Great Northern Highway: Bindoon Bypass
Targeted Fauna Surveys

Jarrah-Marri Woodland over grasstrees. Photo: W. Bancroft

Prepared for: ASJV (Arup Jacobs Joint Venture)
11th Floor, Durack Centre
263 Adelaide Terrace
PERTH WA 6001

Prepared by: Wes Bancroft, Andrew Moore and Mike Bamford
M.J. & A.R. BAMFORD CONSULTING ECOLOGISTS.
23 Plover Way
KINGSLEY WA 6026

In association with:

FOCUSED VISION consulting

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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), in association with Main Roads Western Australia, who together are the Integrated Project Team (IPT), to conduct targeted fauna assessments of the proposed road corridor for the Bindoon Bypass. The purpose of these assessments was to provide baseline information for the environmental impact assessment of the proposed road. A comprehensive field programme was undertaken through 2017 to focus on a number of potential constraints in relation to fauna, most notably the Forest Red-tailed and Carnaby's Black-Cockatoos. The field programme also included studies on other conservation significant fauna that the desktop review suggested might be present. These previous studies identified fauna for additional targeted surveys, and as a result, the following surveys were undertaken within the proposed Bindoon Bypass Corridor:

- Black-cockatoo habitat analysis (breeding, foraging and roosting values) for Forest Red-tailed and Carnaby's Black-Cockatoos;
- Motion-sensitive camera surveys for mammals: Mardo, Chuditch, Brush-tailed Phascogale, Quenda, Brushtail Possum, Brush Wallaby and Rakali (Water-rat);
- Call-playback surveys for owls: Barking Owl and, incidentally, Masked Owl;
- Aquatic surveys for Freshwater Cobbler, Western Mud Minnow, Nightfish and Carter's Freshwater Mussel;
- Aural surveys for frogs: Hooting Frog, Whooping Frog and Ticking Frog;
- Short-range endemic invertebrate collection; and
- Acoustic surveys for bats.

This report presents the findings of those surveys.

Black-cockatoo habitat analysis

A total of 11,554 potential black-cockatoo nest-trees was recorded from the 3,118 ha study area (the subregion of the Bindoon Bypass Corridor for which access and assessment was possible), including one active nest (Carnaby's Black-Cockatoo), 68 highly likely nest-trees and a further 1,148 trees that had potential black-cockatoo nesting hollows but no sign of recent use. Extrapolation of the tree data suggests there are at least another 589 potential nest-trees in two of the areas that could not be directly assessed.

The entire corridor was mapped for foraging suitability for both black-cockatoo species. The quality of potential foraging habitat varies considerably throughout the site (largely dependent on vegetation and substrate associations, and the degree of land clearing) but, overall, the Bindoon Bypass Corridor was moderate foraging habitat for both Forest Red-tailed and Carnaby's Black-Cockatoos. There were 113 foraging observations of Forest Red-tailed Black-Cockatoos throughout the southern two-thirds of the referral area. There were 115 foraging records for Carnaby's Black-Cockatoo, spread across the entire area. The Bindoon Bypass corridor appears to pass across the northern boundary of the Forest Red-tailed Black-Cockatoo's distribution.

Three black-cockatoo roosts were identified in the vicinity of the Bindoon Bypass corridor; all supporting between 10 and 30 Forest Red-tailed Black-Cockatoos. There is the potential for more (presently undetected) roosts within the corridor.

Motion-sensitive camera surveys for mammals

None of the targeted species of mammals was recorded in the motion-sensitive camera surveys. Only three native (non-target) species were detected.

Call-playback surveys for owls

No owls were recorded in the call-playback surveys.

Aquatic surveys

No target species were detected in the aquatic surveys. Two species, the native Western Minnow and the introduced Mosquitofish, were recorded from wetlands and drainage lines in the referral area.

Aural surveys for frogs

Seven species of frog were recorded across the referral area but none of these was a target species.

Short-range endemic invertebrate collection

Several of the millipede specimen collected may represented one or more species that could not be identified, and were considered to be potential SREs. Further investigation may be required to assess these taxa correctly.

Acoustic surveys for bats.

At least four species of bat were recorded but none of these is of conservation significance.

Opportunistic and indirect observations

Four of the target species were detected within the referral area opportunistically, or by indirect evidence: Forest Red-tailed and Carnaby's Black-Cockatoo, Brush Wallaby and Rakali (Water-rat).

Summary

Even if significant fish, frogs, reptiles or mammals are present, impacts can largely be mitigated through route selection to avoid areas of native vegetation wherever possible and particularly to avoid impacts on wetlands. However, avoiding impacts upon some potential black-cockatoo nests trees may not be possible. Thus, native vegetation remnants in an agricultural landscape, and wetlands, could be considered as constraints if not managed appropriately, and are considered below.

In summary, key constraints and other important considerations with respect to fauna are:

- Black-Cockatoo nest-trees or potential nest-trees (rank of 1, 2 or 3). Lower ranking trees are less critical but still have the potential for a concealed hollow or a future hollow.
- Unknown roosting sites (usually groups of locally tall trees, often near water).
- Wetlands (for a range of fauna and because drainage lines provide movement corridors).
- 'Bottlenecks' of native vegetation that link larger patches and where movement of fauna may be concentrated and where the alignment passes through the bottleneck to minimise actual habitat loss.

The locations of all potential black-cockatoo nest-trees, roost sites and foraging assessment mapping have been provided digitally to assist planning and management decisions.

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1 Introduction

1.1 Background

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

During their Level 1 assessment, Bamford Consulting Ecologists (BCE) identified several species of conservation significant fauna for which additional field investigations would likely assist more detailed impact assessment and finer-scale route planning (by helping to determine species' presence and/or distributions within the project area) (Bancroft *et al.* 2017),. These species are listed below (see Appendix 1 and Appendix 2 for explanation of conservation significance, 'CS', codes):

- Freshwater Cobbler ('*Tandanus*' *bostocki*) – CS3
- Western Mud Minnow (*Galaxiella munda*) – CS1
- Nightfish (*Bostockia porosa* var. I *sensu* Morgan *et al.* 2016) – CS3
- Hooting Frog (*Heleioporus barycragus*) – CS3
- Whooping Frog (*Heleioporus inornatus*) – CS3
- Ticking Frog (*Geocrinia leai*) – CS3
- Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*) – CS1
- Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*) – CS1
- Barking Owl (southwestern) (*Ninox connivens connivens*) – CS2
- Mardo (*Antechinus flavipes leucogaster*) – CS3
- Chuditch (*Dasyurus geoffroii*) – CS1
- Brush-tailed Phascogale (*Phascogale tapoatafa wambenger*) – CS1
- Quenda (*Isoodon obesulus fusciventer*) – CS2
- Brushtail Possum (*Trichosurus vulpecula*) – CS3
- Brush Wallaby (*Notamacropus irma*) – CS2
- Rakali or Water-rat (*Hydromys chrysogaster*) – CS2
- Carter's Freshwater Mussel (*Westralunio carteri*) – CS1
- Short-range endemic invertebrates – CS3

BCE was commissioned by Focused Vision Consulting Pty Ltd (FVC), who was in turn commissioned by the Arup Jacobs Joint Venture (ASJV), in association with Main Roads Western Australia, who together are the Integrated Project Team (IPT), to conduct targeted fauna surveys of the proposed Bindoon Bypass corridor for the aforementioned species. The purpose of these assessments was to provide baseline information for the environmental impact assessment of the proposed road. This report presents the findings of those surveys.

1.2 Description of project area

1.2.1 General location

The project 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. Most of the environment is terrestrial with small seasonal swamps and streams. The general environment of the area is described in more detail in Bancroft *et al.* (2017).

Bancroft *et al*. (2017) noted that the Bindoon Bypass corridor runs along the border of two IBRA Bioregions, the Jarrah Forest (JAF) and Swan Coastal Plain (SWA). Both of these bioregions are divided into subregions, with the project area passing through the Northern Jarrah Forest Subregion (JAF1) and the Dandaragan Plateau Subregion (SWA1).

1.2.2 Definition of project boundaries

Several boundaries are relevant to this report, so to ensure consistency of usage, the following terms are defined:

Route options envelope – the boundary of the route that was initially chosen following community consultation and preliminary studies (e.g. in the case of fauna, the impact assessment report of Bancroft *et al*. 2017). This route was chosen from three options and corresponds to the 'common area' (in the south) and the 'Western A' option (in the north), as described by Bancroft *et al*. (2017). Route options envelope = c. 2386 ha.

Bindoon Bypass Corridor area – an amended route, based on the *route options envelope*, and the current basis of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) referral for the project. The *referral area* is the focus of the present report. Corridor area = c. 3405 ha.

Project area – the combined area of the *route options envelope* and the Corridor *area*. Project area = c. 3657 ha.

Survey area – a subset of the *project area* for which landowner permission to access private property was granted (and, hence, on-ground surveys were possible); and also the areas which could be confidently surveyed remotely without direct access (where on-ground access was not permitted/possible). Survey area = 3135 ha.

Study area – a subset of the *referral area*, corresponding to those parts that also fell within the survey area (i.e. could be directly accessed). Study area = c. 3118 ha.

A map of these boundaries is shown in Figure 1.

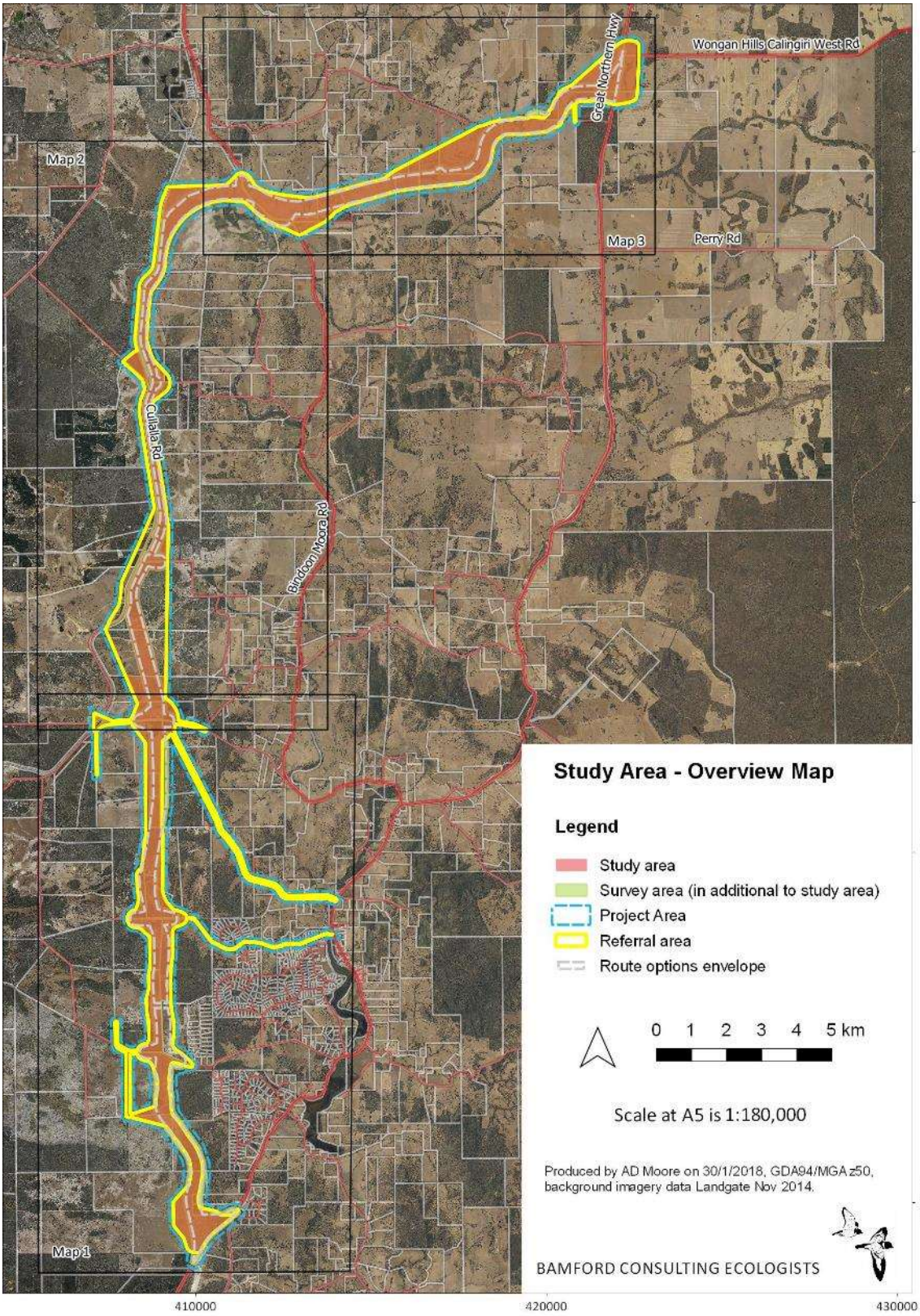

Figure 1. The Bindoon Bypass 'project area' and relevant boundaries (route options envelope, referral area, survey area and study area) for this report.

See Appendix 3 for three finer-scale maps.

2 Methods

2.1 Overview

The target species (as outlined in Section 1.1) were surveyed as follows:

- Black-cockatoo habitat analysis (breeding, foraging and roosting values) for Forest Red-tailed and Carnaby's Black-Cockatoos;
- Motion-sensitive camera surveys for mammals: Mardo, Chuditch, Brush- tailed Phascogale, Quenda, Brushtail Possum, Brush Wallaby and Rakali (Water-rat);
- Call-playback surveys for owls: Barking Owl and, incidentally, Masked Owl (southwestern), *Tyto novaehollandiae novaehollandiae*;
- Aquatic surveys for Freshwater Cobbler, Western Mud Minnow, Nightfish and Carter's Freshwater Mussel;
- Aural surveys for frogs: Hooting Frog, Whooping Frog and Ticking Frog; and
- Short-range endemic invertebrate collection.

In addition, the following was conducted for non-target species:

- Acoustic surveys for bats.

Previous work, documented by Bancroft *et al.* (2017), had determined that the landscape and wetlands were not suitable for migratory waterbirds.

2.2 Personnel

The following personnel were involved in the field surveys:

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

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

2.3 Licences and permits

The field survey was conducted under Department of Biodiversity, Conservation and Attractions (DBCA) Regulation 17 licence SF010998.

2.4 Black-cockatoo habitat analysis

2.4.1 Guidelines

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

2.4.2 Dates of survey

The black-cockatoo habitat surveys were undertaken on the following dates:

- 6th and 7th October 2016
- 12th October 2016
- 18th October 2016
- 9th April 2017
- 7th May 2017
- 17th May 2017
- 31st May 2017
- 31st July 2017 to 4th August 2017
- 4th to 8th September 2017
- 9th to 13th October 2017
- 17th October 2017
- 12th November 2017

2.4.3 Breeding

The aim of the breeding surveys was to record all potential hollow-bearing trees (suitable for black-cockatoo nesting) within the proposed envelope of the Bindoon Bypass. This was initially the *route options envelope* (see
Figure 1) but adjustments to the proposed bypass location subsequently altered the focus of the surveys to the *referral area* (see
Figure 1, which largely incorporated the route options envelope but also included additional areas). Access limitations meant that some parts of the referral area could not be directly surveyed. The *study area* (as indicated in
Figure 1) defines the region (within the referral area) in which direct breeding surveys were possible and is the major focus of this report. Note that the *survey area* (see
Figure 1) is defined as all areas (within the route options envelope and the referral area) in which direct survey access was possible (i.e. it includes surveys outside of the referral area). Tree data from outside of the study area have been excluded from the analysis and discussion here.

Within the survey area, the following information was recorded for every suitable tree [1] (predominantly Jarrah, *Eucalyptus marginata*; Wandoo, *E. wandoo*; Marri, *Corymbia calophylla*) with a diameter at breast height (DBH) equal to or greater than 500 mm (or 300 mm for Wandoo):

- tree location;
- tree species;
- life status;
- DBH; and
- nest-tree rank: trees were assessed (from the ground) for the potential presence/quality of nest-hollows and allocated a nesting rank (developed by BCE) as described in Table 1.

Table 1. Ranking system for the assessment of potential nest-trees for black-cockatoos.

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

Rank	Description of tree and hollows/activity
1	Active nest observed; adult (or immature) bird seen entering or emerging from hollow.
2	Hollow of suitable size and angle (i.e. near-vertical) visible with chew marks around entrance.
3	Potentially suitable hollow visible but no chew marks present; or potentially suitable hollow present (as suggested by structure of tree, such as large, vertical trunk broken off at a height of >10m).
4	Tree with large hollows or broken branches that might contain large hollows but hollows or potential hollows are not vertical or near-vertical; thus a tree with or likely to have hollows of sufficient size but not to have hollows of the angle preferred by black-cockatoos.
5	Tree lacking large hollows or broken branches that might have large hollows; a tree with more or less intact branches and a spreading crown.
x	Where a hollow that is (otherwise) potentially suitable for black-cockatoo nesting has been colonised by feral Honey Bees (*Apis mellifera*), and therefore rendered unusable, the nest-tree rank is preceded by 'x' (e.g. x2, x3, x4).

BCE has also developed a tree measurement protocol, based on Federal guidelines, and this is outlined in Appendix 4.

2.4.3.1 Extrapolation of tree data

On-ground access was not permitted/possible in some parts of the referral area (see Figure 1). Estimation of the number of potential nest-trees in these areas was investigated for two regions on a property along Cullalla Road as shown in Figure 2. These regions were divided into zones of similar 'habitat' type ('estimation zones'), based on the vegetation and substrate mapping of Bancroft *et al*. (2017). The Vegetation and Substrate Association (VSA) mapping was also used to delineate adjacent areas of similar VSA type for which breeding tree surveys (see Section 2.4.3) had been completed. The number of known potential nest-trees in these 'reference' zones was used to calculate potential nest-

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

tree density for each tree species and for each category of nest-tree rank (see Section 2.4.3). These reference densities were then multiplied by the areas of the estimation zones to calculate an expected number of trees.

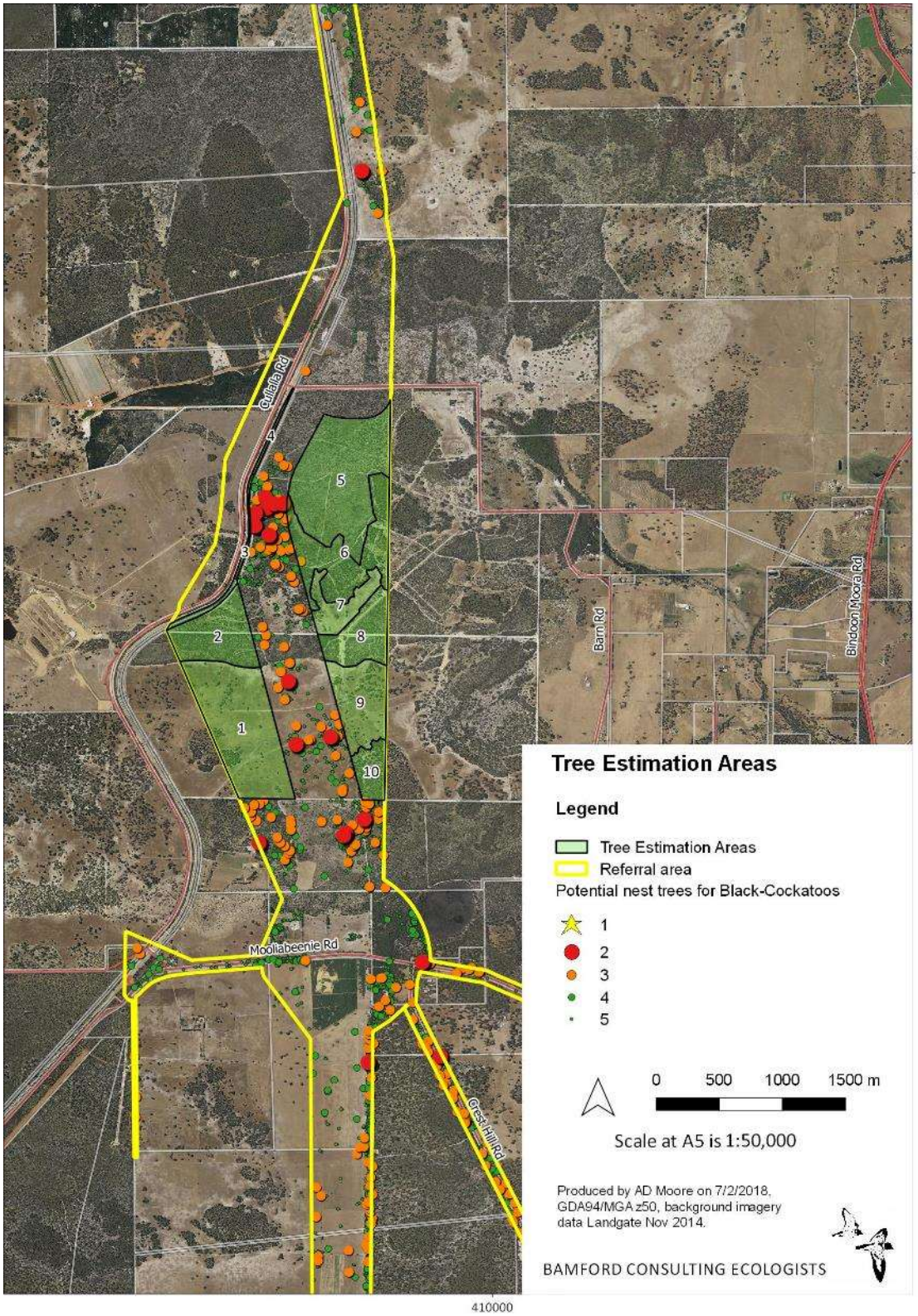

Figure 2. Tree estimation areas. Potential nest trees are assigned a rank as outlined in Section 2.4.3, with 1 being the highest rank.

2.4.4 Foraging

The foraging value of the survey area was assessed by calculating a foraging score for areas of similar vegetation type/condition (see Appendix 5). The foraging score provides a numerical value that reflects the significance of vegetation as foraging habitat for black-cockatoos, and this numerical value is designed to provide the sort of information needed by the Federal DEE to assess impact significance and offset requirements. The foraging value of the vegetation depends upon the type, density and condition of trees and shrubs in an area, and can be influenced by the context such as the availability of foraging habitat nearby. The BCE scoring system for value of foraging habitat has three components as detailed in Appendix 5. These three components are drawn from the DEE offset calculator but with the scoring approach developed by BCE:

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

Foraging value can thus be assigned a score out of six, based upon site vegetation characteristics, or a score out of 10 if context and species density are also considered. A higher score represents better foraging value. In this report, a score out of six is used so that vegetation characteristics and value can be compared across the project area. A score out of 10 is presented for the purposes of aiding offset calculations. The score out of 10 is calculated only for vegetation of at least Low to Moderate foraging value (vegetation characteristics score of >3). Vegetation with No, Negligible or Low foraging value is effectively assigned context and species density scores of '0' as context and species density are of little relevance if the vegetation does not support foraging by the birds. Foraging value scores are calculated differently for the three black-cockatoo species (Appendix 5) depending upon the vegetation present.

Black-cockatoo foraging signs were also recorded in conjunction with the breeding tree surveys (see Section 2.4.3). 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/foliage, the degree of weathering or decay of debris, the presence of small fragments of nut debris, the position/compression of the foraging debris relative to surrounding vegetation and leaf litter, and the strength of the eucalypt smell emitted. Despite the absence of empirical data, four categories of foraging activity were recognised, based on the time since foraging:

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

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

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

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

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

2.4.5 Roosting

As the breeding and foraging surveys were conducted, areas likely to be used as roosting sites (e.g. sites adjacent to watercourses with large trees) or areas that had cockatoo activity in the late-afternoon were noted. These were revisited in the 30 minutes before and after sunset to watch for cockatoos moving towards their roost sites, as recommended by DEE (DotE 2018a, c). Several other locations were added to the roost surveys to ensure an even spread of sites in and around the referral area. Roost survey sites and survey dates are shown in Table 2.

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

Table 2. Roost survey sites and survey dates.

Datum: GDA94. UTM Zone: 50J.

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

2.5 Motion-sensitive camera surveys for mammals

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

Nineteen cameras were placed in, and adjacent to, the project area, in areas that represented the most likely habitats of the target species (denser areas of eucalypt forest; riparian vegetation; creeklines), as listed in Table 3 (Camera01 to Camera19) and mapped in Figure 3. A brief habitat description of each location is also provided in Table 3. Cameras were generally positioned on a southerly-facing angled branch or trunk (to avoid direct sun exposure into the camera lens), facing the ground, and, where appropriate, directed towards fallen logs or rock piles (potential den or exploratory sites for Chuditch). Camera locations were baited with a tethered PVC bait tube containing universal bait (a mixture of sardines, rolled oats and peanut paste) in order to attract animals.

A second round of motion-sensitive camera surveys was conducted in spring to specifically target the Rakali (Water-rat). Cameras were deployed on the 4th September 2017 and retrieved on the 8th September 2017. Eleven cameras (Camera20 to Camera30) were placed along drainage lines in and around the project area as listed in Table 3 and mapped in Figure 3.

Table 3. Motion-sensitive camera survey sites.

Datum: GDA94. UTM Zone: 50J.

Camera	Easting	Northing	Notes
Camera01	421153	6550822	Wandoo Woodland.
Camera02	421098	6550835	Rock pile in Wandoo Woodland.
Camera03	418737	6550920	Paperbarks in drainage line.
Camera04	408991	6543514	Marri Woodland.
Camera05	408612	6542248	Banksia-Marri Woodland.
Camera06	409445	6533941	Paperbark at edge of Lake Nangar.
Camera07	409014	6531788	Log in Jarrah Woodland.
Camera08	409061	6530978	In Jarrah-Marri-Banksia Woodland.
Camera09	408393	6528200	Jarrah Woodland.
Camera10	409117	6528253	Looking into a hollowed-out Jarrah in Jarrah Woodland.
Camera11	409286	6527650	Open Jarrah Woodland.
Camera12	409089	6527184	Under a banksia tree in Banksia Woodland.
Camera13	409019	6524377	Jarrah Woodland at Edge of Banksia Woodland.
Camera14	409683	6523915	Paperbark and rushes/reeds at edge of wetland.
Camera15	409696	6523914	Flooded Gum and *Hypocalymma* at edge of wetland.
Camera16	409359	6522420	Jarrah Woodland - Banksia Woodland transition.
Camera17	409742	6521954	Very open Jarrah Woodland.
Camera18	409614	6521484	On Jarrah in open Jarrah Woodland.
Camera19	410691	6519675	Rock pile in paddock with Wandoo/Marri/Jarrah.
Camera20	410068	6521134	South of Corella Road.
Camera21	410093	6521154	South of Corella Road.

Camera	Easting	Northing	Notes
Camera22	420418	6550893	Hay Flat Road drainage line.
Camera23	420248	6550923	Hay Flat Road drainage line.
Camera24	420982	6550938	Udumung Nature Reserve drainage line.
Camera25	420267	6550940	Hay Flat Road drainage line.
Camera26	419094	6550973	Hay Flat Road drainage line.
Camera27	419984	6550985	Hay Flat Road drainage line.
Camera28	421222	6550989	Udumung Nature Reserve drainage line.
Camera29	419527	6551006	Hay Flat Road drainage line.
Camera30	419899	6551012	Hay Flat Road drainage line.

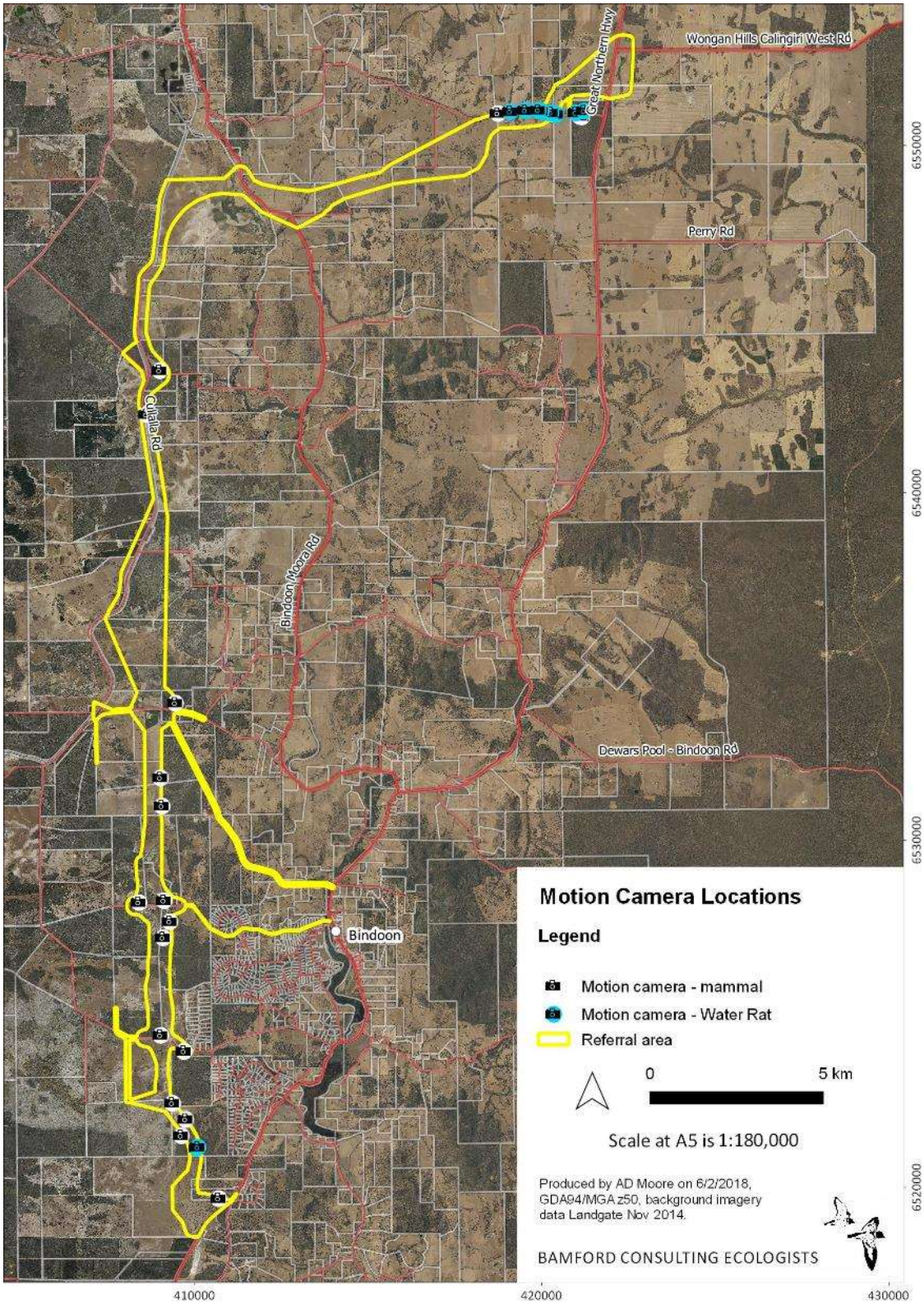

Figure 3. Location of the motion-camera survey sites.

2.6 Call-playback surveys for owls

The call-playback surveys for owls were conducted on the 31st May 2017; timed to coincide with the autumn period in which the two target species (see Section 1.1) are most likely to respond to playback (Liddlelow *et al.* 2002; Parker *et al.* 2007; Fulton 2017).

Fourteen sites were selected in, and adjacent to, the project area to represent the most likely habitats of the target species (denser areas of eucalypt forest), as listed in Table 4 and mapped in Figure 4. Survey protocol was based on that established by authors such as Liddlelow *et al*. (2002), Parker *et al.* (2007) and Fulton (2017). At each site, 5-15 minutes was spent listening for owl calls prior to playback. Pre-recorded calls (from the Bird Observers Club of Australia) of Barking Owl and Masked Owl were intermittently broadcast at loud volume for approximately five minutes, listening for a response in the breaks. Thereafter, surrounding perch points (e.g. trees, fencelines) were scanned with a spotlight to look for owls. As per Debus (1995) and Fulton (2017), calls were played back in the order of smallest (Barking Owl) to largest owl (Masked Owl) to avoid frightening off smaller owls with calls from the larger owls.

Table 4. Owl call-playback survey sites.

Datum: GDA94. UTM Zone: 50J.

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

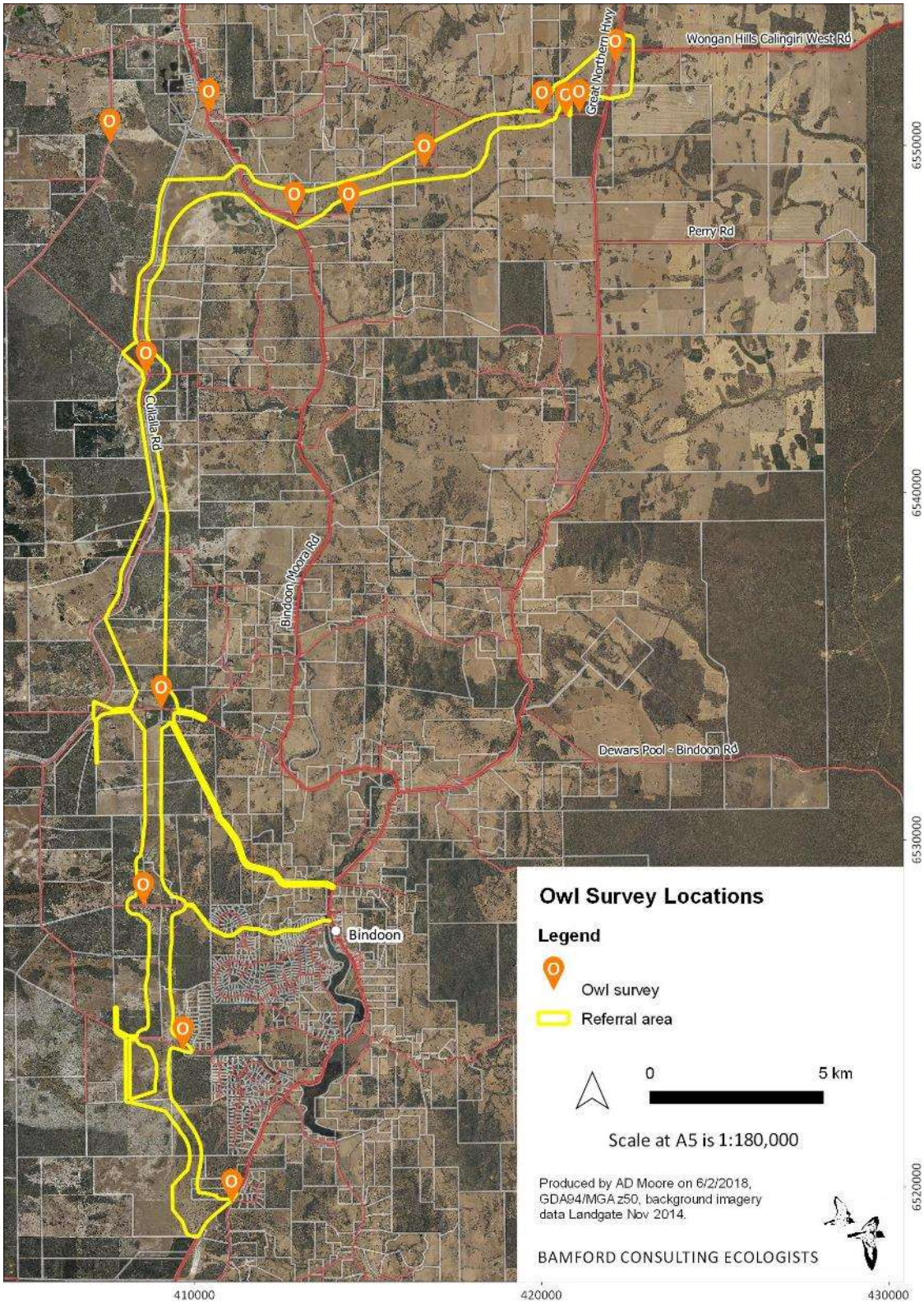

Figure 4. Location of owl call-playback survey sites.

2.7 Aquatic surveys

The aquatic surveys focused on the main wetland areas in the vicinity of the referral area, as shown in Figure 5 (these wetland areas are indicative only). Surveys were by observation, as most native freshwater fish are conspicuous (except Freshwater Cobbler and Nightfish which are cryptic and tend to be most active at night), and Carter's Freshwater Mussel can be found either through dead shells, distinctive trails in soft sediment or live animals. Observational surveys were conducted at the Teatree Road wetland (7th July and 3rd October 2017) and Hay Flat drainage line (9th (observations, netting and trapping) and 13th October 2017).

Netting and deployment of a fish trap (baited, funnel-entrance trap) were carried out at the Teatree Road wetland (3rd October 2017, see Figure 5) to target the Freshwater Cobbler and Nightfish, and to target other freshwater fish as the deeply gilvin-stained water at this site limited visibility.

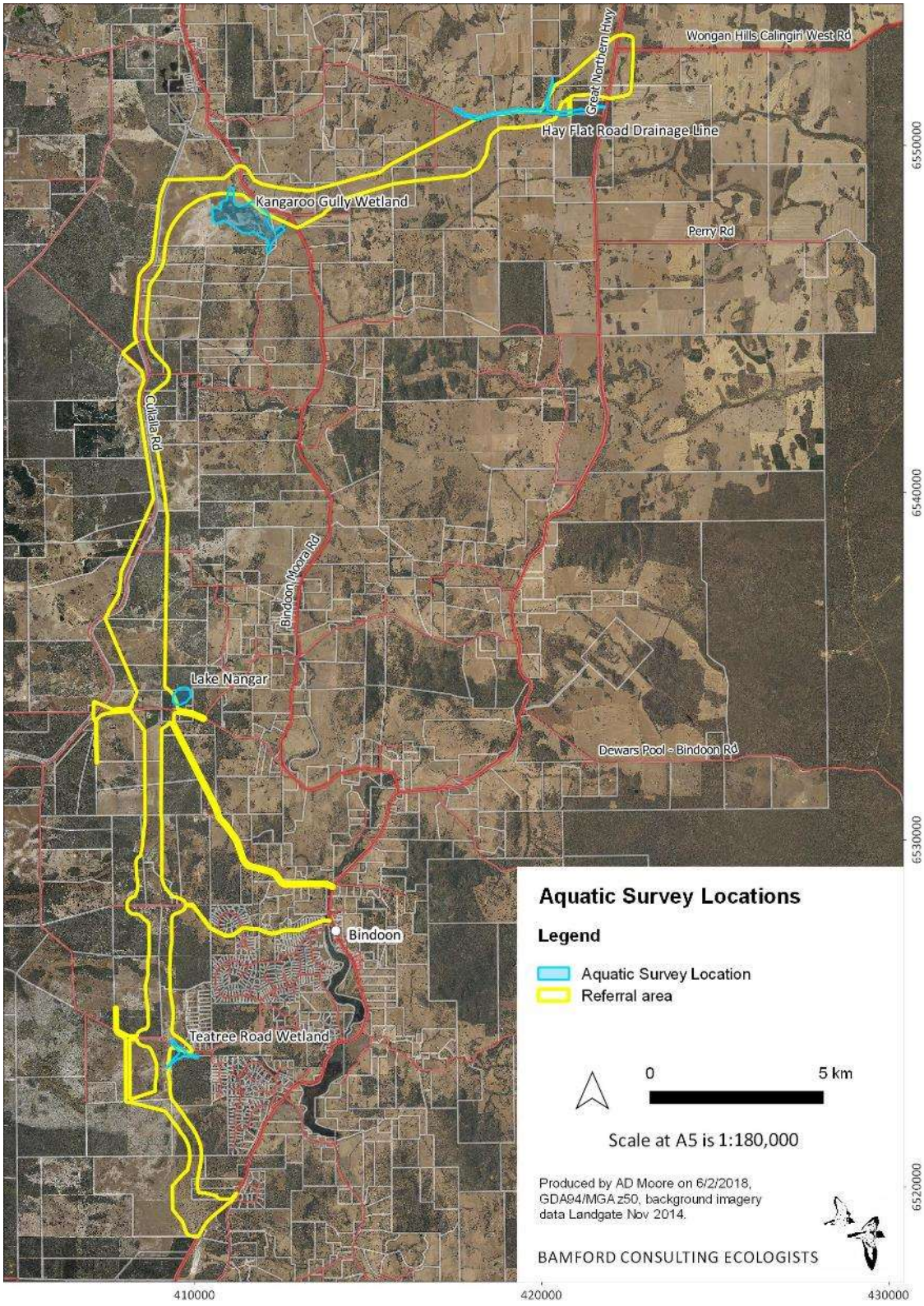

Figure 5. Location of the focus areas for the aquatic surveys.

2.8 Aural surveys for frogs

Aural surveys for frogs were conducted on the 31st May 2017; timed to coincide with the late autumn period in which all three of the target species (see Section 1.1) breed (and, hence, call) concurrently. It also falls within the period in which the majority of other frog species in the region can be detected aurally.

Twenty-three sites were selected in, and adjacent to, the project area to represent the favoured breeding habitats of the target species (flowing creeks and low-lying, seasonally inundated areas, in particular), as listed in Table 5 and mapped in Figure 6. Sites were visited after sunset for long enough to identify all calling species within earshot, and to determine whether the target species were present (usually c. 5-15 minutes).

Table 5. Frog aural survey sites.

Datum: GDA94. UTM Zone: 50J.

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

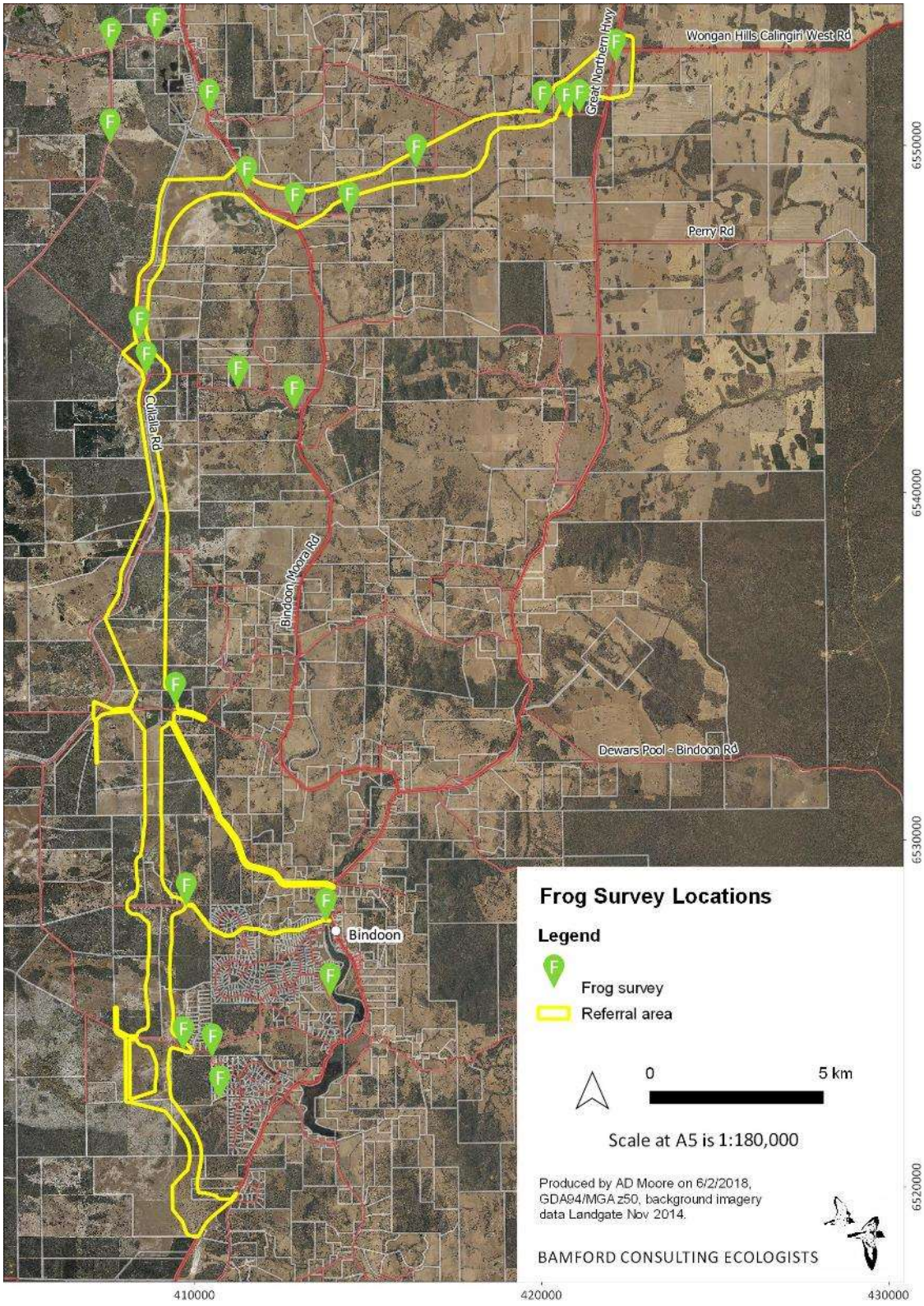

Figure 6. Locations of frog aural survey sites.

2.9 Short-range endemic invertebrate collection

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

2.10 Acoustic surveys for bats

In conjunction with other surveys conducted at the time, an Anabat SD1 (Titley Electronics) ultrasonic detector was deployed at two locations within the project area as listed in Table 6 and mapped in Figure 7. A brief habitat description of each location and the survey dates are also provided in Table 6.

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

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

Table 6. Bat survey sites.

Datum: GDA94. UTM Zone: 50J.

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

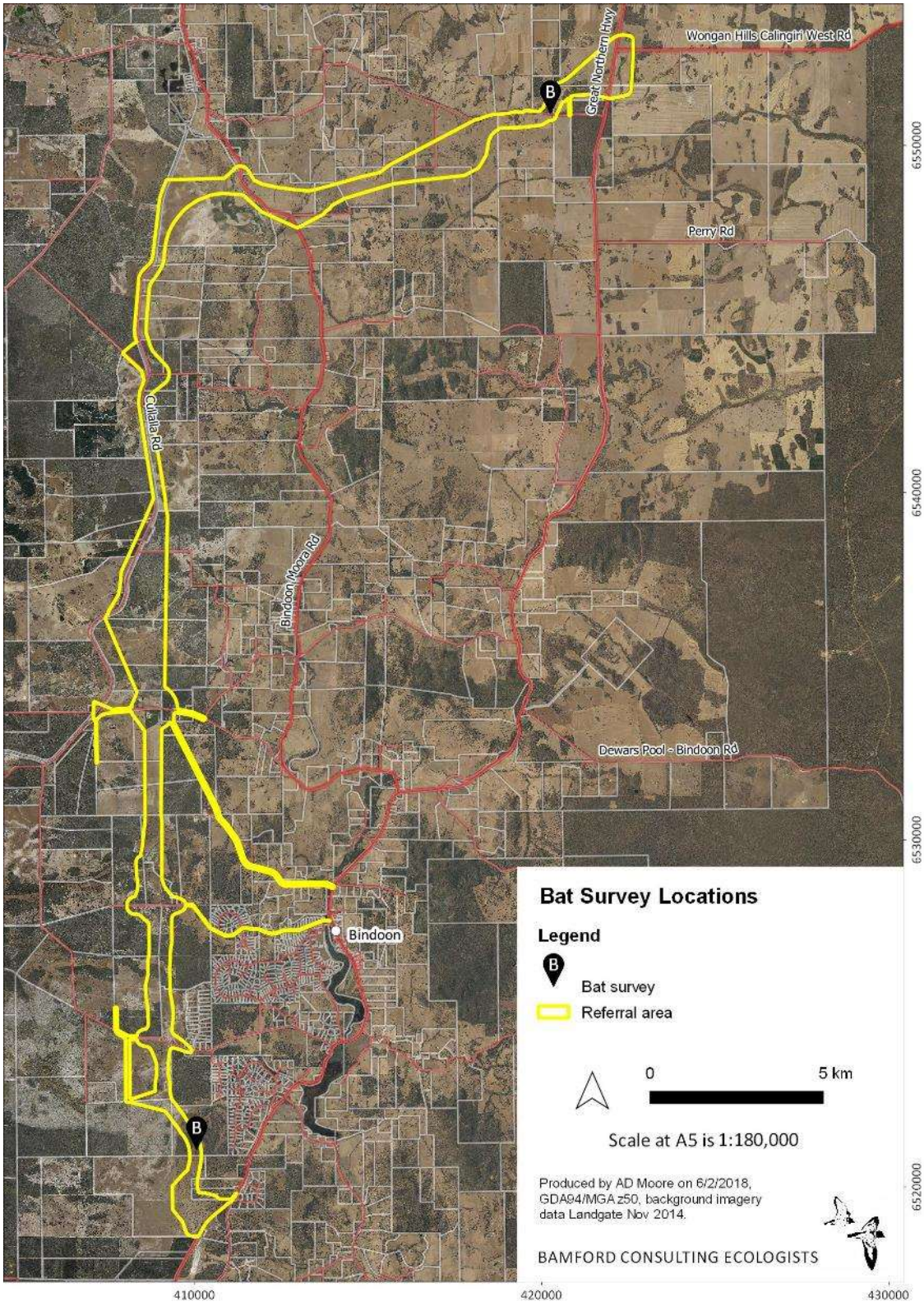

Figure 7. Location of the bat survey sites.

2.11 Opportunistic and indirect observations

Observations of fauna were noted when they contributed to the accumulation of information on the significant fauna of the referral area. These included casual observations such as animals seen while conducting other surveys or travelling through/near the referral area.

Some of the target species can be detected 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); and
- Rakali or Water-rat (foraging middens, tracks, scats).

2.12 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 their first instance.

3 Results and Discussion

3.1 Black-cockatoo habitat analysis

3.1.1 Breeding

3.1.1.1 Overview

A total of 11,554 'potential nest-trees' that met the hollow-bearing criteria of DEE (2018a, c) and DEE (2017) was recorded from the 3,118 ha study area (within the referral area, see Figure 1). These comprised at least sixteen species, as shown in Table 7. Three species accounted for almost 97% of trees: Marri, Jarrah and Wandoo (c. 45%, 27% and 25% of all potential nest-trees, respectively, as shown in Table 8). In addition, a further 1,190 trees were recorded outside of the Bindoon Bypass corridor area. The assessment data (species, life status, DBH and nest-tree rank) for all trees are provided in Addendum A. Note that, hereafter, the analysis and discussion refer only to those trees recorded within the accessible parts of the Corridor area (*the study area*).

Table 7. Species and number of potential black-cockatoo nest-trees recorded within the study area.

Tree Species		Number of Trees
Banksia littoralis	Swamp Banksia	3
Corymbia calophylla	Marri	5172
Corymbia citriodora	Lemon Scented Gum	12
Corymbia maculata	Spotted Gum	1
Eucalyptus camaldulensis	River Red Gum	6
Eucalyptus globulus	Tasmanian Blue Gum	2
Eucalyptus gomphocephala	Tuart	1
Eucalyptus loxophleba	York Gum	1
Eucalyptus marginata	Jarrah	3082
Eucalyptus rudis	Flooded Gum	109
Eucalyptus todtiana	Coastal Blackbutt	161
Eucalyptus wandoo	Wandoo	2922
Eucalyptus sp.	Unidentified eucalypt	35
Melaleuca preissiana/rhaphiophylla	Stout/Swamp Paperbark	20
Nuytsia floribunda	Christmas Tree	8
Pinus sp.	Pine species	19
TOTAL		11 554

For the study area, the numbers of potential nest-trees of each species recorded in each ranking category are shown in Table 8, and the locations of these trees are mapped in Figure 8. The majority

(c. 75%) of potential nest-trees surveyed in the study did not have hollow entrances suited to black-cockatoos that were observable from ground level. One active nest was located (Carnaby's Black-Cockatoo) and 68 trees (c 0.6% of all potential nest-trees, see Table 8) had evidence of hollow-entrance chewing by black-cockatoos and, therefore, are highly likely to be used for breeding. A further 1,148 trees (c. 9.9%, see Table 8) had potential black-cockatoo nesting hollows (but no sign of recent use).

The potentially black-cockatoo-suitable hollows in 30 trees (0.26% of all potential nest-trees) had been colonised by feral Honey Bees and, thus, rendered the trees unusable for breeding at the time of the survey. The number of these trees in each species in each ranking category are presented in Table 8.

The DBH profile of the potential nest-trees within the study area is presented in Figure 9. While almost 40% of the trees that were measured had a DBH between 500 and 650 mm, this probably reflects a typical profile in the remnant woodlands of the area (i.e. given considerable clearing, logging and intensive land use).

Of the 11,554 potential nest-trees, 10,836 (93.8%) were live trees.

Table 8. The number of potential nest-trees of each species in each nest-tree rank category in the study area.

See Section 2.4.3 for full explanation of tree categories. Parentheses indicate the number of trees in that category that were unsuitable for use because of bee hives.
† 'Other' tree species: *Banksia littoralis*, *Corymbia citriodora*, *C. maculata*, *Eucalyptus camaldulensis*, *E. globulus*, *E. gomphocephala*, *E. loxophleba*, *Eucalyptus* sp., *Melaleuca preissiana/rhaphiophylla*, *Nuytsia floribunda* and *Pinus* sp.

Category		Number of Trees						TOTAL	Percentage (of Grand Total)
		Marri	Jarrah	Wandoo	Coastal Blackbutt	Flooded Gum	Other†		
1	Active nest.	1	-	-	-	-	-	1	0.01
2	Potential hollow with chew-marks.	43 (1)	15	10	-	-	-	68 (1)	0.59
3	Potential hollow, no chew marks.	472 (9)	406	240 (6)	23	4	3	1148 (15)	9.94
4	Potential hollow, unsuitable orientation.	670 (5)	553 (4)	350 (5)	44	12	11	1640 (14)	14.19
5	Sufficient DBH, no observable hollows.	3986	2108	2322	94	93	94	8697	75.27
	TOTAL:	5172 (15)	3082 (4)	2922 (11)	161	109	108	**11 554** (30)	100.00
	Percentage (of Grand Total)	44.76	26.67	25.29	1.39	0.94	0.93	100.00	

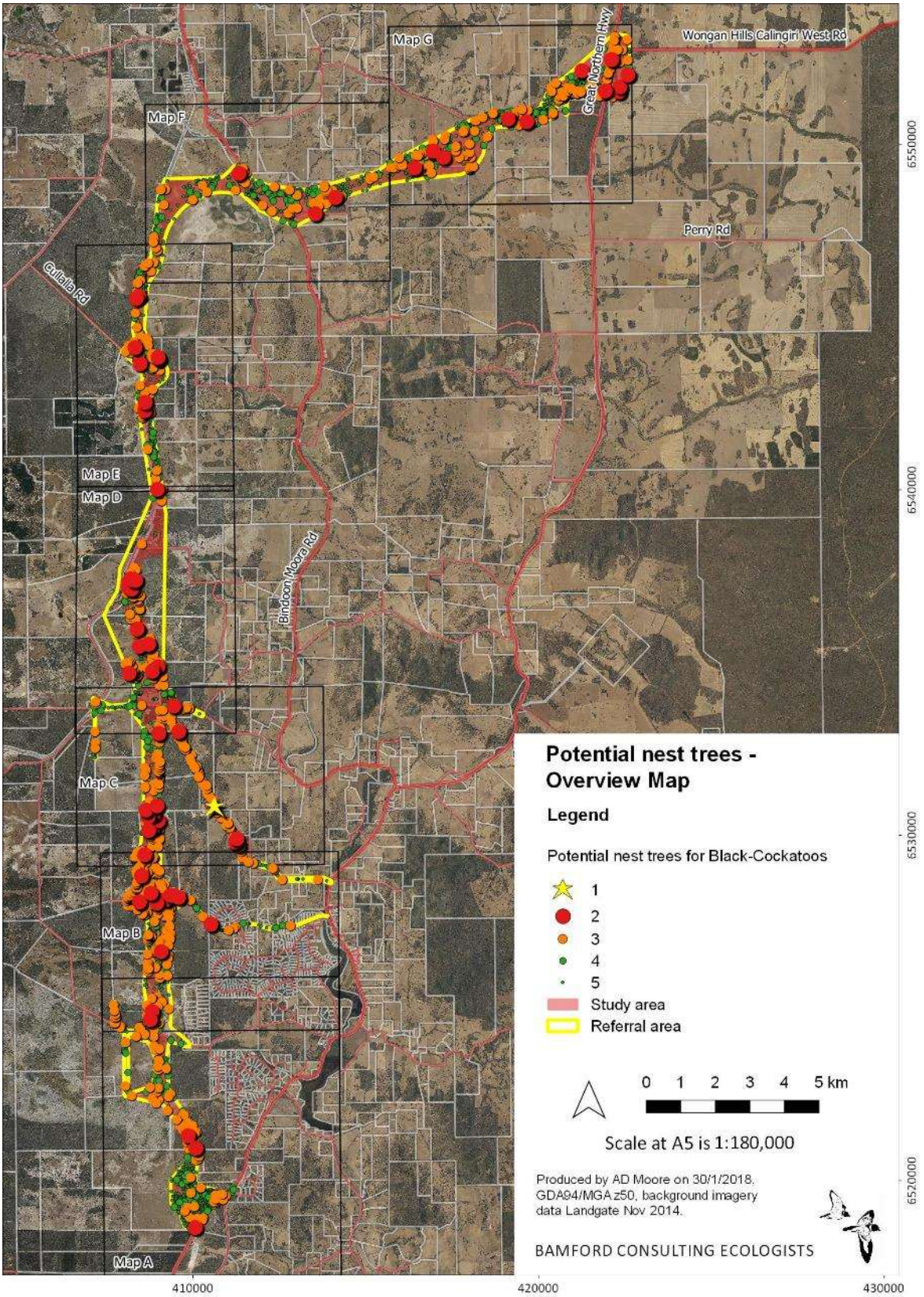

Figure 8. Location of potential nest-trees within the study area, as classified according to nest-tree rank.

See Appendix 7 for seven finer-scale maps.

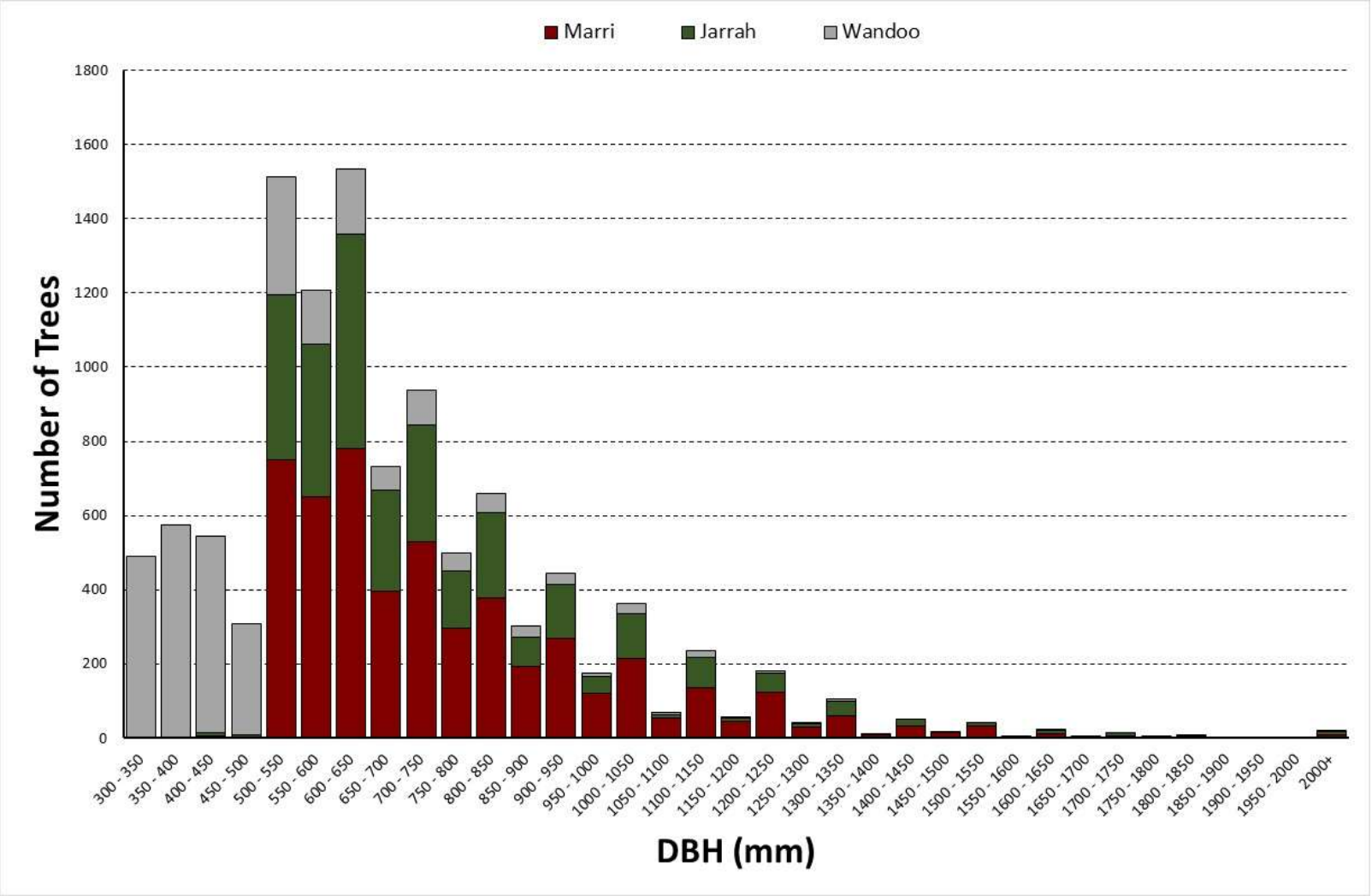

Figure 9. DBH profile of the potential black-cockatoo nest-trees within the study area.

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

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

A summary of the trees that are highly likely to be nesting sites for black-cockatoos (nest-tree rank category 2) is presented in Table 9. These are trees that had evidence of chewing by black-cockatoos around the hollow entrance but which birds were not observed within the nest itself. The majority of these trees were Marri (c 63%), with the remainder Jarrah or Wandoo (see Table 9). This is a disproportionately higher representation of Marri than was observed in the general profile of potential nest-trees (c. 45% of all trees; Section 3.1.1.1 and Table 8), a similar proportion of Jarrah and a lower proportion of Wandoo.

The DBH profile of the highly likely nest-trees within the study area is presented in Figure 10. It is clear when this is compared with the general DBH profile of potential nest-trees (Figure 9) that there is a very strong preference for larger (more mature) trees. More than 70% of the highly likely nest-trees were greater than 800 mm DBH (c. 25% of all 'potential' trees).

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

Table 9. The number of trees of each species, and their life status, that were assessed as highly likely to be black-cockatoo nest sites (nest-tree rank category 2: evidence of black-cockatoo chew marks around the hollow entrance).

Percentages (of the grand total) are given in parentheses.
† one of the dead Marri trees had a hollow that had been colonised by feral Honey Bees.

Tree Species	Live	Dead	TOTAL
Marri	38 (55.9%)	5 (7.4%)†	43 (63.2%)
Jarrah	13 (19.1%)	2 (2.9%)	15 (22.1%)
Wandoo	6 (8.8%)	4 (5.9%)	10 (14.7%)
TOTAL	57 (83.8%)	11 (16.2%)	**68** (100%)

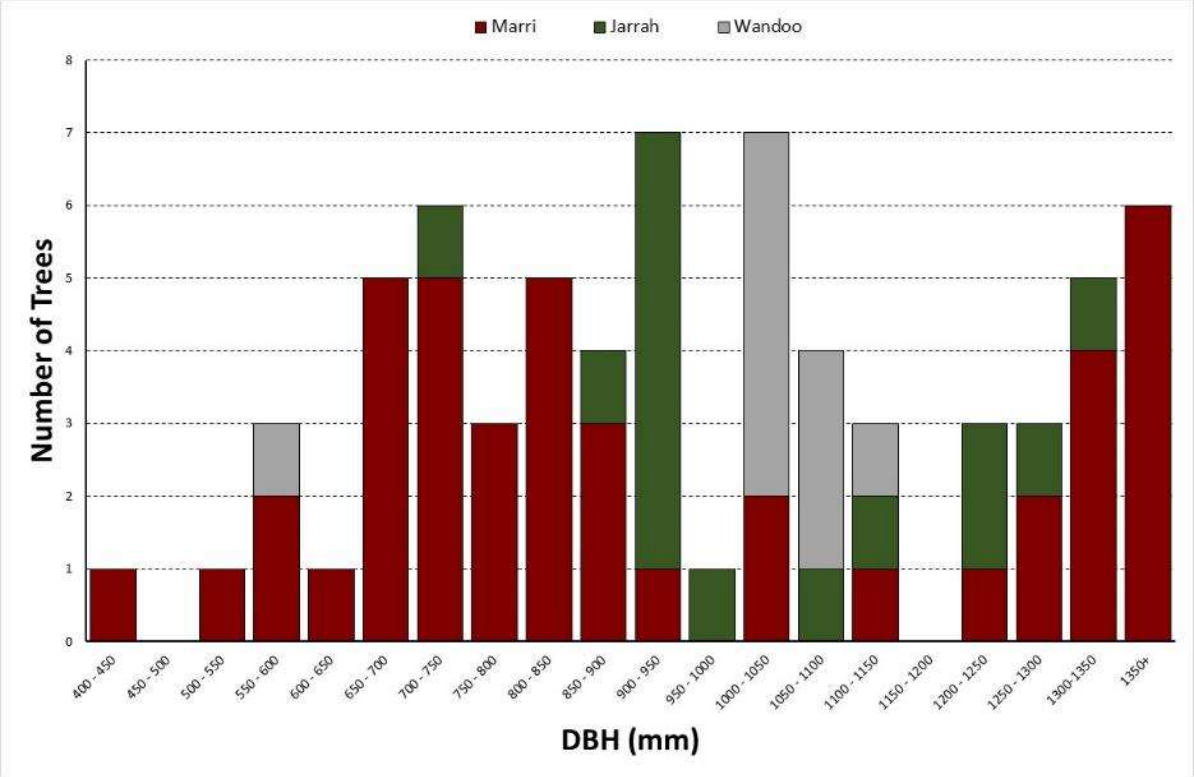

Figure 10. DBH profile of the highly likely (nest-tree rank category 2) black-cockatoo nest-trees within the study area.

3.1.1.3 Extrapolation of tree data

Extrapolation of the potential nest-tree data was trialled at two locations: a property along Cullalla Road and a property along Cook Road, as indicated in Figure 2. The Cullalla Road property was divided into ten estimation zones based on VSAs, and the Cook Road property a single zone (a uniform VSA type). Four reference zones were established for the Cullalla Road property and one for the Cook Road property, and the number of potential nest-trees in each (for each nest-tree rank category) is indicated in Table 10.

The number of estimated potential nest trees for each estimation zone is presented in Table 11 (zones 1 to 10 at Cullalla Road, zone 11 at Cook Road). It is expected that a further c. 546 potential nest-trees will occur in the Cullalla Road property (including 102 trees of nest-tree rank category 3 or better), and a further c. 43 trees in the Cook Road property (including five trees of nest-tree rank category 3 or better).

This extrapolation technique could be applied to other areas of restricted access should it be required.

Table 10. The number of potential nest-trees in each reference zone.

Reference Zone	Area (ha)	Tree Species	Nest-tree Rank Category				
			1	2	3	4	5
Cullalla01	57.44	Marri	-	3	17	12	118
		Jarrah	-	-	-	-	2
Cullalla02	11.24	Marri	-	-	3	1	8
Cullalla03	48.87	Marri	-	5	29	21	65
		Jarrah	-	2	14	21	44
		Coastal Blackbutt	-	-	1	3	2
Cullalla04	4.01	Marri	-	1	1	1	14
		Jarrah	-	-	5	3	7
Cook01	13.51	Marri	-	2	11	27	81
		Wandoo	-		5	5	30

Table 11. The estimated number of potential nest-trees in each estimation zone.

† Banksia Woodland VSA with no potential nest-trees.

Zone	Area (ha)	Tree Species	Nest-tree Rank Category					TOTAL
			1	2	3	4	5	
1	57.44	Marri	0	3	17	12	118	150
		Jarrah	0	0	0	0	2	2
2	26.91	Marri	0	0	7	2	19	28
3	3.83	Marri	0	0	2	2	5	9
		Jarrah	0	0	1	2	3	6
		Coastal Blackbutt	0	0	0	0	0	0
4†	1.35	-	-	-	-	-	-	0
5†	63.41	-	-	-	-	-	-	0
6	35.9	Marri	0	4	21	15	48	88
		Jarrah	0	1	10	15	32	58
		Coastal Blackbutt	0	0	1	2	1	4
7	13.22	Marri	0	1	4	3	27	35
		Jarrah	0	0	0	0	0	0
8	20.14	Marri	0	0	5	2	14	21
9	25.91	Marri	0	1	8	5	53	67
		Jarrah	0	0	0	0	1	1
10	9.99	Marri	0	2	2	2	35	41
		Jarrah	0	0	12	7	17	36
CULLALLA TOTAL			**0**	**12**	**90**	**69**	**375**	**546**
11	3.61	Marri	0	1	3	7	22	33
		Wandoo	0	0	1	1	8	10
COOK TOTAL			**0**	**1**	**4**	**8**	**30**	**43**

3.1.2 Foraging

3.1.2.1 Forest Red-tailed Black-Cockatoo

Foraging habitat for Forest Red-tailed Black-Cockatoo was present throughout the referral area. This is due to the occurrence of Marri and Jarrah, known to be mainstays of the Forest Red-tailed Black-Cockatoo diet (Johnstone and Kirkby 1999). These trees were present in variable densities (from absent to high) across the referral area. A map of vegetation scores of the referral area for Forest Red-tailed Black-Cockatoo foraging is presented in Figure 11. The areas (and percentages) of each vegetation score are shown in Table 12.

There are approximately 93 004 ha of remnant native vegetation within 15 km of the referral area, which itself has c. 933 ha of native vegetation (see Figure 12). Therefore, the site comprises c. 1% of the native vegetation in the 'local area' (as per the methods outlined in Section 2.4.4). It is almost certain that the Forest Red-tailed Black-Cockatoo breeds within the Corridor area, and as part of this study, active nests were found outside this area. Thus, a 'context' score of 2 (out of 3) has been assigned to the referral area (see Section 2.4.4 and Appendix 5). The referral area was assigned a species density score for Forest Red-tailed Black-Cockatoo of 1 (out of 1). These values have been added on to the vegetation scores to yield the overall foraging value scores (with areas and percentages) that are also presented in Table 12.

There was considerable evidence of foraging by Forest Red-tailed Black-Cockatoos throughout the southern two-thirds of the Corridor area. A summary of the 113 foraging observations made during the nest-tree surveys is presented in Table 13 (see Appendix 9 for individual records) and mapped in Figure 13. The Corridor area is, generally, moderate foraging habitat for Forest Red-tailed Black-Cockatoos and there was strong evidence to show that this species presently (and previously) uses the site for feeding.

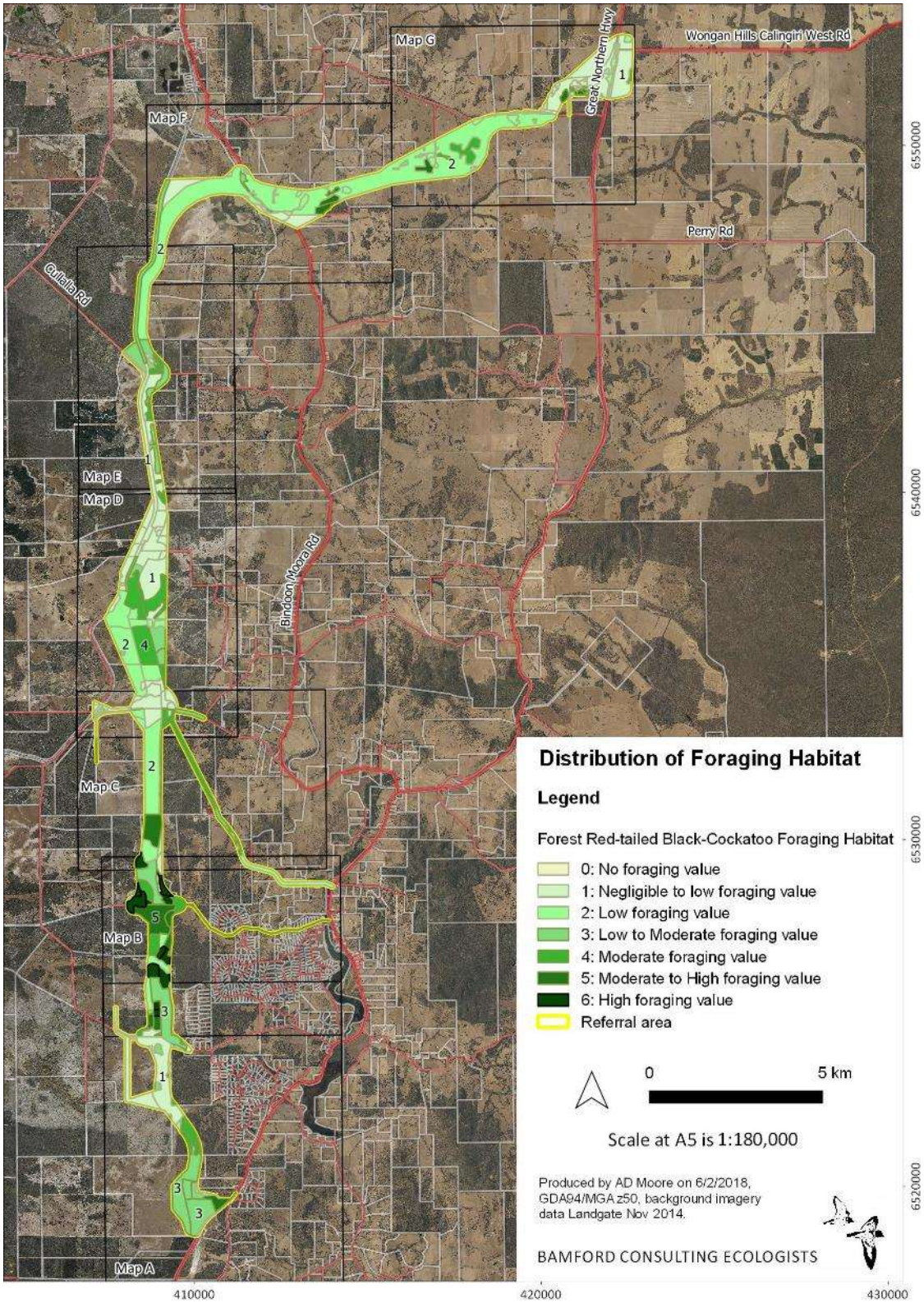

Figure 11. Distribution of Forest Red-tailed Black-Cockatoo foraging habitat within the referral area.

See Appendix 8 for seven finer scale maps.

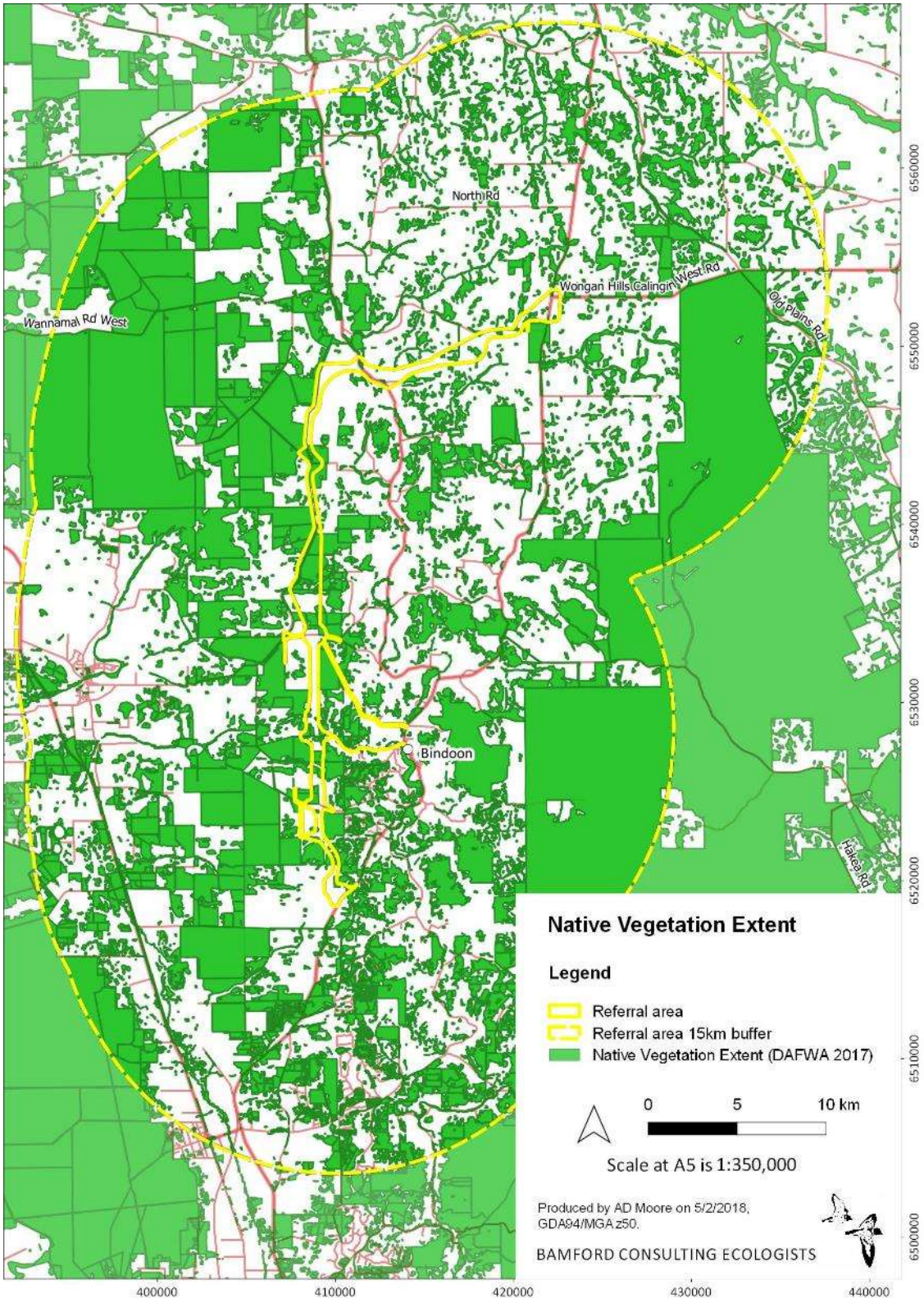

Figure 12. Native vegetation extent in the vicinity of the referral area.

The area of native vegetation within a 15 km radius is 93,004 ha.

Table 12. Areas (ha) and proportions (%) of each category (vegetation score, combined foraging score) of foraging habitat at the referral area for the three black-cockatoo species present in south-western Australia.

See Section 0 and Appendix 5 for explanation of vegetation, context, species density and (combined) foraging scores.

	Forest Red-tailed Black-Cockatoo		Carnaby's Black-Cockatoo		Baudin's Black-Cockatoo	
Vegetation Score/Value	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**
6: High	105.9	3.1	230.1	6.8	-	-
5: Moderate to High	205.5	6.0	412.4	12.1	-	-
4: Moderate	359.3	10.6	662.6	19.5	-	-
3: Low to Moderate	520.9	15.3	270.3	7.9	-	-
2: Low	1,238.5	36.4	1,178.2	34.6	-	-
1: Negligible	975.5	28.6	651.8	19.1	-	-
0: Nil	0	0.0	0	0.0	-	-
TOTAL	3,405.5	100.0	3,405.5	100.0	-	-
Context Score	2		2		-	
Species Density Score	1		1		-	
Foraging Score						
10	0	0.0	0	0.0	-	-
9	105.9	3.1	230.1	6.8	-	-
8	205.5	6.0	412.4	12.1	-	-
7	359.3	10.6	662.6	19.5	-	-
6	520.9	15.3	270.3	7.9	-	-
NA (Vegetation Score < 3)	2,213.9	65.0	1,830.0	53.7	-	-
TOTAL	3,405.5	100.0	3,405.5	100.0	-	-

Table 13. The number of Forest Red-tailed Black-Cockatoo foraging records for each feed species (and age group) made within the referral area.

See Appendix 9 for a list of feed species scientific names.

Feed Species	Most Recent Age of Feed Sign				
	Active	Recent	Intermediate	Old	TOTAL
Jarrah	-	5	5	3	13
Marri	3	29	52	16	100
TOTAL	3	34	57	19	113

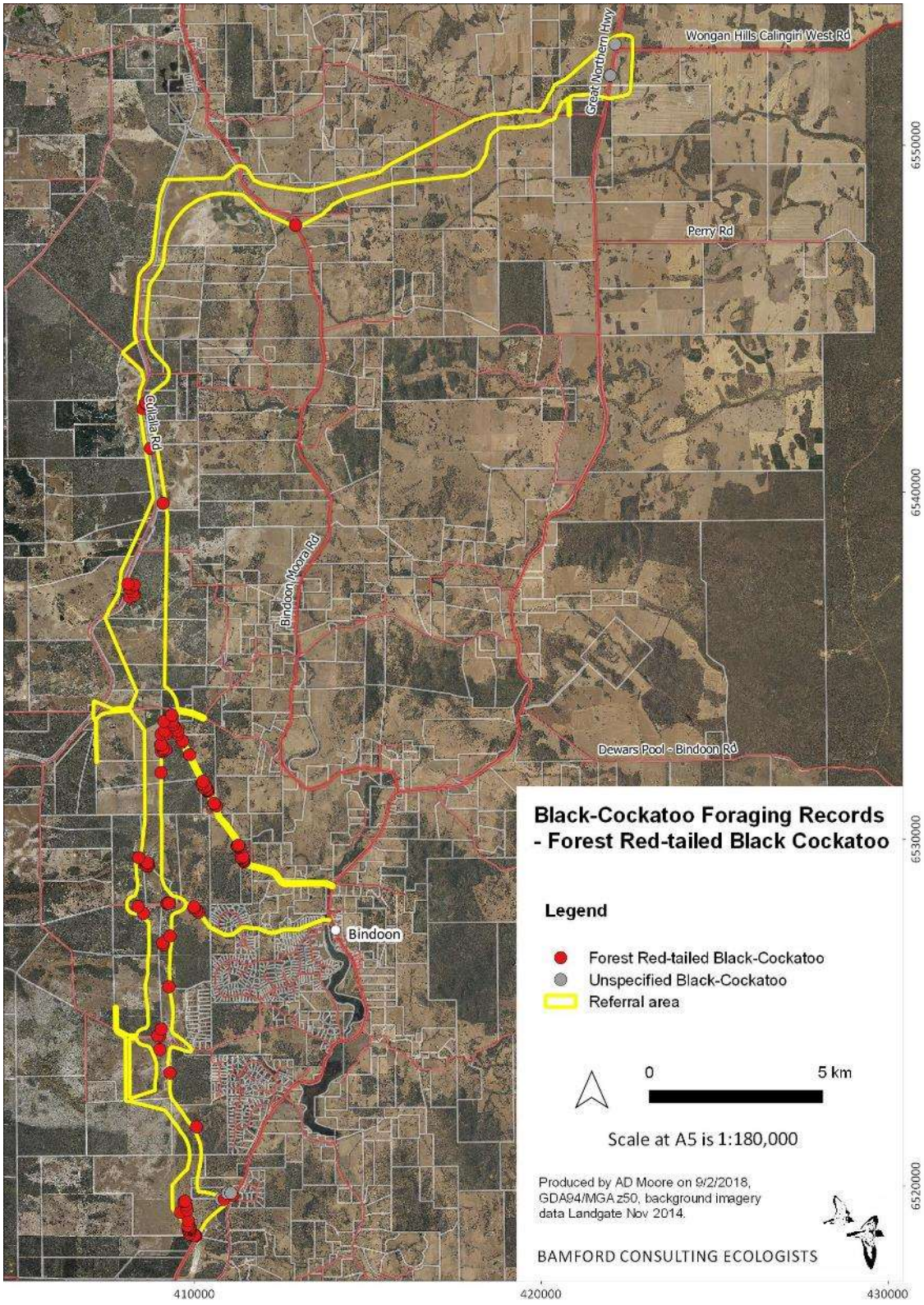

Figure 13. Distribution of Forest Red-tailed Black-Cockatoo foraging records within the referral area.

3.1.2.2 Carnaby's Black-Cockatoo

Foraging habitat for Carnaby's Black-Cockatoo was present throughout the referral area. This is predominantly due to the presence of several plant species known to be mainstays of the Carnaby's Black-Cockatoo diet including *Banksia attenuata*, *B. menziesii*, *B. sessilis* and Marri (Groom 2011). These trees were present in variable densities across the referral area. A map of vegetation scores of the referral area for Carnaby's Black-Cockatoo foraging is presented in Figure 14. The areas (and percentages) of each vegetation score are shown in Table 12.

There are approximately 93,004 ha of remnant native vegetation within 15 km of the referral area, which itself has c. 933 ha of native vegetation (see Figure 12). Therefore, the site comprises c. 1% of the native vegetation in the 'local area' (as per the methods outlined in Section 2.4.4). It is known that Carnaby's Black-Cockatoo breeds within the referral area as evidenced by the active nest recorded during the surveys. Thus, a 'context' score of 2 (out of 3) has been assigned to the referral area (see Section 2.4.4 and Appendix 5). The referral area was assigned a species density score for Carnaby's Black-Cockatoo of 1 (out of 1). These values have been added on to the vegetation scores to yield the overall foraging value scores (with areas and percentages) that are also presented in Table 12.

There was considerable evidence of foraging by Carnaby's Black-Cockatoos throughout the referral area. A summary of the 115 foraging observations made during the nest-tree surveys is presented in Table 14 (see Appendix 9 for individual records) and the observations are mapped in Figure 15. These comprised c. 66% Marri and c. 19% *Banksia* species and included most ages of evidence (recent, intermediate and old), suggesting a history of foraging activity at the site.

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

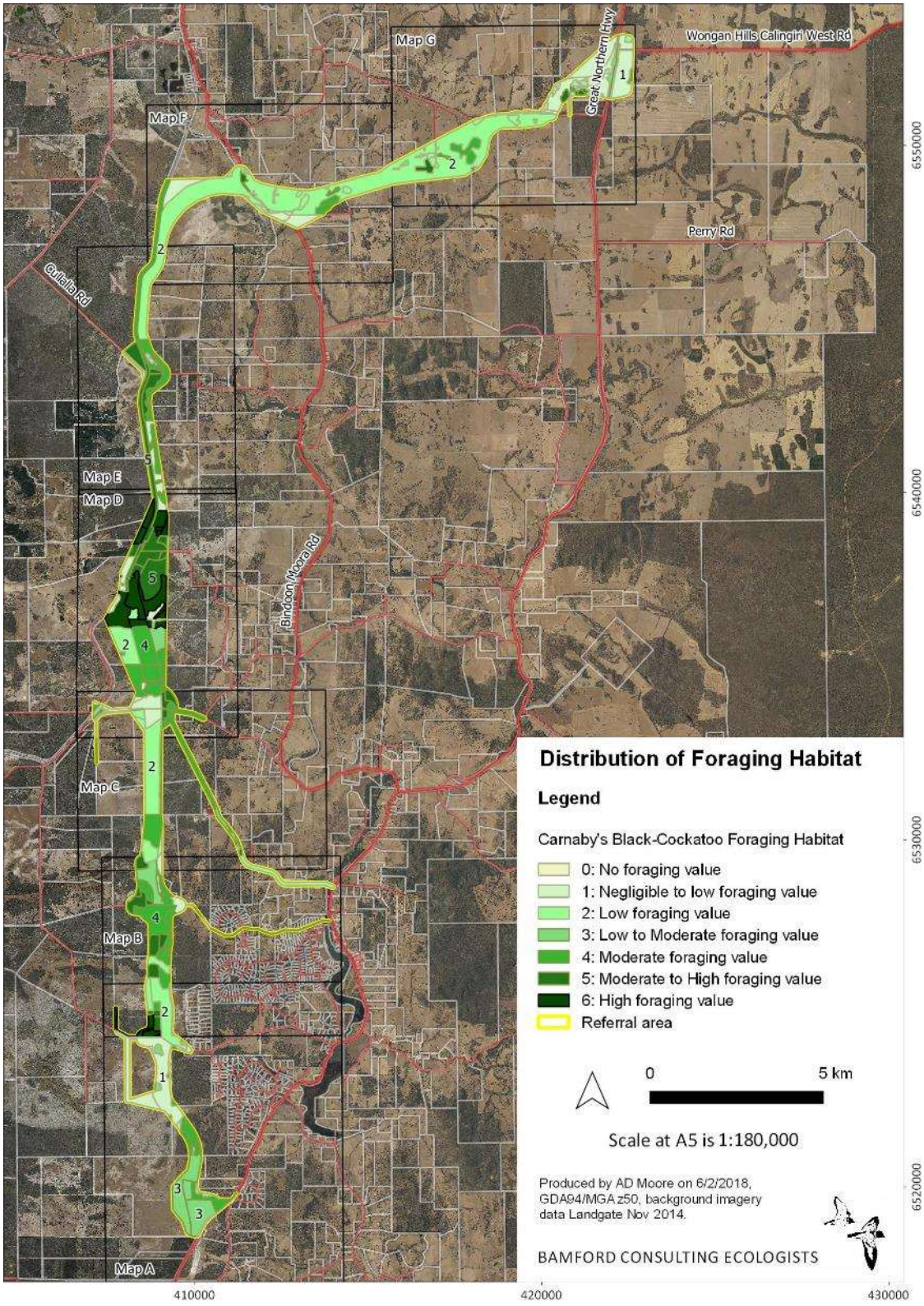

Figure 14. Distribution of Carnaby's Black-Cockatoo foraging habitat within the referral area.

See Appendix 10 for seven finer scale maps.

Table 14. The number of Carnaby's Black-Cockatoo foraging records for each feed species (and age group) made within the referral area.

See Appendix 9 for a list of feed species scientific names.

Feed Species	Most Recent Age of Feed Sign				
	Active	Recent	Intermediate	Old	TOTAL
Candlestick Banksia	-	1	4	9	14
Coastal Blackbutt	-	1	-	-	1
Firewood Banksia	-	-	-	1	1
Jarrah	-	4	2	-	6
Marri	-	15	50	11	76
Parrot Bush	-	1	-	-	1
Unspecified banksia	-	-	6	-	6
Unspecified	-	8	2	-	10
TOTAL	0	30	64	21	115

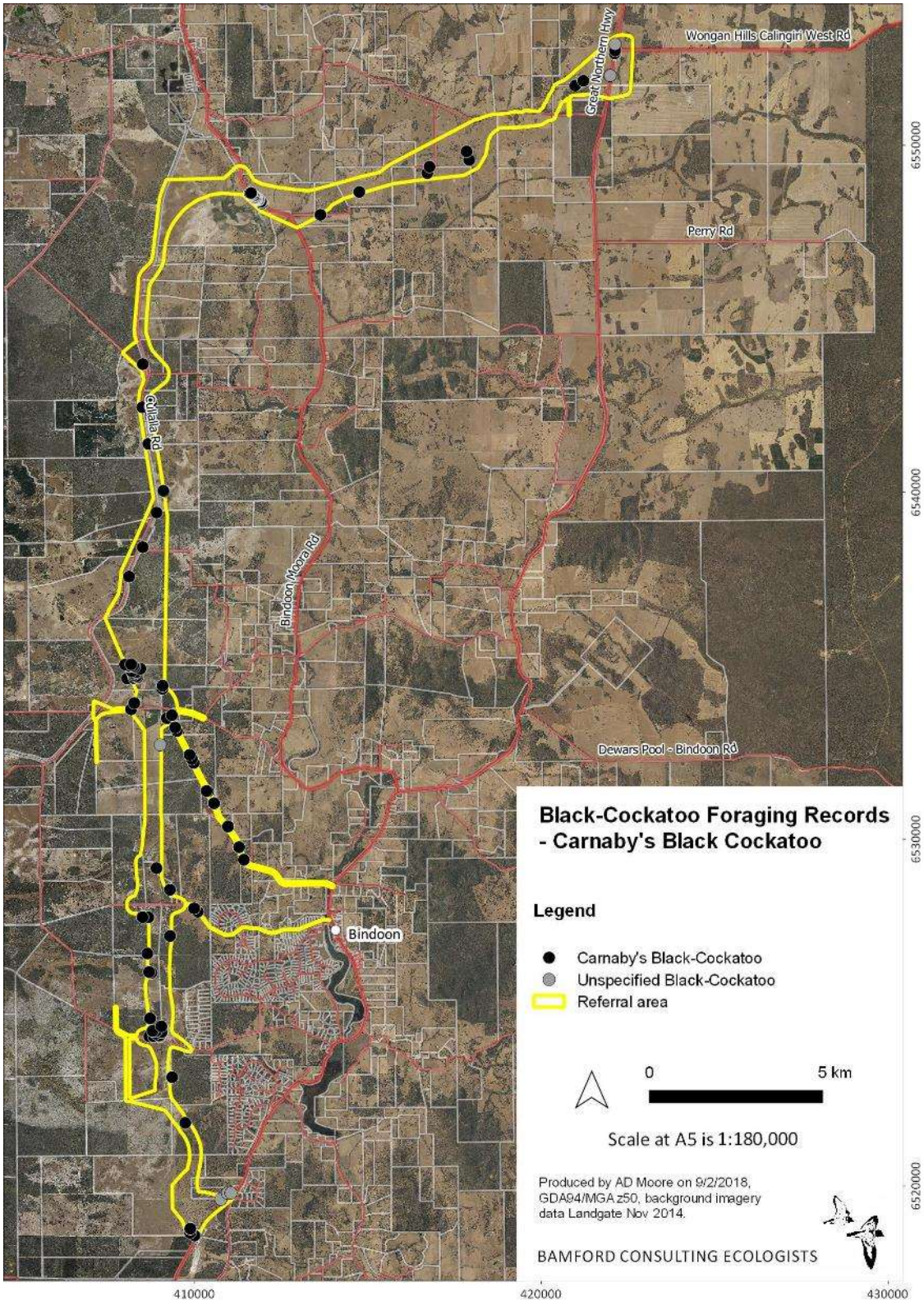

Figure 15. Distribution of Carnaby's Black-Cockatoo foraging records within the referral area.

3.1.3 Roosting

The locations of the black-cockatoo roost survey sites are mapped in Figure 16. The surveys identified three black-cockatoo roost sites, all of Forest Red-tailed Black-Cockatoos, in the vicinity of the referral area, as listed in Table 15. These roosts are mapped in Figure 16, along with previously known (or likely) roost locations from the Great Cocky Count database (Peck *et al.* 2016).

Table 15. Black-cockatoo roost sites located during the roosting surveys.

Datum: GDA94. UTM Zone: 50J.

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

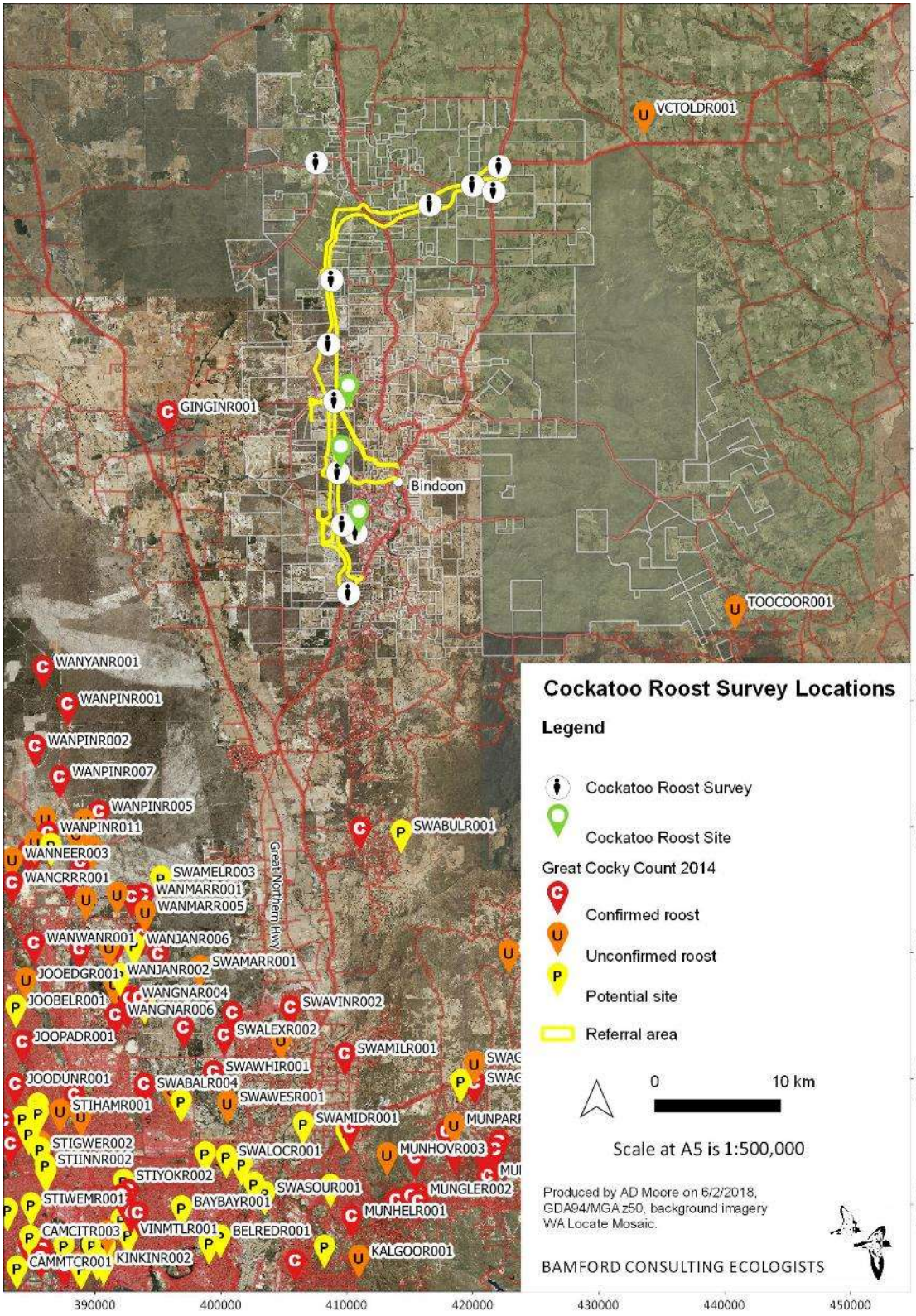

Figure 16. Black-cockatoo roost survey sites, black-cockatoo roosts (this project; green symbols) and previously known black-cockatoo roost locations in the vicinity of the referral area (Great Cocky Count data; red, yellow and orange symbols).

3.2 Motion-sensitive camera surveys for mammals

None of the targeted species of mammals was recorded in the motion-sensitive camera surveys. Notably, intensive sampling of the drainage line along Hay Flat Road and into Udumung Nature Reserve (see Figure 3) failed to detect Rakali (Water-rat); although some evidence of this species was observed (as outlined in Section 3.8). Eight species of fauna were recorded from the cameras, as summarised in Table 16. Only three of these were native species (Splendid Fairy-wren, Echidna and Western Grey Kangaroo).

Table 16. Species recorded in the motion-sensitive camera surveys.

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

3.3 Call-playback surveys for owls

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

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

3.4 Aquatic surveys

The only native freshwater fish recorded was the Western Minnow (*Galaxia occidentalis*) in the Hay Flat drainage line. It was coexisting with the introduced Mosquitofish (*Gambusia holbrooki*), which was also present in the Teatree Road wetland and Lake Chittering. There was no evidence of Carter's Freshwater Mussel.

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

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

The native freshwater fish present in the project area are the Western Minnow (widespread), Western Pygmy-perch (limited distribution in south), Nightfish (widespread but patchy), Freshwater Cobbler, Western Hardyhead (widespread) and Swan River Goby (widespread). Carter's Freshwater Mussel may be extinct in the project area. Of these, the Nightfish and Freshwater Cobbler are considered of CS3 (ie locally significant), while Carter's Freshwater Mussel is of CS1 (listed under legislation).

3.5 Aural surveys for frogs

Seven species of frog were recorded across 21 of the 23 survey sites, as shown in Table 17. The three target species (Hooting Frog, Whooping Frog and Ticking Frog) were not recorded. These species were all listed as conservation significance level CS3 by Bancroft *et al*. (2017) because, if present, would be at the extremity of their range. The results of the aural frog surveys suggest that they may not be present within the project area. The nearest record of the Hooting Frog is from about 5 km north-east (and therefore east of the existing Great Northern Highway) of the Bindoon town site in 2011 (BCE database).

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

Table 17. Frog species recorded at each frog survey site.

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

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

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

3.6 Short-range endemic invertebrate collection

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

Gingilling Road, Bindoon

31°13'28.08"E; 116°02'17.52"E.

Antichiropus variabilis (widespread and not an SRE)

Antichiropus sp. (unidentified and possible SRE).

Gray Road, Bindoon

31°22'48.66"E; 116°02'19.32"E.

Antichiropus sp. (unidentified and possible SRE).

Egret Place, Chittering

31°26'34.22"E; 116°03'47.77"E.

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

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

3.7 Acoustic surveys for bats

At least four species of bat were recorded in the acoustic surveys, as indicated in Table 18. None of these species is of conservation significance (Bancroft *et al.* 2017). The only conservation significant bat species to occur in the Northern Jarrah Forest and Dandaragan Plateau biosubregions (see Section 1.2.1) is the Western False Pipistrelle (*Falsistrellus mackenziei*). This species was not listed as expected in the vicinity of the project area by Bancroft *et al*. (2017) because its known range is south of the Swan River (ALA 2018), and it was not detected in the acoustic surveys here. It almost certainly does not occur in the referral area.

Table 18. The number of call sequences of each bat species recorded at each bat survey site.

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

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

3.8 Opportunistic and indirect observations

Four of the target species were detected within the referral area opportunistically, or by indirect evidence: Forest Red-tailed and Carnaby's Black-Cockatoo, Brush Wallaby and Water-rat. The details of these records are presented in Table 19 and they are mapped in Figure 17.

The Forest Red-tailed Black-Cockatoo was observed in the southern half of the referral area, with birds not seen north of Mooliabeenee Road (see Figure 17). This largely supports the foraging observations (see Section 3.1.2.1) for this species. Thus it seems that the referral area crosses over the northern boundary of this species' distribution on the Swan Coastal Plan, with the boundary somewhere between Mooliabeenee Road (observations of birds) and Cook Road (foraging records).

Carnaby's Black-Cockatoo was observed throughout the referral area (see Figure 17), mostly in association with large eucalypts (especially Marri and Wandoo) or water sources (e.g. in the vicinity of the Teatree Road wetland). Curiously, few records of this species (either direct observations or foraging evidence, see Section 3.1.2.2) were made in Banksia Woodland within the referral area (usually a major food source for this species).

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

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

Table 19. Opportunistic and indirect observations of target species.

Datum: GDA94. UTM Zone: 50J.

Species	Date	Easting	Northing	Count	Notes
Brush Wallaby	10/10/2017	408892	6524645	1	Seen in Jarrah-Marri Woodland north of Teatree Road.
Brush Wallaby	17/10/2017	408501	6534576	1	Seen in Banksia Woodland, north of Mooliabeenee Road (west of Lake Nangar).
Carnaby's Black-Cockatoo	1/08/2017	410269	6518867	2	
Carnaby's Black-Cockatoo	4/09/2017	409125	6523297	5	
Carnaby's Black-Cockatoo	5/09/2017	409336	6523834	5	Flying west.
Carnaby's Black-Cockatoo	10/10/2017	410291	6523905	4	
Carnaby's Black-Cockatoo	4/09/2017	408596	6524149	2	
Carnaby's Black-Cockatoo	11/10/2017	409222	6524198	1	
Carnaby's Black-Cockatoo	4/08/2017	414343	6524211	1	
Carnaby's Black-Cockatoo	11/10/2017	408947	6524302		
Carnaby's Black-Cockatoo	7/09/2017	408257	6524305	3	Pair plus juvenile, feeding on *Banksia menziesii*.
Carnaby's Black-Cockatoo	10/10/2017	412240	6524535	6	Flying north.
Carnaby's Black-Cockatoo	11/10/2017	410887	6527231	1	
Carnaby's Black-Cockatoo	11/10/2017	410664	6527351	2	Flying west.
Carnaby's Black-Cockatoo	11/10/2017	410615	6527366	3	Flying east.
Carnaby's Black-Cockatoo	11/10/2017	411378	6527448	1	Flying north.
Carnaby's Black-Cockatoo	4/09/2017	409033	6528131	10	
Carnaby's Black-Cockatoo	4/09/2017	408719	6528369	4	Flying south.
Carnaby's Black-Cockatoo	5/09/2017	408423	6528593	6	Flying north.

Species	Date	Easting	Northing	Count	Notes
Carnaby's Black-Cockatoo	4/09/2017	408705	6529237	2	Flying west.
Carnaby's Black-Cockatoo	4/09/2017	408768	6529260	5	Flying west.
Carnaby's Black-Cockatoo	4/09/2017	408661	6529297	10	Flying west.
Carnaby's Black-Cockatoo	11/10/2017	408881	6529350	8	
Carnaby's Black-Cockatoo	10/10/2017	410619	6530814	1	Male inspecting nest hollow in Marri.
Carnaby's Black-Cockatoo	10/10/2017	410619	6530814	2	Inspecting tree hollow.
Carnaby's Black-Cockatoo	10/10/2017	410569	6531013	2	Inspecting tree hollows to east.
Carnaby's Black-Cockatoo	12/10/2017	410553	6531019	2	
Carnaby's Black-Cockatoo	10/10/2017	410488	6531080	1	
Carnaby's Black-Cockatoo	10/10/2017	410427	6531201	2	Feeding on Marri.
Carnaby's Black-Cockatoo	10/10/2017	410396	6531297	13	Flying south.
Carnaby's Black-Cockatoo	10/10/2017	410375	6531342	1	
Carnaby's Black-Cockatoo	10/10/2017	410375	6531342	2	Entering nest hollow 500m away.
Carnaby's Black-Cockatoo	10/10/2017	410375	6531342	3	To east.
Carnaby's Black-Cockatoo	10/10/2017	410363	6531368	2	
Carnaby's Black-Cockatoo	10/10/2017	410367	6531375	1	To east.
Carnaby's Black-Cockatoo	9/10/2017	410370	6531378	2	Pair mating in Dead Marri.
Carnaby's Black-Cockatoo	9/10/2017	410274	6531476	2	Flying east.
Carnaby's Black-Cockatoo	12/10/2017	410200	6531679	1	
Carnaby's Black-Cockatoo	12/10/2017	409964	6532310	1	Flying north.
Carnaby's Black-Cockatoo	3/08/2017	409005	6532542	6	
Carnaby's Black-Cockatoo	12/10/2017	409816	6532546	3	Flying north-west.
Carnaby's Black-Cockatoo	6/09/2017	409093	6532747	2	Chewing on hollow entrance.
Carnaby's Black-Cockatoo	17/10/2017	407656	6534312		
Carnaby's Black-Cockatoo	17/10/2017	408838	6534470	2	One parent and one young.
Carnaby's Black-Cockatoo	17/10/2017	408210	6534605	2	
Carnaby's Black-Cockatoo	17/10/2017	408083	6534900	2	
Carnaby's Black-Cockatoo	17/10/2017	408263	6534924	3	Flying east.
Carnaby's Black-Cockatoo	9/10/2017	413642	6548066	3	Feeding on the ground to east.
Carnaby's Black-Cockatoo	8/09/2017	412765	6548082	2	
Carnaby's Black-Cockatoo	9/10/2017	413723	6548228	2	
Carnaby's Black-Cockatoo	6/09/2017	411809	6548761	3	Flying north.
Carnaby's Black-Cockatoo	3/08/2017	411184	6548864	2	Flying west.
Carnaby's Black-Cockatoo	7/09/2017	417975	6549249	2	Flying west.
Carnaby's Black-Cockatoo	6/09/2017	416641	6549454	2	Flying to north-east.
Carnaby's Black-Cockatoo	10/10/2017	417556	6549970		
Carnaby's Black-Cockatoo	9/10/2017	417796	6550795	9	Flying west.

Species	Date	Easting	Northing	Count	Notes
Carnaby's Black-Cockatoo	8/09/2017	421922	6551377	2	Flying east.
Carnaby's Black-Cockatoo	7/09/2017	421534	6551523	2	Flying east.
Carnaby's Black-Cockatoo	7/09/2017	421424	6551536	3	Flying south.
Carnaby's Black-Cockatoo	7/09/2017	421363	6551615	3	Flying south.
Carnaby's Black-Cockatoo	7/09/2017	421270	6551650	6	
Carnaby's Black-Cockatoo	6/09/2017	421133	6551766	2	Flying to dam.
Carnaby's Black-Cockatoo	6/09/2017	421184	6551882	4	
Carnaby's Black-Cockatoo	10/10/2017	415155	6551926	2	Flying north.
Carnaby's Black-Cockatoo	9/10/2017	422203	6553123	1	
Forest Red-tailed Black-Cockatoo	11/10/2017	409728	6518830	5	
Forest Red-tailed Black-Cockatoo	31/07/2017	411042	6519674	3	
Forest Red-tailed Black-Cockatoo	5/09/2017	409270	6523208		
Forest Red-tailed Black-Cockatoo	7/09/2017	410348	6523904	2	
Forest Red-tailed Black-Cockatoo	4/09/2017	408961	6523988	3	
Forest Red-tailed Black-Cockatoo	7/09/2017	413247	6524425	6	Feeding on Marri.
Forest Red-tailed Black-Cockatoo	12/10/2017	408656	6527778		
Forest Red-tailed Black-Cockatoo	12/10/2017	408447	6527969	2	Pair in probable nest tree.
Forest Red-tailed Black-Cockatoo	12/10/2017	407884	6528113		
Forest Red-tailed Black-Cockatoo	4/09/2017	409157	6528126	1	
Forest Red-tailed Black-Cockatoo	11/10/2017	409292	6528132	3	
Forest Red-tailed Black-Cockatoo	5/09/2017	408390	6529571	2	Female in hollow. Male nearby.
Forest Red-tailed Black-Cockatoo	2/08/2017	408743	6529731	3	
Forest Red-tailed Black-Cockatoo	11/10/2017	409054	6529929		Feeding.
Forest Red-tailed Black-Cockatoo	11/10/2017	409097	6529961	3	Two adults and one juvenile.
Forest Red-tailed Black-Cockatoo	10/10/2017	410614	6531002	2	
Forest Red-tailed Black-Cockatoo	10/10/2017	410436	6531283	2	Feeding on Marri.
Forest Red-tailed Black-Cockatoo	5/09/2017	410193	6531690	3	
Forest Red-tailed Black-Cockatoo	12/10/2017	409594	6532804	2	Flying east.
Unidentified black-cockatoo	10/10/2017	417058	6549762		Potential roost site in Marri tree; lots of fresh droppings on ground.
Unidentified black-cockatoo	10/10/2017	408704	6526054		Potential roost site in Marri tree; lots of fresh droppings on ground.
Rakali (Water-rat)	8/09/2017	420278	6550935		Possible foraging signs (freshwater crayfish remains) or scats.

Species	Date	Easting	Northing	Count	Notes
Rakali (Water-rat)	8/09/2017	420982	6550938		Possible foraging signs (freshwater crayfish remains) or scats.
Rakali (Water-rat)	8/09/2017	420264	6550939		Possible foraging signs (freshwater crayfish remains) or scats.
Rakali (Water-rat)	8/09/2017	421077	6550982		Possible foraging signs (freshwater crayfish remains) or scats.
Rakali (Water-rat)	8/09/2017	421071	6550989		Possible foraging signs (freshwater crayfish remains) or scats.

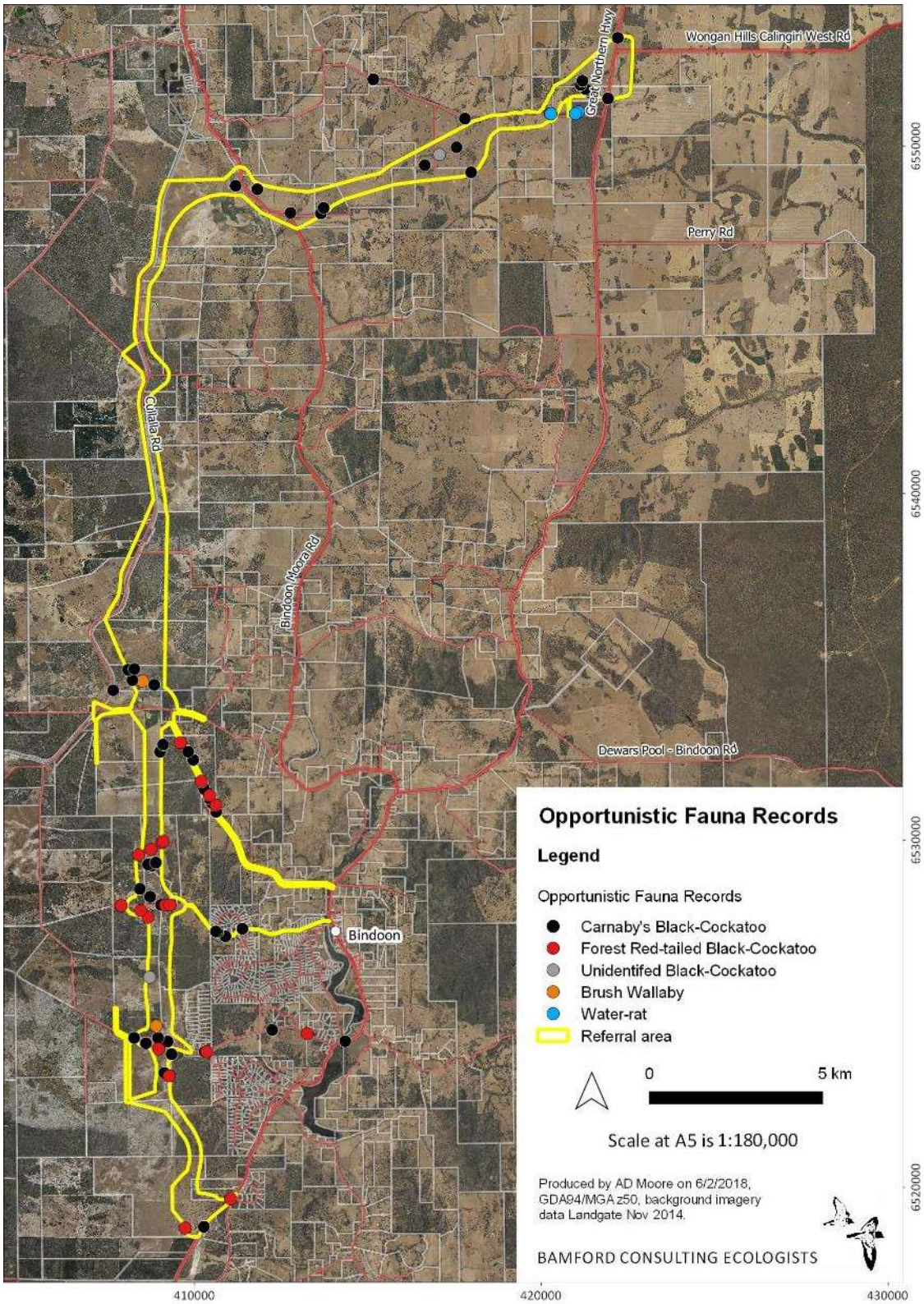

Figure 17. Opportunistic and indirect conservation significant fauna records in the referral area.

4 Synthesis

Following the desktop assessment by Bancroft *et al*. (2017) and the targeted fauna surveys reported here, the following conclusions have been made about conservation significant fauna within the proposed Bindoon Bypass referral area:

Significant fish

Two CS3 (locally significant species) recorded in the Brockman River Catchment by Beatty *et al.* (2010): the Nighfish and the Freshwater Cobbler. Other significant freshwater fish in the region appear to be confined to small parts of the Ellen Brook catchment to the south-west. Beatty *et al.* (2010) note that the Brockman River is partly affected by salinization but remains an important freshwater refuge in the region.

Significant frogs

None found. A population of Hooting Frogs (CS3) that was previously recorded by BCE in a creek approximately 3 km north of Bindoon represents the northernmost record for this species. Given that, in the region, it is generally associated with the Darling Scarp (Tyler and Doughty 2009; Bush *et al.* 2010), it is probably absent the referral area (which, predominately, extends much further to the west). Similarly, the Whooping Frog (CS3) and Ticking Frog (CS3) have distributions that probably end south of the referral area (Tyler and Doughty 2009; ALA 2018).

Significant reptiles

None found. Carpet Pythons (not targeted by the surveys reported here) are regularly reported by residents in the area, but have recently been removed from the priority list.

Significant birds

Most of the conservation significant birds listed by Bancroft *et al*. (2017) cannot be considered a key constraint. The two significant owl species (Barking Owl, CS2; Masked Owl, probably locally extinct) known from the biosubregions in which the referral area is located ((see Section 1.2.1) were not detected and are probably not present. If present, the only locations of concern would be very large trees used for roosting and breeding.

Migratory birds and waterbirds are not a constraint due to limited suitable habitat.

Black-cockatoos are a key constraint because the project passes through a region where both the Forest Red-tailed and Carnaby's Black-Cockatoo (both CS1) forage, roost and breed. The project will impact small areas of foraging habitat, will inevitably directly impact some nest-trees and could lead to disturbance of roosting sites. There is also the potential for a reduction in roosting site options and the possibility that roost sites not used in 2016/2017 (hence undetected) may be present within the project area. With regard to these constraints:

- The loss of foraging habitat is not critical as areas are small, native vegetation can be largely avoided and offsets can be arranged, including revegetation nearby.
- There is uncertainty regarding roosting sites as, while known roosting sites can be avoided, not all roosting sites are used all the time (e.g. on a weekly or seasonal basis) and thus there may be roosting sites that have not yet been identified.

- Impacts on nest-trees would be significant as natural hollows take centuries to develop and avoidance of all potential nest trees will not be possible. Management is possible, such as installing artificial hollows, but these require ongoing maintenance. There is a risk of direct impact on active nests, as the nests used each year may vary, but active nests can be avoided during clearing.

The locations of all potential nest-trees (Addendum A) and roost sites (Table 15), as well as the foraging assessment mapping (Figure 11 and Figure 14), have been provided digitally to assist planning and management decisions.

Significant mammals

Field investigations failed to locate Mardo (CS3), Chuditch (CS1), Brush-tailed Phascogale (CS1), Quenda (CS2) and Brushtail Possum (CS3), and while this does not necessarily mean the species are absent, it indicates that if they are present, they occur at very low levels of abundance. Previous experience indicates that these species are all readily detected through the use of motion-sensitive cameras as deployed as part of this project. The ALA database shows the core distribution of Mardo and Brush-tailed Phascogale to be in the Jarrah forest south of Gidgegannup (south of the referral area) and there were several DBCA database records of the latter species in the general referral area vicinity (Bancroft *et al.* 2017). There are anecdotal reports of Chuditch around Bindoon and there were several DBCA database records of this species within the vicinity of the referral area (Bancroft *et al.* 2017). The Quenda and Brushtail Possum occur around Bullsbrook and just south of Muchea (BCE database) but may not occur regularly as far north as the referral area. In addition, bat acoustic surveys failed to detect the Western False Pipistrelle; but this species was not included in the expected species list (Bancroft *et al.* 2017) as its core range is south of Perth (ALA 2018).

There were two sight-records of the Brush Wallaby (CS2) in the referral area, but the species was not picked up on motion-sensitive cameras. It is probably present at low densities in all large areas of native vegetation in the region.

There were five potential records (scats, feeding remains) of the Water-rat (Rakali, CS2) along the Hay Flat drainage line, although intensive motion-sensitive camera surveys in this area failed to detect the species. Residents around Lake Chittering consider this species disappeared about 20 years ago. The species has been recorded recently near Gingin townsite along Gingin Brook (2015, BCE database).

Significant mammals are not a key constraint even when present due to the linear nature of the project, and the risk of habitat fragmentation and roadkill can be substantially reduced through route selection and the use of underpasses.

Significant invertebrates

No significant invertebrates were recorded although up to three unidentified and potential SRE *Antichiropus* sp. were found. Given the nature of the landscape these are probably widespread, but collection of invertebrates in the region has been limited. A comprehensive survey of aquatic macro-invertebrates was not conducted on the basis that wetlands would not be impacted. Carter's Freshwater Mussel is present in the lower Brockman River but is probably locally extinct along the drainage systems in the project area.

Summary

Even if significant fish, frogs, reptiles or mammals are present, impacts can be mitigated through route selection to avoid areas of native vegetation wherever possible and particularly to avoid impacts on wetlands. Thus, native vegetation remnants in an agricultural landscape, and wetlands, could be considered as constraints if not managed appropriately, and are considered below.

In summary, key constraints and other important considerations with respect to fauna are:

- Black-Cockatoo nest-trees or potential nest-trees (rank of 1, 2 or 3). Lower ranking trees are less critical but still have the potential for a concealed hollow or a future hollow.
- Unknown roosting sites (usually groups of locally tall trees, often near water).
- Wetlands (for a range of fauna and because drainage lines provide movement corridors).
- 'Bottlenecks' (i.e. corridors for fauna movement) of native vegetation where movement of fauna may be concentrated and where the alignment passes through the bottleneck to minimise actual habitat loss.

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6 Appendices

Appendix 1. Species of conservation significance.

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

Conservation Significance (CS) 1: Species listed under State or Commonwealth Acts.
Species listed under the EPBC Act are assigned to categories recommended by the International Union for the Conservation of Nature and Natural Resources (IUCN 2012), or are listed as migratory. Migratory species are recognised under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA), the Republic of South Korea Australia Migratory Bird Agreement (ROKAMBA), and/or the Convention on the Conservation of Migratory Species of Wild Animals (CMS; also referred to as the Bonn Convention). The *Biodiversity Conservation Act 2016* uses a series of seven Schedules to classify conservation status that largely reflect the IUCN categories (IUCN 2012).

Conservation Significance (CS) 2: Species listed as Priority by DBCA but not listed under State or Commonwealth Acts.
In Western Australia, DBCA has produced a supplementary list of Priority Fauna, being species that are not considered threatened under the *Biodiversity Conservation Act 2016* but for which DBCA feels there is cause for concern.

Conservation Significance (CS) 3: Species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution.
This level of significance has no legislative or published recognition and is based on interpretation of distribution information, but is used here as it may have links to preserving biodiversity at the genetic level (EPA 2002). If a population is isolated but a subset of a widespread (common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Conservation significance is applied to allow for the preservation of genetic richness at a population level, and not just at a species level. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3, as may colonies of waterbirds. The Western Australian Department of Environmental Protection, now DBCA, used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan (DEP 2000).

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

Introduced species

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

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*

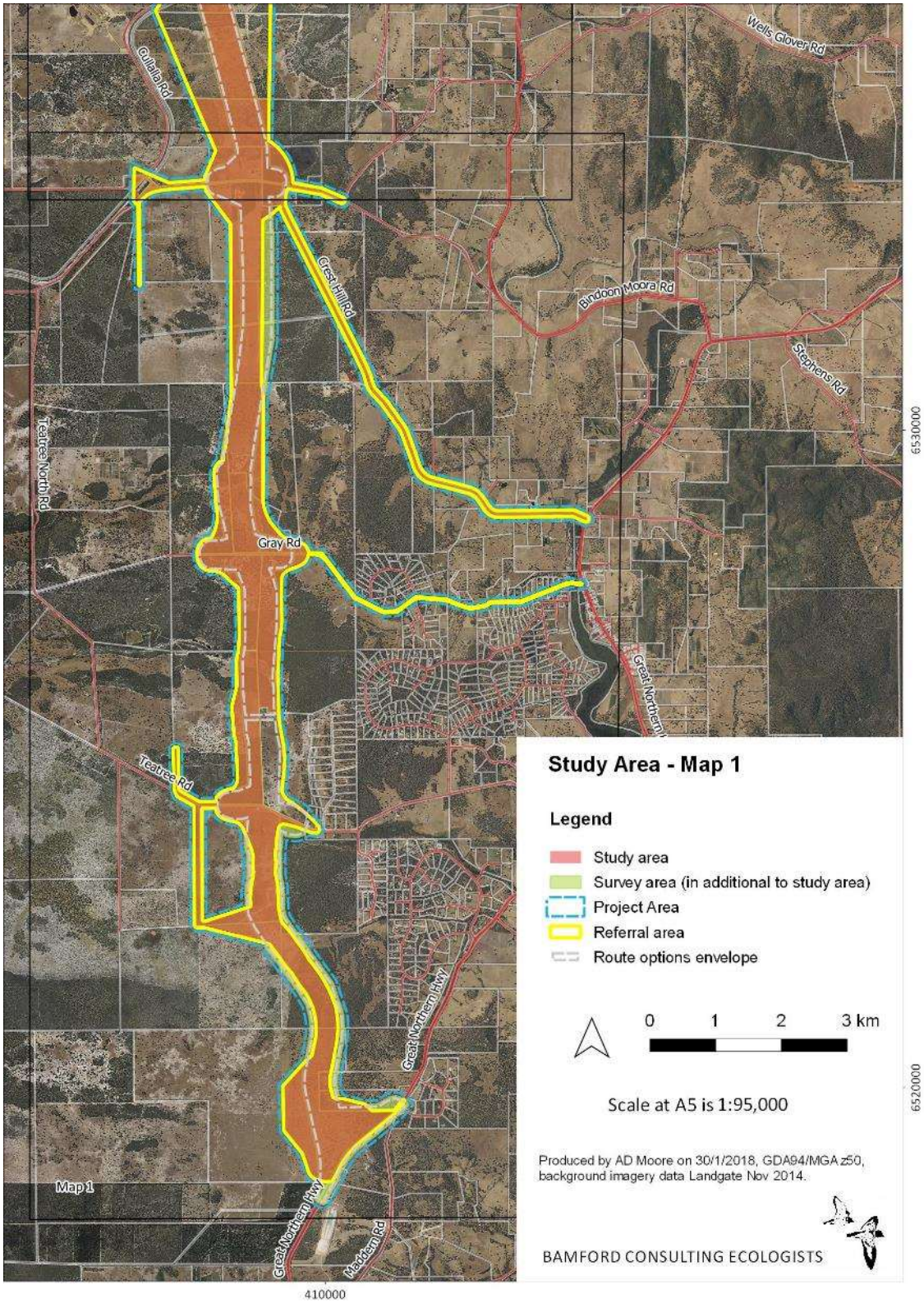
Schedule 1	Fauna that is rare or is likely to become extinct as critically endangered fauna.
Schedule 2	Fauna that is rare or is likely to become extinct as endangered fauna.
Schedule 3	Fauna that is rare or is likely to become extinct as vulnerable fauna.
Schedule 4	Fauna presumed to be extinct.
Schedule 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.

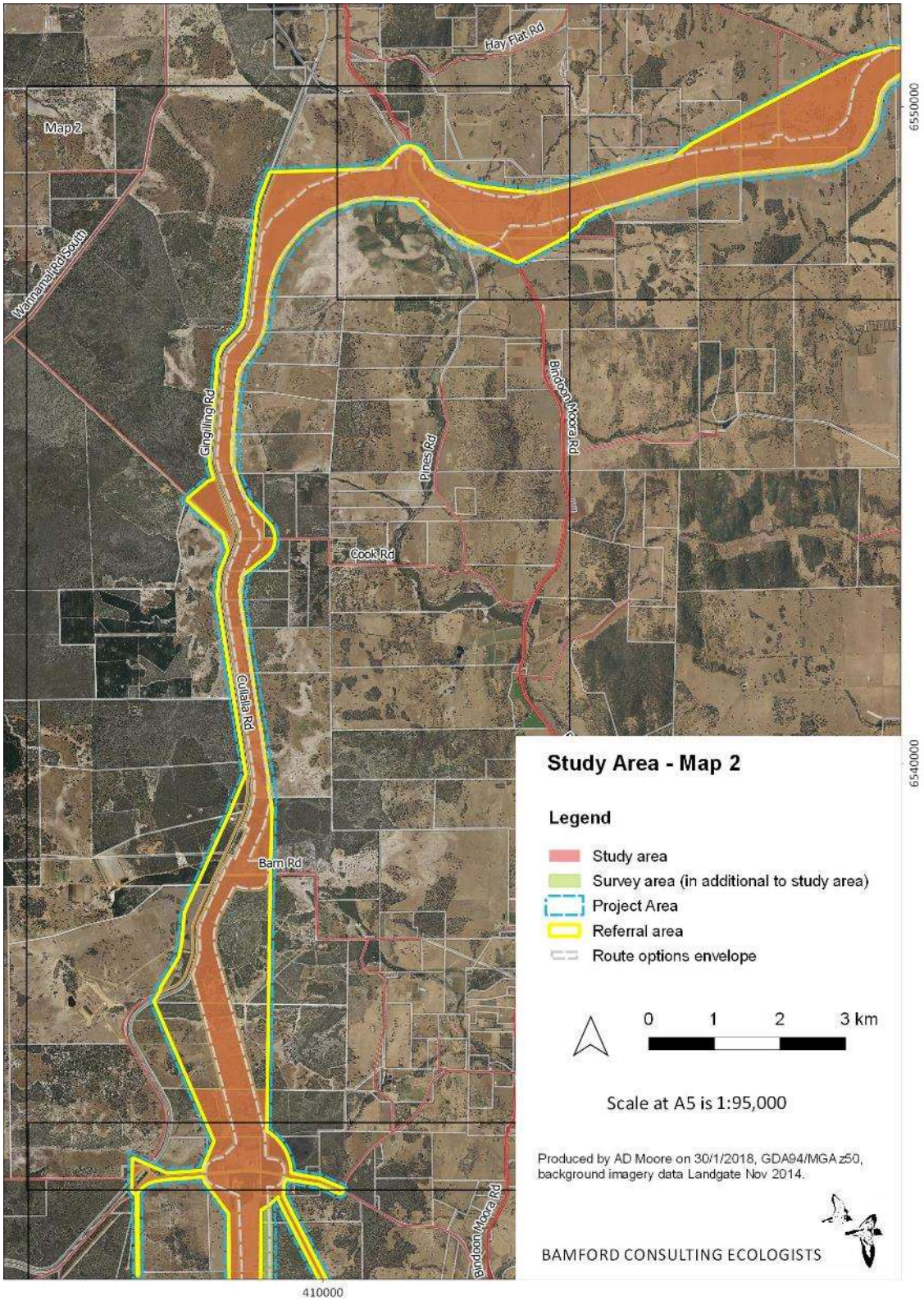
WA Department of Parks and Wildlife Priority species (species not listed under the *Wildlife Conservation Act 1950*, but for which there is some concern).

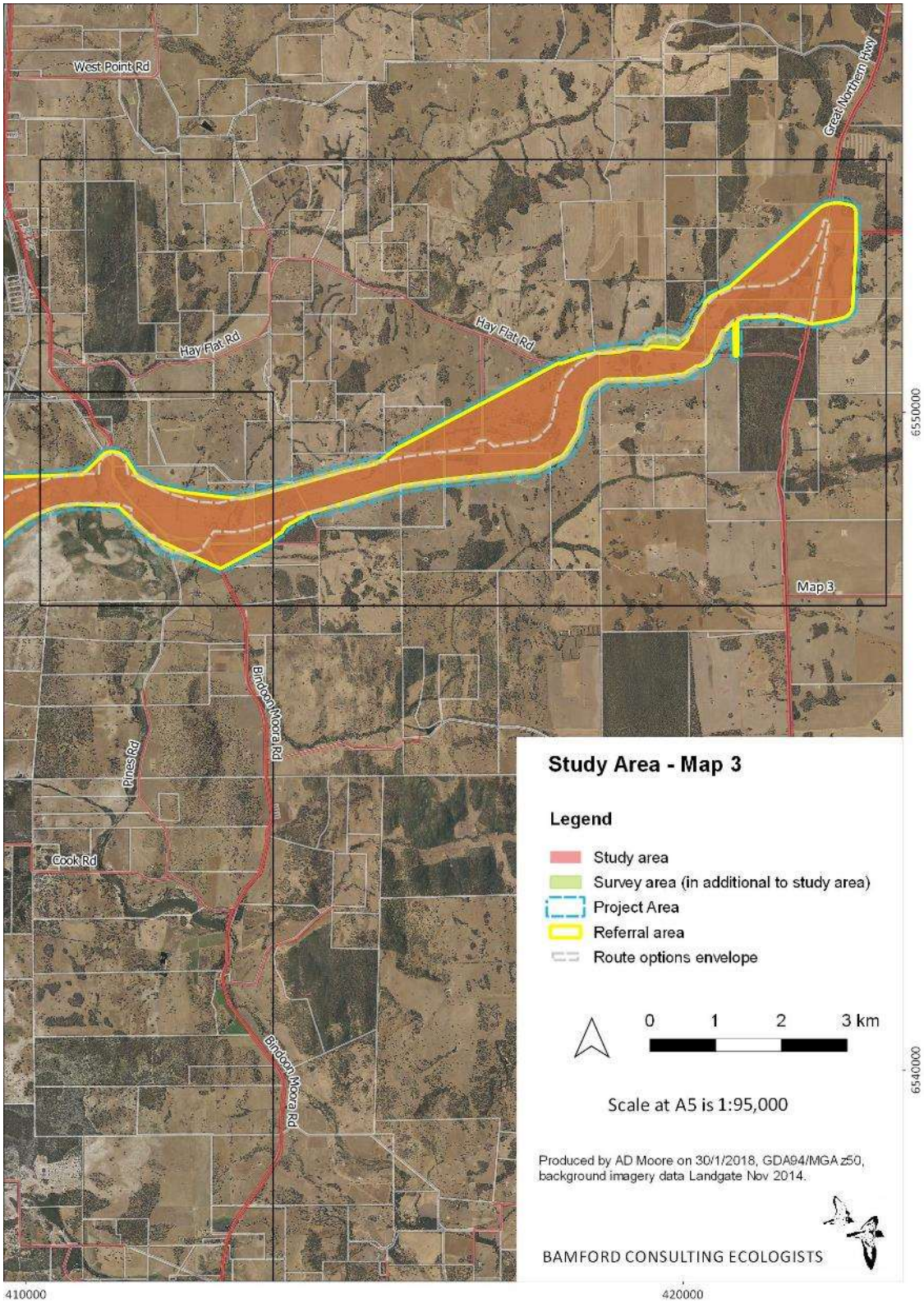
Priority 1 (Poorly-known species)	Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel 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.
Priority 2 (Poorly-known species)	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.
Priority 3 (Poorly-known species)	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.
Priority 4 (Rare, Near Threatened and other species in need of monitoring)	(a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands. (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."

Appendix 3. Finer-scale maps of the Bindoon Bypass 'project area' and relevant boundaries (route options envelope, referral area, survey area and study area) for this report.

See Figure 1 for overview map.




Hay Flat Rd
Map 2
Wannamal Rd South
Gingilling Rd
Pines Rd
Bindoon Moora Rd
Cook Rd
Culalla Rd
Barn Rd
Bindoon Moora Rd
6550000
6540000
410000
Study Area - Map 2
Legend
Study area
Survey area (in additional to study area)
Project Area
Referral area
Route options envelope
0 1 2 3 km
Scale at A5 is 1:95,000
Produced by AD Moore on 30/1/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS


West Point Rd
Great Northern Hwy
Hay Flat Rd
Hay Flat Rd
Map 3
Bindoon Moora Rd
Pines Rd
Cook Rd
Bindoon Moora Rd
6550000
6540000
410000
420000
Study Area - Map 3
Legend
Study area
Survey area (in additional to study area)
Project Area
Referral area
Route options envelope
0 1 2 3 km
Scale at A5 is 1:95,000
Produced by AD Moore on 30/1/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS

Appendix 4. Bamford Consulting Ecologists black-cockatoo nesting-tree assessment protocol.

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

Measuring DBH

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

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

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

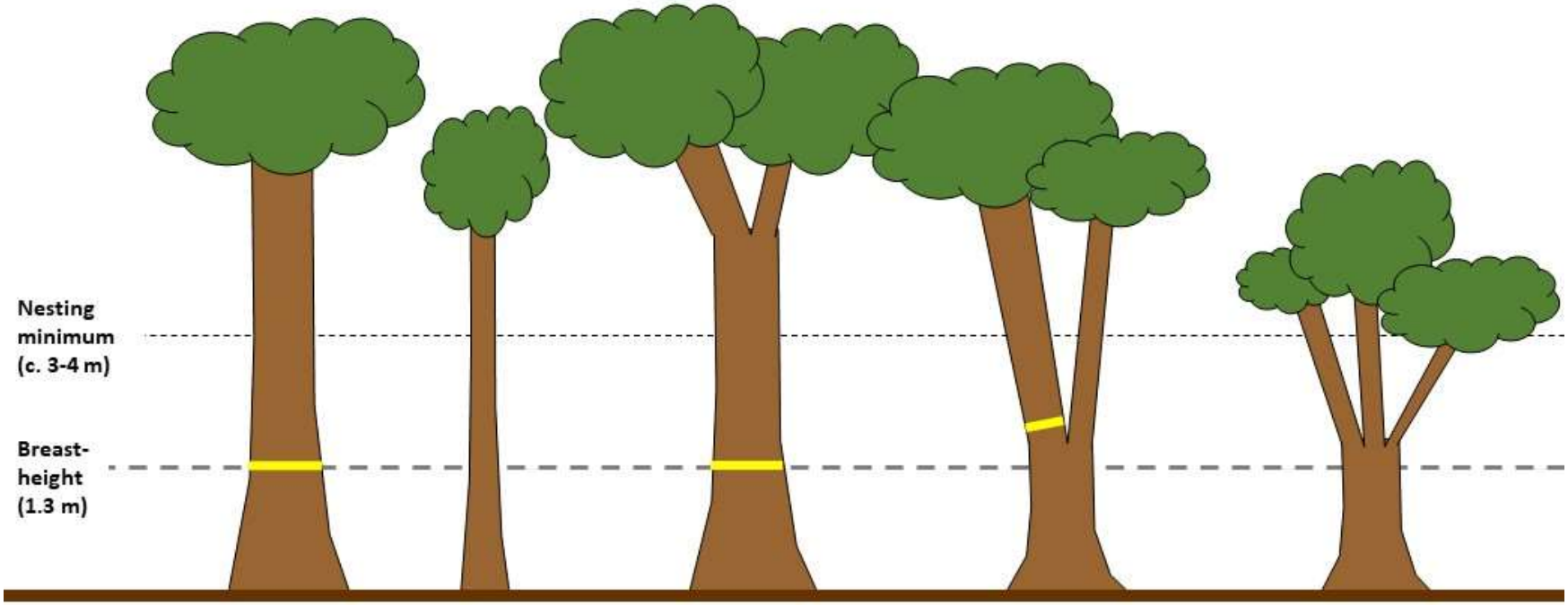
Nest height minima

For Carnaby's Black-Cockatoo, the minimum height of known nests is c. 3 m (Saunders 1979)[2]. For Forest Red-tailed Black-Cockatoo, the minimum height of a known nest is 6.5 m (Johnstone *et al.* 2013a). Thus, a 3-4 m threshold seems a pragmatic "general" one to use for the purposes of field surveys where both species are likely and multiple tree species are under consideration.

Tree forms

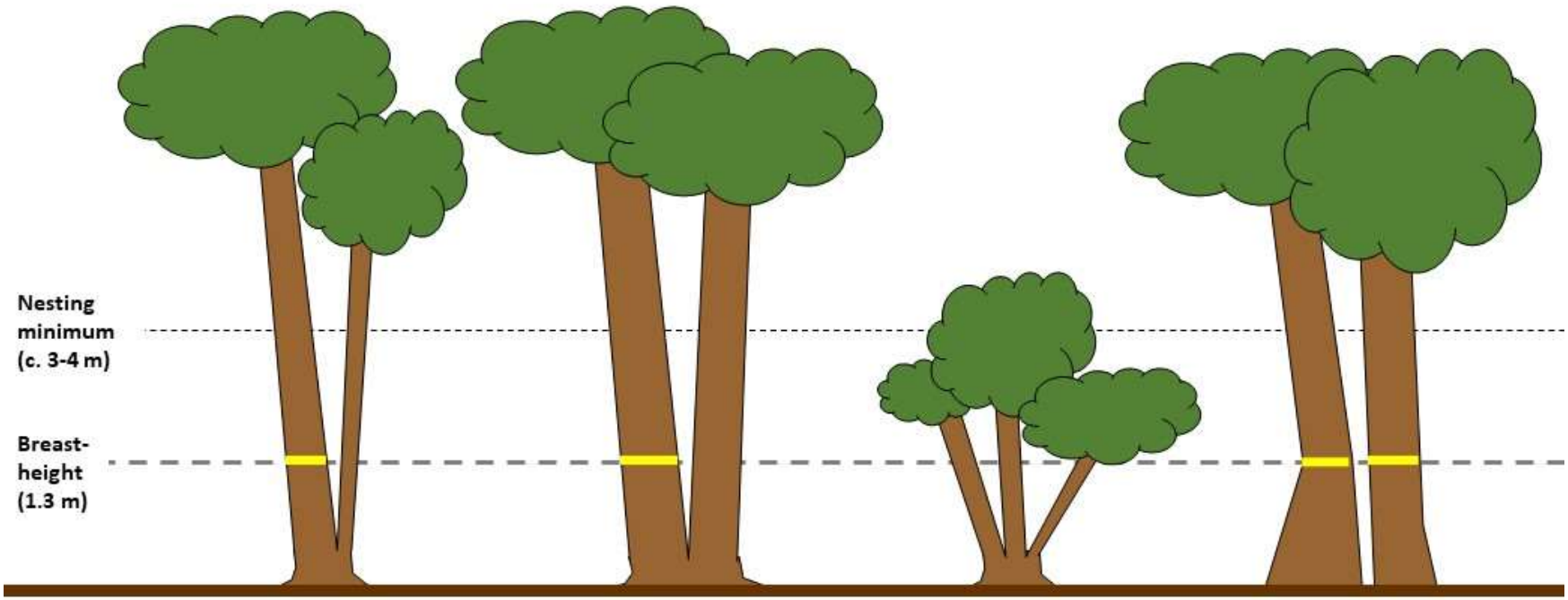
Quite obviously, trees have a range of forms and growth-habits. These can occasionally affect black-cockatoo nesting-tree surveys. As such, the following table has been developed (with reference to the information above) to guide tree assessment.

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



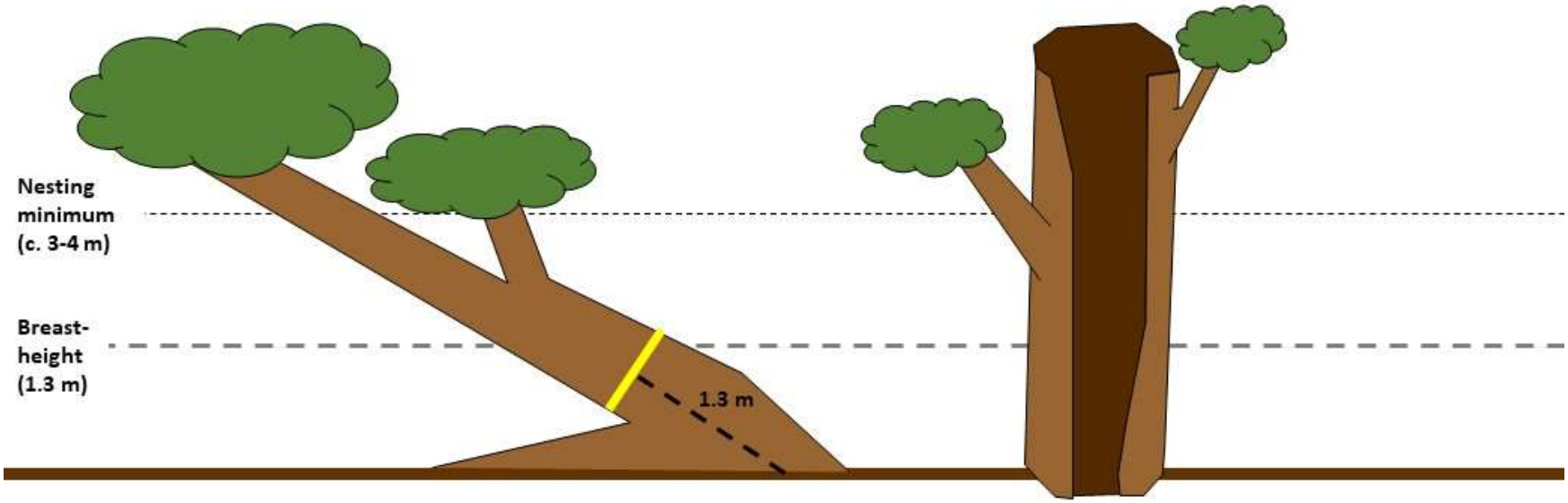
Tree Description:	Straight trunk. DBH > 500 mm*.	Straight trunk. DBH < 500 mm*.	Trunk forks above 3 m. DBH > 500 mm*.	Trunk forks between 1.3 m & 3 m. Diameter of at least one trunk above fork > c. 500 mm*.	Trunk forks between 1.3 m & 3 m. DBH > 500 mm* but no trunks above fork have diameter > c. 500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

* Or 300 mm DBH for Wandoo, Salmon Gum.



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

* Or 300 mm DBH for Wandoo, Salmon Gum.



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

* Or 300 mm DBH for Wandoo, Salmon Gum.

Appendix 5. 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	Low foraging value. Examples: • 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).	Low foraging value. Example: • 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.	Low foraging value. Examples: • 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, *Eucalyptus caesia* and *Eucalyptus erythrocorys*.
3	Low to Moderate foraging value. Examples: • Shrubland in which species of foraging value, such as shrubby banksias, with 10-20% projected foliage cover • Woodland with tree banksias 2-20% projected foliage cover • Eucalypt woodland/mallee of small-fruited species; Marri, if present, <10% project foliage cover.	Low to Moderate foraging value. Examples: • 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.	Low to Moderate foraging value. Examples: • 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	Moderate foraging value. Examples: • Woodland with tree banksias 20-40% projected foliage cover. • Eucalypt woodland/forest with Marri 20-40% projected foliage cover.	Moderate foraging value. Examples: • 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.	Moderate foraging value. Examples: • Eucalypt woodland/forest (i.e. Marri, Jarrah, Wandoo, and Blackbutt) with 20-40% projected foliage cover.
5	Moderate to High foraging value. Examples: • 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.	Moderate to High foraging value. Examples: • 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.	Moderate to High foraging value. Examples: • 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	High foraging value. Example: • Banksia Woodlands of key species (e.g. *B. attenuata, B. menziesii*) 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.	High foraging value. Example: • 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.	High foraging value. Example: • Eucalypt woodland/forest (i.e. Marri, Jarrah, Wandoo, and Blackbutt) with >60% projected foliage cover. Vegetation condition good with low weed invasion and low tree death to indicate it is robust and unlikely to decline in the medium term.

B. Site context.

The maximum score is given in situations where foraging habitat is supporting breeding birds. It can also be given in fragmented landscapes where there is little foraging habitat remaining and thus what is left has a high contextual value. The site context score is species-specific as it depends upon factors such as the vegetation type and extent, and the presence of breeding birds, and the following table, developed by Bamford consulting in conjunction with DEE, provides a *guide* to the assignation of site context scores (note that 'local area' is defined as within a 15 km radius of the centre point of the study site):

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

C. Species density.

Assignation of the species density score (0 or 1) is based upon the black-cockatoo species being either abundant or not abundant, and is species specific. A score of 1 is used where the species is seen or reported regularly and/or there is abundant foraging evidence. Regularly is when the species is seen at intervals of every few days or weeks for at least several months of the year. A score of 0 is used when the species is recorded or reported very infrequently and there is little or no foraging evidence.

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

Active/Recent ↔ Intermediate ↔ Old

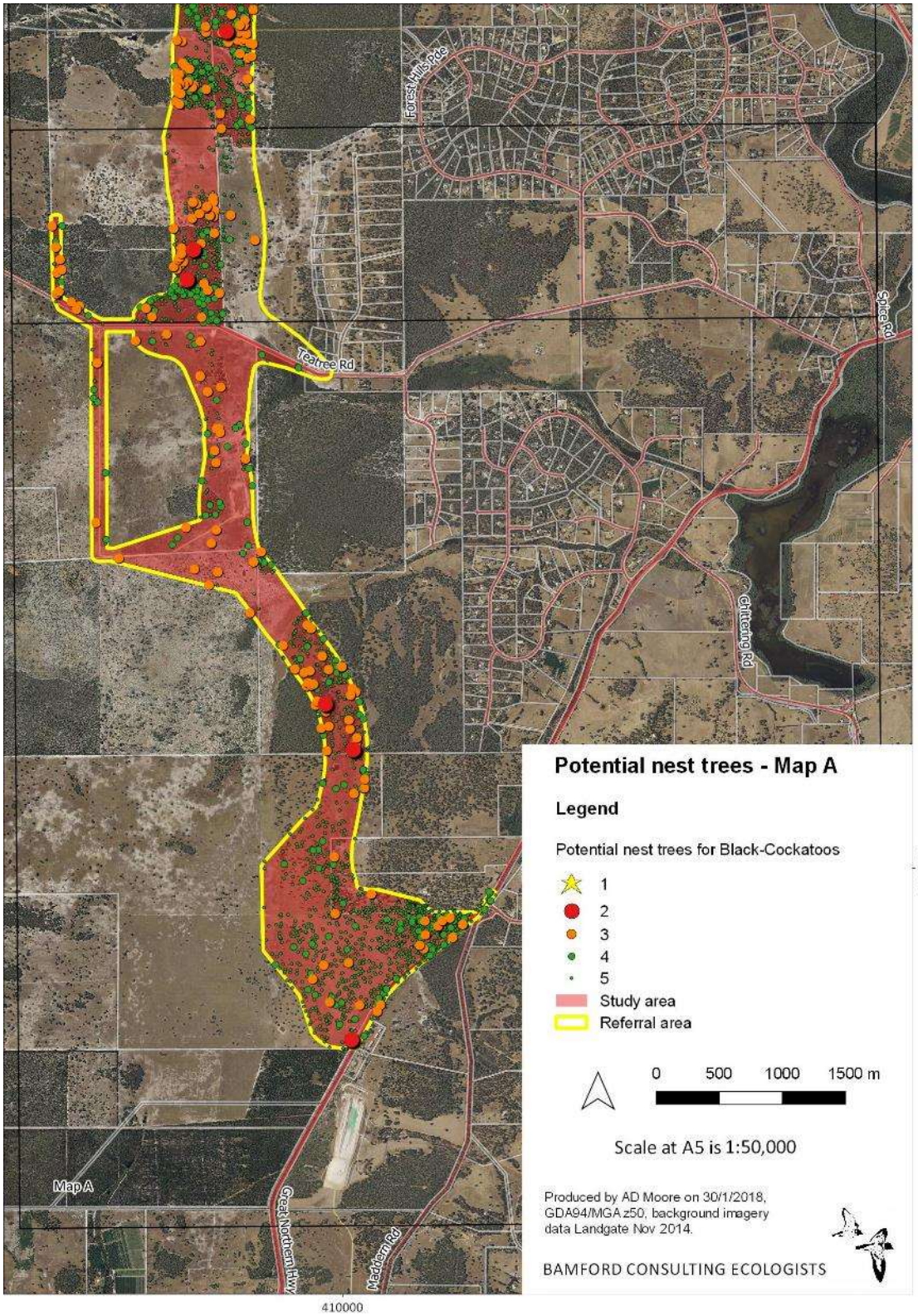
Jarrah nuts

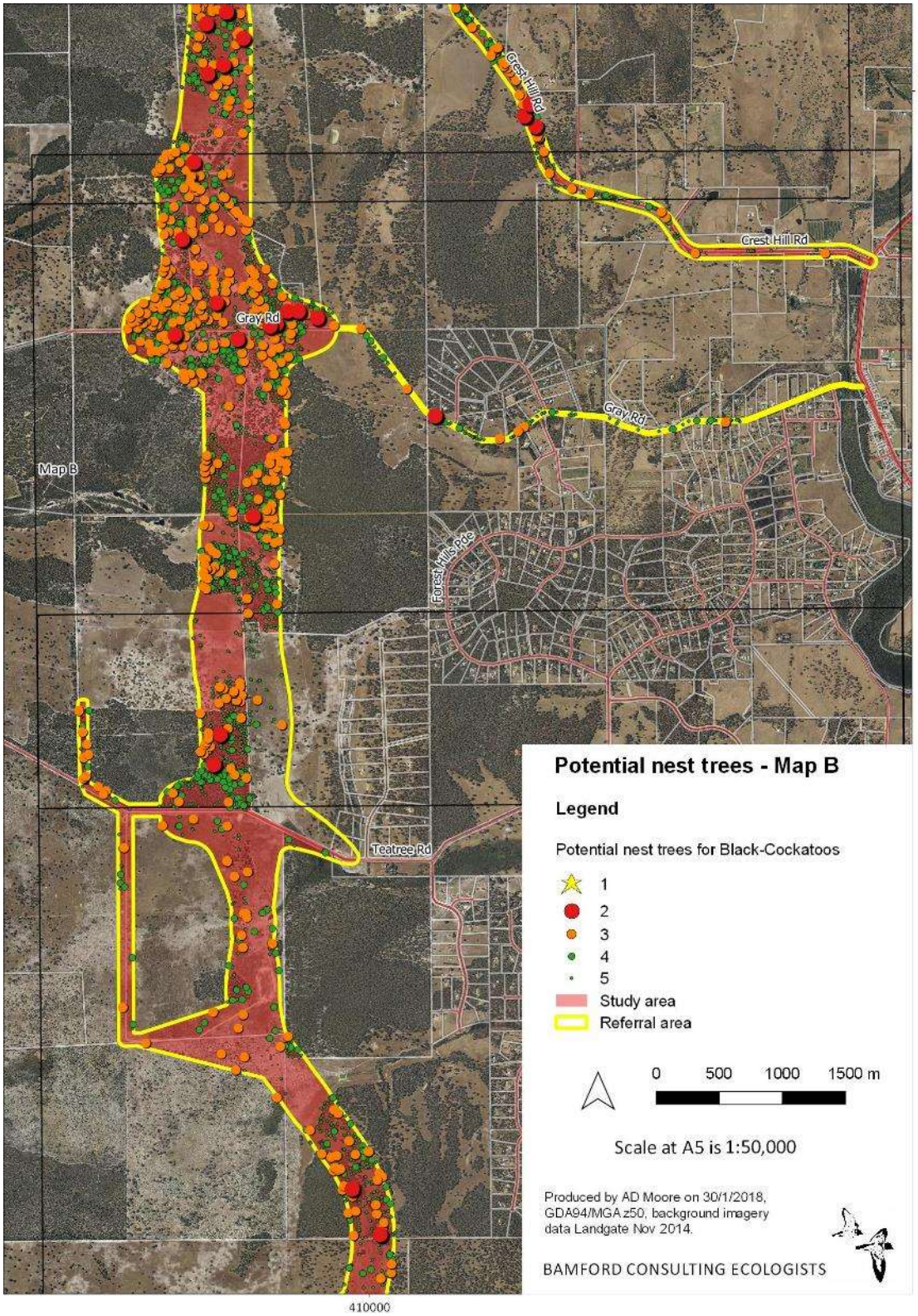
Jarrah leaves

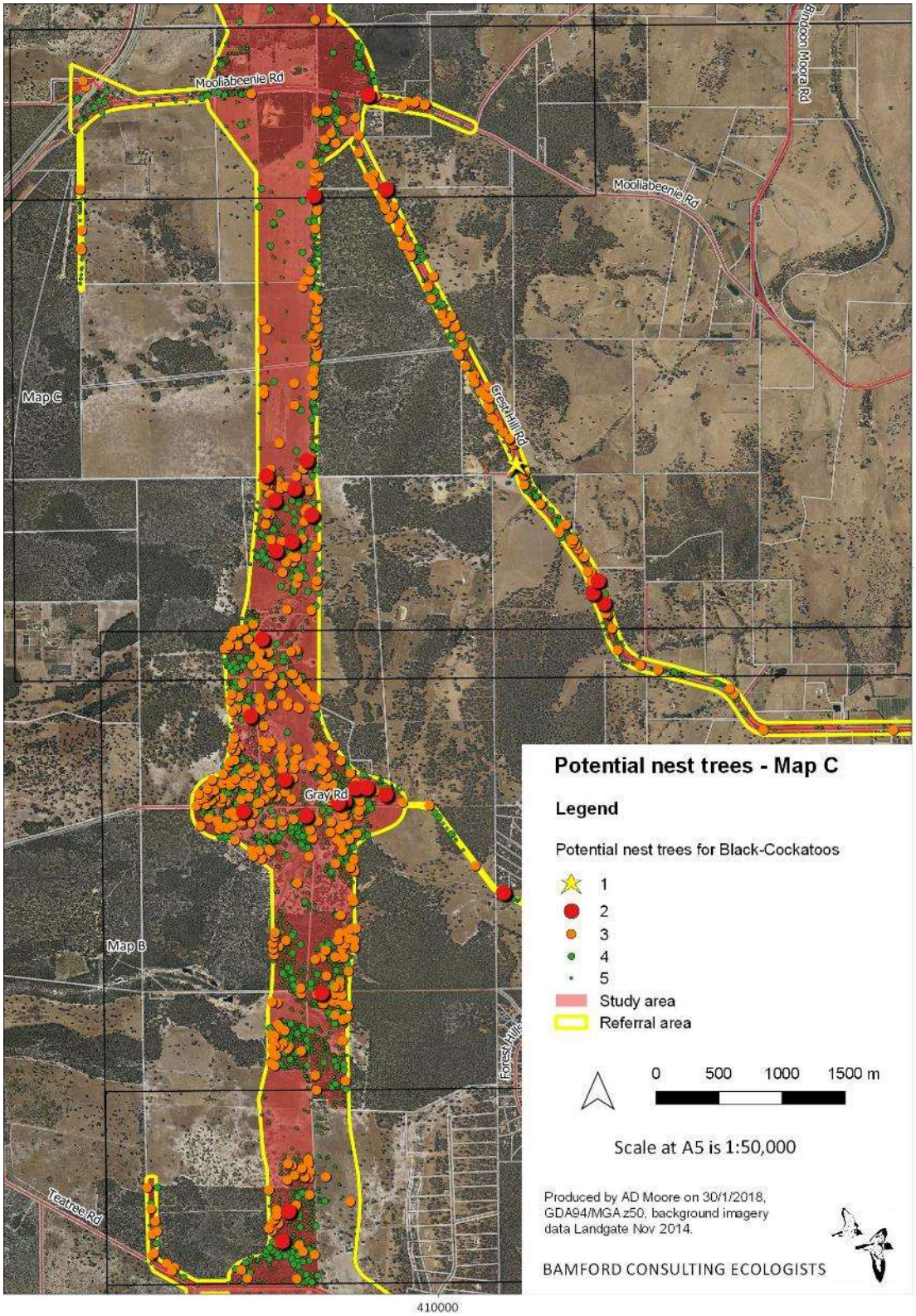
Marri nuts

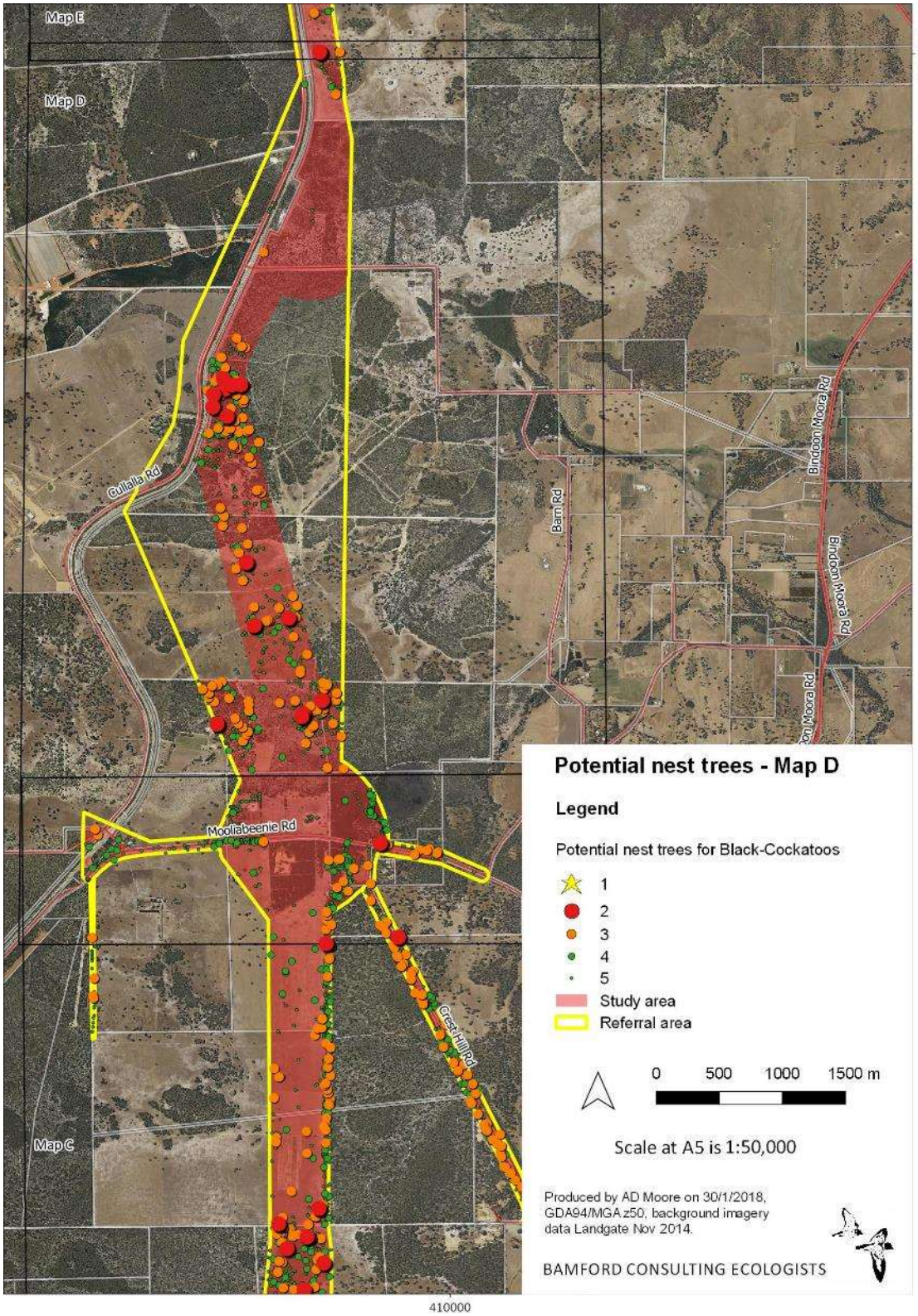
Appendix 7. Finer-scale maps of the location of potential nest-trees within the study area, as classified according to nest-tree rank.

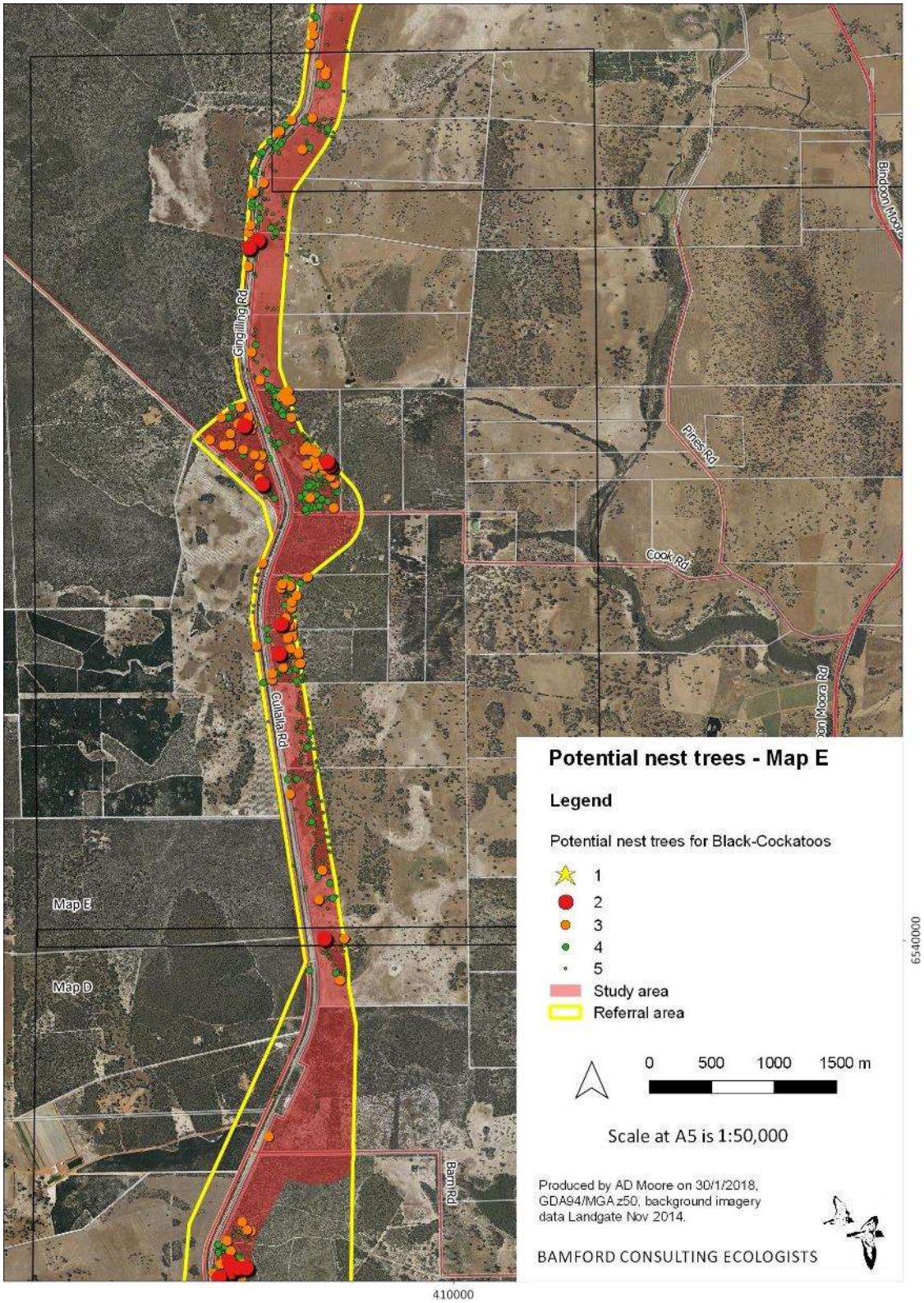
See Figure 8 for overview map.

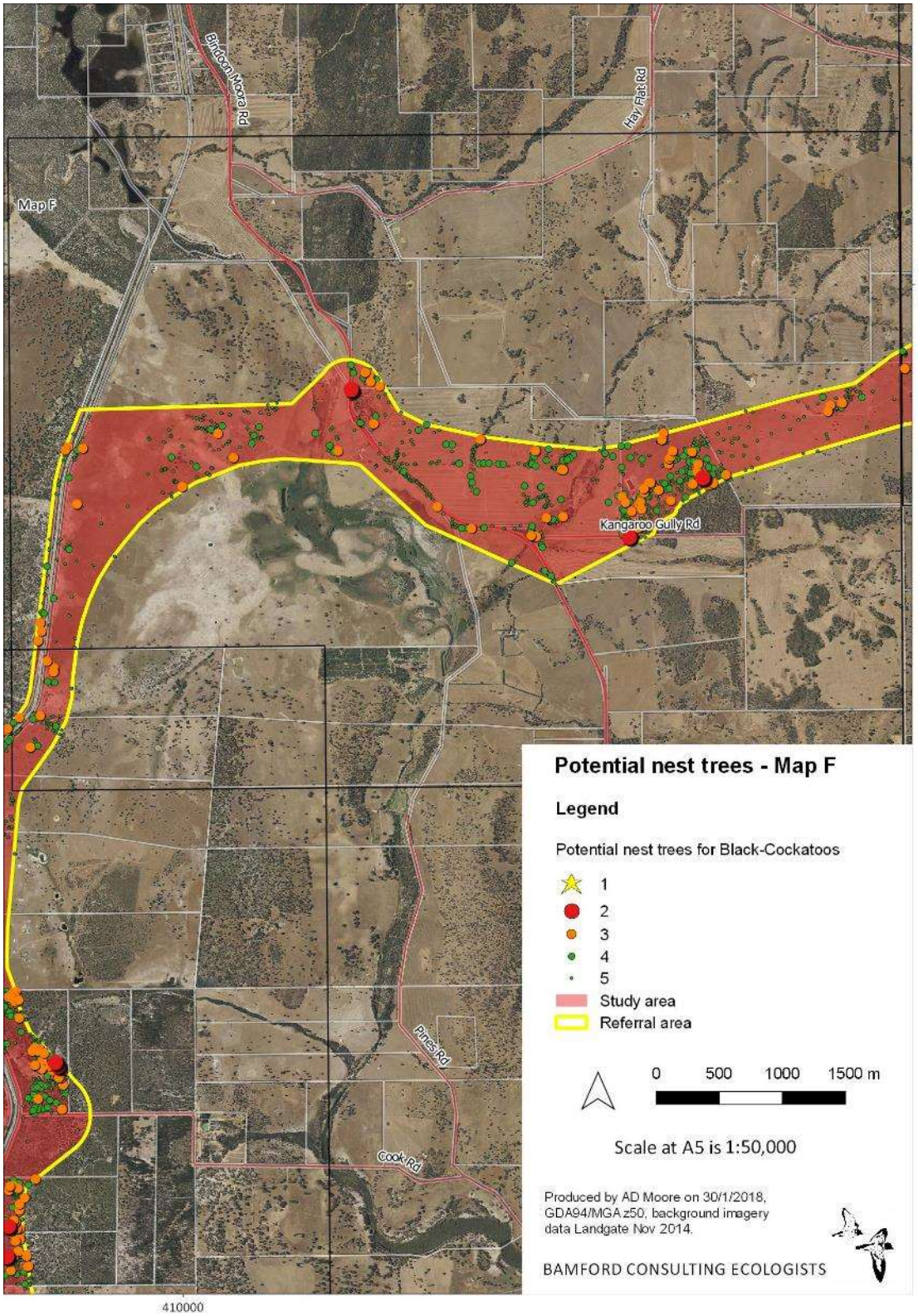


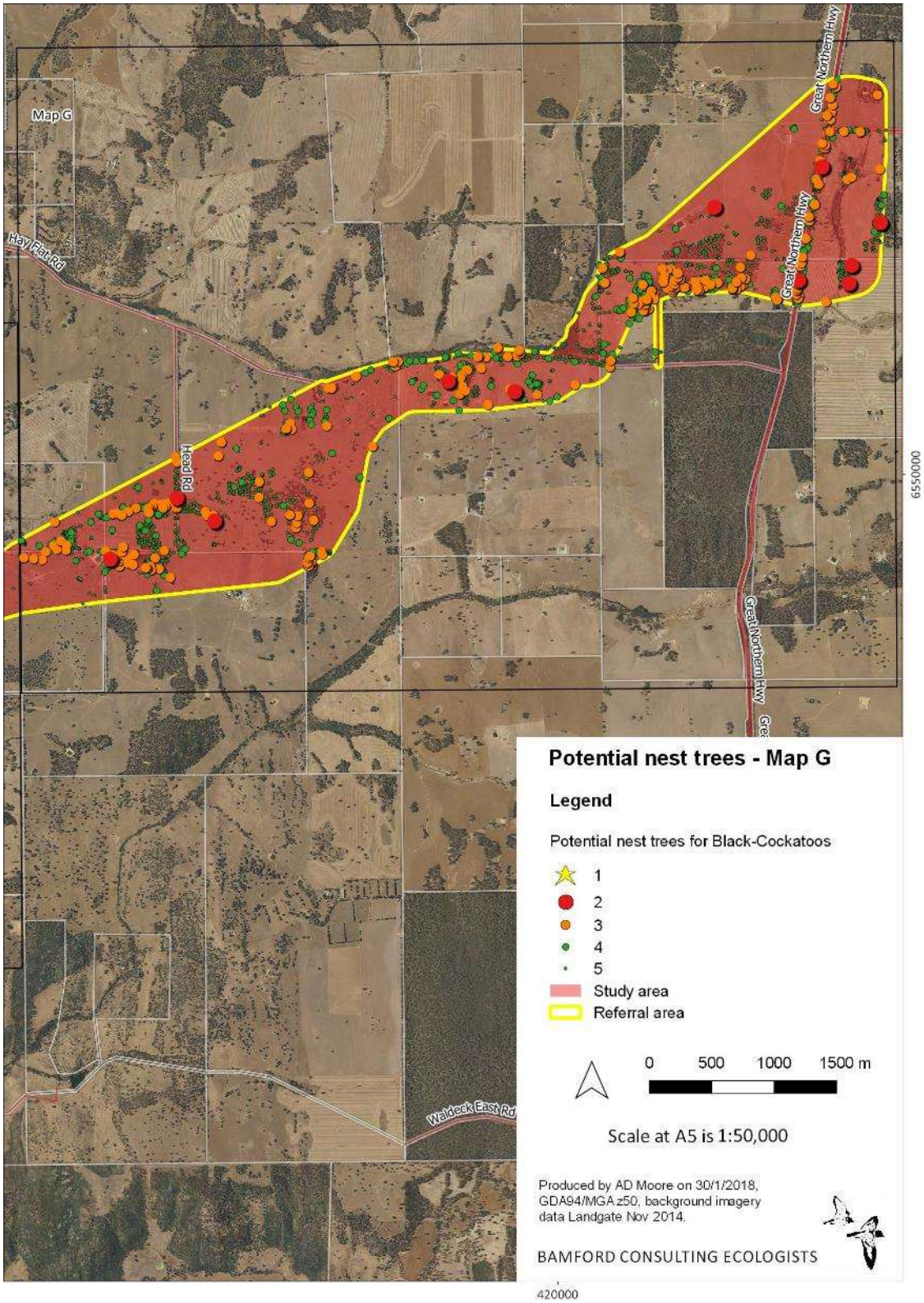

Crest Hill Rd
Crest Hill Rd
Gray Rd
Gray Rd
Map B
Forest Hills Pde
Teatree Rd
6530000
410000
Potential nest trees - Map B
Legend
Potential nest trees for Black-Cockatoos
1
2
3
4
5
Study area
Referral area
0
500
1000
1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 30/1/2018.
GDA94/MGA z50, background imagery
data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS


Mooliabeenie Rd
Bindoon Moora Rd
Mooliabeenie Rd
Map C
Crest Hill Rd
6530000
Gray Rd
Map B
Forest Hills
Teatree Rd
410000
Potential nest trees - Map C
Legend
Potential nest trees for Black-Cockatoos
1
2
3
4
5
Study area
Referral area
0 500 1000 1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 30/1/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS


Map E
Map D
Map C
6540000
410000
Cullalla Rd
Bam Rd
Bindoon Moora Rd
Mooliabeenie Rd
Crest Hill Rd
Potential nest trees - Map D
Legend
Potential nest trees for Black-Cockatoos
1
2
3
4
5
Study area
Referral area
0 500 1000 1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 30/1/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS

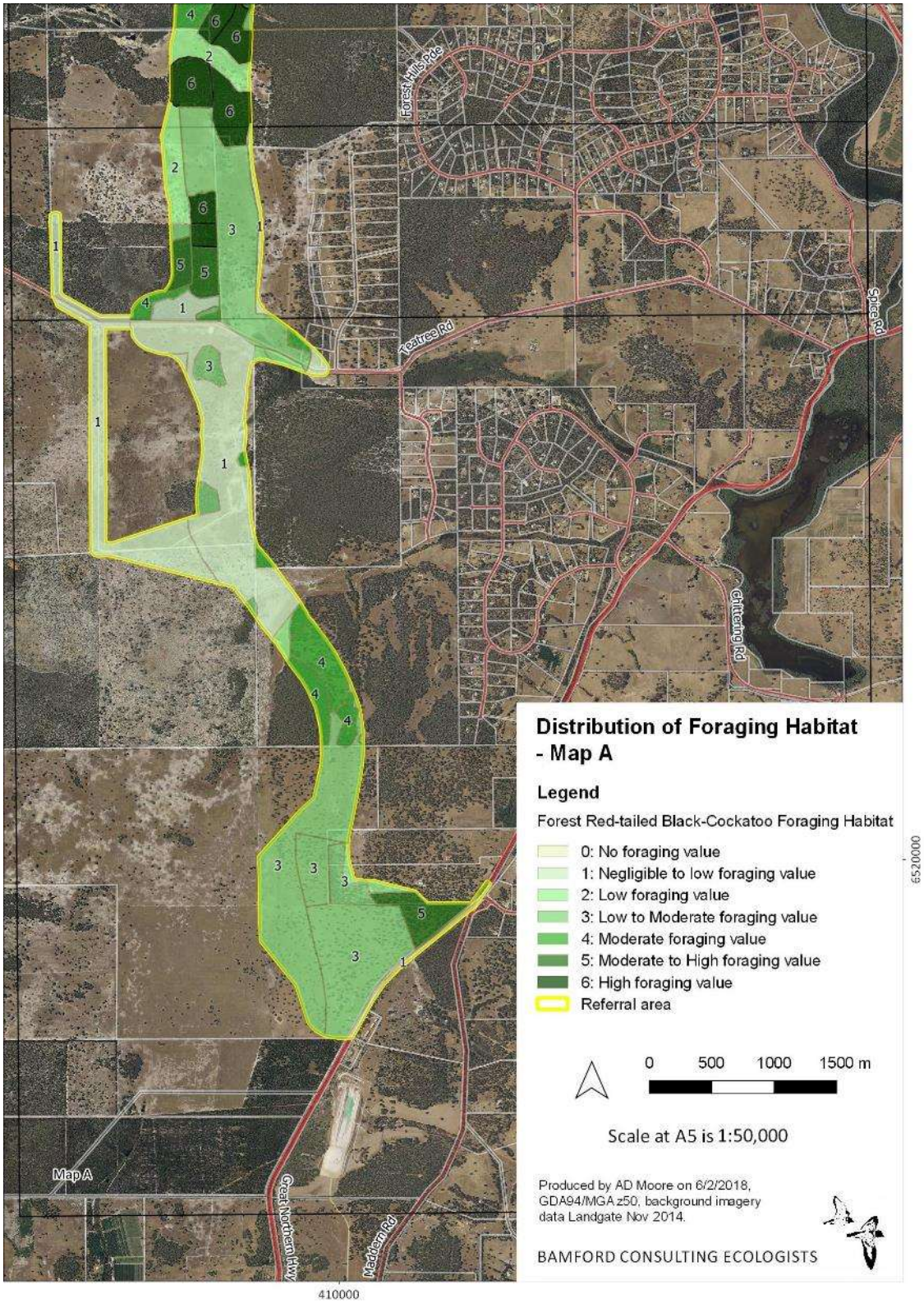

Gingilling Rd
Pines Rd
Cook Rd
Gulalla Rd
Bindoon Moora Rd
Barn Rd
Map E
Map D
410000
6540000
Potential nest trees - Map E
Legend
Potential nest trees for Black-Cockatoos
1
2
3
4
5
Study area
Referral area
0 500 1000 1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 30/1/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS

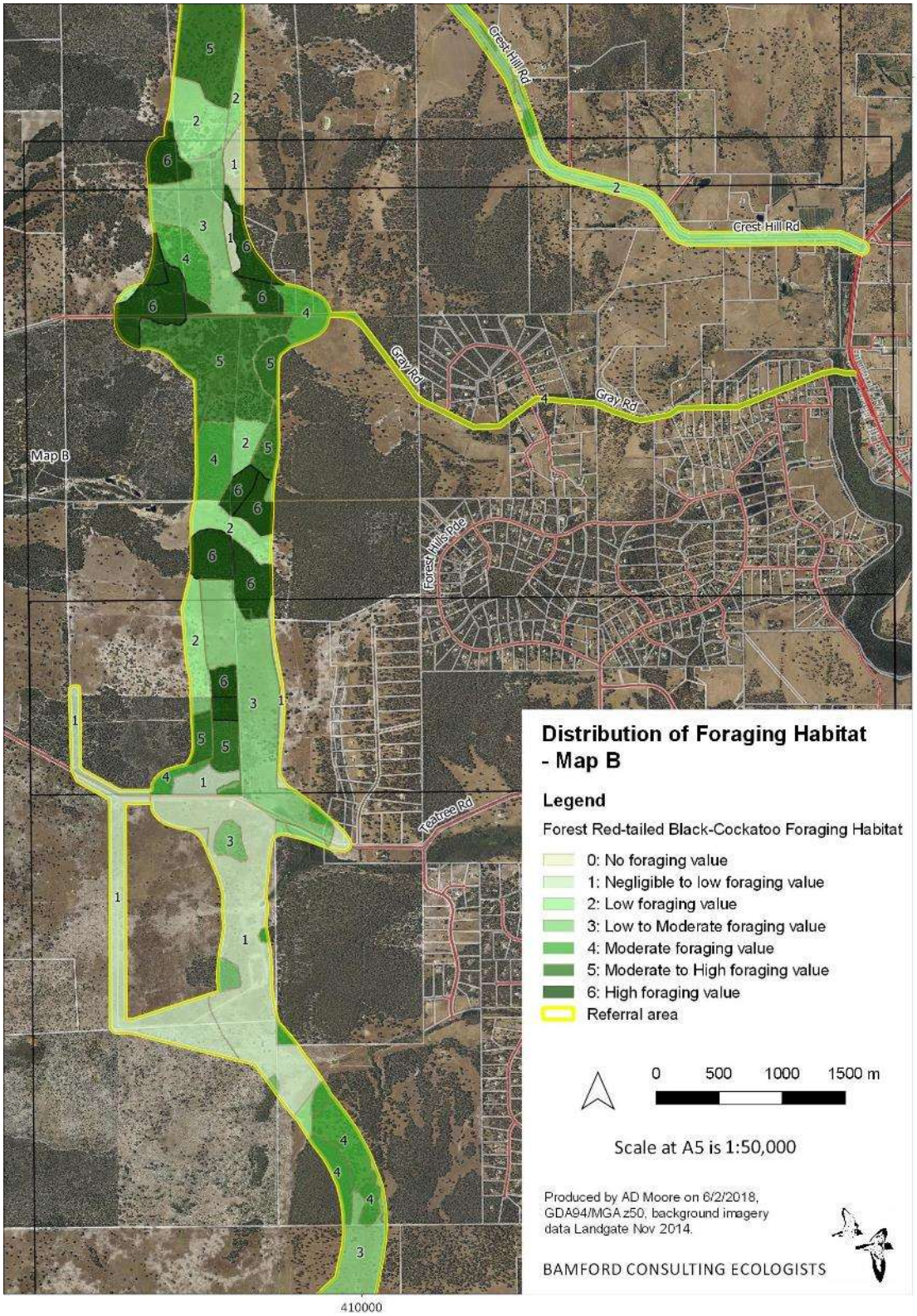

Bindoon Moora Rd
Hay Rat Rd
Map F
Kangaroo Gully Rd
Pines Rd
Cook Rd
6550000
410000
Potential nest trees - Map F
Legend
Potential nest trees for Black-Cockatoos
1
2
3
4
5
Study area
Referral area
0
500
1000
1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 30/1/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS

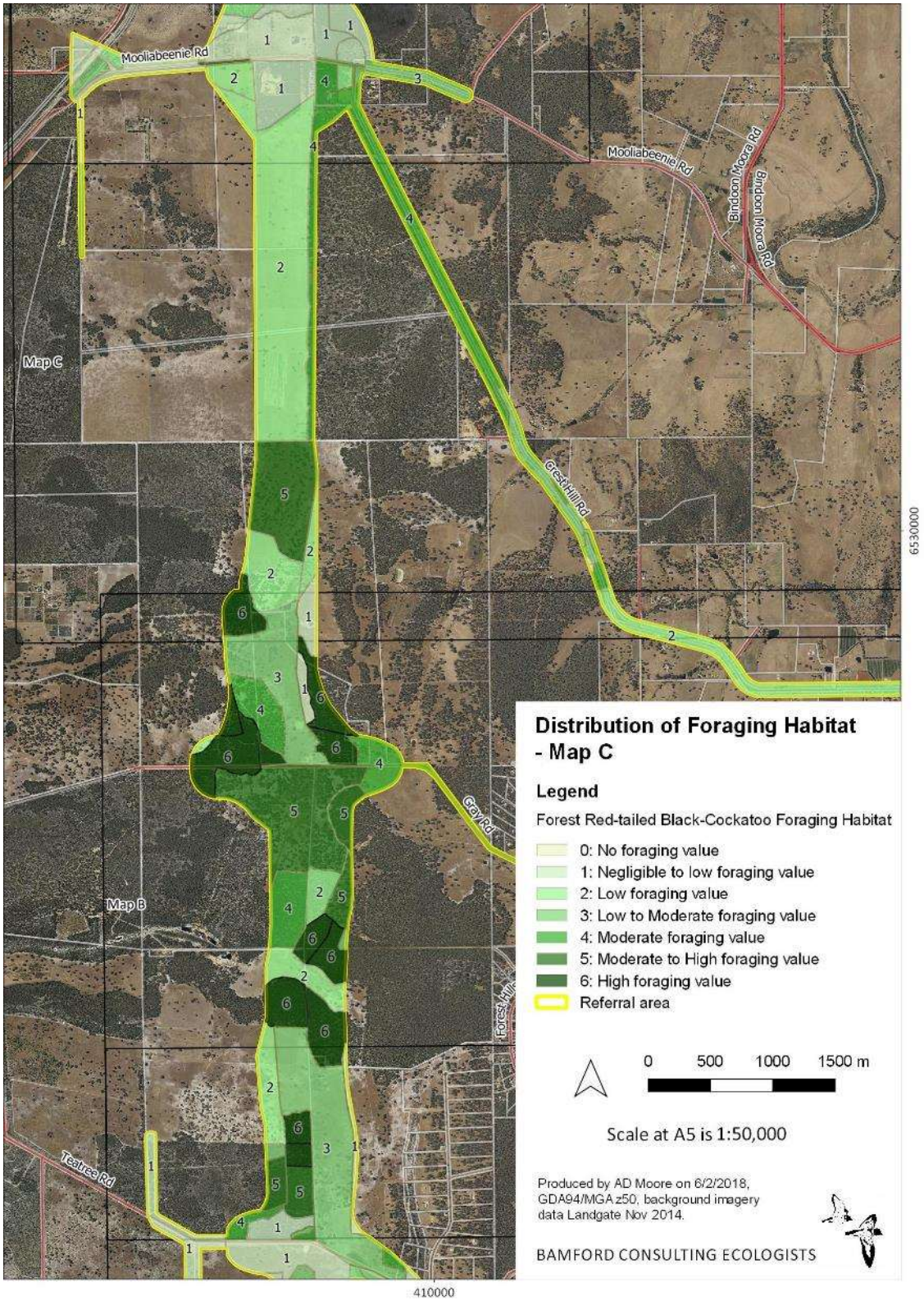

Map G
Hay Flat Rd
Head Rd
Great Northern Hwy
Great Northern Hwy
Great Northern Hwy
Waldeck East Rd
6550000
420000
Potential nest trees - Map G
Legend
Potential nest trees for Black-Cockatoos
1
2
3
4
5
Study area
Referral area
0
500
1000
1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 30/1/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS

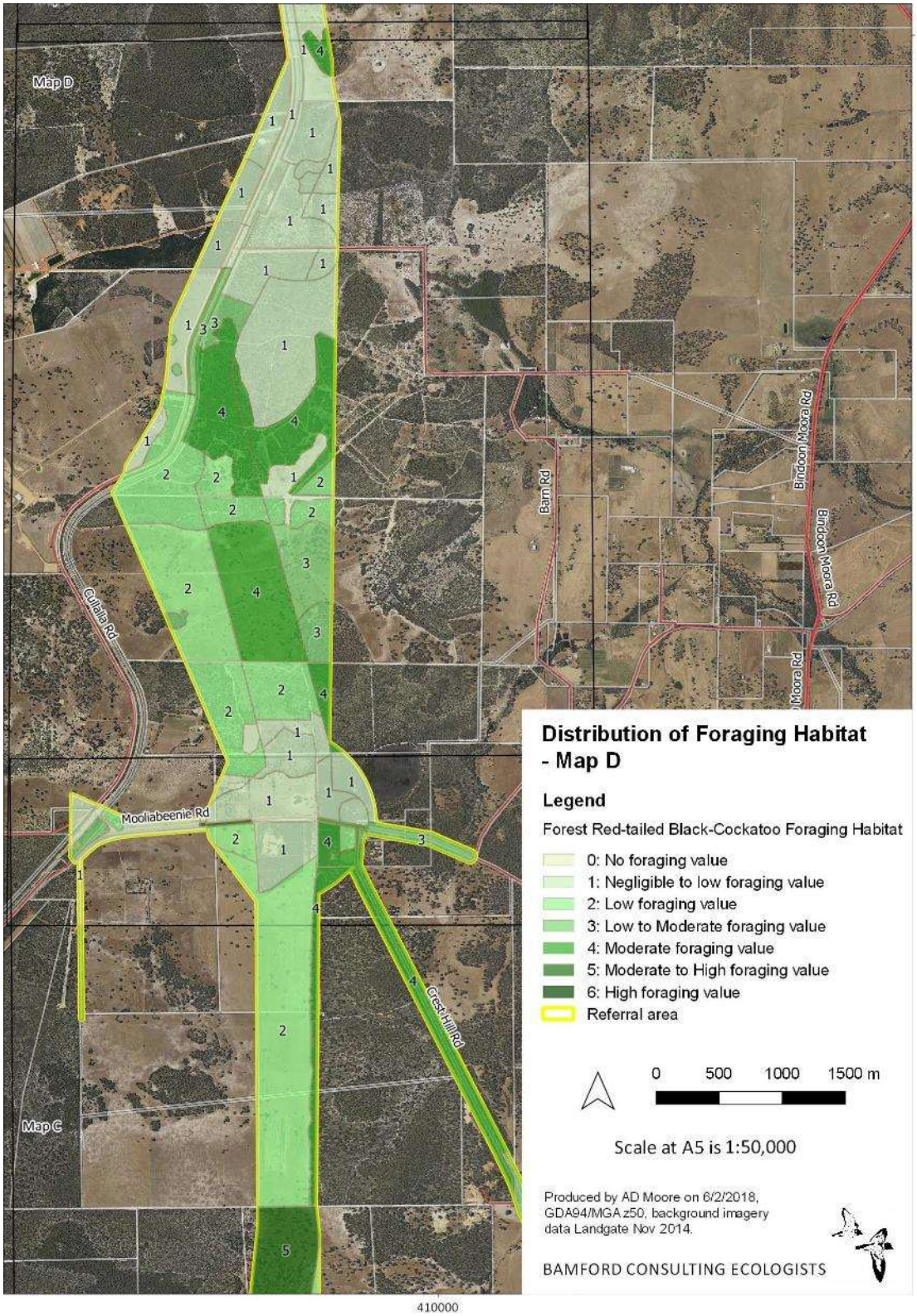
Appendix 8. Finer-scale maps of the distribution of Forest Red-tailed Black-Cockatoo foraging habitat within the referral area.

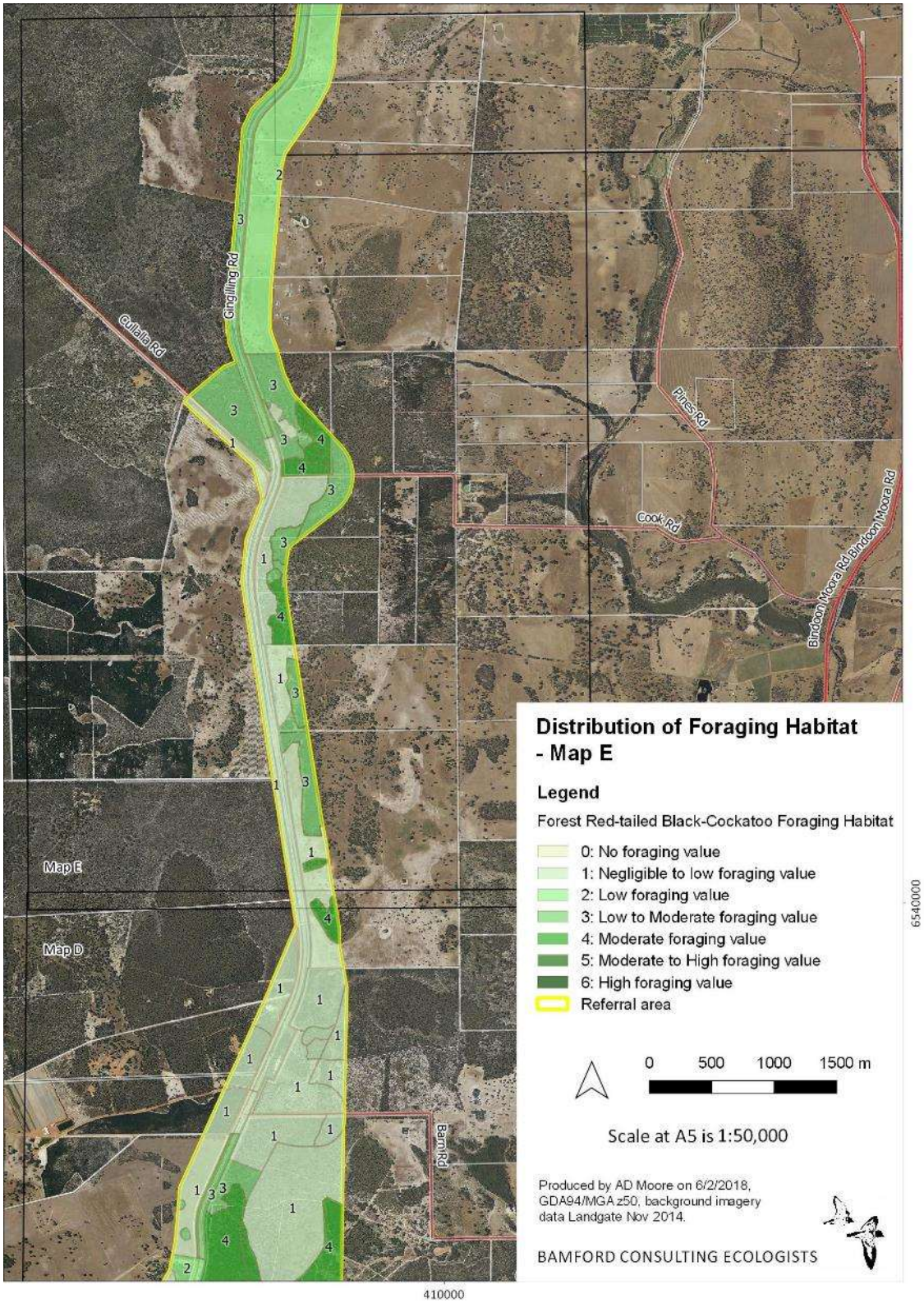
See Figure 11 for overview map.

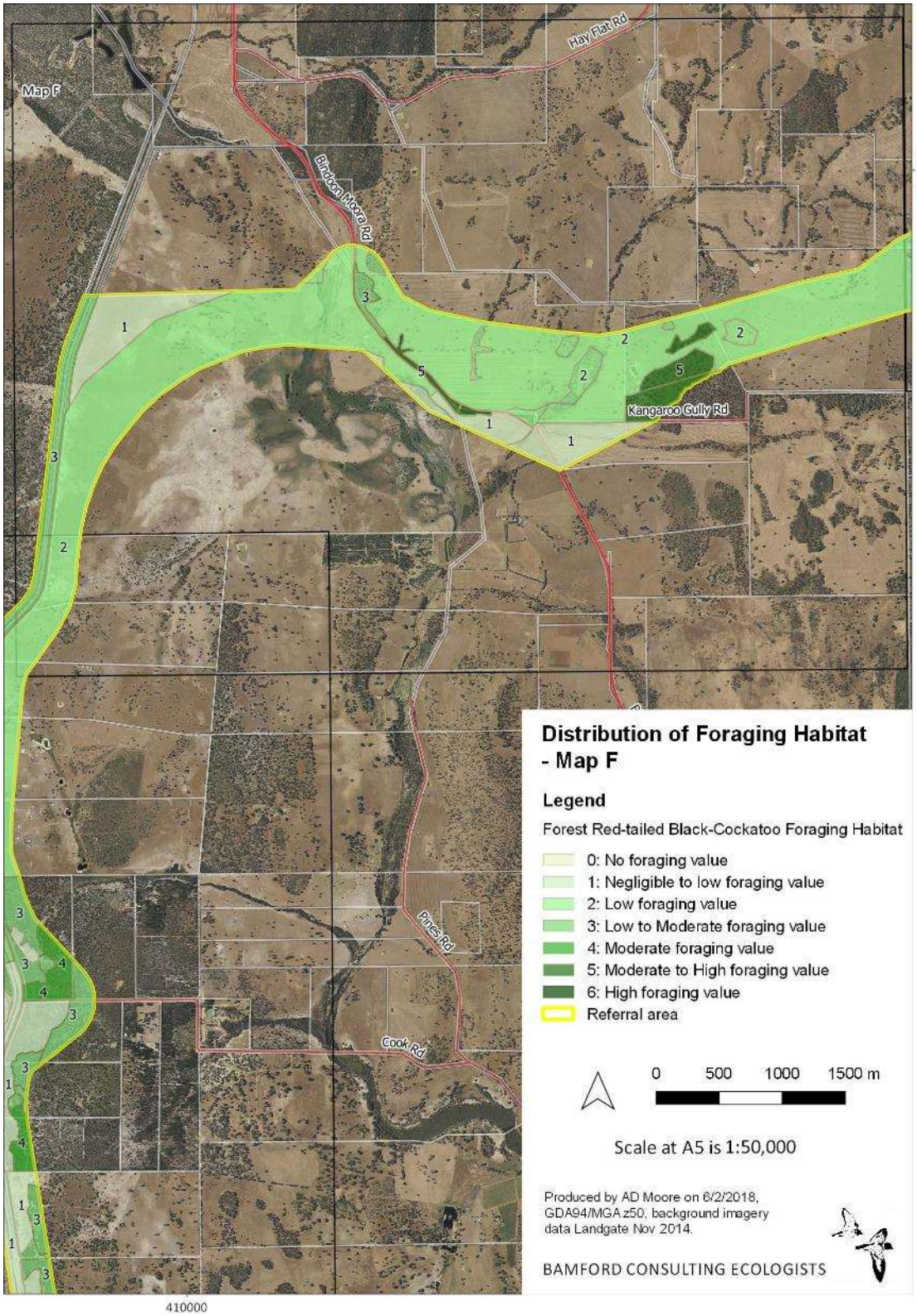


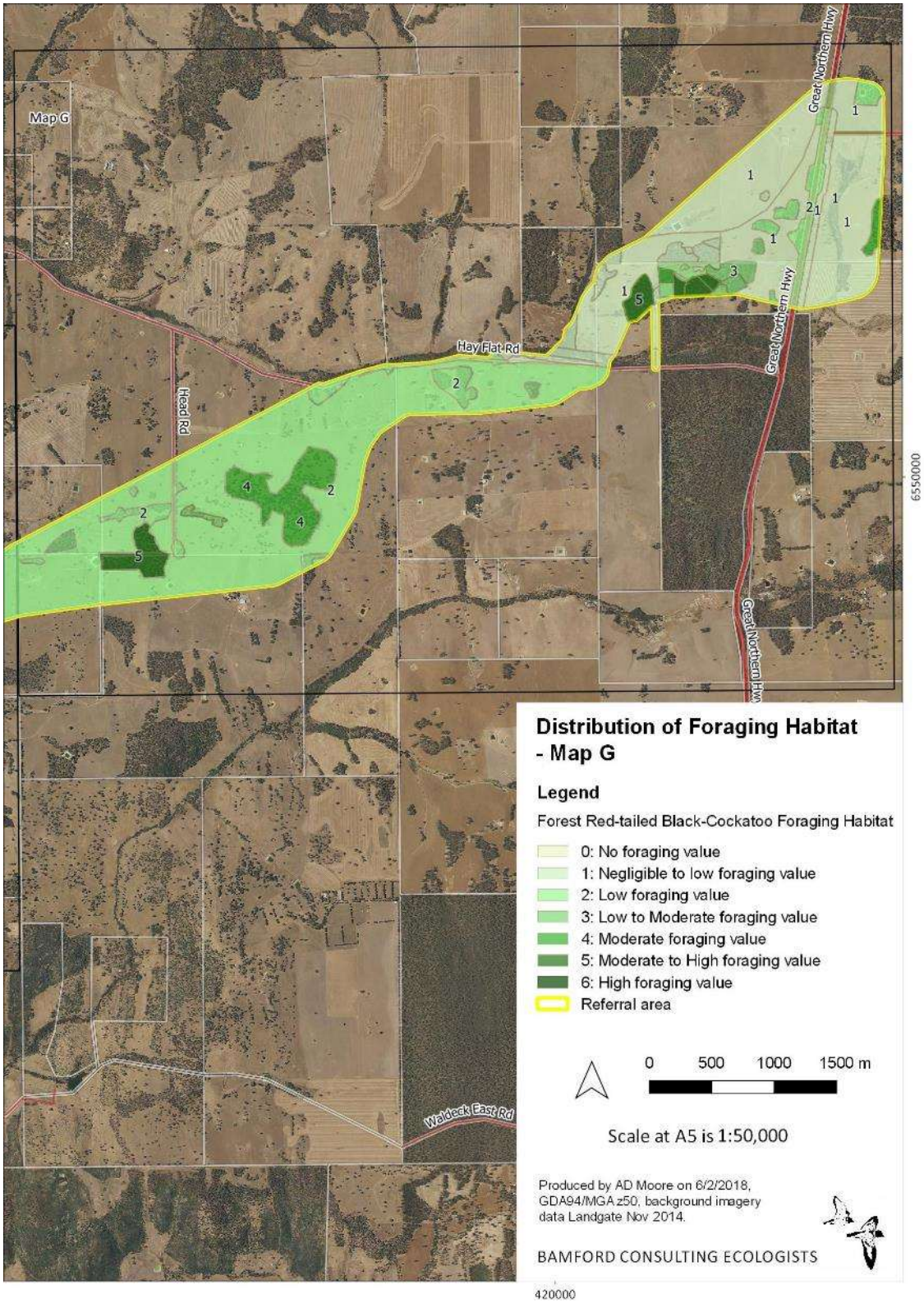

Crest Hill Rd
Crest Hill Rd
Gray Rd
Gray Rd
Forest Hills Pde
Map B
Teatree Rd
6530000
410000
Distribution of Foraging Habitat - Map B
Legend
Forest Red-tailed Black-Cockatoo Foraging Habitat
0: No foraging value
1: Negligible to low foraging value
2: Low foraging value
3: Low to Moderate foraging value
4: Moderate foraging value
5: Moderate to High foraging value
6: High foraging value
Referral area
0 500 1000 1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 6/2/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS


Mooliabeenie Rd
Mooliabeenie Rd
Bindoon Moora Rd
Bindoon Moora Rd
Map C
Great Hill Rd
Gray Rd
Map B
Forest Hill
Testree Rd
6530000
410000
Distribution of Foraging Habitat - Map C
Legend
Forest Red-tailed Black-Cockatoo Foraging Habitat
0: No foraging value
1: Negligible to low foraging value
2: Low foraging value
3: Low to Moderate foraging value
4: Moderate foraging value
5: Moderate to High foraging value
6: High foraging value
Referral area
0 500 1000 1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 6/2/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS


6540000
Map D
Bindoon Moora Rd
Barn Rd
Bindoon Moora Rd
Moore Rd
Quilalla Rd
Mooliabeenie Rd
Crest Hill Rd
Map C
410000
Distribution of Foraging Habitat - Map D
Legend
Forest Red-tailed Black-Cockatoo Foraging Habitat
0: No foraging value
1: Negligible to low foraging value
2: Low foraging value
3: Low to Moderate foraging value
4: Moderate foraging value
5: Moderate to High foraging value
6: High foraging value
Referral area
0 500 1000 1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 6/2/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS


Distribution of Foraging Habitat - Map E
Legend
Forest Red-tailed Black-Cockatoo Foraging Habitat
0: No foraging value
1: Negligible to low foraging value
2: Low foraging value
3: Low to Moderate foraging value
4: Moderate foraging value
5: Moderate to High foraging value
6: High foraging value
Referral area
0 500 1000 1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 6/2/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS
Gingilling Rd
Guilderton Rd
Pines Rd
Cook Rd
Bindoon Moora Rd
Barn Rd
Map E
Map D
410000
6540000


Map F
Hay Flat Rd
Bindoon Moora Rd
Kangaroo Gully Rd
Pines Rd
Cook Rd
6550000
410000
Distribution of Foraging Habitat - Map F
Legend
Forest Red-tailed Black-Cockatoo Foraging Habitat
0: No foraging value
1: Negligible to low foraging value
2: Low foraging value
3: Low to Moderate foraging value
4: Moderate foraging value
5: Moderate to High foraging value
6: High foraging value
Referral area
0 500 1000 1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 6/2/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS


Map G
Great Northern Hwy
Hay Flat Rd
Head Rd
Great Northern Hwy
Great Northern Hwy
Waldeck East Rd
6550000
420000
Distribution of Foraging Habitat - Map G
Legend
Forest Red-tailed Black-Cockatoo Foraging Habitat
0: No foraging value
1: Negligible to low foraging value
2: Low foraging value
3: Low to Moderate foraging value
4: Moderate foraging value
5: Moderate to High foraging value
6: High foraging value
Referral area
0 500 1000 1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 6/2/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS

Appendix 9. Records of foraging by black-cockatoos within the referral area.

Feed species: *Banksia attenuata* (Candlestick Banksia), *B. menziesii* (Firewood Banksia), *B. sessilis* (Parrot Bush), *Banksia* sp. (Unspecified banksia), *Corymbia calophylla* (Marri*), E. marginata* (Jarrah), and *E. todtiana* (Coastal Blackbutt).

Foraging Record	Zone	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
1	2/08/2017	410035	6518565	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
2	2/08/2017	410035	6518565	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
3	2/08/2017	410031	6518568	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
4	2/08/2017	410031	6518568	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
5	2/08/2017	410031	6518568	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
6	2/08/2017	410031	6518568	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
7	2/08/2017	410005	6518569	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
8	2/08/2017	410005	6518569	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
9	2/08/2017	410000	6518571	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Recent
10	2/08/2017	410000	6518571	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent
11	11/10/2017	409854	6518623	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
12	11/10/2017	409874	6518655	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
13	11/10/2017	409862	6518716	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Old
14	11/10/2017	409825	6518720	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
15	11/10/2017	409875	6518766	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
16	11/10/2017	409875	6518766	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
17	11/10/2017	409827	6518768	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate + old
18	11/10/2017	409877	6518770	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate

Foraging Record	Zone	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
19	11/10/2017	409868	6518789	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
20	11/10/2017	409817	6518806	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
21	11/10/2017	409856	6518824	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent + intermediate
22	11/10/2017	409806	6518847	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent + intermediate + old
23	11/10/2017	409814	6518996	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Old
24	11/10/2017	409593	6519244	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
25	11/10/2017	409784	6519305	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
26	11/10/2017	409754	6519445	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
27	11/10/2017	409694	6519542	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
28	11/10/2017	409728	6519560	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
29	2/08/2017	410759	6519616	Unspecified black-cockatoo	*Eucalyptus marginata*	Recent
30	2/08/2017	410858	6519621	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
31	31/07/2017	411101	6519730	Forest Red-tailed Black-Cockatoo	*Eucalyptus marginata*	Intermediate
32	31/07/2017	410945	6519796	Unspecified black-cockatoo	*Eucalyptus marginata*	Intermediate
33	31/07/2017	411049	6519800	Unspecified black-cockatoo	*Corymbia calophylla*	Intermediate
34	2/08/2017	410051	6521707	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
35	2/08/2017	409731	6521820	Carnaby's Black-Cockatoo	*Eucalyptus marginata*	Recent + intermediate
36	4/08/2017	409355	6523138	Carnaby's Black-Cockatoo	*Eucalyptus marginata*	Recent
37	5/09/2017	409288	6523260	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
38	4/09/2017	408997	6523932	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
39	10/10/2017	409007	6524309	Carnaby's Black-Cockatoo	*Unspecified sp.*	Recent + intermediate
40	3/08/2017	408697	6524312	Carnaby's Black-Cockatoo	*Banksia sp.*	Intermediate

Foraging Record	Zone	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
41	3/08/2017	408823	6524314	Carnaby's Black-Cockatoo	*Banksia sp.*	Intermediate
42	2/08/2017	408995	6524320	Carnaby's Black-Cockatoo	*Eucalyptus marginata*	Intermediate
43	2/08/2017	408997	6524324	Forest Red-tailed Black-Cockatoo	*Eucalyptus marginata*	Intermediate
44	2/08/2017	408932	6524331	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent
45	10/10/2017	408981	6524336	Carnaby's Black-Cockatoo	*Unspecified sp.*	Recent + intermediate
46	2/08/2017	408879	6524394	Carnaby's Black-Cockatoo	*Banksia sp.*	Intermediate
47	10/10/2017	409052	6524437	Carnaby's Black-Cockatoo	*Unspecified sp.*	Recent
48	2/08/2017	408891	6524464	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
49	11/10/2017	408789	6524470	Carnaby's Black-Cockatoo	*Banksia attenuata*	Intermediate
50	2/08/2017	409040	6524526	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
51	10/10/2017	409043	6524602	Carnaby's Black-Cockatoo	*Unspecified sp.*	Recent
52	11/10/2017	408716	6524831	Carnaby's Black-Cockatoo	*Eucalyptus marginata*	Recent
53	11/10/2017	409261	6525743	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Old
54	3/08/2017	408734	6526135	Carnaby's Black-Cockatoo	*Eucalyptus marginata*	Intermediate
55	3/08/2017	408757	6526147	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
56	10/10/2017	408690	6526172	Carnaby's Black-Cockatoo	*Unspecified sp.*	Recent
57	12/10/2017	408640	6526702	Carnaby's Black-Cockatoo	*Banksia attenuata*	Intermediate
58	12/10/2016	409102	6526950	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Old
59	4/08/2017	409076	6527008	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
60	11/10/2017	409293	6527206	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Old
61	4/08/2017	409292	6527208	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
62	12/10/2017	408667	6527743	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate

Foraging Record	Zone	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
63	12/10/2017	408500	6527752	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
64	3/08/2017	408530	6527854	Forest Red-tailed Black-Cockatoo	*Eucalyptus marginata*	Recent + intermediate
65	10/10/2017	410109	6527886	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
66	10/10/2017	410091	6527910	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
67	10/10/2017	410064	6527946	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
68	18/10/2016	409988	6528005	Carnaby's Black-Cockatoo	*Eucalyptus marginata*	Recent + intermediate
69	18/10/2016	409988	6528005	Forest Red-tailed Black-Cockatoo	*Eucalyptus marginata*	Recent + intermediate
70	18/10/2016	409982	6528048	Forest Red-tailed Black-Cockatoo	*Eucalyptus marginata*	Intermediate
71	3/08/2017	408370	6528057	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
72	7/10/2016	409195	6528144	Forest Red-tailed Black-Cockatoo	*Eucalyptus marginata*	Old
73	7/10/2016	409219	6528151	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Old
74	7/10/2016	409259	6528152	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent + old
75	11/10/2017	409290	6528542	Carnaby's Black-Cockatoo	*Unspecified sp.*	Intermediate
76	11/10/2017	408900	6529162	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Old
77	4/09/2017	408657	6529219	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent
78	4/09/2017	408622	6529223	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Old
79	4/09/2017	408662	6529238	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
80	4/09/2017	408660	6529299	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
81	4/09/2017	408638	6529320	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
82	9/10/2017	411430	6529348	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate + old
83	9/10/2017	411416	6529387	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent + intermediate
84	9/10/2017	411413	6529395	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Active + intermediate

Foraging Record	Zone	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
85	10/10/2017	411400	6529396	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Active
86	9/10/2017	411425	6529405	Carnaby's Black-Cockatoo	*Unspecified sp.*	Intermediate
87	10/10/2017	411353	6529445	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
88	5/09/2017	408388	6529465	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
89	10/10/2017	411339	6529470	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Old
90	9/10/2017	411391	6529495	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent + intermediate
91	9/10/2017	411283	6529758	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate + old
92	9/10/2017	411283	6529769	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Recent
93	15/11/2017	411316	6529770	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Active
94	9/10/2017	411270	6529794	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent
95	10/10/2017	411227	6529801	Forest Red-tailed Black-Cockatoo	*Eucalyptus marginata*	Recent
96	10/10/2017	411238	6529801	Forest Red-tailed Black-Cockatoo	*Eucalyptus marginata*	Intermediate
97	9/10/2017	411265	6529823	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent + intermediate + old
98	10/10/2017	410965	6530364	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Recent
99	10/10/2017	410633	6530957	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
100	10/10/2017	410566	6531024	Forest Red-tailed Black-Cockatoo	*Eucalyptus marginata*	Recent
101	10/10/2017	410560	6531032	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Recent
102	10/10/2017	410560	6531032	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent
103	9/10/2017	410371	6531377	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent
104	10/10/2017	410391	6531379	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Recent
105	10/10/2017	410391	6531379	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent
106	9/10/2017	410346	6531385	Carnaby's Black-Cockatoo	*Banksia attenuata*	Recent

Foraging Record	Zone	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
107	9/10/2017	410374	6531409	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent + intermediate
108	9/10/2017	410365	6531426	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent + intermediate
109	9/10/2017	410277	6531479	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate + old
110	9/10/2017	410315	6531517	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent
111	10/10/2017	410327	6531517	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
112	9/10/2017	410314	6531521	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent
113	9/10/2017	410219	6531598	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent + intermediate
114	9/10/2017	410244	6531665	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent
115	6/09/2017	409033	6531918	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
116	12/10/2017	409976	6532196	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
117	12/10/2017	409921	6532310	Carnaby's Black-Cockatoo	*Banksia attenuata*	Intermediate
118	12/10/2017	409858	6532429	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Recent
119	12/10/2017	409858	6532429	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent
120	6/09/2017	409073	6532515	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
121	3/08/2017	409036	6532536	Forest Red-tailed Black-Cockatoo	*Eucalyptus marginata*	Old
122	6/09/2017	409091	6532559	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
123	5/09/2017	409170	6532587	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent
124	6/09/2017	409096	6532617	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
125	3/08/2017	409009	6532718	Unspecified black-cockatoo	*Corymbia calophylla*	Intermediate
126	3/08/2017	409038	6532722	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent
127	12/10/2017	409631	6532787	Forest Red-tailed Black-Cockatoo	*Eucalyptus marginata*	Old
128	12/10/2017	409658	6532831	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate

Foraging Record	Zone	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
129	3/08/2017	409035	6533028	Forest Red-tailed Black-Cockatoo	*Eucalyptus marginata*	Intermediate
130	15/11/2017	409523	6533029	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Old
131	3/08/2017	409194	6533040	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
132	12/10/2017	409513	6533117	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
133	12/10/2017	409492	6533119	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Old
134	3/08/2017	409138	6533123	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Old
135	12/10/2017	409439	6533219	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Old
136	12/10/2017	409439	6533219	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Old
137	15/11/2017	409383	6533292	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Old
138	15/11/2017	409348	6533376	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Old
139	3/08/2017	409119	6533393	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent
140	3/08/2017	409203	6533488	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
141	3/08/2017	409345	6533572	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate + old
142	3/08/2017	409345	6533572	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate + old
143	11/10/2017	408170	6533742	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Old
144	1/08/2017	408262	6533922	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
145	17/10/2017	409035	6534331	Carnaby's Black-Cockatoo	*Eucalyptus todtiana*	Recent
146	17/10/2017	409072	6534334	Carnaby's Black-Cockatoo	*Banksia attenuata*	Old
147	17/10/2017	409079	6534422	Carnaby's Black-Cockatoo	*Banksia attenuata*	Old
148	17/10/2017	408057	6534631	Carnaby's Black-Cockatoo	*Unspecified sp.*	Recent + intermediate
149	17/10/2017	408264	6534637	Carnaby's Black-Cockatoo	*Banksia attenuata*	Old
150	17/10/2017	408353	6534665	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate

Foraging Record	Zone	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
151	17/10/2017	408319	6534693	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Recent
152	17/10/2017	408238	6534729	Carnaby's Black-Cockatoo	*Banksia attenuata*	Old
153	17/10/2017	408221	6534781	Carnaby's Black-Cockatoo	*Banksia attenuata*	Old
154	17/10/2017	408345	6534797	Carnaby's Black-Cockatoo	*Banksia sp.*	Intermediate
155	17/10/2017	408307	6534812	Carnaby's Black-Cockatoo	*Banksia sp.*	Intermediate
156	17/10/2017	408190	6534840	Carnaby's Black-Cockatoo	*Banksia attenuata*	Old
157	17/10/2017	408439	6534912	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Recent + intermediate
158	17/10/2017	408271	6534968	Carnaby's Black-Cockatoo	*Banksia sp.*	Intermediate
159	17/10/2017	408119	6534978	Carnaby's Black-Cockatoo	*Banksia attenuata*	Intermediate + old
160	17/10/2017	408111	6534992	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Recent + intermediate
161	17/10/2017	408226	6535003	Carnaby's Black-Cockatoo	*Unspecified sp.*	Recent + intermediate
162	17/10/2017	407999	6535031	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Recent + intermediate
163	17/10/2017	408171	6535038	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
164	3/08/2017	408126	6536978	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent + intermediate
165	3/08/2017	408255	6537032	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Old
166	3/08/2017	408206	6537136	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
167	3/08/2017	408133	6537231	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
168	3/08/2017	408256	6537325	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate + old
169	3/08/2017	408082	6537356	Forest Red-tailed Black-Cockatoo	*Eucalyptus marginata*	Recent + intermediate
170	3/08/2017	408112	6537566	Carnaby's Black-Cockatoo	*Banksia menziesii*	Old
171	1/08/2017	408506	6538415	Carnaby's Black-Cockatoo	*Banksia attenuata*	Old
172	1/08/2017	408905	6539413	Carnaby's Black-Cockatoo	*Banksia attenuata*	Old

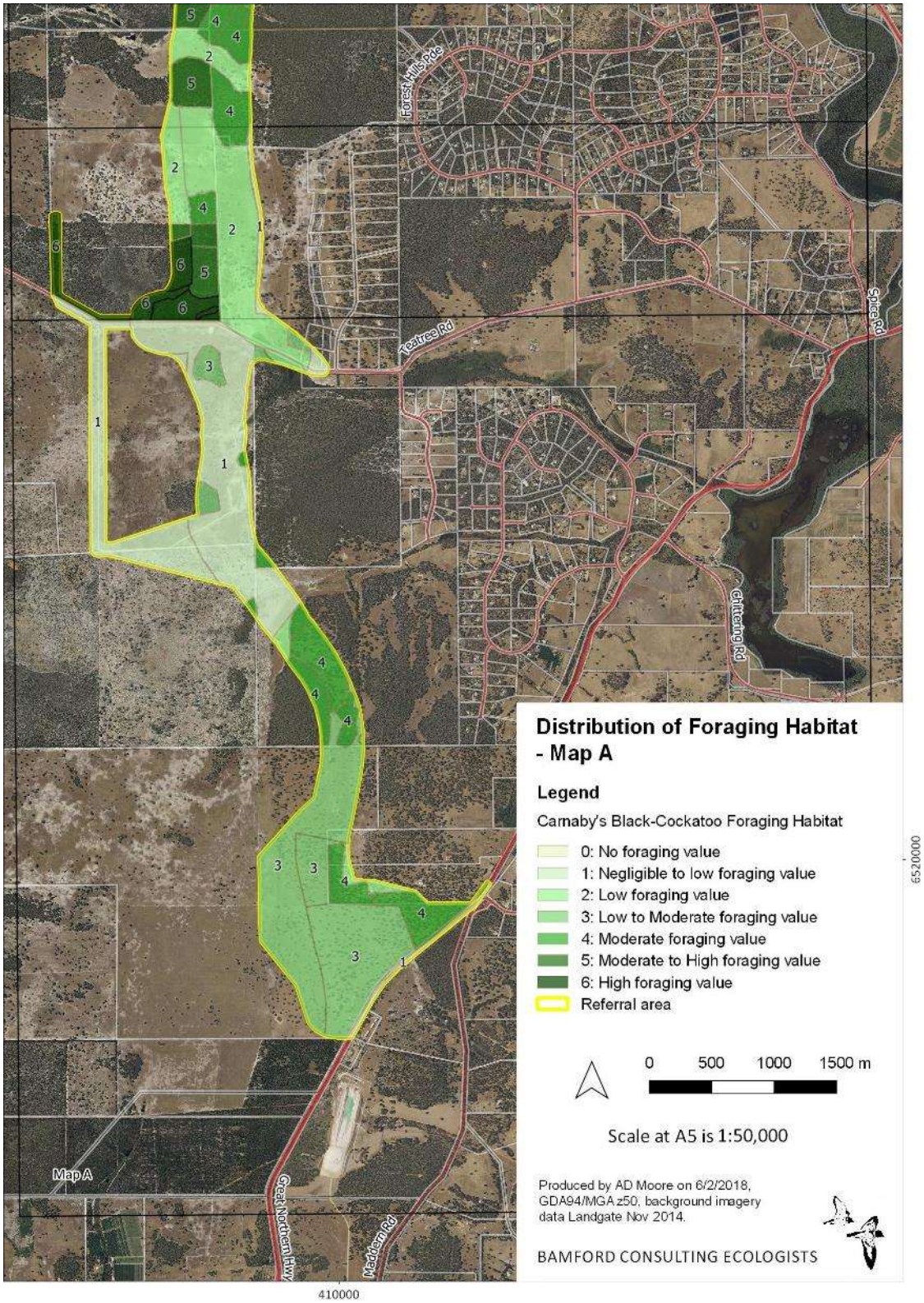
Foraging Record	Zone	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
173	1/08/2017	409093	6539681	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Old
174	1/08/2017	409125	6540015	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Old
175	1/08/2017	409100	6540039	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Old
176	1/08/2017	408722	6541264	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent + intermediate
177	6/10/2016	408668	6541392	Carnaby's Black-Cockatoo	*Banksia attenuata*	Unspecified
178	1/08/2017	408745	6542286	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
179	1/08/2017	408760	6542298	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent
180	1/08/2017	408760	6542305	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
181	1/08/2017	408515	6542407	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent + intermediate
182	1/08/2017	408494	6542448	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Recent
183	1/08/2017	408682	6542459	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
184	1/08/2017	408709	6542466	Unspecified black-cockatoo	*Corymbia calophylla*	Old
185	2/08/2017	408616	6542534	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
186	2/08/2017	408686	6542569	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
187	2/08/2017	408583	6542571	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
188	2/08/2017	408681	6542573	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
189	2/08/2017	408594	6542582	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Intermediate
190	2/08/2017	408751	6542602	Carnaby's Black-Cockatoo	*Banksia attenuata*	Old
191	2/08/2017	408707	6542640	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Old
192	15/11/2017	408508	6543693	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
193	8/09/2017	412913	6547701	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent
194	8/09/2017	412913	6547701	Forest Red-tailed Black-Cockatoo	*Corymbia calophylla*	Recent

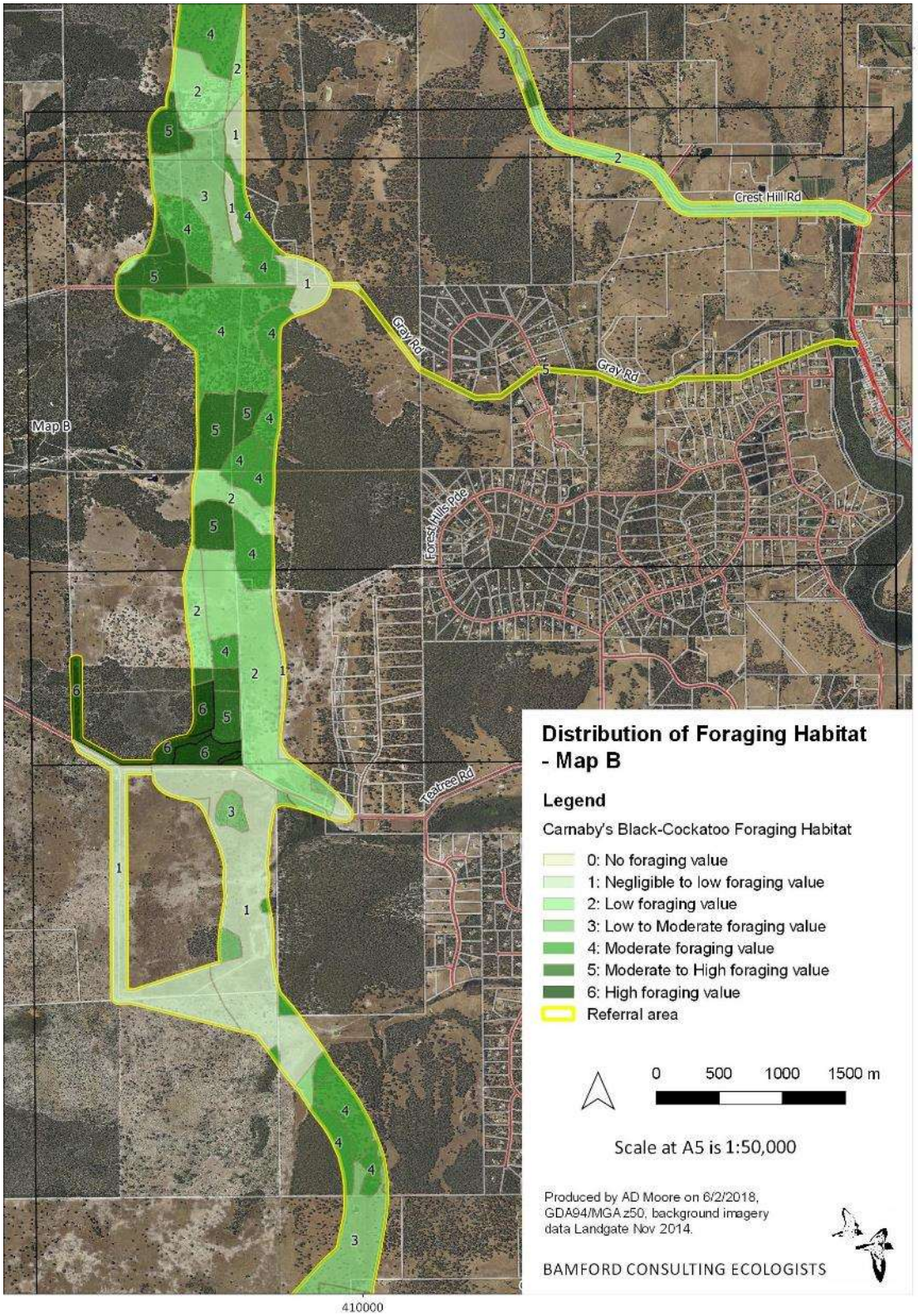
Foraging Record	Zone	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
195	10/10/2017	413629	6547997	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Recent
196	18/10/2016	411958	6548321	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
197	18/10/2016	411933	6548329	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
198	18/10/2016	411927	6548366	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
199	18/10/2016	411913	6548375	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
200	18/10/2016	411855	6548430	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
201	18/10/2016	411812	6548441	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
202	18/10/2016	411846	6548444	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
203	18/10/2016	411806	6548446	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
204	18/10/2016	411829	6548449	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
205	18/10/2016	411798	6548451	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
206	18/10/2016	411790	6548461	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
207	18/10/2016	411784	6548465	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
208	18/10/2016	411789	6548478	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
209	18/10/2016	411767	6548480	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
210	18/10/2016	411760	6548482	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
211	18/10/2016	411749	6548491	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
212	18/10/2016	411754	6548507	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
213	18/10/2016	411724	6548510	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
214	18/10/2016	411719	6548537	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
215	18/10/2016	411691	6548541	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
216	18/10/2016	411682	6548542	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate

Foraging Record	Zone	Easting	Northing	Black-cockatoo Species	Feed Species	Age Of Feed Sign
217	18/10/2016	411700	6548551	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
218	18/10/2016	411670	6548577	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
219	18/10/2016	411637	6548581	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
220	18/10/2016	411624	6548598	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
221	18/10/2016	411612	6548608	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
222	18/10/2016	411594	6548619	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
223	18/10/2016	411598	6548622	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
224	18/10/2016	411629	6548626	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Intermediate
225	6/09/2017	414750	6548656	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Recent + intermediate
226	18/10/2016	416712	6549199	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Recent + intermediate + old
227	18/10/2016	416775	6549381	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Recent
228	6/09/2017	417919	6549576	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Old
229	10/10/2017	417845	6549821	Carnaby's Black-Cockatoo	*Unspecified sp.*	Recent
230	7/09/2017	420978	6551723	Carnaby's Black-Cockatoo	*Banksia sessilis*	Recent + intermediate
231	6/09/2017	421212	6551856	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Old
232	8/09/2017	421988	6552012	Unspecified black-cockatoo	*Corymbia calophylla*	Old
233	8/09/2017	421988	6552012	Unspecified black-cockatoo	*Corymbia calophylla*	Old
234	18/10/2016	422111	6552626	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Old
235	18/10/2016	422114	6552651	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Old
236	18/10/2016	422127	6552731	Carnaby's Black-Cockatoo	*Corymbia calophylla*	Old
237	6/09/2017	422125	6552917	Unspecified black-cockatoo	*Corymbia calophylla*	Old

Appendix 10. Finer-scale maps of the distribution of Carnaby's Black-Cockatoo foraging habitat within the referral area.

See Figure 14 for overview map.




6530000
Crest Hill Rd
Gray Rd
Gray Rd
Map B
Forest Hills Pde
Textree Rd
410000
Distribution of Foraging Habitat - Map B
Legend
Carnaby's Black-Cockatoo Foraging Habitat
0: No foraging value
1: Negligible to low foraging value
2: Low foraging value
3: Low to Moderate foraging value
4: Moderate foraging value
5: Moderate to High foraging value
6: High foraging value
Referral area
0 500 1000 1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 6/2/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
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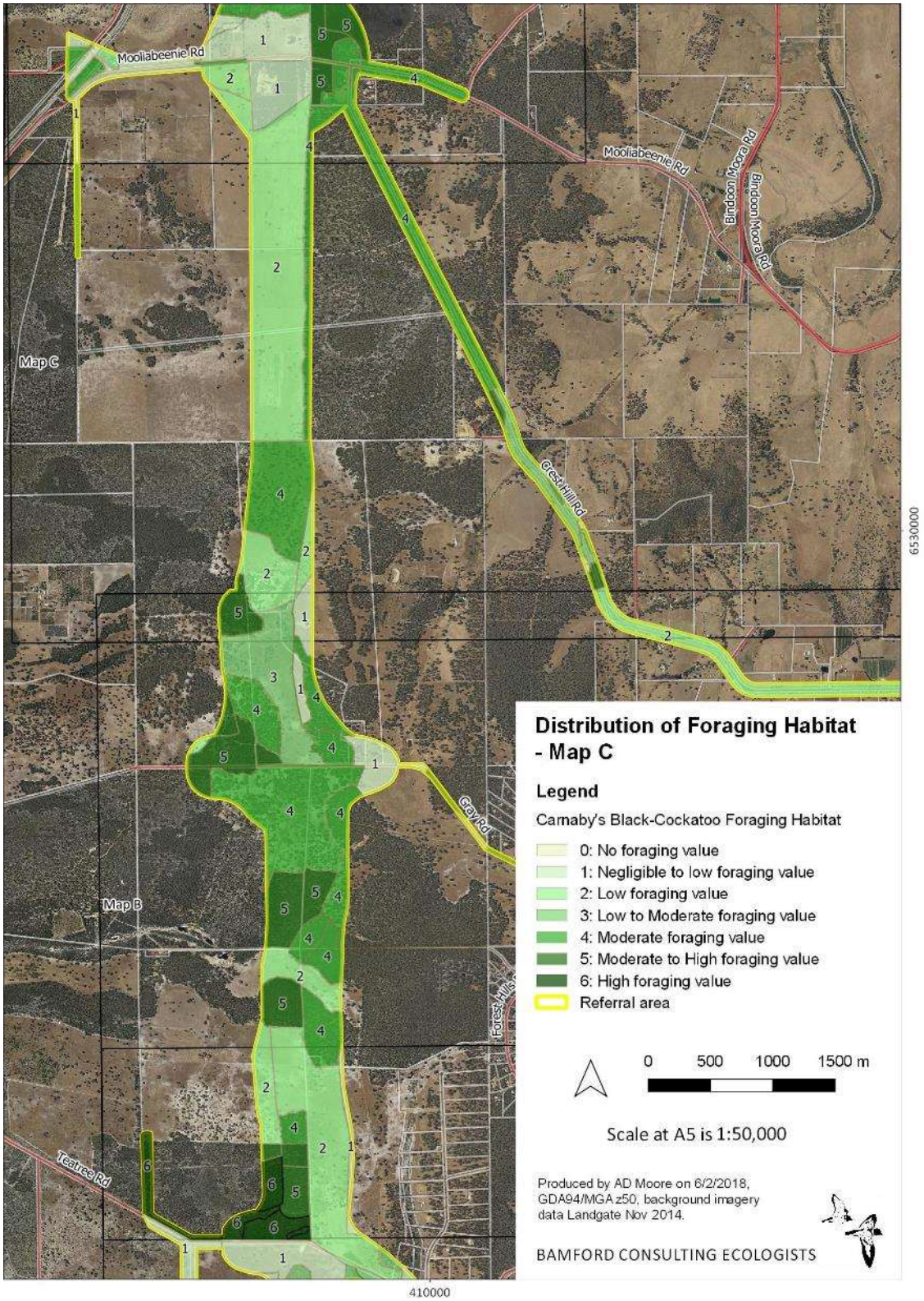
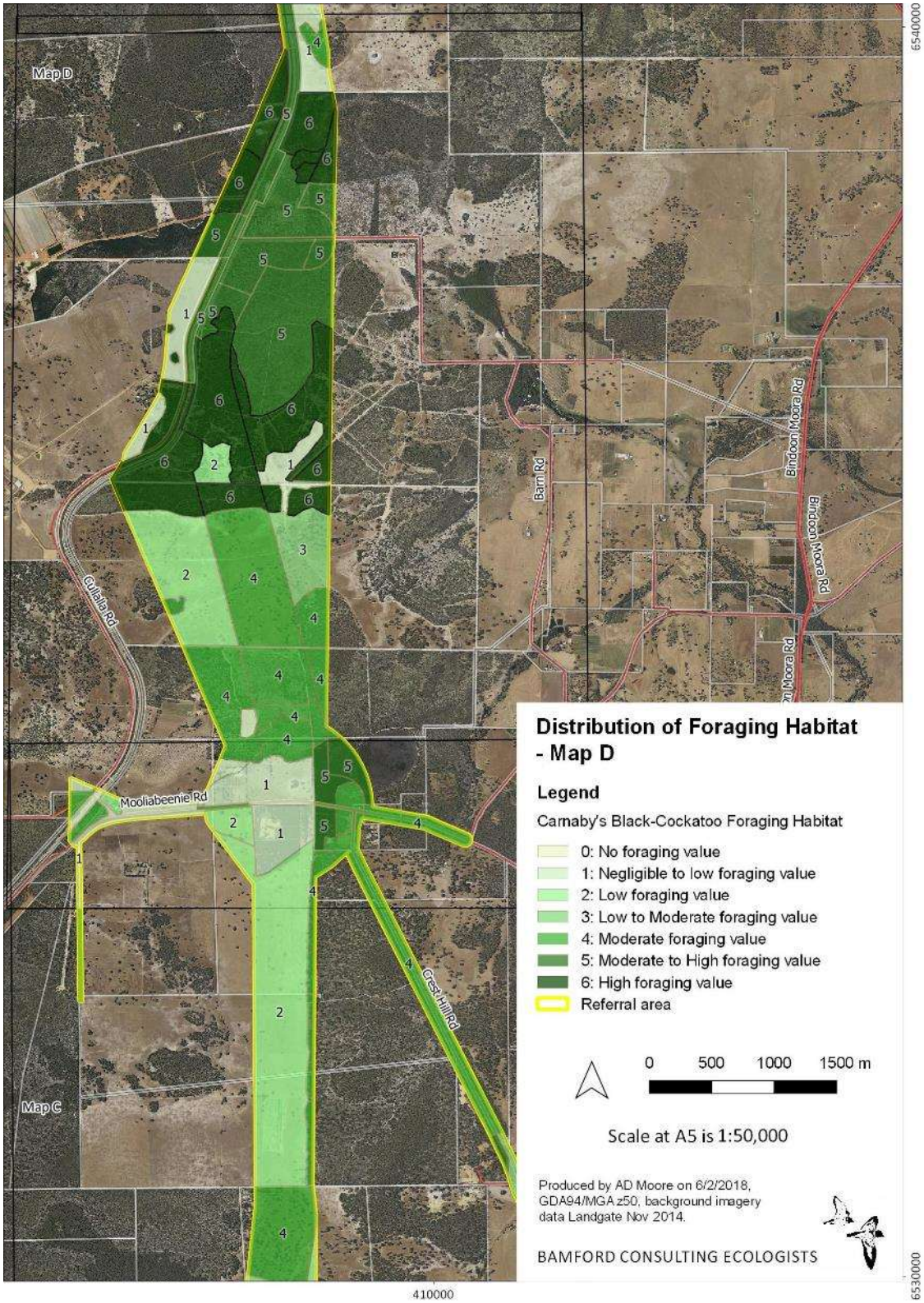
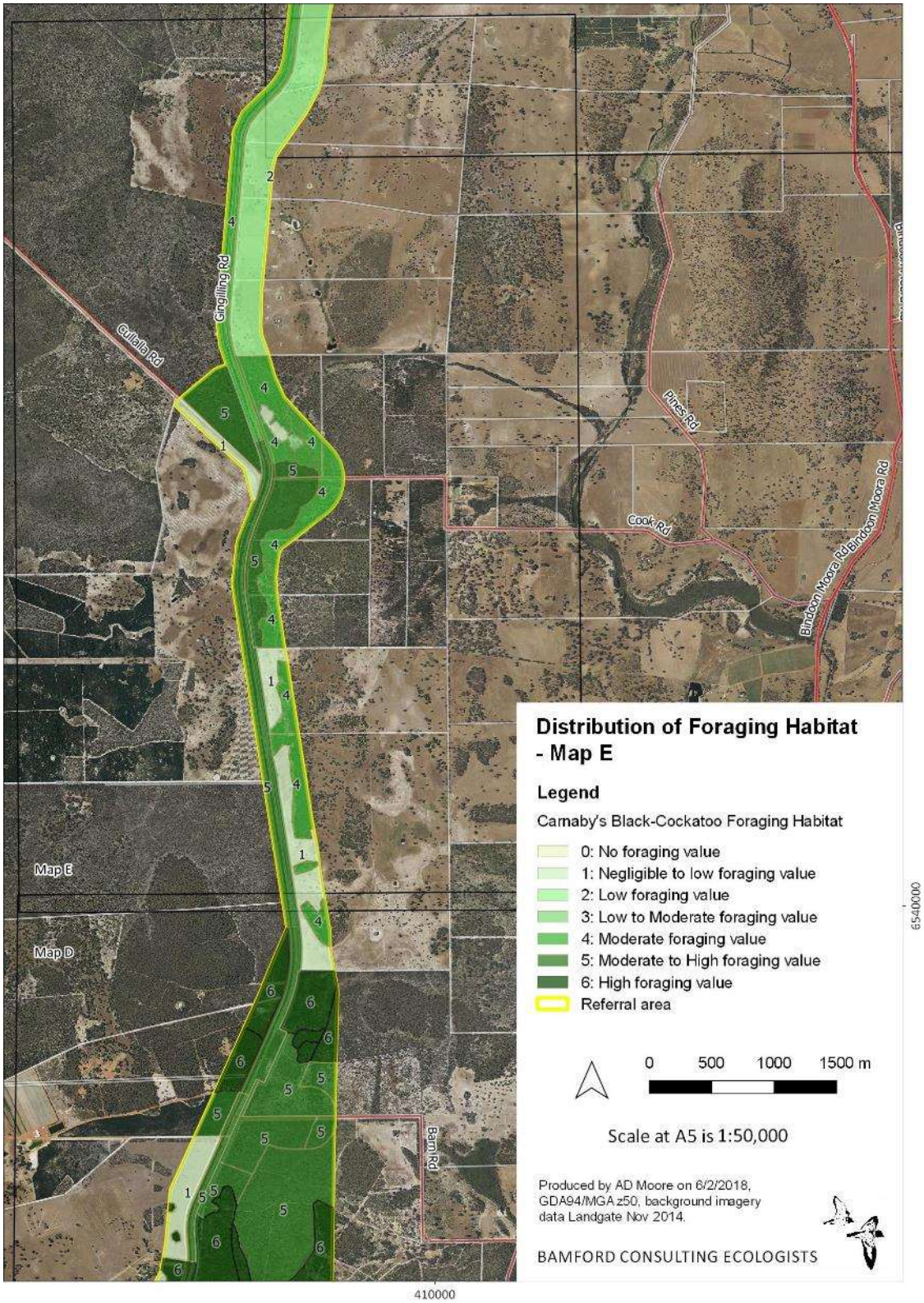
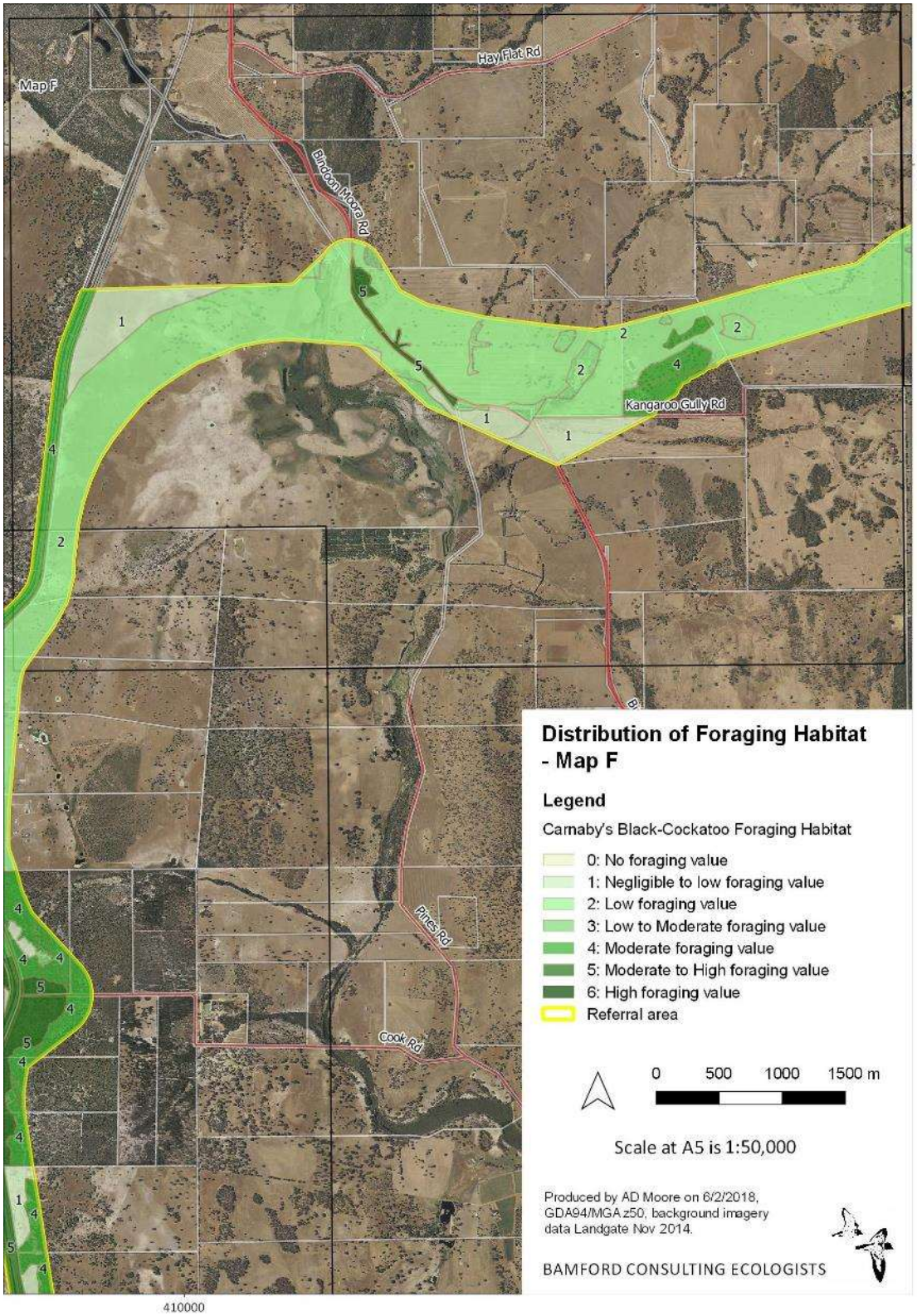
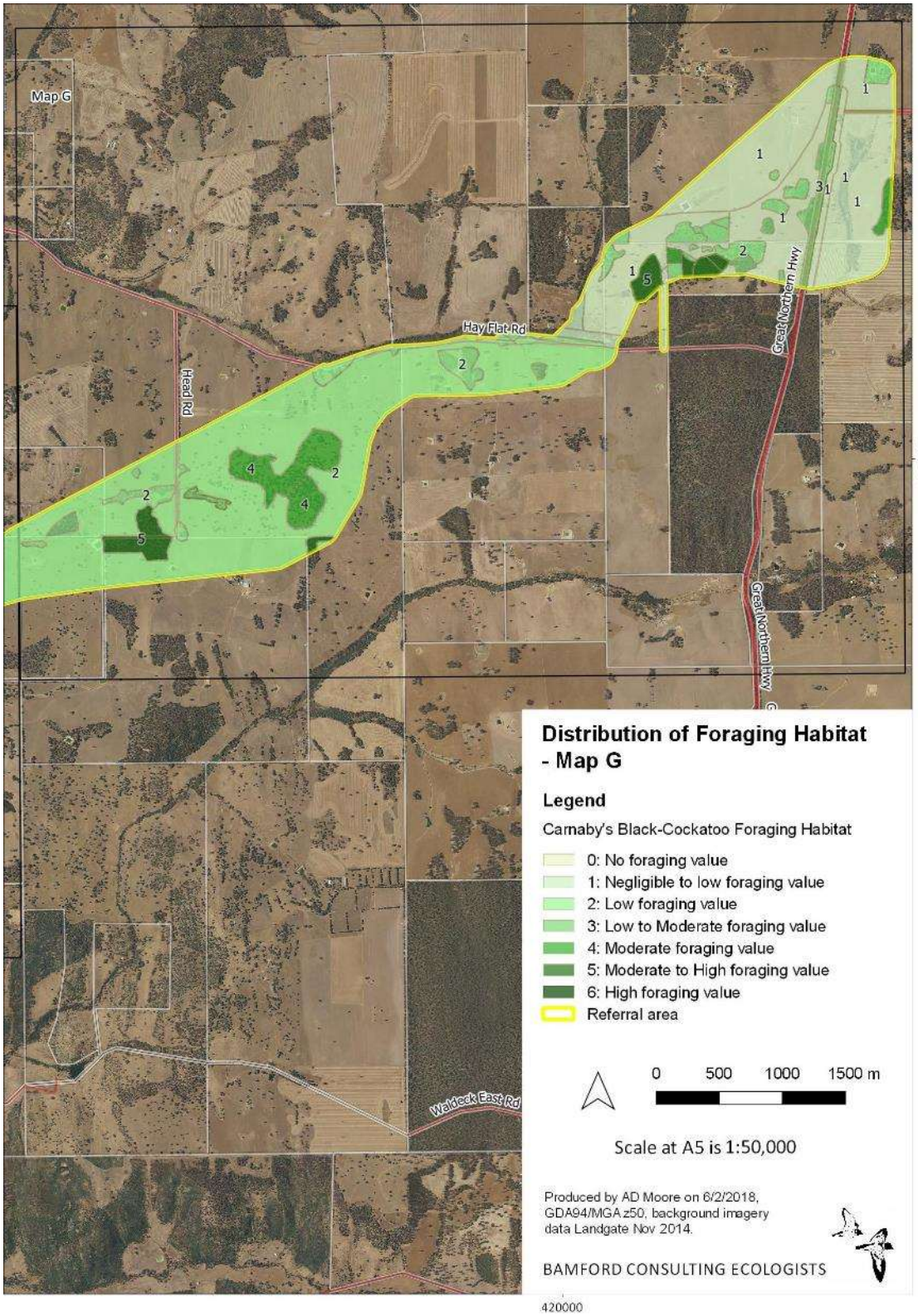

Mooliabeenie Rd
Mooliabeenie Rd
Bindoon Moora Rd
Bindoon Moora Rd
Map C
Crest Hill Rd
Map B
Gray Rd
Forest Hills
Teatree Rd
6530000
410000
Distribution of Foraging Habitat - Map C
Legend
Carnaby's Black-Cockatoo Foraging Habitat
0: No foraging value
1: Negligible to low foraging value
2: Low foraging value
3: Low to Moderate foraging value
4: Moderate foraging value
5: Moderate to High foraging value
6: High foraging value
Referral area
0 500 1000 1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 6/2/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS


Map D
Map C
Barn Rd
Bindoon Moora Rd
Cullalla Rd
Mooliabeenie Rd
Great Hill Rd
6540000
6530000
410000
Distribution of Foraging Habitat - Map D
Legend
Carnaby's Black-Cockatoo Foraging Habitat
0: No foraging value
1: Negligible to low foraging value
2: Low foraging value
3: Low to Moderate foraging value
4: Moderate foraging value
5: Moderate to High foraging value
6: High foraging value
Referral area
0 500 1000 1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 6/2/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS


Gingilling Rd
Gulbalia Rd
Pines Rd
Cook Rd
Bindoon Moora Rd
Bindoon Moora Rd
Barn Rd
Map E
Map D
Distribution of Foraging Habitat - Map E
Legend
Carnaby's Black-Cockatoo Foraging Habitat
0: No foraging value
1: Negligible to low foraging value
2: Low foraging value
3: Low to Moderate foraging value
4: Moderate foraging value
5: Moderate to High foraging value
6: High foraging value
Referral area
0 500 1000 1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 6/2/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS
410000
6540000


Map F
Hay Flat Rd
Bindoon Moora Rd
Kangaroo Gully Rd
Pines Rd
Cook Rd
6550000
410000
Distribution of Foraging Habitat - Map F
Legend
Carnaby's Black-Cockatoo Foraging Habitat
0: No foraging value
1: Negligible to low foraging value
2: Low foraging value
3: Low to Moderate foraging value
4: Moderate foraging value
5: Moderate to High foraging value
6: High foraging value
Referral area
0 500 1000 1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 6/2/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
BAMFORD CONSULTING ECOLOGISTS


Map G
Hay Flat Rd
Head Rd
Great Northern Hwy
Great Northern Hwy
Waldeck East Rd
6550000
420000
Distribution of Foraging Habitat - Map G
Legend
Carnaby's Black-Cockatoo Foraging Habitat
0: No foraging value
1: Negligible to low foraging value
2: Low foraging value
3: Low to Moderate foraging value
4: Moderate foraging value
5: Moderate to High foraging value
6: High foraging value
Referral area
0 500 1000 1500 m
Scale at A5 is 1:50,000
Produced by AD Moore on 6/2/2018, GDA94/MGA z50, background imagery data Landgate Nov 2014.
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