarraah	Live	700	5	
246	7	8	408970	6525691	Marri	Live	600	5	
247	7	8	408940	6525707	Marri	Live	700	5	
248	8	8	409003	6525729	Marri	Live	800	5	
249	8	8	409108	6525692	Marri	Live	600	5	
250	8	8	409056	6525640	Marri	Live	700	5	
251	8	8	409066	6525633	Marri	Live	550	5	
252	8	8	409080	6525634	Marri	Live	600	5	
253	8	8	409032	6525582	Jarraah	Live	550	5	
254	8	8	409063	6525572	Marri	Live	680	5	
255	8	8	409105	6525557	Jarraah	Live	670	5	
256	8	8	409079	6525517	Marri	Live	520	5	
257	8	8	409058	6525338	Marri	Live	600	5	
258	8	8	409057	6525338	Marri	Live	800	5	
259	8	8	409116	6525322	Jarraah	Live	500	5	
260	8	8	409126	6525330	Marri	Live	600	5	
261	8	8	409126	6525330	Marri	Live	500	5	
262	8	8	409128	6525329	Marri	Live	500	5	
263	8	8	409309	6525376	Marri	Live	700	5	
264	8	8	409302	6525372	Jarraah	Live	700	5	
265	8	8	409301	6525371	Marri	Live	1000	5	
266	8	8	409179	6525256	Marri	Live	600	5	
267	8	8	409117	6525160	Marri	Live	1000	5	
268	8	8	409110	6525174	Marri	Live	700	3	
269	8	8	409102	6525166	Marri	Live	600	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
270	8	8	409047	6525082	Marri	Live	650	5	
271	8	8	409046	6525058	Marri	Live	650	5	
272	8	8	409052	6525007	Marri	Live	550	5	
273	8	8	409051	6525007	Marri	Live	600	5	
274	8	8	409049	6524980	Marri	Live	600	5	
275	8	8	409065	6524978	Marri	Live	700	5	
276	8	8	409101	6524981	Marri	Live	1100	4	
277	8	8	409108	6524983	Marri	Live	800	5	
278	8	8	409110	6524990	Marri	Live	600	5	
279	8	8	409112	6524991	Marri	Live	1000	5	
280	8	8	409215	6525113	Marri	Live	510	5	
281	8	8	409216	6525115	Marri	Live	630	5	
282	8	8	409241	6525020	Marri	Dead	1130	5	
283	8	8	409309	6524968	Marri	Live	600	5	
284	8	8	409303	6524976	Marri	Live	1200	3	
285	8	8	409295	6524986	Marri	Live	900	5	
286	8	8	409288	6524986	Marri	Live	700	5	
287	9	5	422123	6552517	Wandoo	Live	350	5	
288	9	5	422124	6552518	Wandoo	Live	450	5	
289	9	5	422125	6552519	Wandoo	Live	500	5	
290	9	5	422127	6552517	Wandoo	Dead	400	5	
291	9	5	422146	6552608	Wandoo	Live	550	5	
292	9	5	422142	6552609	Wandoo	Live	600	3	
293	9	5	422136	6552612	Wandoo	Live	600	3	
294	9	5	422136	6552615	Wandoo	Live	400	5	
295	9	5	422143	6552613	Wandoo	Live	650	3	Australian Ringnecks nesting.
296	9	5	422142	6552635	Wandoo	Live	700	3	
297	9	5	422158	6552682	Wandoo	Live	500	5	
298	9	5	422159	6552695	Marri	Dead	650	5	
299	9	5	422157	6552722	Wandoo	Live	850	5	
300	9	5	422178	6552742	Wandoo	Live	900	3	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
301	9	5	422165	6552777	Wandoo	Live	550	5	
302	9	5	422168	6552781	Wandoo	Live	350	5	
303	9	5	422169	6552782	Wandoo	Live	450	5	
304	9	5	422169	6552783	Wandoo	Live	350	5	
305	9	5	422171	6552783	Wandoo	Live	350	5	
306	9	5	422174	6552814	Wandoo	Live	450	5	
307	9	5	422177	6552812	Wandoo	Live	450	5	
308	9	5	422181	6552826	Wandoo	Live	450	5	
309	9	5	422181	6552826	Wandoo	Dead	350	5	
310	9	5	422177	6552829	Wandoo	Dead	300	5	
311	9	5	422183	6552840	Wandoo	Live	600	3	
312	9	5	422184	6552849	Wandoo	Live	350	5	
313	9	5	422185	6552852	Wandoo	Live	400	5	
314	9	5	422187	6552882	Marri	Live	550	5	
315	9	5	422184	6552890	Marri	Dead	550	5	
316	9	5	422194	6552890	Wandoo	Live	550	5	
317	9	5	422189	6552899	Wandoo	Live	600	3	
318	9	5	422191	6552903	Wandoo	Live	400	5	
319	9	5	422191	6552904	Wandoo	Live	300	5	
320	9	5	422190	6552920	Wandoo	Live	300	5	
321	9	5	422191	6552928	Wandoo	Dead	350	5	
322	9	5	422190	6552937	Wandoo	Live	400	5	
323	9	5	422195	6552944	Wandoo	Live	350	5	
324	9	5	422195	6552945	Wandoo	Live	350	5	
325	9	5	422196	6552945	Wandoo	Live	450	5	
326	9	5	422197	6552945	Wandoo	Live	350	5	
327	9	5	422199	6552950	Wandoo	Live	350	5	
328	9	5	422199	6552957	Wandoo	Live	700	3	
329	9	5	422173	6552941	Wandoo	Live	350	5	
330	9	5	422169	6552923	Wandoo	Live	300	5	
331	9	5	422167	6552914	Wandoo	Live	400	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
332	9	5	422160	6552893	Wandoo	Live	350	5	
333	9	5	422156	6552872	Wandoo	Live	300	5	
334	9	5	422155	6552871	Wandoo	Live	400	3	
335	9	5	422152	6552838	Wandoo	Live	600	5	
336	9	5	422135	6552769	Wandoo	Live	350	5	
337	9	5	422119	6552678	Marri	Live	550	5	
338	9	5	422115	6552648	Wandoo	Live	650	3	
339	9	5	422111	6552626	Marri	Live	750	5	
340	9	5	422098	6552559	Wandoo	Live	350	5	
341	9	5	422094	6552534	Wandoo	Live	400	5	
342	9	5	422101	6552515	Wandoo	Live	550	5	
343	9	5	422100	6552511	Wandoo	Live	600	3	
344	9	5	422093	6552482	Marri	Dead	600	5	
345	9	5	422087	6552462	Wandoo	Live	350	5	
346	9	5	422069	6552361	Wandoo	Live	600	3	
347	9	5	422064	6552329	Wandoo	Live	350	5	Twin trunks.
348	9	5	422057	6552284	Wandoo	Live	350	5	
349	9	5	422088	6552321	Wandoo	Live	450	3	
350	9	5	422085	6552326	Wandoo	Live	450	5	Twin trunks.
351	9	5	422087	6552346	Wandoo	Live	350	5	
352	9	5	422088	6552347	Wandoo	Live	300	5	
353	9	5	422096	6552356	Wandoo	Live	350	5	
354	9	5	422105	6552361	Wandoo	Live	700	5	
355	9	5	422112	6552393	Wandoo	Live	300	5	
356	9	5	422100	6552397	Wandoo	Live	350	5	
357	9	5	422113	6552422	Wandoo	Live	600	3	
358	9	5	422114	6552432	Wandoo	Live	700	4	
359	9	5	422113	6552438	Wandoo	Live	300	5	
360	9	5	422118	6552454	Wandoo	Dead	500	5	
361	9	5	422115	6552459	Wandoo	Live	450	3	
362	9	5	422114	6552460	Wandoo	Live	650	2	CaBC seen inspecting on 06.10.16.

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
363	9	5	422114	6552462	Wandoo	Live	750	3	
364	10	5	420084	6550915	Wandoo	Live	450	5	
365	10	5	420051	6550918	Wandoo	Live	550	5	
366	10	5	420015	6550920	Wandoo	Live	300	5	
367	10	5	420015	6550920	Wandoo	Live	300	5	
368	10	5	419993	6550921	Wandoo	Live	350	5	
369	10	5	419955	6550924	Wandoo	Live	300	5	
370	10	5	419930	6550924	Wandoo	Live	450	5	
371	10	5	419929	6550925	Wandoo	Live	500	5	
372	10	5	419927	6550927	Wandoo	Live	400	5	
373	10	5	419891	6550928	Wandoo	Live	350	5	
374	10	5	419837	6550931	Wandoo	Live	300	5	
375	10	5	419798	6550936	Wandoo	Dead	450	5	
376	10	5	419769	6550936	Wandoo	Live	300	5	
377	10	5	419748	6550939	Wandoo	Live	400	5	
378	10	5	419694	6550941	Wandoo	Dead	500	5	
379	10	5	419674	6550939	Wandoo	Live	400	5	
380	10	5	419673	6550947	Wandoo	Live	850	3	
381	10	5	419652	6550940	Wandoo	Live	450	5	
382	10	5	419652	6550947	Wandoo	Live	700	5	
383	10	5	419629	6550944	Wandoo	Live	400	5	
384	10	5	419627	6550946	Wandoo	Live	450	5	
385	10	5	419627	6550951	Wandoo	Live	700	5	
386	10	5	419601	6550947	Wandoo	Live	350	5	
387	10	5	419597	6550942	Wandoo	Dead	700	3	
388	10	5	419571	6550946	Wandoo	Live	400	5	
389	10	5	419561	6550949	Wandoo	Live	400	5	
390	10	5	419533	6550936	Wandoo	Live	300	5	
391	10	5	419547	6550932	Wandoo	Live	800	5	
392	10	5	419577	6550934	Wandoo	Live	350	5	
393	10	5	419630	6550932	Wandoo	Live	450	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
394	10	5	419712	6550930	Wandoo	Live	450	5	
395	10	5	419762	6550926	Wandoo	Live	350	5	
396	10	5	419771	6550926	Wandoo	Live	600	5	
397	10	5	419920	6550916	Wandoo	Live	300	5	
398	10	5	419938	6550915	Wandoo	Live	350	5	
399	10	5	420062	6550905	Wandoo	Live	400	5	
400	10	5	420134	6550901	Wandoo	Live	950	4	Australian Ringnecks nesting.
401	10	5	420155	6550898	Wandoo	Live	450	5	
402	10	5	420173	6550899	Wandoo	Live	300	5	
403	10	5	420173	6550899	Wandoo	Live	300	5	
404	10	5	420209	6550896	Wandoo	Live	600	5	
405	10	5	420266	6550890	Wandoo	Live	350	5	
406	10	5	420266	6550889	Wandoo	Live	400	5	
407	10	5	420267	6550888	Wandoo	Live	300	5	
408	10	5	420268	6550887	Wandoo	Live	300	5	
409	10	5	420286	6550885	Wandoo	Live	600	5	
410	10	5	420304	6550885	Wandoo	Live	550	5	
411	10	5	420322	6550879	Wandoo	Live	600	5	
412	10	5	420322	6550880	Wandoo	Live	450	5	
413	10	5	420342	6550878	Wandoo	Live	450	5	
414	10	5	420350	6550870	Wandoo	Live	300	5	
415	10	5	420362	6550869	Wandoo	Live	350	5	
416	10	5	420399	6550859	Wandoo	Live	400	5	
417	10	5	420416	6550858	Wandoo	Live	450	3	
418	10	5	420419	6550859	Wandoo	Live	450	5	
419	10	5	420436	6550858	Wandoo	Live	300	5	
420	10	5	420405	6550877	Wandoo	Live	350	5	
421	10	5	420407	6550875	Wandoo	Live	350	5	
422	10	5	420392	6550881	Wandoo	Live	400	5	
423	10	5	420381	6550883	Wandoo	Live	600	5	
424	10	5	420356	6550891	Wandoo	Live	450	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
425	10	5	420346	6550896	Wandoo	Live	350	5	
426	10	5	420287	6550902	Wandoo	Live	350	5	
427	10	5	420263	6550906	Wandoo	Live	300	5	
428	10	5	420234	6550911	Wandoo	Live	350	5	
429	10	5	420176	6550911	Wandoo	Live	400	5	
430	10	5	420160	6550911	Wandoo	Live	300	5	
431	10	5	420116	6550913	Wandoo	Live	300	5	
432	10	5	420105	6550914	Wandoo	Live	400	5	
433	11	3	416877	6549345	Marri	Live	500	5	
434	11	3	416857	6549324	Marri	Live	650	5	
435	11	3	416857	6549314	Jarraah	Live	500	5	
436	11	3	416868	6549309	Jarraah	Live	1100	5	
437	11	3	416859	6549304	Jarraah	Live	500	5	
438	11	3	416845	6549298	Marri	Live	700	5	
439	11	3	416838	6549307	Marri	Live	600	5	
440	11	3	416825	6549306	Jarraah	Dead	1000	5	
441	11	3	416822	6549288	Jarraah	Dead	700	5	
442	11	3	416821	6549278	Marri	Live	650	5	
443	11	3	416833	6549267	Marri	Dead	500	5	
444	11	3	416831	6549263	Jarraah	Dead	500	5	
445	11	3	416818	6549267	Marri	Live	600	5	
446	11	3	416822	6549234	Marri	Dead	900	5	
447	11	3	416845	6549235	Marri	Live	750	5	
448	11	3	416855	6549222	Marri	Live	800	5	
449	11	3	416857	6549209	Marri	Live	600	5	
450	11	3	416834	6549209	Marri	Dead	550	x4	Bees in hollow.
451	11	3	416808	6549207	Marri	Live	550	5	
452	11	3	416811	6549223	Jarraah	Dead	600	5	
453	11	3	416820	6549226	Marri	Live	550	5	
454	11	3	416802	6549231	Marri	Live	550	5	
455	11	3	416800	6549233	Jarraah	Dead	800	4	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
456	11	3	416806	6549243	Marri	Live	650	3	
457	11	3	416784	6549247	Jarraah	Live	700	5	
458	11	3	416774	6549262	Marri	Live	600	5	
459	11	3	416760	6549295	Marri	Live	550	5	
460	11	3	416779	6549326	Marri	Live	550	5	
461	11	3	416773	6549331	Jarraah	Live	850	3	
462	11	3	416796	6549326	Marri	Live	800	5	
463	11	3	416794	6549353	Marri	Live	800	5	
464	11	3	416810	6549367	Marri	Live	650	5	
465	11	3	416775	6549381	Marri	Live	700	5	
466	11	3	416757	6549336	Jarraah	Live	1000	5	
467	11	3	416743	6549300	Jarraah	Dead	600	5	
468	11	3	416734	6549279	Jarraah	Dead	600	5	
469	11	3	416733	6549264	Marri	Live	700	3	
470	11	3	416728	6549256	Jarraah	Dead	550	5	
471	11	3	416726	6549241	Jarraah	Dead	550	5	
472	11	3	416741	6549235	Jarraah	Dead	700	3	
473	11	3	416726	6549227	Jarraah	Dead	600	5	Australian Ringnecks nesting.
474	11	3	416715	6549200	Marri	Live	700	5	
475	11	3	416712	6549199	Marri	Live	800	4	
476	11	3	416711	6549244	Jarraah	Dead	700	3	
477	11	3	416698	6549252	Marri	Live	600	3	
478	11	3	416706	6549276	Jarraah	Live	550	5	
479	11	3	416694	6549295	Jarraah	Dead	700	5	
480	11	3	416697	6549305	Jarraah	Dead	550	5	
481	11	3	416699	6549308	Jarraah	Live	500	5	
482	11	3	416703	6549313	Jarraah	Dead	700	5	
483	11	3	416702	6549318	Jarraah	Live	700	5	
484	11	3	416713	6549313	Marri	Live	500	5	
485	11	3	416740	6549321	Jarraah	Dead	500	5	
486	11	3	416739	6549334	Marri	Live	500	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
487	11	3	416740	6549338	Marri	Live	500	5	
488	11	3	416746	6549370	Marri	Live	950	5	
489	12	5	411933	6548329	Marri	Live	550	5	
490	12	5	411812	6548441	Marri	Live	500	5	
491	12	5	411806	6548446	Marri	Live	700	5	
492	12	5	411798	6548451	Marri	Live	600	5	
493	12	5	411790	6548461	Marri	Live	550	5	
494	12	5	411784	6548465	Marri	Live	500	5	
495	12	5	411767	6548480	Marri	Live	550	5	
496	12	5	411760	6548482	Marri	Live	550	5	
497	12	5	411749	6548491	Marri	Live	500	5	
498	12	5	411724	6548510	Marri	Live	500	5	
499	12	5	411691	6548541	Marri	Live	600	5	
500	12	5	411682	6548542	Marri	Live	550	5	
501	12	5	411637	6548581	Marri	Live	500	5	
502	12	5	411624	6548598	Marri	Live	500	5	
503	12	5	411612	6548608	Marri	Live	550	5	
504	12	5	411598	6548622	Marri	Live	750	5	
505	12	5	411594	6548619	Marri	Live	500	5	
506	12	5	411629	6548626	Marri	Live	500	5	
507	12	5	411670	6548577	Marri	Live	500	5	
508	12	5	411700	6548551	Marri	Live	600	5	
509	12	5	411719	6548537	Marri	Dead	600	5	
510	12	5	411754	6548507	Marri	Live	500	5	
511	12	5	411762	6548503	Wandoo	Live	500	5	
512	12	5	411766	6548504	Wandoo	Live	400	5	
513	12	5	411789	6548478	Marri	Live	500	5	
514	12	5	411829	6548449	Marri	Live	550	5	
515	12	5	411846	6548444	Marri	Live	850	5	
516	12	5	411850	6548435	Wandoo	Live	300	5	
517	12	5	411855	6548430	Marri	Live	800	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
518	12	5	411873	6548414	Wandoo	Live	400	5	
519	12	5	411881	6548409	Wandoo	Live	400	5	
520	12	5	411888	6548404	Wandoo	Live	350	5	
521	12	5	411889	6548402	Wandoo	Live	750	5	
522	12	5	411895	6548395	Wandoo	Live	450	5	
523	12	5	411913	6548375	Marri	Live	700	5	
524	12	5	411927	6548366	Marri	Live	750	5	
525	12	5	411958	6548321	Marri	Live	600	5	
526	13	5	412483	6532764	Marri	Live	500	5	
527	13	5	412485	6532780	Marri	Live	550	5	
528	13	5	412485	6532788	Marri	Live	500	5	
529	13	5	412486	6532789	Jarraah	Live	500	3	
530	13	5	412485	6532803	Marri	Live	500	5	
531	13	5	412484	6532837	Marri	Live	700	5	
532	13	5	412485	6532840	Wandoo	Live	400	5	
533	13	5	412484	6532844	Marri	Live	500	5	
534	13	5	412484	6532852	Marri	Live	600	5	
535	13	5	412483	6532854	Marri	Live	500	5	
536	13	5	412486	6532856	Jarraah	Dead	550	3	
537	13	5	412486	6532867	Wandoo	Live	350	5	
538	13	5	412486	6532870	Wandoo	Live	300	5	
539	13	5	412487	6532873	Wandoo	Live	450	5	
540	13	5	412489	6532872	Wandoo	Live	450	5	
541	13	5	412497	6532878	Wandoo	Live	300	5	
542	13	5	412502	6532871	Wandoo	Live	450	5	
543	13	5	412508	6532881	Wandoo	Live	700	5	Multi trunk.
544	13	5	412521	6532905	Wandoo	Live	350	5	
545	13	5	412523	6532913	Wandoo	Live	400	5	
546	13	5	412531	6532924	Wandoo	Live	350	5	
547	13	5	412534	6532938	Wandoo	Live	400	5	
548	13	5	412570	6533000	Flooded Gum	Live	500	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
549	13	5	412574	6533010	Flooded Gum	Live	500	5	
550	13	5	412581	6533020	Flooded Gum	Live	550	5	
551	13	5	412590	6533038	Flooded Gum	Live	500	5	
552	13	5	412593	6533043	Flooded Gum	Live	550	5	
553	13	5	412596	6533052	Flooded Gum	Live	700	3	
554	13	5	412608	6533069	Wandoo	Live	300	5	
555	13	5	412609	6533072	Wandoo	Live	300	5	
556	13	5	412608	6533077	Flooded Gum	Live	650	5	
557	13	5	412614	6533082	Wandoo	Live	300	5	
558	13	5	412616	6533084	Wandoo	Live	350	5	
559	13	5	412649	6533145	Wandoo	Live	350	5	
560	13	5	412649	6533146	Wandoo	Live	500	5	
561	13	5	412655	6533150	Wandoo	Live	350	5	
562	13	5	412657	6533168	Wandoo	Live	550	3	
563	13	5	412663	6533175	Wandoo	Dead	400	5	
564	13	5	412664	6533175	Wandoo	Live	550	3	
565	13	5	412667	6533189	Wandoo	Dead	450	5	
566	13	5	412680	6533206	Wandoo	Dead	450	5	
567	13	5	412691	6533228	York Gum	Live	600	5	
568	13	5	412695	6533236	York Gum	Live	500	5	
569	13	5	412728	6533293	Marri	Live	550	5	
570	13	5	412742	6533322	Wandoo	Live	500	3	
571	13	5	412753	6533344	Marri	Live	700	5	
572	13	5	412799	6533453	Marri	Live	550	5	
573	13	5	412800	6533420	Marri	Live	650	5	
574	13	5	412803	6533409	Marri	Live	600	5	
575	13	5	412791	6533388	Marri	Live	550	5	
576	13	5	412726	6533258	Wandoo	Live	450	5	
577	13	5	412717	6533243	Marri	Live	750	5	
578	13	5	412716	6533240	Wandoo	Live	550	5	
579	13	5	412707	6533226	Wandoo	Live	350	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
580	13	5	412688	6533191	Wandoo	Live	550	5	
581	13	5	412689	6533185	Wandoo	Live	300	5	
582	13	5	412678	6533167	Wandoo	Live	700	4	
583	13	5	412676	6533165	Wandoo	Live	400	5	
584	13	5	412662	6533142	Wandoo	Live	500	5	
585	13	5	412656	6533122	Wandoo	Live	500	5	
586	13	5	412651	6533121	Wandoo	Live	350	5	
587	13	5	412651	6533120	Wandoo	Live	350	5	
588	13	5	412653	6533120	Wandoo	Live	350	5	
589	13	5	412648	6533112	Wandoo	Live	350	5	
590	13	5	412640	6533103	Wandoo	Live	550	5	
591	13	5	412635	6533093	Flooded Gum	Live	500	5	
592	13	5	412632	6533074	Wandoo	Live	450	5	
593	13	5	412631	6533075	Wandoo	Live	350	5	
594	13	5	412613	6533048	Flooded Gum	Live	550	5	
595	13	5	412600	6533027	Flooded Gum	Live	500	3	
596	13	5	412598	6533025	Flooded Gum	Live	600	5	
597	13	5	412596	6533019	Flooded Gum	Live	550	5	
598	13	5	412593	6533010	Flooded Gum	Live	500	5	
599	13	5	412583	6532994	Flooded Gum	Live	550	5	
600	13	5	412557	6532940	Wandoo	Live	300	5	
601	13	5	412549	6532934	Wandoo	Live	500	5	
602	13	5	412550	6532930	Wandoo	Live	550	5	
603	13	5	412500	6532746	Marri	Live	650	5	
604	13	5	412500	6532736	Marri	Live	650	5	
605	13	5	412501	6532727	Marri	Live	500	5	
606	13	5	412500	6532715	Marri	Live	500	5	
607	13	5	412501	6532709	Marri	Live	600	5	
608	13	5	412498	6532702	Marri	Live	650	5	
609	14	3	408796	6528142	Marri	Live	700	5	
610	14	3	408787	6528134	Jarraah	Live	600	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
611	14	3	408761	6528135	Marri	Live	500	5	
612	14	3	408726	6528135	Marri	Live	600	5	
613	14	3	408710	6528141	Jarraah	Live	550	5	
614	14	3	408692	6528144	Jarraah	Live	500	5	
615	14	3	408680	6528144	Marri	Live	550	5	
616	14	3	408680	6528150	Jarraah	Live	500	5	
617	14	3	408662	6528134	Jarraah	Live	650	5	
618	14	3	408650	6528132	Jarraah	Live	750	5	
619	14	3	408635	6528144	Jarraah	Dead	500	5	
620	14	3	408630	6528120	Jarraah	Live	700	5	
621	14	3	408626	6528126	Marri	Live	550	5	
622	14	3	408623	6528163	Jarraah	Live	700	3	
623	14	3	408687	6528171	Jarraah	Live	500	5	
624	14	3	408726	6528163	Marri	Live	500	4	
625	14	3	408765	6528194	Marri	Live	600	5	
626	14	3	408754	6528196	Jarraah	Live	600	5	
627	14	3	408751	6528198	Jarraah	Live	500	5	
628	14	3	408779	6528222	Marri	Live	800	5	
629	14	3	408788	6528221	Jarraah	Live	1200	3	
630	14	3	408748	6528231	Marri	Live	650	5	
631	14	3	408735	6528212	Jarraah	Live	800	5	
632	14	3	408741	6528207	Marri	Live	500	5	
633	14	3	408718	6528196	Jarraah	Live	500	5	
634	14	3	408720	6528186	Jarraah	Dead	500	3	
635	14	3	408683	6528204	Jarraah	Live	600	3	
636	14	3	408680	6528218	Marri	Live	600	3	
637	14	3	408616	6528207	Jarraah	Dead	550	5	
638	14	3	408625	6528243	Jarraah	Dead	700	5	
639	14	3	408626	6528262	Jarraah	Live	550	5	
640	14	3	408652	6528266	Jarraah	Live	950	3	
641	14	3	408665	6528257	Marri	Live	500	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
642	15	4	409973	6528055	Jarrah	Live	800	5	
643	15	4	409982	6528048	Jarrah	Live	550	5	
644	15	4	409986	6528018	Marri	Live	700	5	
645	15	4	409988	6528005	Jarrah	Live	500	5	
646	15	4	409996	6528000	Marri	Live	500	5	
647	15	4	410019	6528000	Jarrah	Live	700	5	
648	15	4	410025	6527978	Jarrah	Live	500	5	
649	15	4	410017	6527978	Jarrah	Live	800	5	
650	15	4	410012	6527966	Jarrah	Dead	650	5	
651	15	4	410004	6527969	Jarrah	Live	550	5	
652	15	4	409993	6527976	Jarrah	Live	500	5	
653	15	4	410003	6527975	Jarrah	Live	650	5	
654	15	4	409983	6527941	Marri	Live	1000	5	
655	15	4	410016	6527929	Jarrah	Live	550	5	
656	15	4	410017	6527944	Marri	Live	500	5	
657	15	4	410035	6527937	Jarrah	Live	600	3	
658	15	4	410040	6527923	Jarrah	Live	600	5	
659	15	4	410013	6527912	Jarrah	Live	550	5	
660	15	4	409996	6527910	Marri	Live	550	5	
661	15	4	410057	6527938	Marri	Live	600	3	
662	15	4	410066	6527934	Jarrah	Live	600	5	
663	15	4	410078	6527907	Marri	Live	800	3	
664	15	4	410036	6527852	Jarrah	Live	650	4	
665	15	4	410019	6527849	Jarrah	Live	850	5	
666	15	4	410006	6527862	Marri	Live	650	5	
667	15	4	410007	6527866	Jarrah	Live	850	5	
668	15	4	410011	6527834	Marri	Live	600	5	
669	15	4	409990	6527830	Marri	Live	850	5	
670	15	4	410012	6527819	Jarrah	Live	700	5	
671	15	4	410014	6527811	Jarrah	Live	600	5	
672	15	4	410019	6527805	Marri	Live	700	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
673	15	4	410026	6527829	Marri	Live	550	5	
674	15	4	410035	6527841	Jarraah	Live	500	5	
675	15	4	410046	6527833	Jarraah	Live	550	5	
676	15	4	410053	6527841	Jarraah	Live	500	5	
677	15	4	410090	6527853	Jarraah	Live	800	3	
678	15	4	410116	6527835	Jarraah	Live	500	5	
679	15	4	410122	6527750	Marri	Live	1000	5	
680	15	4	410141	6527749	Jarraah	Live	700	4	
681	15	4	410155	6527750	Jarraah	Dead	650	5	
682	15	4	410172	6527751	Marri	Live	500	5	
683	15	4	410197	6527762	Jarraah	Live	500	5	
684	15	4	410159	6527787	Marri	Live	700	5	
685	15	4	410166	6527797	Jarraah	Live	500	5	
686	15	4	410082	6527775	Marri	Live	800	5	
687	15	4	410043	6527777	Jarraah	Live	650	5	
688	15	4	410032	6527770	Marri	Live	1100	5	
689	15	4	410025	6527770	Marri	Live	900	5	
690	16	3	409602	6521822	Marri	Live	760	5	
691	16	3	409614	6521829	Jarraah	Live	530	5	
692	16	3	409608	6521852	Jarraah	Live	650	5	
693	16	3	409609	6521856	Marri	Live	600	5	
694	16	3	409615	6521862	Marri	Live	550	5	
695	16	3	409623	6521882	Jarraah	Live	550	5	
696	16	3	409627	6521881	Jarraah	Live	550	5	
697	16	3	409613	6521937	Jarraah	Live	700	5	
698	16	3	409637	6521949	Jarraah	Live	600	5	
699	16	3	409646	6521975	Jarraah	Live	600	5	
700	16	3	409647	6521982	Jarraah	Live	700	5	
701	16	3	409664	6521979	Jarraah	Live	550	5	
702	16	3	409664	6521976	Jarraah	Live	550	5	
703	16	3	409684	6522022	Jarraah	Live	550	5	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
704	16	3	409698	6522033	Jarrah	Live	550	5	
705	16	3	409708	6522021	Jarrah	Live	650	4	
706	16	3	409716	6522045	Jarrah	Live	650	5	Multi trunk.
707	16	3	409734	6522072	Jarrah	Live	500	5	
708	16	3	409735	6522073	Jarrah	Live	500	5	
709	16	3	409756	6522103	Jarrah	Live	650	5	
710	16	3	409765	6522074	Jarrah	Live	550	5	
711	16	3	409758	6522046	Jarrah	Live	650	5	
712	16	3	409746	6521976	Jarrah	Live	650	5	
713	16	3	409751	6521966	Jarrah	Live	550	5	
714	16	3	409716	6521925	Marri	Dead	550	3	
715	16	3	409713	6521906	Jarrah	Dead	500	4	
716	16	3	409715	6521900	Jarrah	Live	550	5	
717	16	3	409692	6521879	Jarrah	Live	500	5	
718	16	3	409662	6521836	Jarrah	Live	600	5	
719	16	3	409659	6521758	Jarrah	Live	650	5	
720	16	3	409609	6521755	Marri	Live	500	5	Multi trunk.
721	16	3	409594	6521782	Jarrah	Live	650	5	
722	16	3	409585	6521790	Jarrah	Live	500	5	
723	17	3	409595	6521447	Jarrah	Live	650	5	
724	17	3	409617	6521418	Marri	Live	500	3	
725	17	3	409624	6521406	Marri	Live	800	4	Old Wedge-tailed Eagle nest.
726	17	3	409637	6521368	Marri	Dead	550	3	
727	17	3	409663	6521346	Jarrah	Live	650	5	
728	17	3	409668	6521316	Jarrah	Live	500	5	
729	17	3	409773	6521121	Marri	Live	840	3	
730	17	3	409765	6521095	Marri	Live	670	3	
731	17	3	409772	6521089	Marri	Live	640	4	
732	17	3	409788	6521082	Marri	Live	650	3	
733	17	3	409784	6521073	Jarrah	Live	500	5	
734	17	3	409788	6521034	Marri	Live	700	3	

Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
735	17	3	409769	6521014	Jarrah	Live	750	5	
736	17	3	409786	6520999	Jarrah	Live	500	5	
737	17	3	409782	6520994	Marri	Live	550	4	
738	17	3	409803	6520958	Jarrah	Live	500	5	
739	17	3	409827	6520923	Marri	Live	600	5	
740	17	3	409837	6520920	Jarrah	Live	500	5	
741	17	3	409872	6520929	Marri	Live	1100	3	
742	17	3	409891	6520926	Marri	Dead	750	4	
743	17	3	409841	6520974	Marri	Live	600	5	
744	17	3	409823	6521062	Marri	Live	550	3	
745	17	3	409845	6521054	Jarrah	Live	750	4	
746	17	3	409835	6521070	Jarrah	Live	500	5	
747	17	3	409828	6521108	Jarrah	Live	700	3	
748	17	3	409825	6521126	Jarrah	Live	600	5	
749	17	3	409800	6521154	Jarrah	Live	550	5	
750	17	3	409797	6521188	Jarrah	Live	600	5	
751	17	3	409805	6521193	Marri	Live	700	3	
752	17	3	409807	6521203	Jarrah	Live	500	5	
753	17	3	409821	6521214	Marri	Live	750	5	
754	17	3	409822	6521215	Jarrah	Live	550	5	
755	17	3	409839	6521222	Marri	Live	600	5	
756	17	3	409840	6521236	Marri	Live	600	5	
757	17	3	409820	6521253	Marri	Live	500	4	
758	17	3	409816	6521247	Jarrah	Live	550	5	
759	17	3	409798	6521240	Marri	Live	700	5	
760	17	3	409792	6521230	Marri	Live	650	3	
761	17	3	409782	6521291	Marri	Live	800	3	
762	17	3	409754	6521306	Jarrah	Live	550	4	
763	17	3	409660	6521441	Marri	Dead	550	x4	Bees in hollow.
764	17	3	409656	6521445	Marri	Live	500	3	
765	17	3	409644	6521476	Jarrah	Live	750	3	

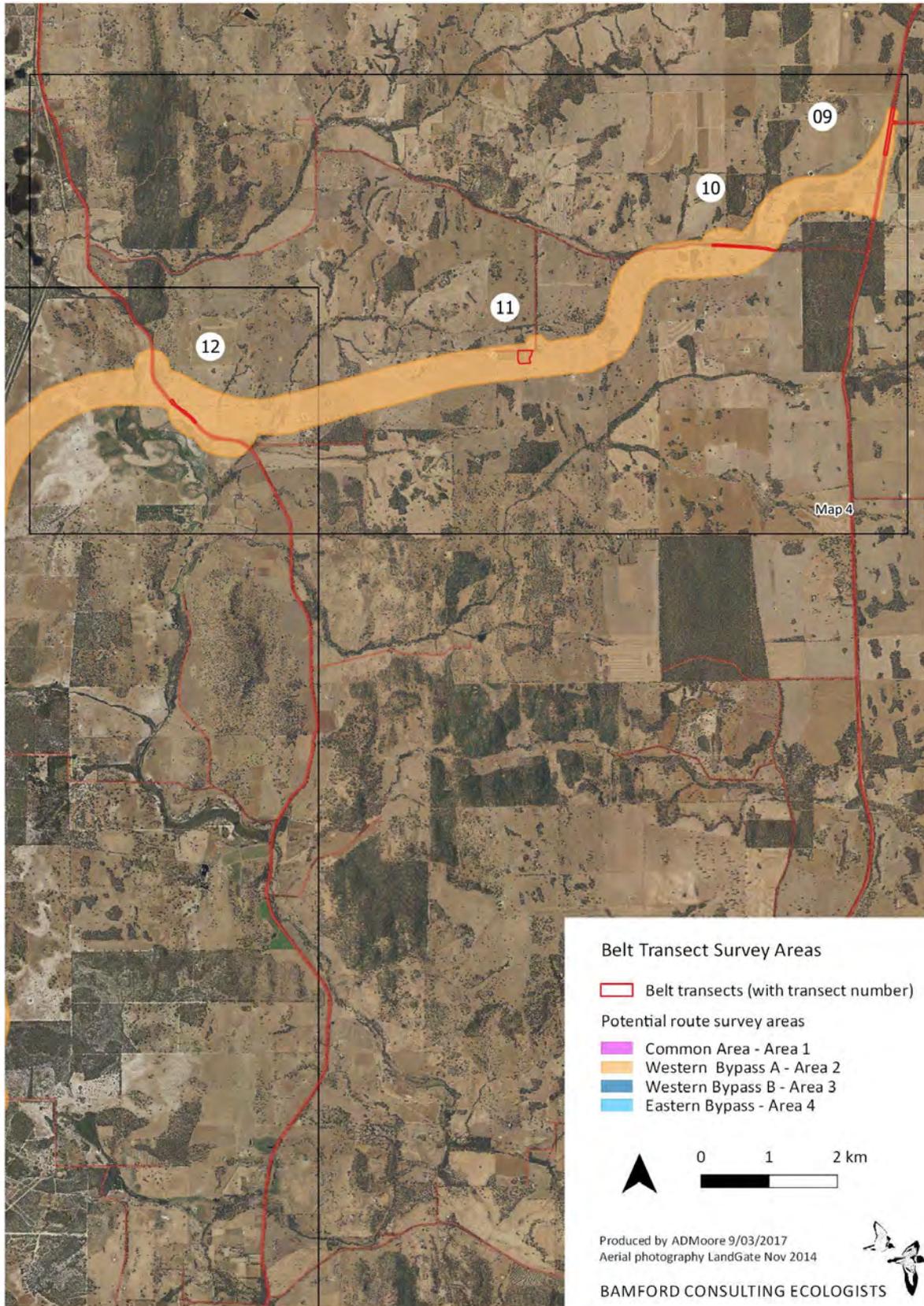
Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
766	17	3	409626	6521477	Marri	Live	500	3	
767	17	3	409622	6521502	Jarraah	Live	500	5	
768	17	3	409585	6521502	Jarraah	Live	800	4	
769	17	3	409588	6521549	Marri	Live	800	3	
770	17	3	409601	6521571	Marri	Live	550	5	
771	17	3	409594	6521572	Jarraah	Dead	500	5	
772	17	3	409576	6521582	Jarraah	Live	900	3	
773	17	3	409584	6521588	Jarraah	Live	500	5	
774	17	3	409604	6521598	Jarraah	Live	550	5	
775	17	3	409619	6521577	Jarraah	Dead	600	3	
776	17	3	409659	6521564	Jarraah	Live	600	5	Multi trunk.
777	17	3	409693	6521550	Marri	Live	650	3	
778	17	3	409680	6521593	Jarraah	Live	500	5	Triple trunk.
779	17	3	409645	6521610	Jarraah	Live	600	5	
780	17	3	409624	6521621	Jarraah	Live	550	5	
781	17	3	409619	6521624	Jarraah	Live	500	5	
782	18	8	408700	6531475	Marri	Live	1300	4	
783	18	8	408860	6531461	Marri	Live	1300	3	
784	18	8	408796	6531653	Marri	Live	1050	5	
785	18	8	408775	6531790	Marri	Live	1100	5	
786	19	8	410727	6519630	Marri	Live	700	5	
787	19	8	410730	6519627	Jarraah	Live	500	5	
788	19	8	410727	6519621	Jarraah	Live	700	5	
789	19	8	410732	6519600	Jarraah	Live	500	5	
790	19	8	410739	6519589	Marri	Live	500	5	
791	19	8	410754	6519541	Marri	Live	900	3	
792	19	8	410755	6519541	Jarraah	Live	550	5	
793	19	8	410755	6519531	Jarraah	Live	700	5	
794	19	8	410768	6519524	Jarraah	Live	500	5	
795	19	8	410777	6519523	Jarraah	Live	700	5	
796	19	8	410781	6519531	Jarraah	Live	500	5	

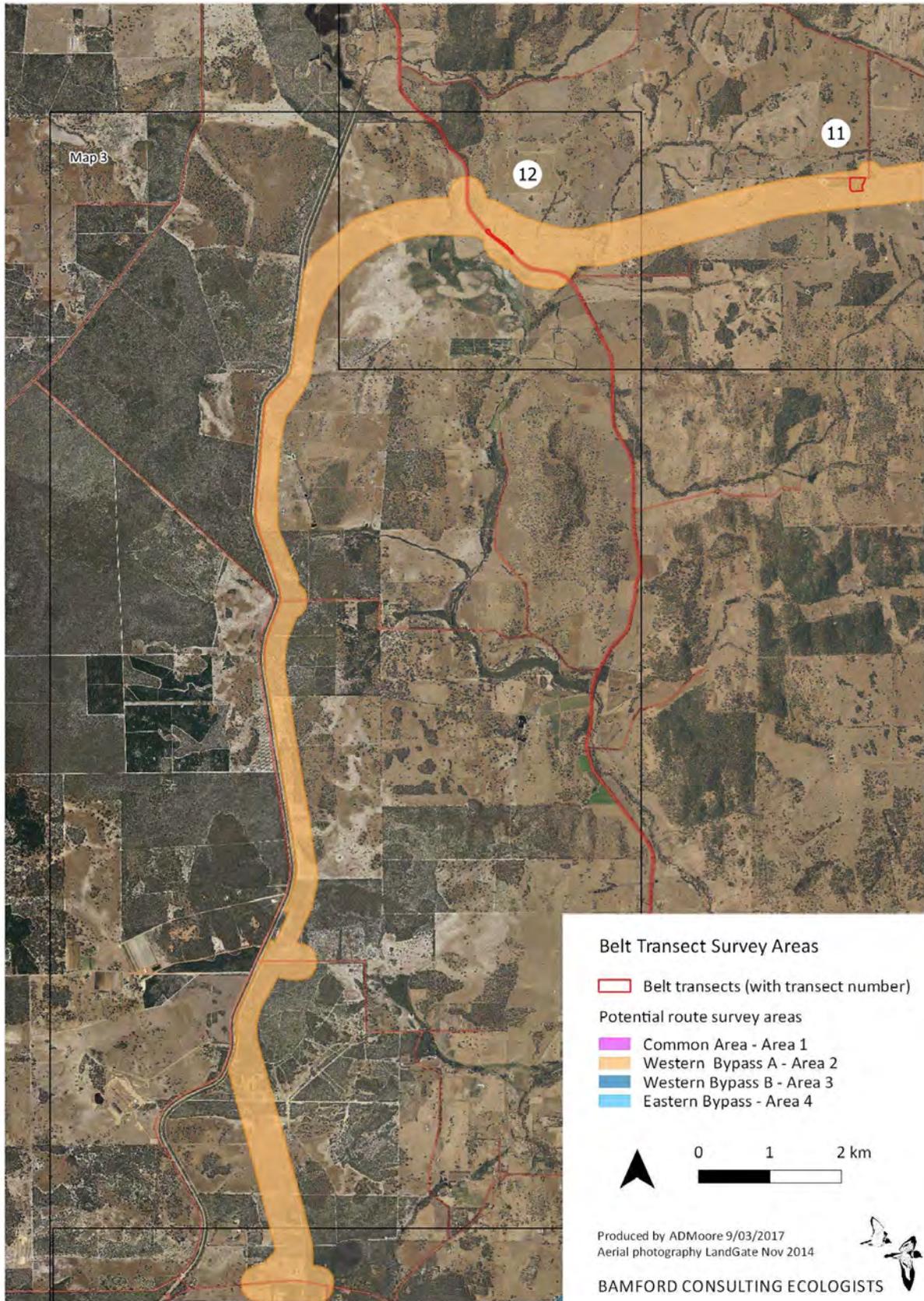
Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
797	19	8	410775	6519492	Jarrah	Live	550	5	
798	19	8	410777	6519490	Jarrah	Live	650	5	
799	19	8	410779	6519485	Jarrah	Live	500	5	
800	19	8	410781	6519482	Jarrah	Live	500	5	
801	19	8	410790	6519486	Marri	Live	600	5	
802	19	8	410797	6519476	Marri	Live	550	5	
803	19	8	410799	6519470	Jarrah	Live	550	5	
804	19	8	410774	6519468	Jarrah	Live	650	5	
805	19	8	410767	6519448	Marri	Live	750	5	
806	19	8	410764	6519443	Marri	Live	600	5	
807	19	8	410739	6519445	Jarrah	Live	600	5	
808	19	8	410721	6519422	Wandoo	Dead	550	5	
809	19	8	410717	6519409	Jarrah	Live	550	5	
810	19	8	410704	6519419	Wandoo	Live	600	5	
811	19	8	410709	6519392	Jarrah	Live	600	5	
812	19	8	410681	6519382	Wandoo	Live	600	4	
813	19	8	410674	6519446	Wandoo	Live	600	5	
814	19	8	410686	6519450	Jarrah	Live	650	5	
815	19	8	410686	6519460	Wandoo	Live	550	5	
816	19	8	410688	6519461	Wandoo	Live	550	5	
817	19	8	410686	6519469	Jarrah	Live	650	5	
818	19	8	410682	6519469	Wandoo	Live	450	5	
819	19	8	410675	6519479	Jarrah	Live	750	5	
820	19	8	410669	6519493	Jarrah	Live	500	5	
821	19	8	410693	6519501	Jarrah	Live	500	5	
822	19	8	410707	6519483	Marri	Live	700	5	
823	19	8	410731	6519497	Jarrah	Live	700	5	
824	19	8	410743	6519483	Jarrah	Live	750	5	
825	19	8	410770	6519514	Jarrah	Live	600	5	
826	19	8	410729	6519544	Jarrah	Live	500	5	
827	19	8	410729	6519545	Jarrah	Live	650	5	

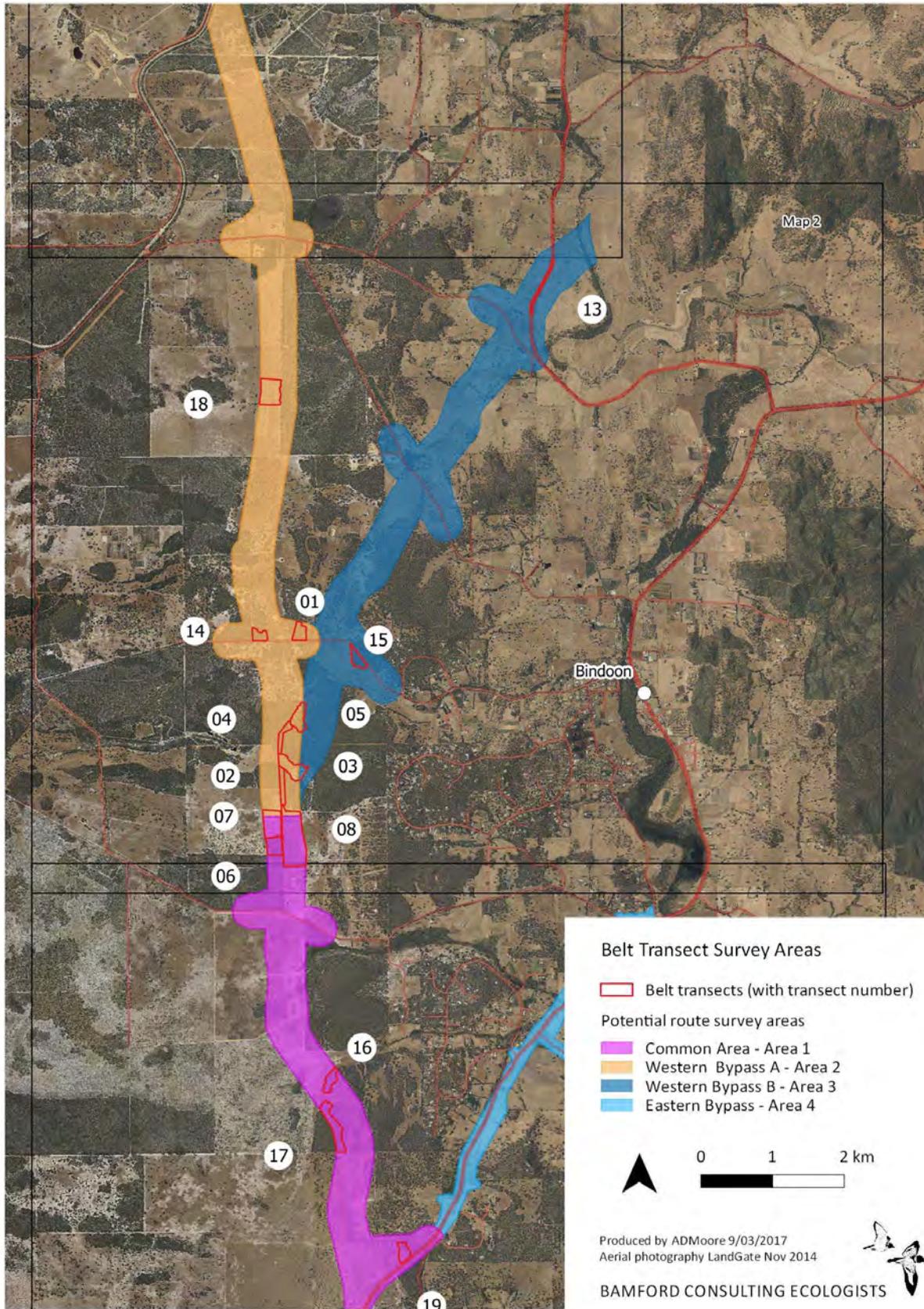
Tree	Belt Transect	VSA	Easting	Northing	Species	Status	DBH (mm)	Hollow Category	Notes
828	19	8	410719	6519535	Jarrah	Live	550	4	
829	19	8	410705	6519529	Jarrah	Live	750	4	
830	19	8	410671	6519534	Jarrah	Live	500	5	
831	19	8	410672	6519534	Jarrah	Live	650	5	
832	19	8	410683	6519543	Jarrah	Live	550	5	
833	19	8	410689	6519543	Jarrah	Live	650	5	
834	19	8	410699	6519552	Wandoo	Live	700	4	
835	19	8	410669	6519556	Jarrah	Live	800	4	
836	19	8	410707	6519564	Jarrah	Live	550	5	
837	19	8	410718	6519571	Wandoo	Live	350	5	
838	19	8	410724	6519582	Jarrah	Live	500	5	
839	19	8	410701	6519602	Jarrah	Live	650	5	
840	19	8	410680	6519594	Jarrah	Live	700	5	
841	19	8	410654	6519587	Wandoo	Live	400	5	
842	19	8	410653	6519587	Wandoo	Live	500	5	
843	19	8	410650	6519580	Jarrah	Live	500	3	
844	19	8	410637	6519610	Jarrah	Live	650	5	
845	19	8	410633	6519614	Jarrah	Live	600	5	
846	19	8	410640	6519625	Jarrah	Live	550	5	

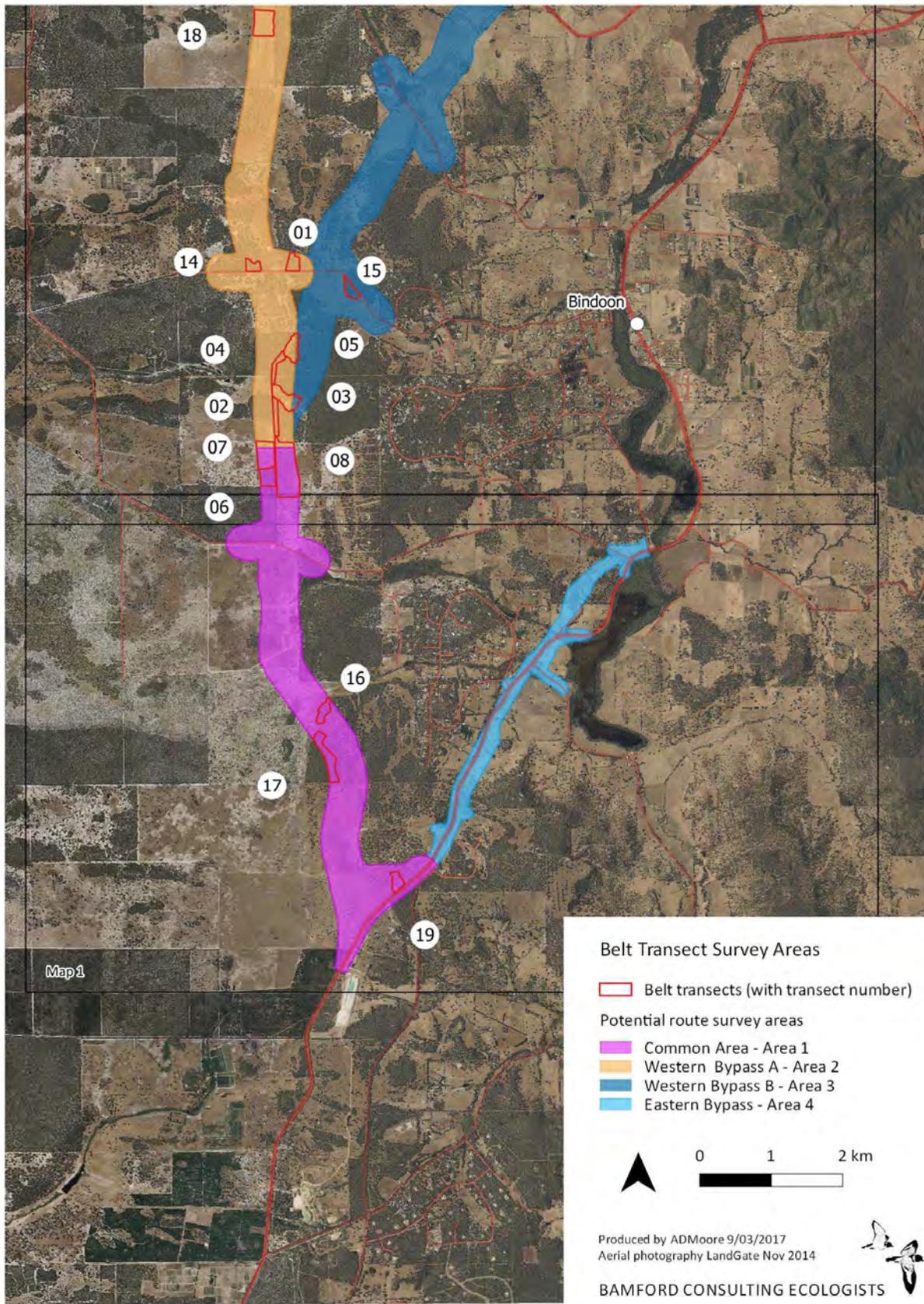
Appendix 10. Finer-scale maps of the location of belt transects within the study area.

See Figure 7 for full map.



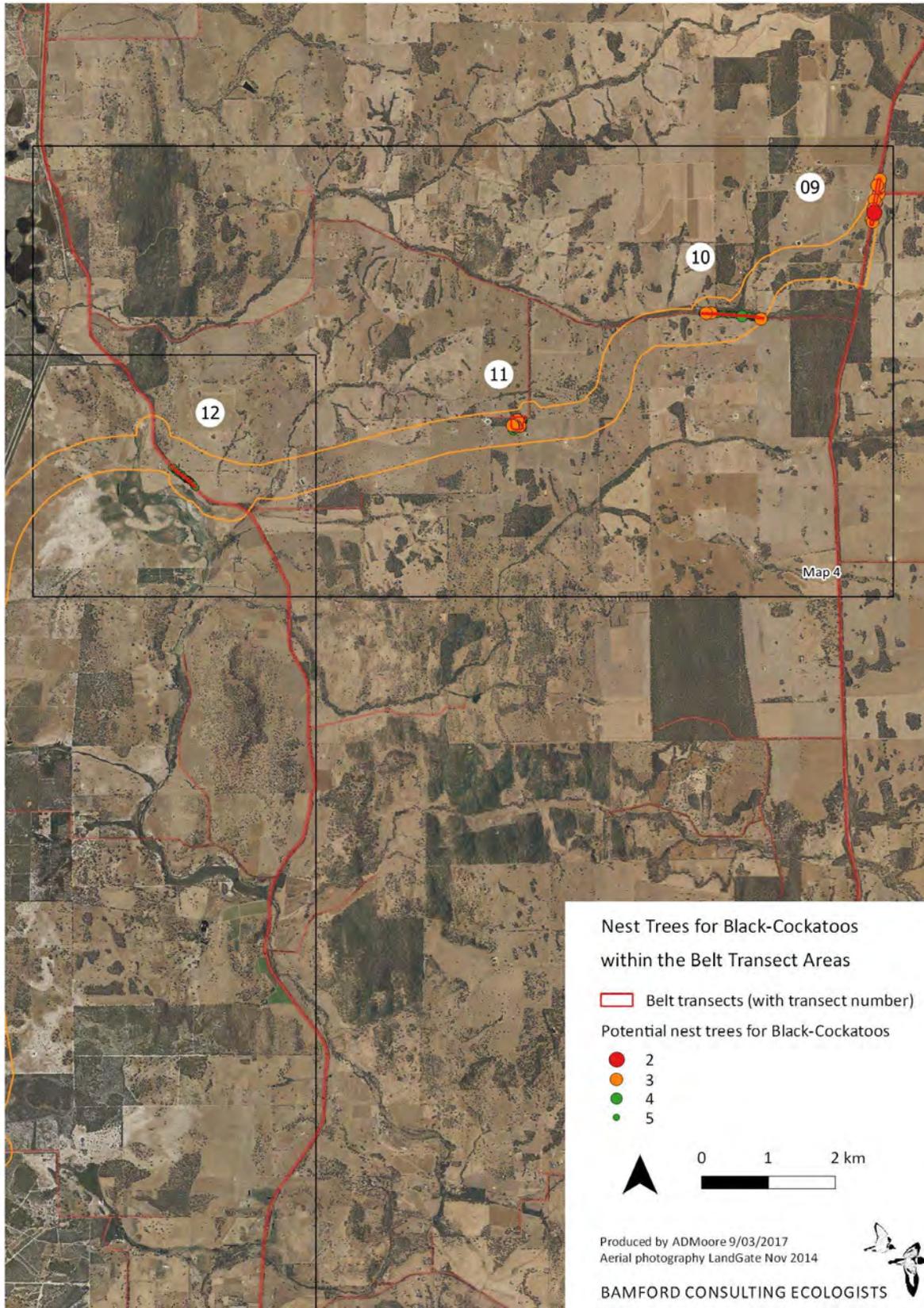


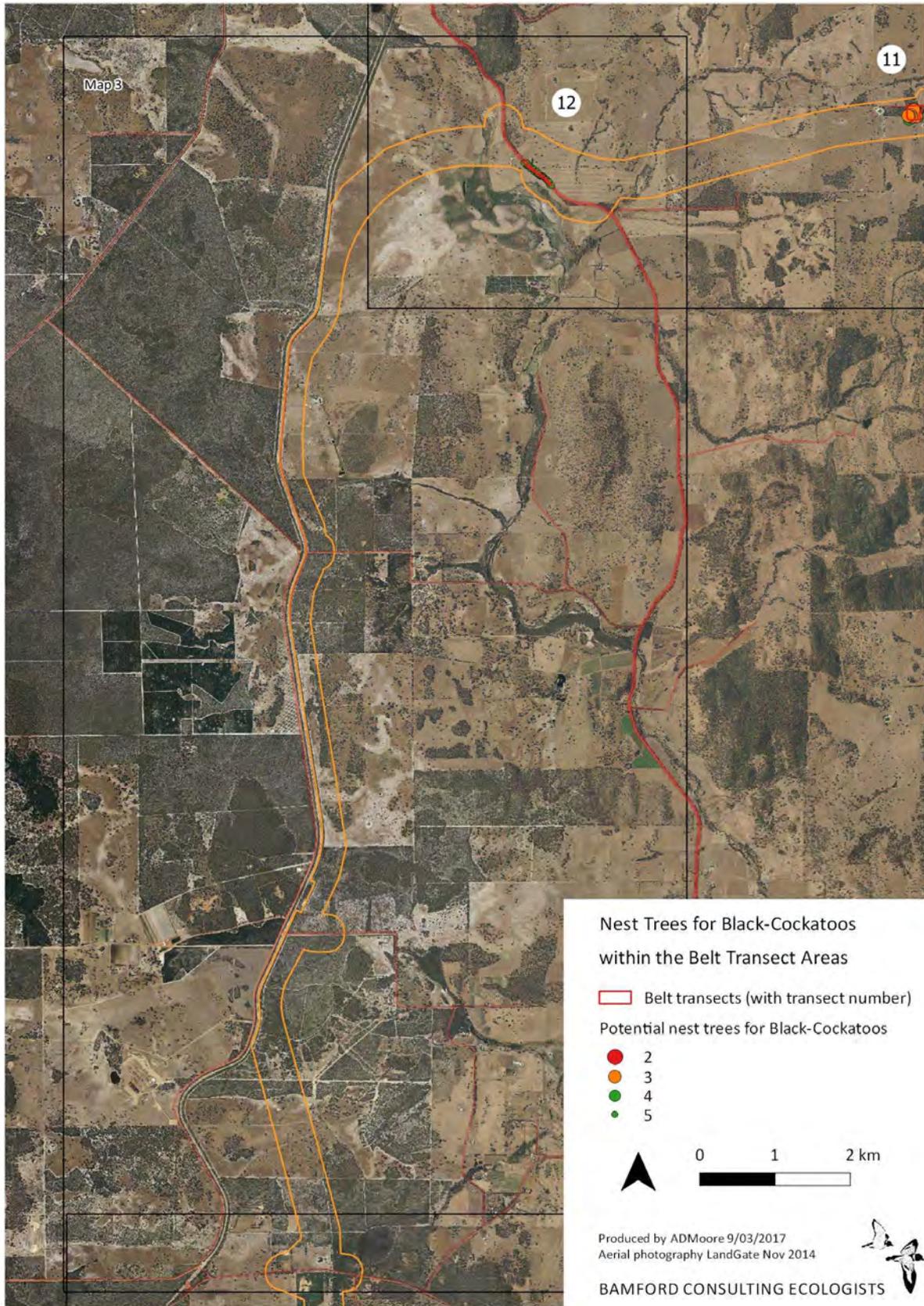


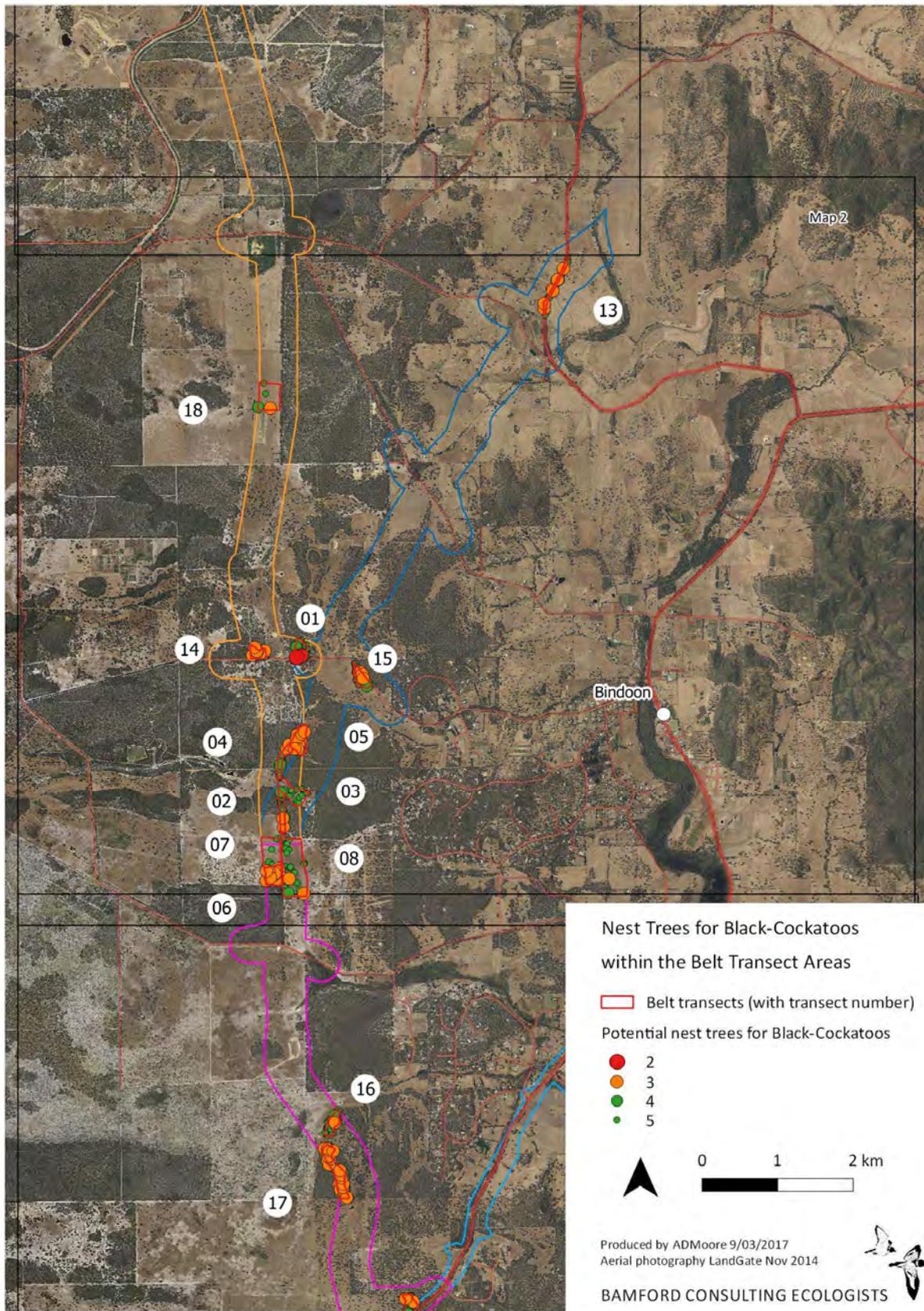


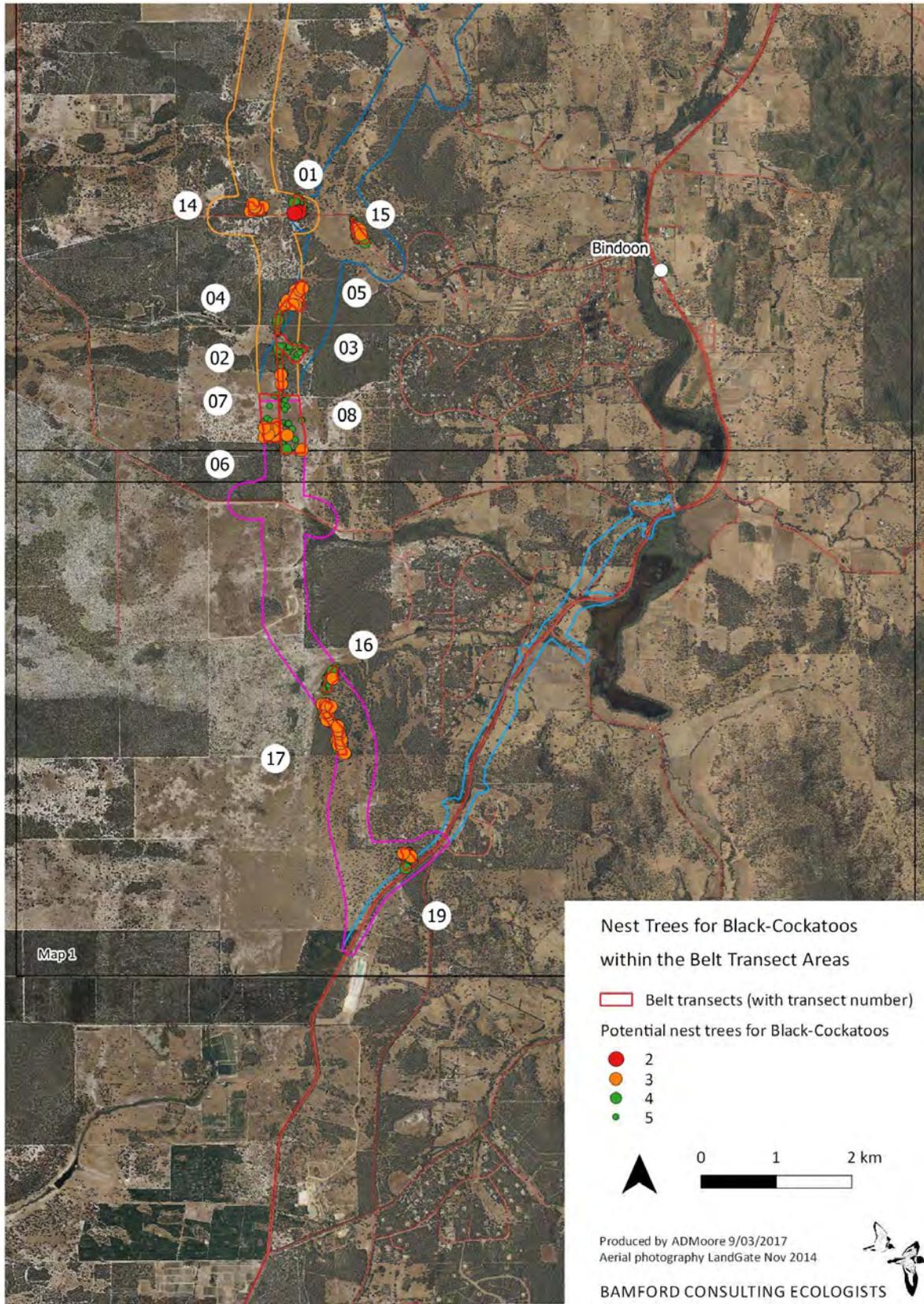
Appendix 11. Finer-scale maps of the location of potential nest trees as classified according to hollow-score.

See Figure 8 for full map.



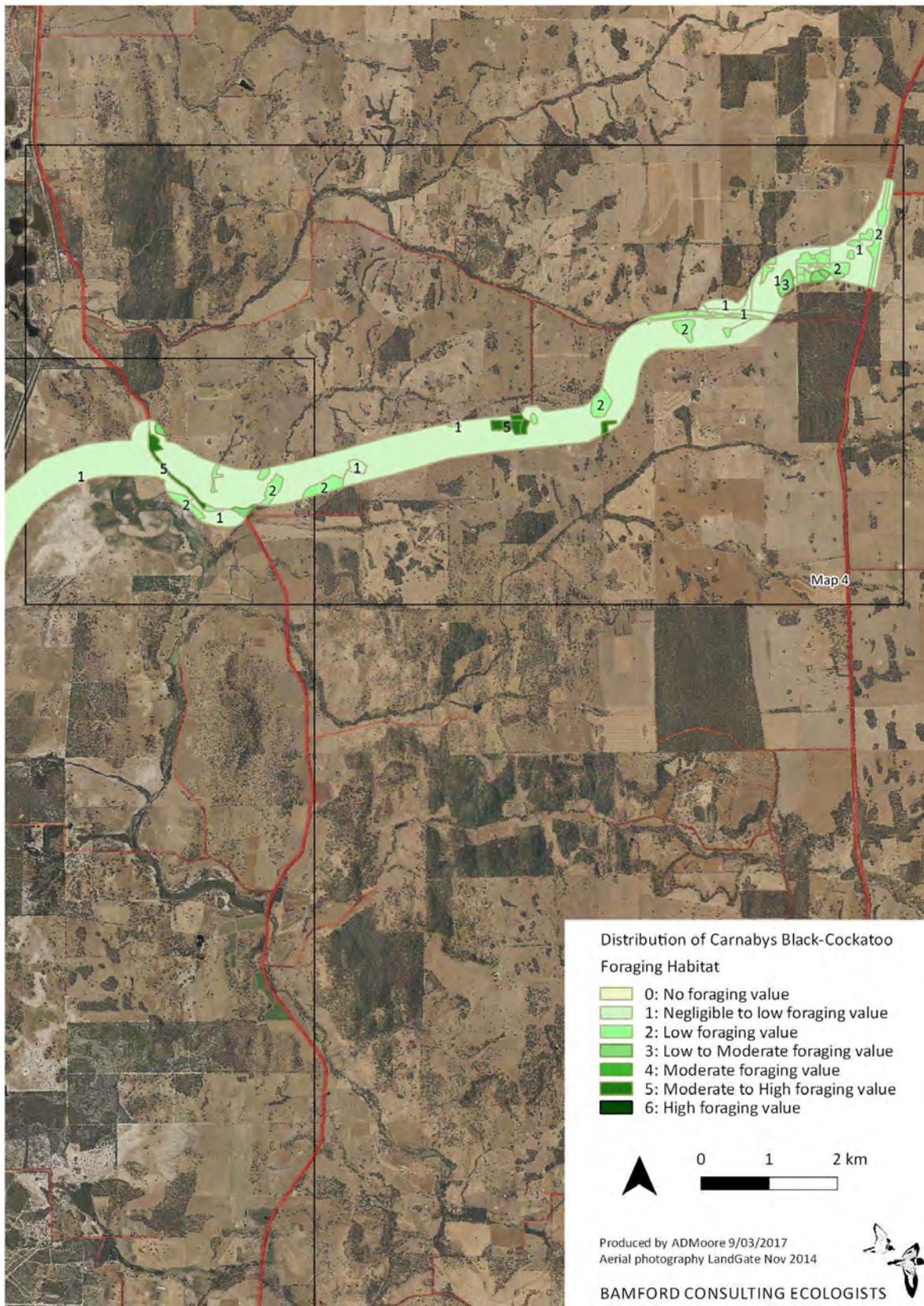


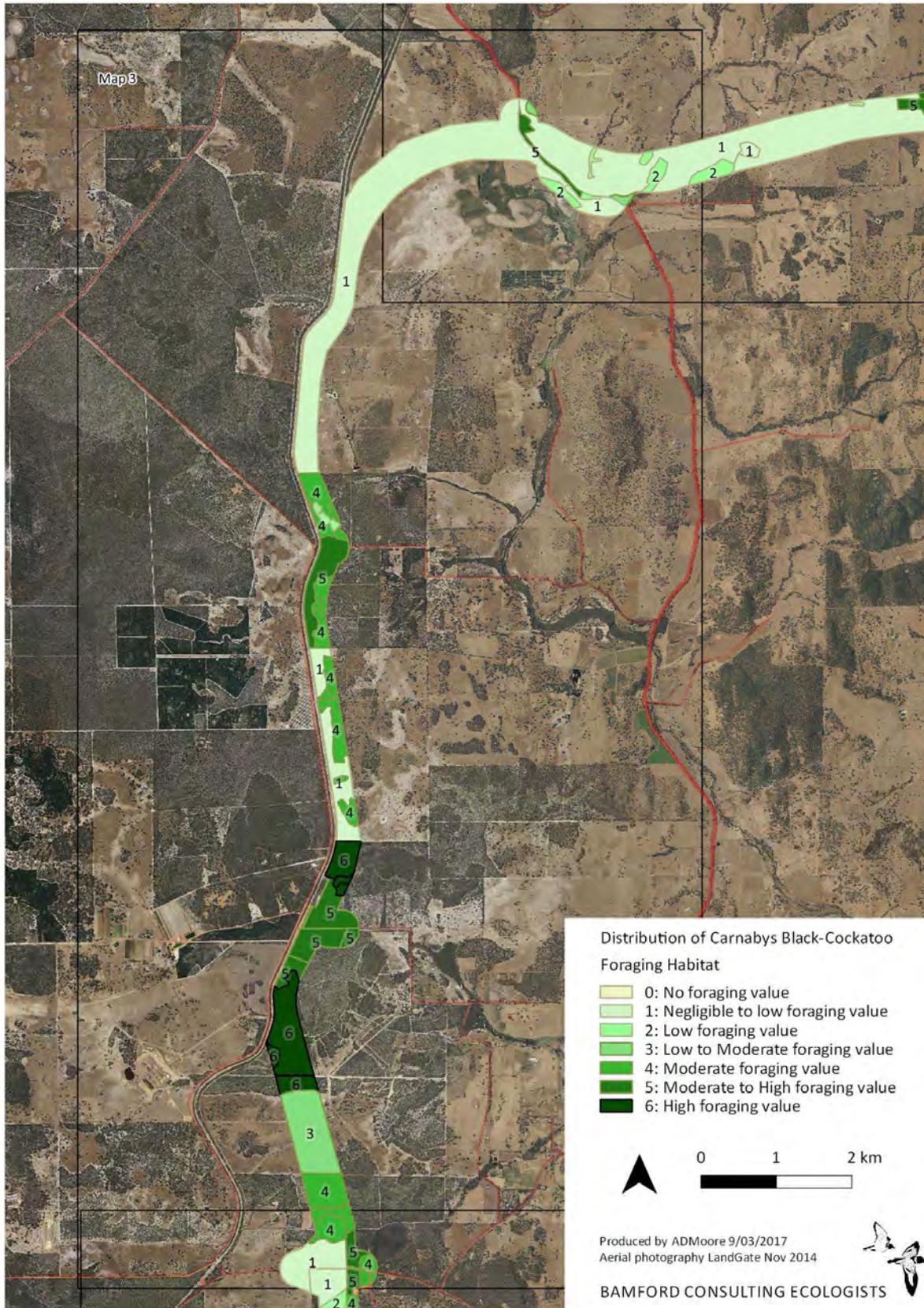


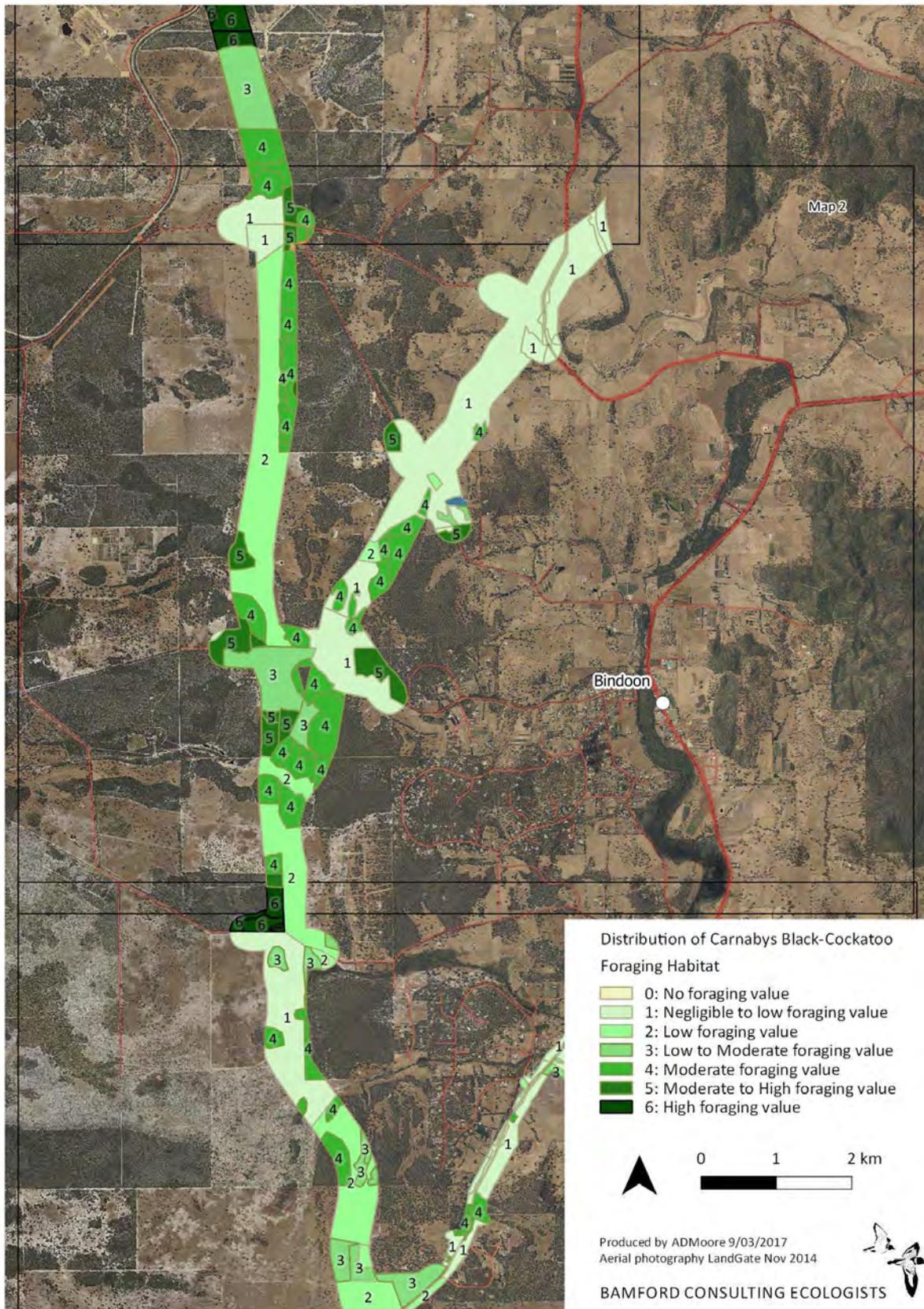


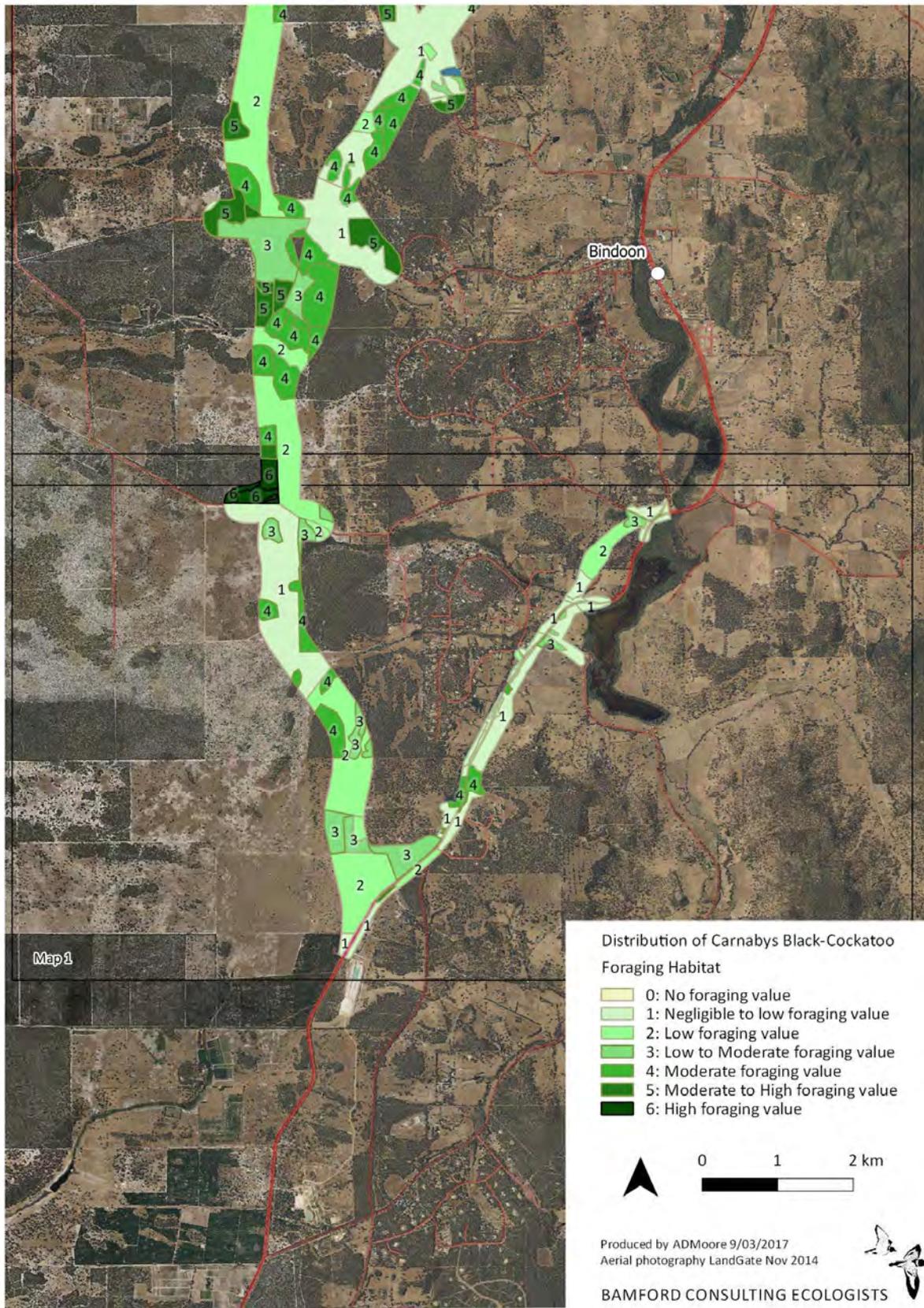
Appendix 12. Finer-scale maps of the distribution of Carnaby's Black-Cockatoo foraging habitat within the survey area.

See Figure 10 for full map.



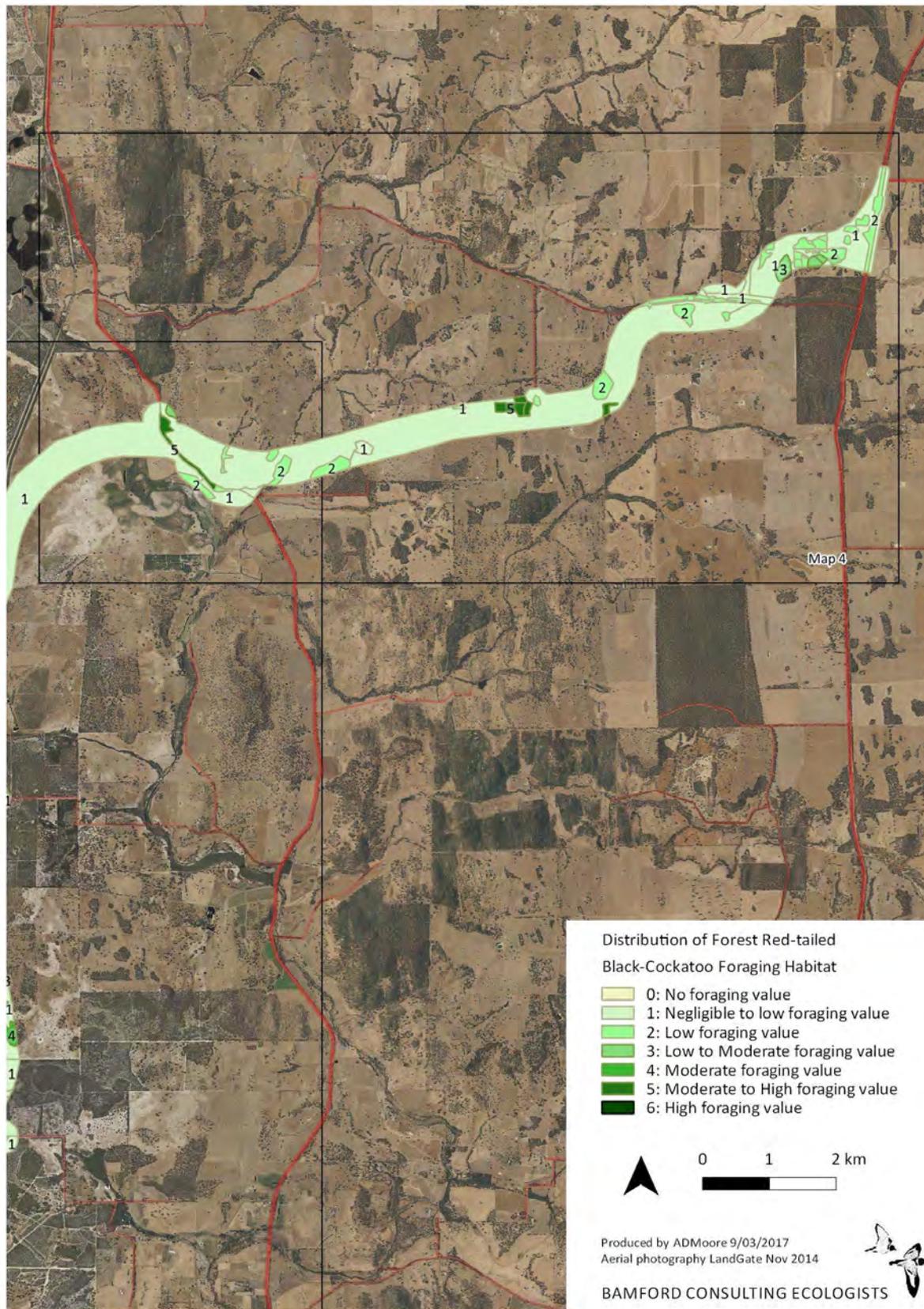


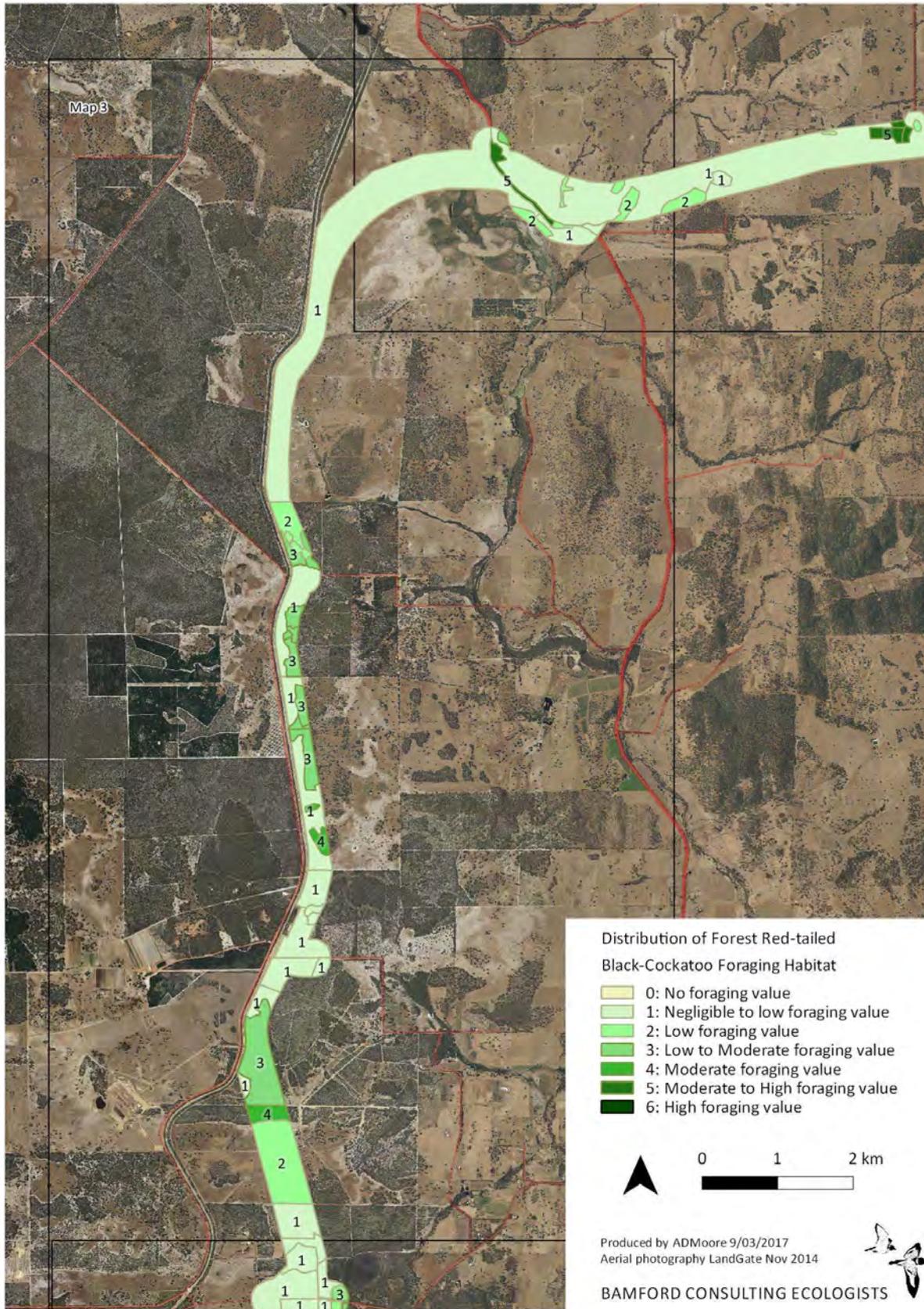


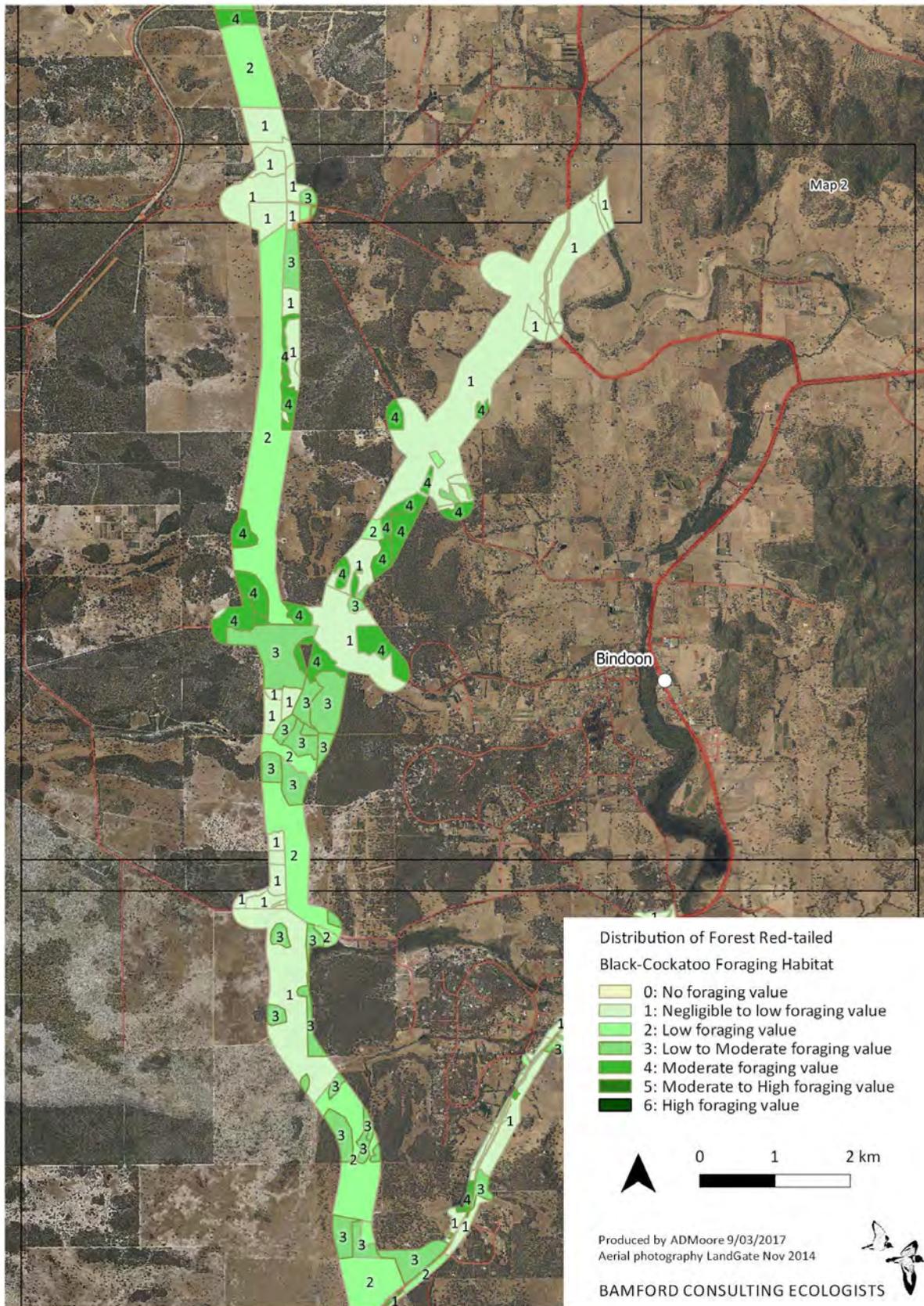


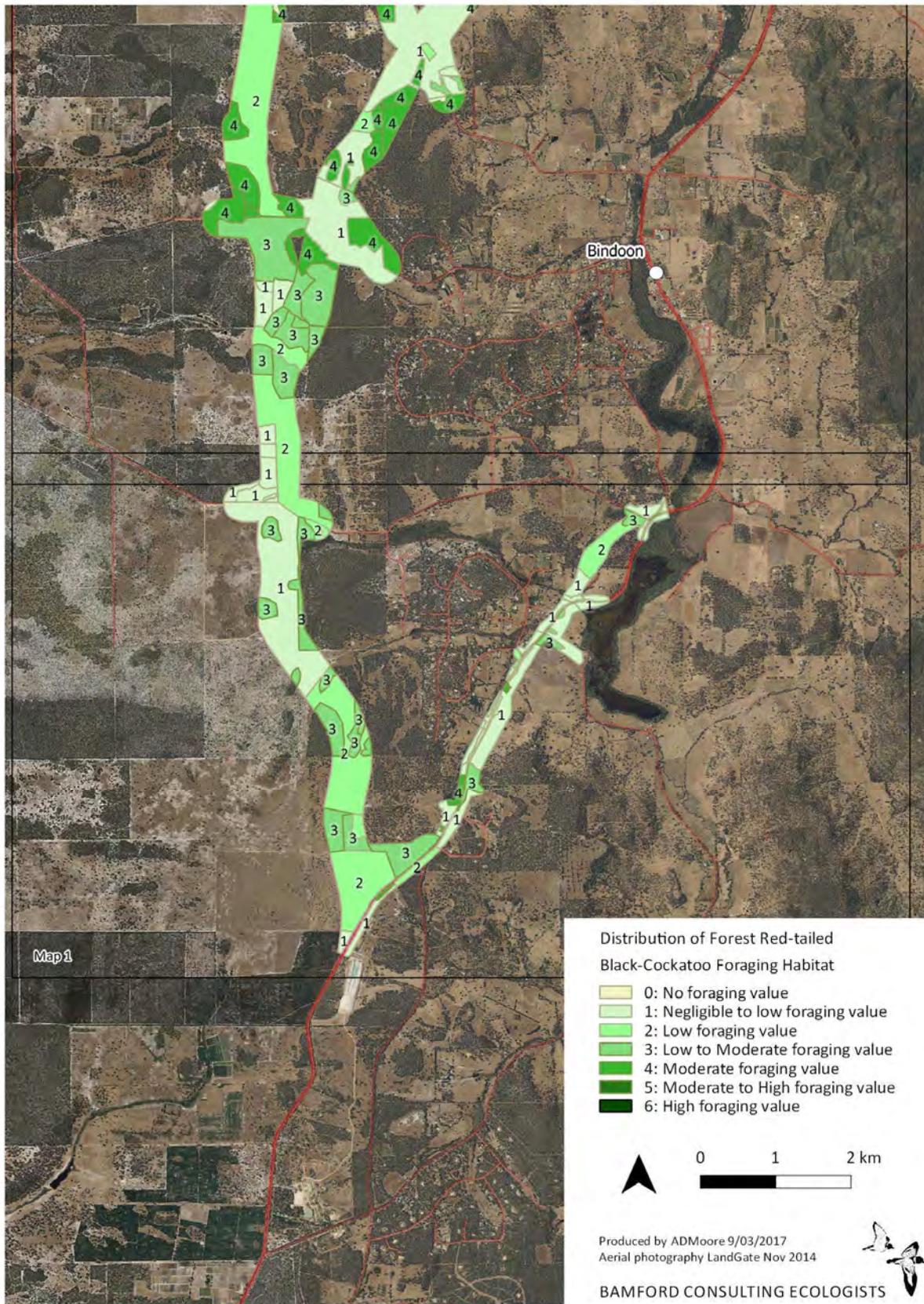
Appendix 13. Finer scale maps of the distribution of Forest Red-tailed Black-Cockatoo foraging habitat within the survey area.

See Figure 11 for full map.









Appendix 14. Black-cockatoo foraging records from within the study area.

See Section 3.3 (Figure 4) for description of age classes.

Record Number	Date	Easting	Northing	Feed Species	Black-Cockatoo Species	Age of Feed Sign
1	7/10/2016	409259	6528152	Marri	Forest Red-tailed	Recent and old
2	7/10/2016	409219	6528151	Marri	Forest Red-tailed	Old
3	7/10/2016	409195	6528144	Jarrah	Forest Red-tailed	Old
4	12/10/2016	409102	6526950	Marri	Forest Red-tailed	Old
5	18/10/2016	422111	6552626	Marri	Carnaby's	Old
6	18/10/2016	416775	6549381	Marri	Carnaby's	Recent
7	18/10/2016	416712	6549199	Marri	Carnaby's	Recent, intermediate and old
8	18/10/2016	411933	6548329	Marri	Carnaby's	Intermediate
9	18/10/2016	411812	6548441	Marri	Carnaby's	Intermediate
10	18/10/2016	411806	6548446	Marri	Carnaby's	Intermediate
11	18/10/2016	411798	6548451	Marri	Carnaby's	Intermediate
12	18/10/2016	411790	6548461	Marri	Carnaby's	Intermediate
13	18/10/2016	411784	6548465	Marri	Carnaby's	Intermediate
14	18/10/2016	411767	6548480	Marri	Carnaby's	Intermediate
15	18/10/2016	411760	6548482	Marri	Carnaby's	Intermediate
16	18/10/2016	411749	6548491	Marri	Carnaby's	Intermediate
17	18/10/2016	411724	6548510	Marri	Carnaby's	Intermediate
18	18/10/2016	411691	6548541	Marri	Carnaby's	Intermediate
19	18/10/2016	411682	6548542	Marri	Carnaby's	Intermediate
20	18/10/2016	411637	6548581	Marri	Carnaby's	Intermediate
21	18/10/2016	411624	6548598	Marri	Carnaby's	Intermediate
22	18/10/2016	411612	6548608	Marri	Carnaby's	Intermediate
23	18/10/2016	411598	6548622	Marri	Carnaby's	Intermediate
24	18/10/2016	411594	6548619	Marri	Carnaby's	Intermediate
25	18/10/2016	411629	6548626	Marri	Carnaby's	Intermediate
26	18/10/2016	411670	6548577	Marri	Carnaby's	Intermediate
27	18/10/2016	411700	6548551	Marri	Carnaby's	Intermediate
28	18/10/2016	411719	6548537	Marri	Carnaby's	Intermediate
29	18/10/2016	411754	6548507	Marri	Carnaby's	Intermediate
30	18/10/2016	411789	6548478	Marri	Carnaby's	Intermediate
31	18/10/2016	411829	6548449	Marri	Carnaby's	Intermediate
32	18/10/2016	411846	6548444	Marri	Carnaby's	Intermediate
33	18/10/2016	411855	6548430	Marri	Carnaby's	Intermediate
34	18/10/2016	411913	6548375	Marri	Carnaby's	Intermediate
35	18/10/2016	411927	6548366	Marri	Carnaby's	Intermediate
36	18/10/2016	411958	6548321	Marri	Carnaby's	Intermediate
37	18/10/2016	409982	6528048	Jarrah	Forest Red-tailed	Intermediate
38	18/10/2016	409988	6528005	Jarrah	Forest Red-tailed	Recent and intermediate

Record Number	Date	Easting	Northing	Feed Species	Black-Cockatoo Species	Age of Feed Sign
39	18/10/2016	409988	6528005	Jarrah	Carnaby's	Recent and intermediate
40	18/10/2016	422127	6552731	Marri	Carnaby's	Old
41	18/10/2016	422114	6552651	Marri	Carnaby's	Old
42	6/10/2016	408668	6541392	<i>Banksia attenuata</i>	Carnaby's	Uncertain