Black-Cockatoo Assessment
Orton Road, Byford

Flock of Carnaby's Black-Cockatoo foraging in Banksia woodland along Orton Road (Photo: J. Wadey)

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Contents

1 Introduction

1.1 Background

The Shire of Serpentine-Jarrahdale is proposing to upgrade Orton Road near Byford on the outskirts of Perth. The upgrade may involve widening of the road and associated clearance of roadside vegetation. Bamford Consulting Ecologists (BCE) was commissioned to conduct a targeted black-cockatoo assessment of the existing roadside vegetation along the proposed upgrade along Orton Road. This included assessing the foraging, breeding and nesting value of the existing vegetation for black-cockatoos. This report presents a summary of the findings of the desktop assessment and the results of the field survey.

1.2 Survey area

The survey area is located within the suburb of Byford on the outskirts of Perth. The section of Orton Road which is planned for upgrade spans approximately 6.5 km from King Road in the west to Hopkinson Road in the east (Figure 1-1). It runs through rural areas comprised mostly of paddocks with scattered remnant trees/woodland and planted trees. The survey area consisted of the roadside verge, bounded by the road and paddock fences or obvious boundaries such as treelines.

1.3 Black-cockatoo species

The three black-cockatoo species of interest are described here:

1. **Carnaby's Black-Cockatoo *Zanda latirostris***

   Listed as: Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and under Schedule 2 Division 2 (Endangered) of the Western Australian *Biodiversity Conservation Act 2016* (BC Act).

   Distribution and habitat: Endemic to south-western Western Australia, from Kalbarri in the north, east to Merredin and Ravensthorpe, and then further east along the south coast to the Esperance area (Johnstone and Storr 1998; DAWE 2021a). Breeds (July to December) predominantly in the east of its range with a migration to coastal areas in the non-breeding period. In recent years, however, the species has expanded its breeding range westward and south into the Jarrah-Marri forests of the Darling Scarp and into the Tuart forests of the Swan Coastal Plain (DAWE 2021a). Heavily reliant on areas of Banksia woodland and proteaceous shrubland/heath for foraging (Johnstone and Storr 1998; DAWE 2021a).

   Ecology: Diurnal granivore, feeding predominantly on the seeds of the Proteaceae (especially banksias) but also known to feed on a very wide variety of plants, including non-native ornamentals and plantation species such as pine (Valentine and Stock 2008; Groom 2011; DPaW 2013; Johnston *et al.* 2016; DAWE 2021a). Reliant on large tree-hollows in eucalypts (especially smooth-barked species such as Wandoo and Salmon Gum) for breeding (Saunders 1974; Johnstone and Storr 1998; DAWE 2021a). Threatened by habitat loss, habitat degradation, nest hollow shortage, and competition for available nest hollows from other parrots and feral Honeybees, illegal shooting and illegal trade (Burbidge 2004; DAWE 2021a).

2. Forest Red-tailed Black-Cockatoo *Calyptorhynchus banksia naso*

Listed as: Vulnerable under the EPBC Act and Vulnerable under Schedule 2 Division 3 (Vulnerable) of the WA BC Act.

Distribution and habitat: Endemic to the deeper south-west of Western Australia, from around Gingin in the north, east to Mount Helena, North Bannister and Mount Saddleback, and south to around Albany (Johnstone and Storr 1998). In recent years there appears to have been a distinct expansion of the range of this species on to the Swan Coastal Plain, including many suburbs within the Perth metropolitan area. Generally restricted to areas of Jarrah-Marri forest, farmlands with remnant trees and urban landscapes. Forest Red-tailed Black-Cockatoos are currently considered not to undergo regular migration (DAWE 2021b). Two other sub-species occur in Western Australia: *C. b. escondidus* in the western mid-west and Pilbara, and *C. b. macrorhynchus* in the Kimberley (Johnstone and Storr 1998). Neither of these are conservation significant species.

Ecology: Diurnal granivore, feeding predominantly on the seeds of Jarrah and Marri (Johnstone and Kirkby 1999; Johnstone *et al.* 2013b) but is also adapting to foraging on urban (introduced) plant species. Reliant on large tree-hollows in eucalypts (especially Marri) for breeding (Johnstone *et al.* 2013a; DAWE 2021b). Threatened by habitat loss, habitat degradation, nest hollow shortage, and competition for available nest hollows from other parrots and feral Honeybees (DAWE 2021b).

3. Baudin's Black-Cockatoo *Zanda baudinii*

Listed as: Endangered under the EPBC Act and Endangered under Schedule 2 Division 2 (Endangered) of the WA BC Act.

Distribution and habitat: Endemic to south-western Western Australia, from Albany in the south to Gidgegannup and Mundaring and inland to Kojonup (DCCEEW 2023). Breeds to the south-west between Leschenault, Collie and Albany, with the most northerly record at Lowden (Johnstone and Storr 1998) and Serpentine (Johnstone and Kirkby 2008). Range varies between breeding and non-breeding seasons with range in far south-west of WA during breeding season (October to January) and range expanding during non-breeding season, with some flocks moving onto southern Swan Coastal Plain (DCCEEW 2023). Mainly in eucalypt forests of Jarrah, Marri and Karri and less frequently in Wandoo, Blackbutt, rural areas including roadside trees (Johnstone and Kirkby 2008).

Ecology: Primary food source is Marri, feeding on its seeds, flowers, nectar and buds (Saunders 1979, Johnstone and Kirkby 2008), with Jarrah as its secondary food source. Will also feed on Sheoak, banksia and other proteaceous shrubs/heath (DCCEEW 2023).

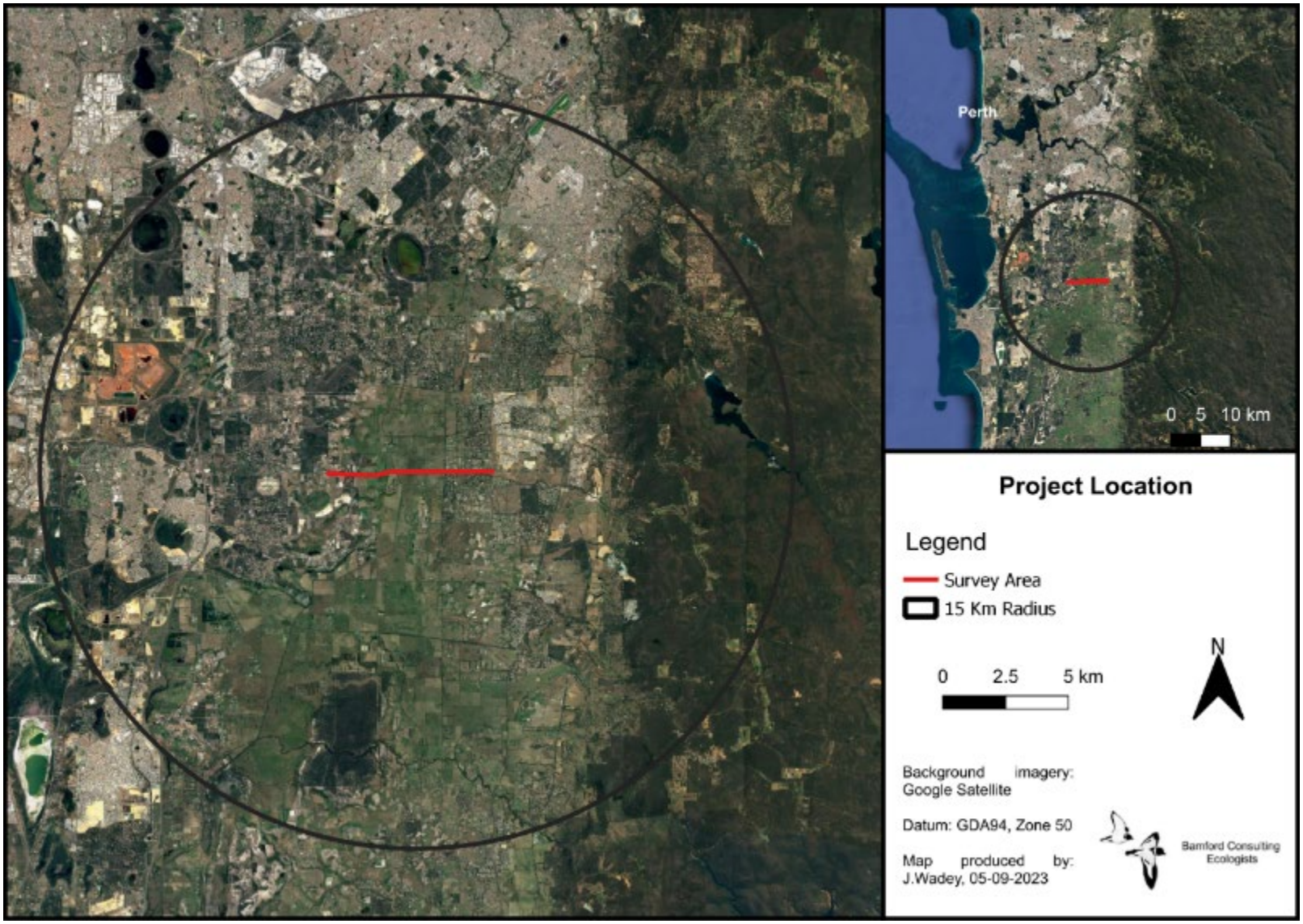

Figure 1-1. Location of survey area and 15 km radius

2 Methods

2.1 Desktop and field investigations

A desktop assessment of black-cockatoo nesting and roosting sites was conducted through BirdLife Australia and the Department of Biodiversity, Conservation and Attractions (DBCA). Their databases provide the most detailed and up-to-date black-cockatoo records, including data from the Great Cocky Count. The BCE database was also consulted; this contains data from many years of surveys throughout the region.

The survey was visited on 1st July 2023 by Ms. Natalia Huang (BSc. Hons. MBA.) and Dr. Jamie Wadey (BSc. Hons. PhD.). This involved driving along and walking through the roadside vegetation along the length of the survey area and assessing its value for black-cockatoos. This included identification of Vegetation and Substrate Associations (VSAs), searching for evidence of foraging by black-cockatoos, assessing foraging value of each VSA, recording potential nest trees and assessing suitability of the area for a roost. Detailed methods of the breeding, foraging and roosting assessment are given in the following section. The GPS tracks of personnel taken throughout the survey area are shown in Figure 2-1, Figure 2-2 and Figure 2-3.

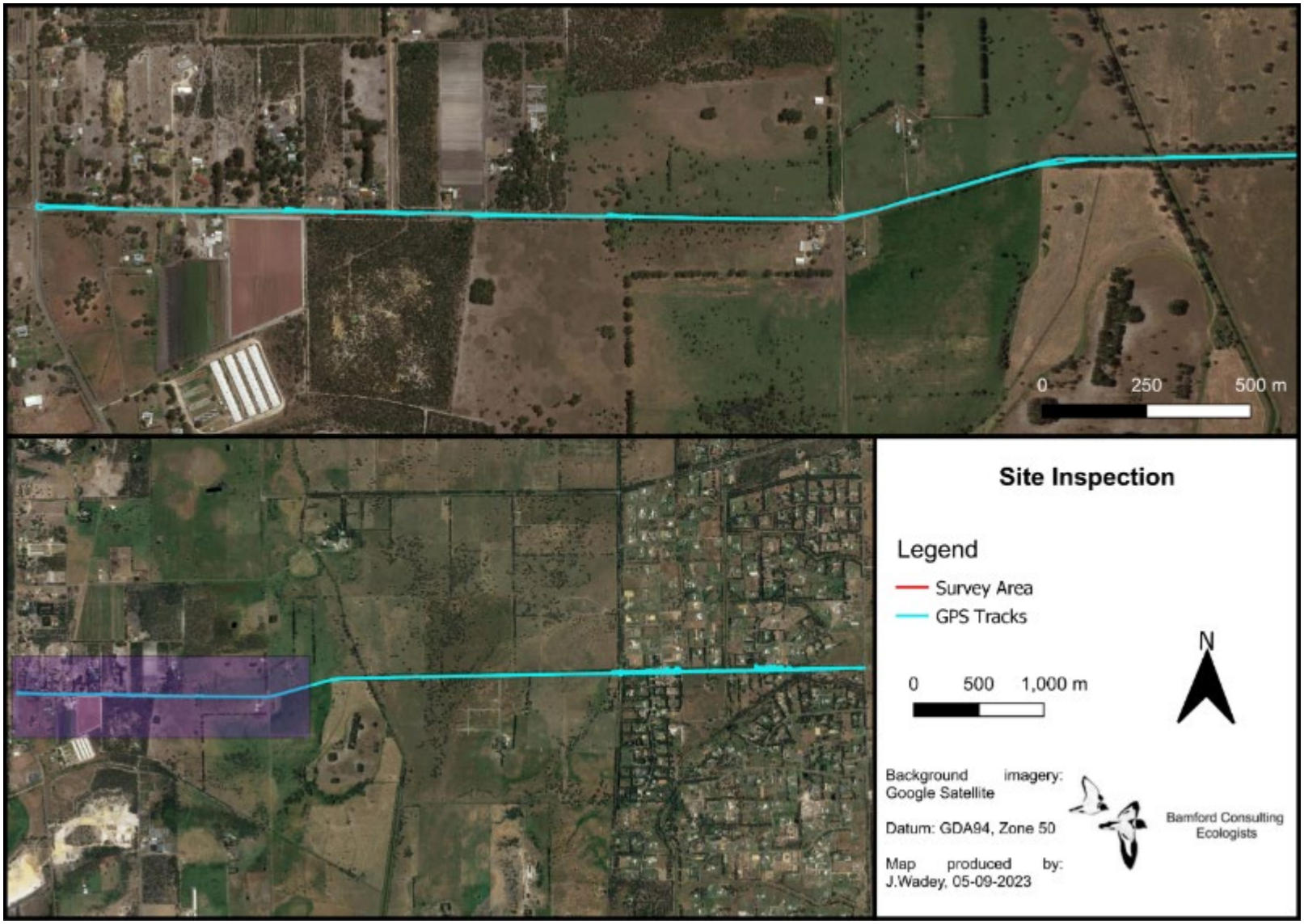

Figure 2-1. GPS tracks through western portion of the survey area during site visit

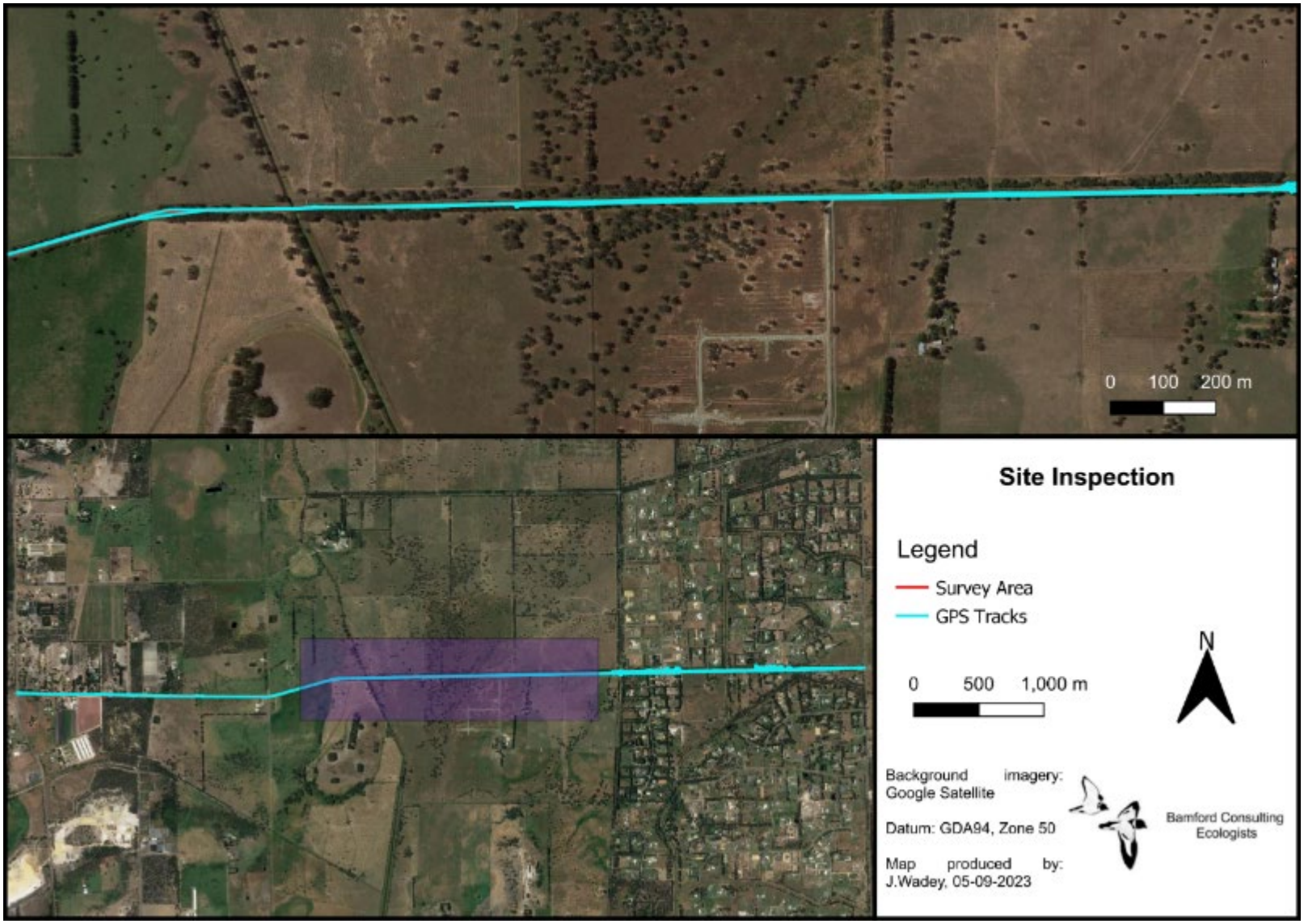

Figure 2-2. GPS tracks through central portion of the survey area during site visit

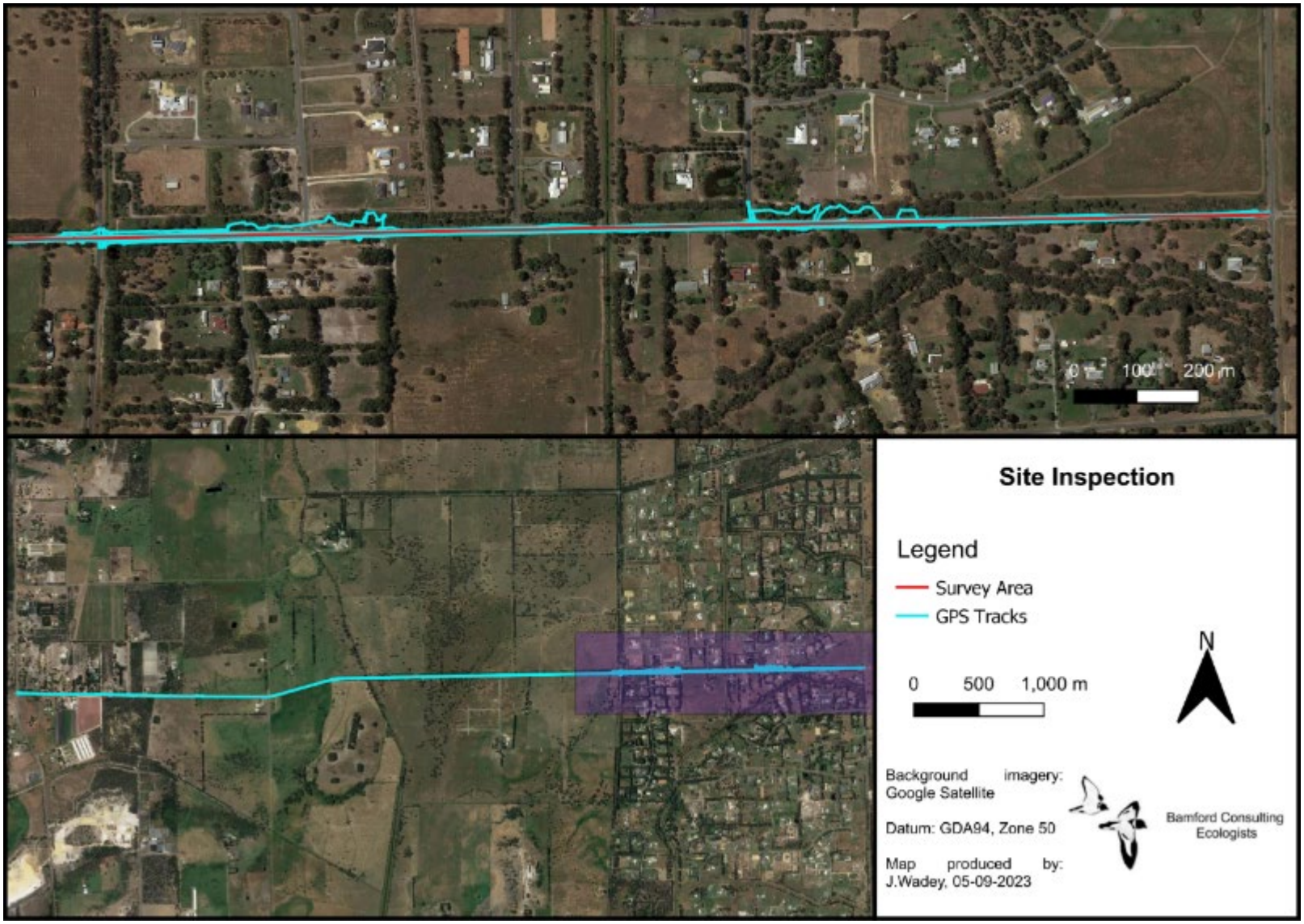

Figure 2-3.GPS tracks through eastern portion of the survey area during site visit

2.2 Vegetation and Substrate Associations

Vegetation and substrate associations (VSAs) combine vegetation types, the soils or other substrate with which they are associated, and the landform. In the context of fauna assessment, VSAs are the environments that provide habitats for fauna. BCE deliberately makes the distinction between 'habitat' (a species-specific term that may encompass the whole or part of one or more VSAs and is the physical subset of an ecosystem that a given species, or species group, utilises) and 'VSA' (a general, discrete and mutually exclusive spatial division of a target area, based on soil, vegetation and topography). It is recognised, however, that, within the broader EIA literature/guidance, the former term is used more or less synonymously to indicate the latter (e.g.' habitat assessment' used by EPA, 2020). Further discussion is provided in Appendix 1.

2.3 Black-cockatoo assessment

2.3.1 Guidelines

The Commonwealth Department of Agriculture, Water and the Environment (DAWE; now the Department of Climate Change, Environment, Energy and Water - DCCEEW) provides guidelines for the referral of actions that may result in impact to black-cockatoos (for assessment under the EPBC Act). The survey and analysis reported here have been conducted with strong reference the recently revised guidelines (DAWE 2022). This includes application of the foraging habitat scoring tool in DAWE (2022). In addition, survey methodology followed the recommendations listed on the DCCEEW's Species Profile and Threats Database (DAWE 2021a,b and DCCEEW 2023). Ecological values for black-cockatoos within the site were based on the definitions of breeding, foraging and roosting habitat as per the EPBC Act referral guidelines for black-cockatoos (DSEWPaC 2012).

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

2.3.2 Breeding

The aim of the breeding surveys was to record all potential hollow-bearing trees suitable for black-cockatoo nesting within the survey area. A potential breeding tree was identified based on EPBC guidance for any suitable tree[1] with a diameter at breast height (DBH) equal to or greater than 500 mm (or 300 mm for Wandoo/Yate). Note that this is guidance only and a suitable breeding tree may contain hollows but have a DBH smaller than these values. For example, active Carnaby's Black-Cockatoo nests have been recorded in Wandoo trees of just under 300 mm which would otherwise have not been recorded if guidance was strictly adhered to (M. Bamford, pers. comm.). The BirdLife Australia database of black-cockatoo breeding surveys was also searched for relevant local records (see Peck 2019). When a potential breeding tree was identified, the following information was recorded:

- tree GPS 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.

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

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

As per DAWE (2022) 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*). Note that black-cockatoos favour vertical hollows for the nest chamber, but the hollow entrance may be vertical (a chimney hollow), have a side entrance or have a horizontal spout entrance.

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

2.3.3 Foraging

The foraging value of the study area was assessed by calculating a foraging score for each area of different vegetation type/condition (see Appendix 1). 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 DAWE, Department of Water and Environmental Regulation (DWER) and the Environmental Protection Authority (EPA) to assess impact significance and offset requirements. The foraging value of the vegetation depends upon the type, density and condition of trees and shrubs in an area, and can be influenced by the context such as the availability of foraging habitat nearby. The BCE scoring system for value of foraging habitat has three components as detailed in Appendix 1. These three components are drawn from the DAWE offset calculator but with the scoring approach developed by BCE:

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

Foraging value can thus be assigned a score out of six, based upon site vegetation characteristics, or a score out of 10 if context and species density are also considered. A higher score represents better foraging value. A score out of 10 is presented for the purposes of aiding offset calculations. The approach to assigning scores for vegetation, context and species density are outlined in Appendix 2.

The survey area was searched for black-cockatoo foraging signs. If 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.

2.3.4 Roosting

Data from the DBCA and BirdLife Australia (both of which include Great Cocky Count data) were included in the assessment. During the site visit, areas with the potential to be used as roosting sites (e.g. sites adjacent to watercourses with large trees) were noted. Note that if a targeted roosting assessment is required, the survey area needs to be revisited in the late afternoon.

3 Results

3.1 Vegetation and Substrate Associations

The survey area supports VSAs typical of rural areas - open grassy areas and patches of remnant or planted vegetation with weedy understoreys. There were eight VSAs identified in the survey area:

VSA 1. Banksia Woodland. Closed remnant woodland of *Banksia attenuata* and *Banksia menziesii* with scattered *Eucalyptus todtiana* over mixed midstorey and understorey on grey sands. Dominant midstorey species consisted of *Kunzea sp.* and Woolly Bush (*Adenanthos sp.*), with understorey dominated by introduced grasses with scattered native small shrubs on grey sand. See Plate 1.

VSA 2. Marri Woodland. Open remnant woodland with Marri (*Corymbia calophylla*) over open midstorey of *Xanthorrhoea preissii* and understorey of exotic grasses on grey sand. See Plate 2.

VSA 3. Mixed Woodland. Open remnant woodland with a mix of Flooded Gum (*Eucalyptus rudis*) and Marri (*Corymbia calophylla*) over open midstorey of *Xanthorrhoea preissii* and understorey of exotic grasses on grey sand. See Plate 3.

VSA 4. Sheoak stands. Closed dense stands of Sheoak (*Allocasuarina fraseriana*) with no midstorey and understorey consisting of invasive grasses and weeds. See Plate 4.

VSA 5. Melaleuca Dampland. Closed dampland of *Melaleuca rhaphiophylla* with midstorey of scattered *Kunzea* and understorey of invasive weeds and grasses on dark grey sand. Appears to be seasonally inundated. See Plate 5.

VSA 6. Planted Eucalypts. Open woodland of scattered planted mature trees such as *Eucalyptus camaldulensis* over a grassy understorey on grey to white sand. See Plate 6.

VSA 7. Revegetated Shrubland. Open low shrubland of native vegetation consisting of *Grevillea* and other shrubs, with scattered eucalypts and a grassy understorey on grey to white sand. See Plate 7.

VSA 8. Open areas. Disturbed open areas ranging from introduced grasses scattered with disturbance species of plants and weeds with occasional *Acacia saligna* on grey to white sand. See Plate 8.

In addition, there were small areas of 'built environment' which are not described nor mapped here; these are areas devoid of vegetation, such as driveways and roads. They provide little or no value to fauna.

The distribution of VSAs within the survey area are shown in Figure 3-1, Figure 3-2 and Figure 3-3.

Plate 1 VSA 1: Banksia Woodland

Plate 2 VSA 2: Marri Woodland

Plate 3 VSA 3: Mixed Woodland

Plate 4 VSA 5: Sheoak Stands

Plate 5 VSA 4: Melaleuca Dampland

Plate 6 VSA 6: Planted Eucalypts

Plate 7 VSA 7: Revegetated Shrubland

Plate 8 VSA 8: Open Areas

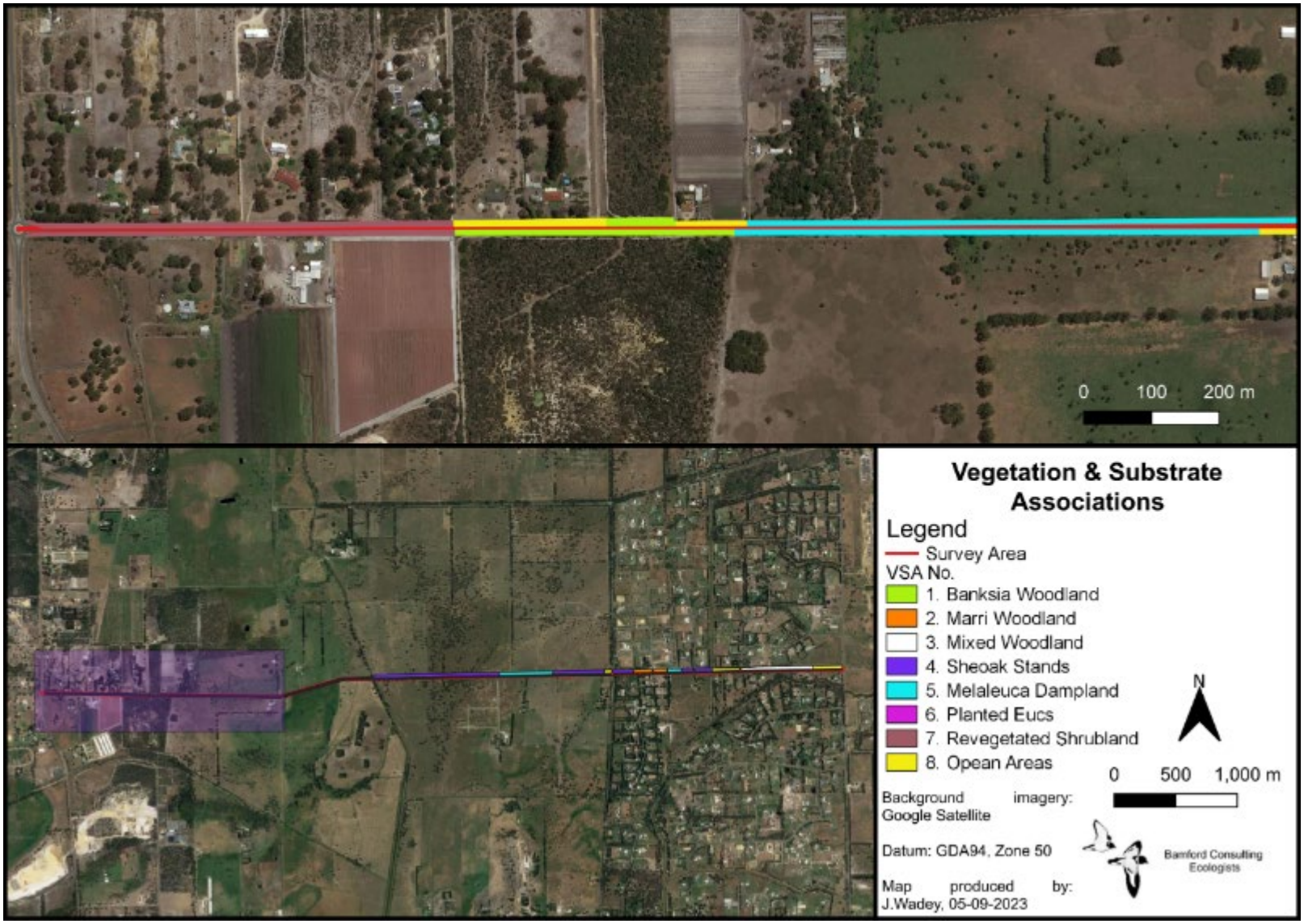

Figure 3-1. Distribution of VSAs through the western portion of the survey area

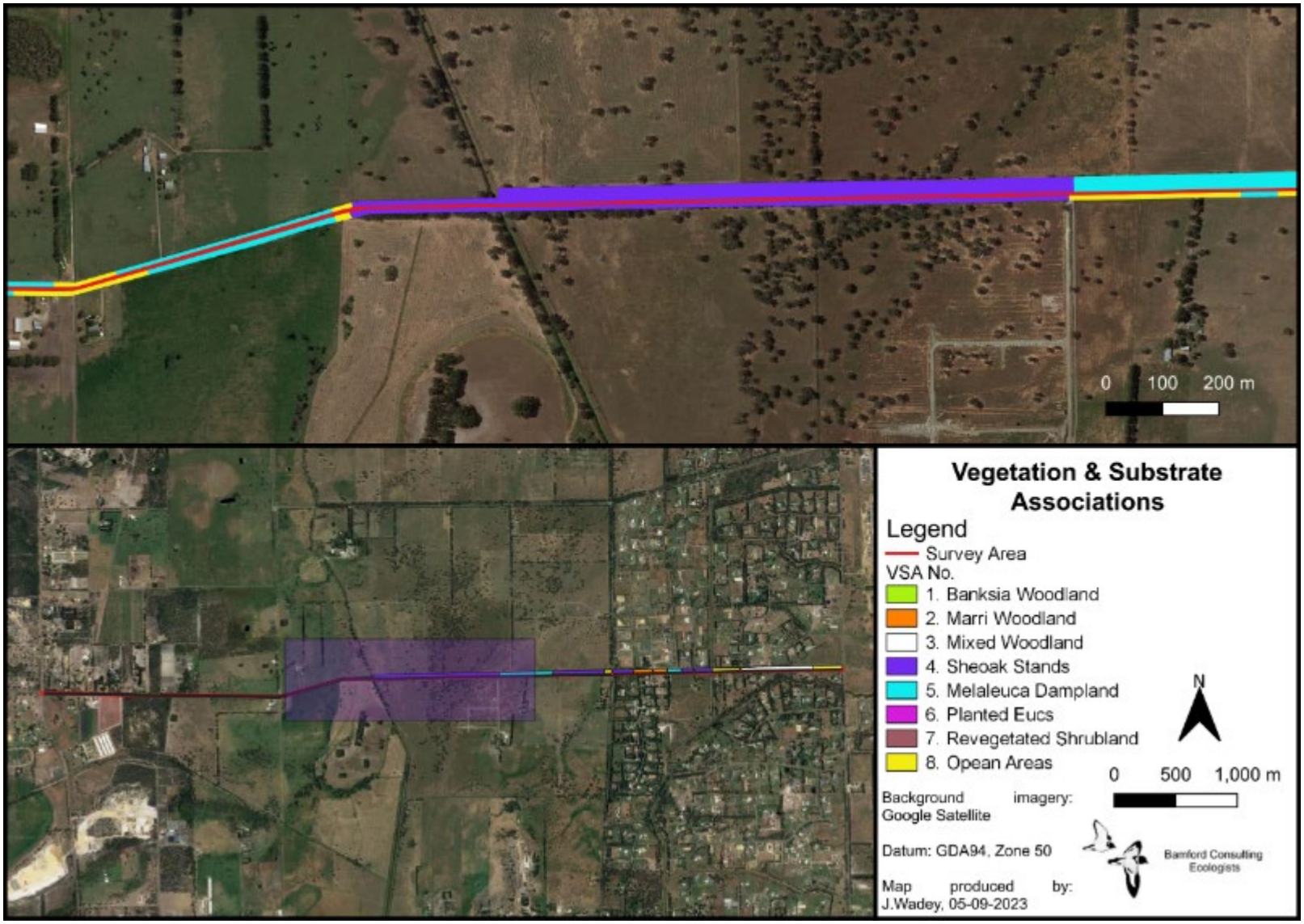

Figure 3-2. Distribution of VSAs through the central portion of the survey area

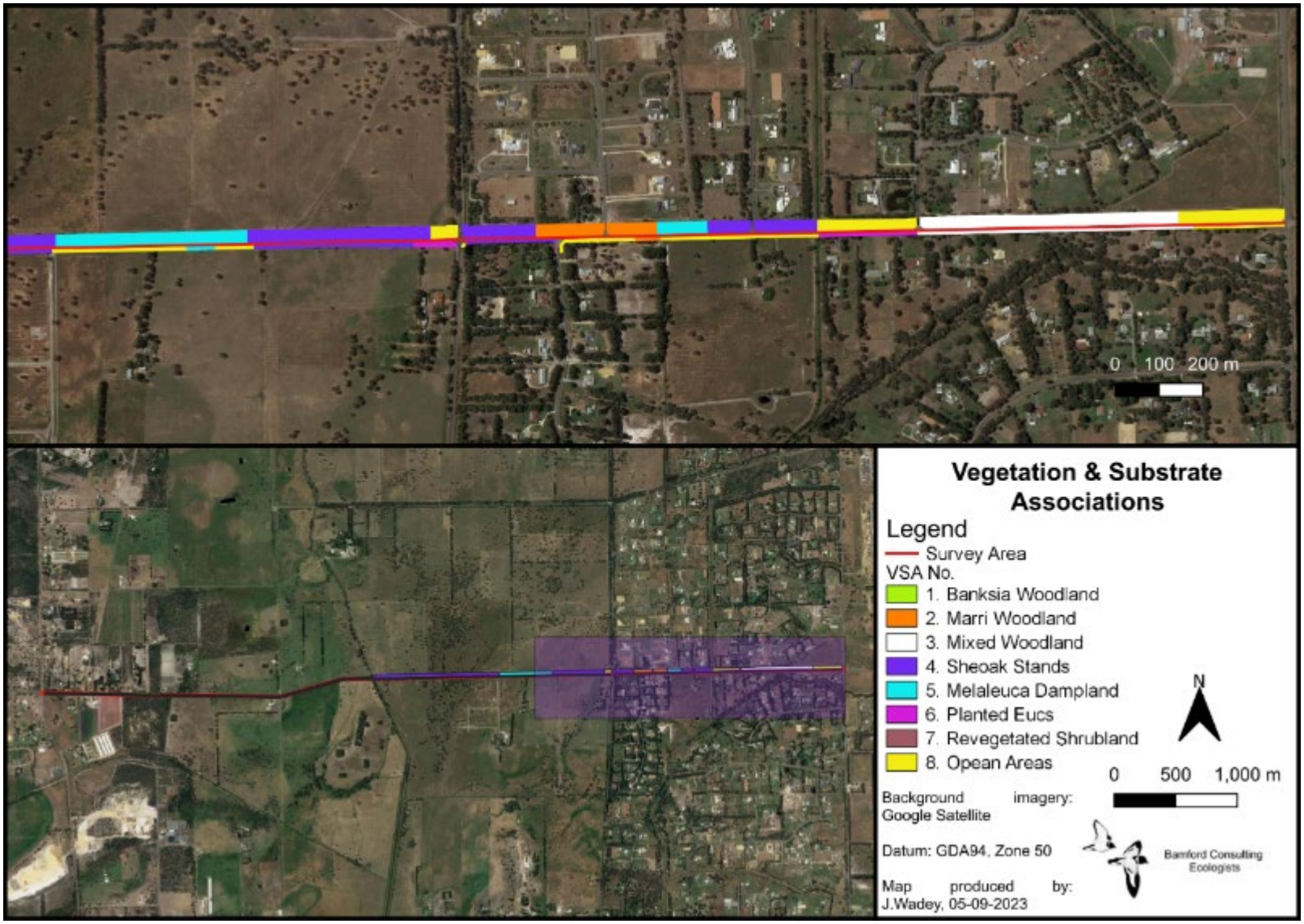

Figure 3-3. Distribution of VSAs through the eastern portion of the survey area

3.2 Black-cockatoo assessment

3.2.1 Black-cockatoo presence

Carnaby's Black-Cockatoo

Carnaby's Black-Cockatoo is expected to be a regular visitor to the survey area. A flock of approximately ten Carnaby's Black-Cockatoos was observed within the survey area during the survey - individuals were foraging on *Banksia menziesii* in the remnant Banksia woodland on the south side of Orton Road (Figure 3-4). The strip of Banksia woodland within the actual survey area is part of a greater patch of Banksia woodland extending south of Orton Road (see Figure 3-4).

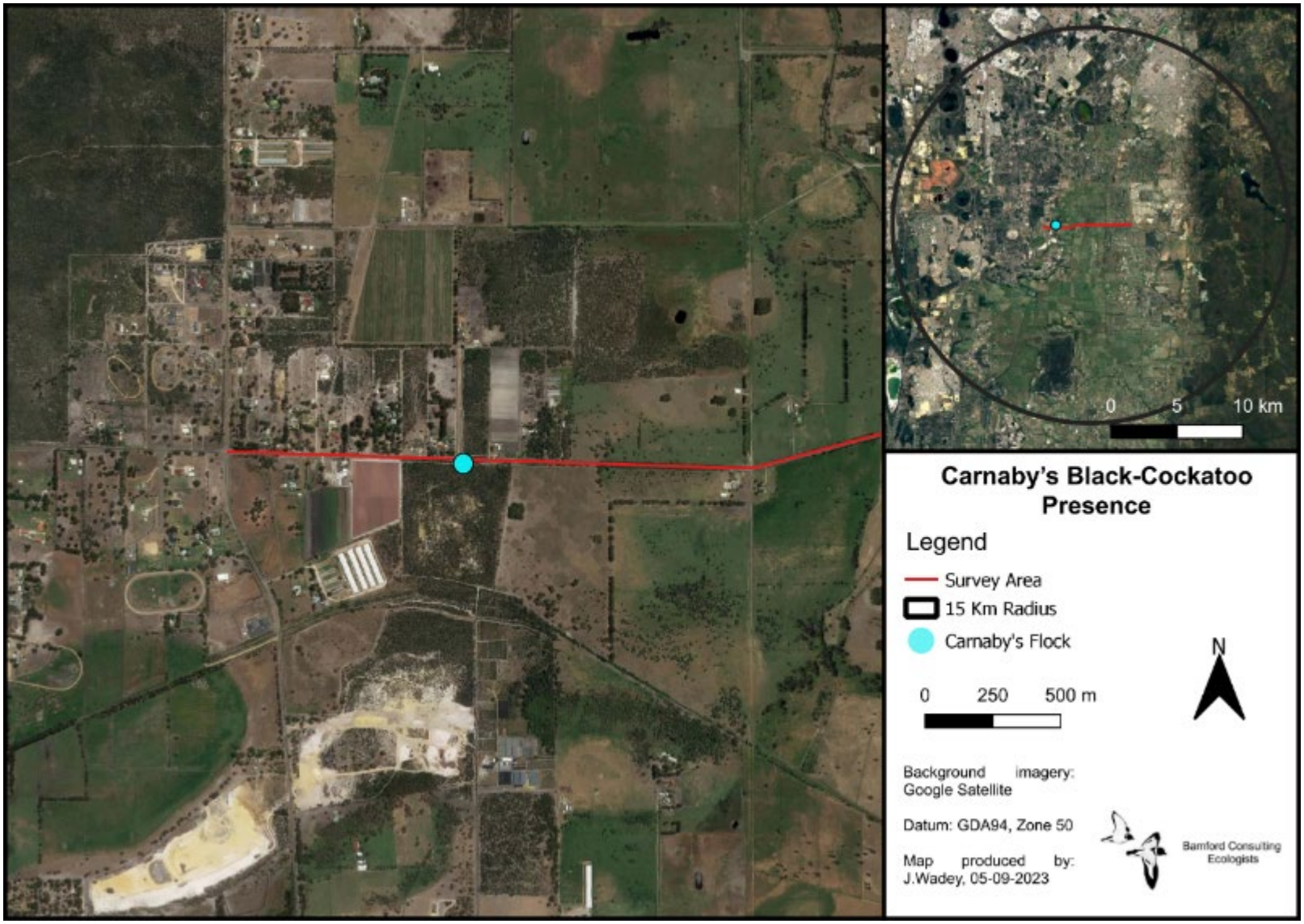

Figure 3-4. Location of Carnaby's Black-Cockatoo sighting on Orton Road.

Forest Red-tailed Black-Cockatoo

Forest Red-tailed Black-Cockatoo is expected as a regular visitor to the survey area. While not historically recorded regularly on the Swan Coastal Plain, the species' distribution has expanded on the Plain due to the presence of non-native food plants (e.g. Cape Lilac) and habitat loss throughout its range. The species was not directly sighted during the survey but old and recent foraging evidence by this species was recorded which suggests the species has visited the site repeatedly. Foraging evidence was recorded on both Marri and Sheoak nuts (see Figure 3-5 and Figure 3-6), with locations of foraging evidence shown in Figure 3-6. In nearby studies, the species and its foraging evidence were recorded along the Byford Rail Extension in 2020 and 2021 (BCE 2021), which is located c. 7 km northeast of the survey area.

Figure 3-5. Evidence of fresh foraging of Marri nuts by Forest Red-tailed Black-Cockatoo.

Figure 3-6. Evidence of old foraging of Marri nuts by Forest Red-tailed Black-Cockatoo.

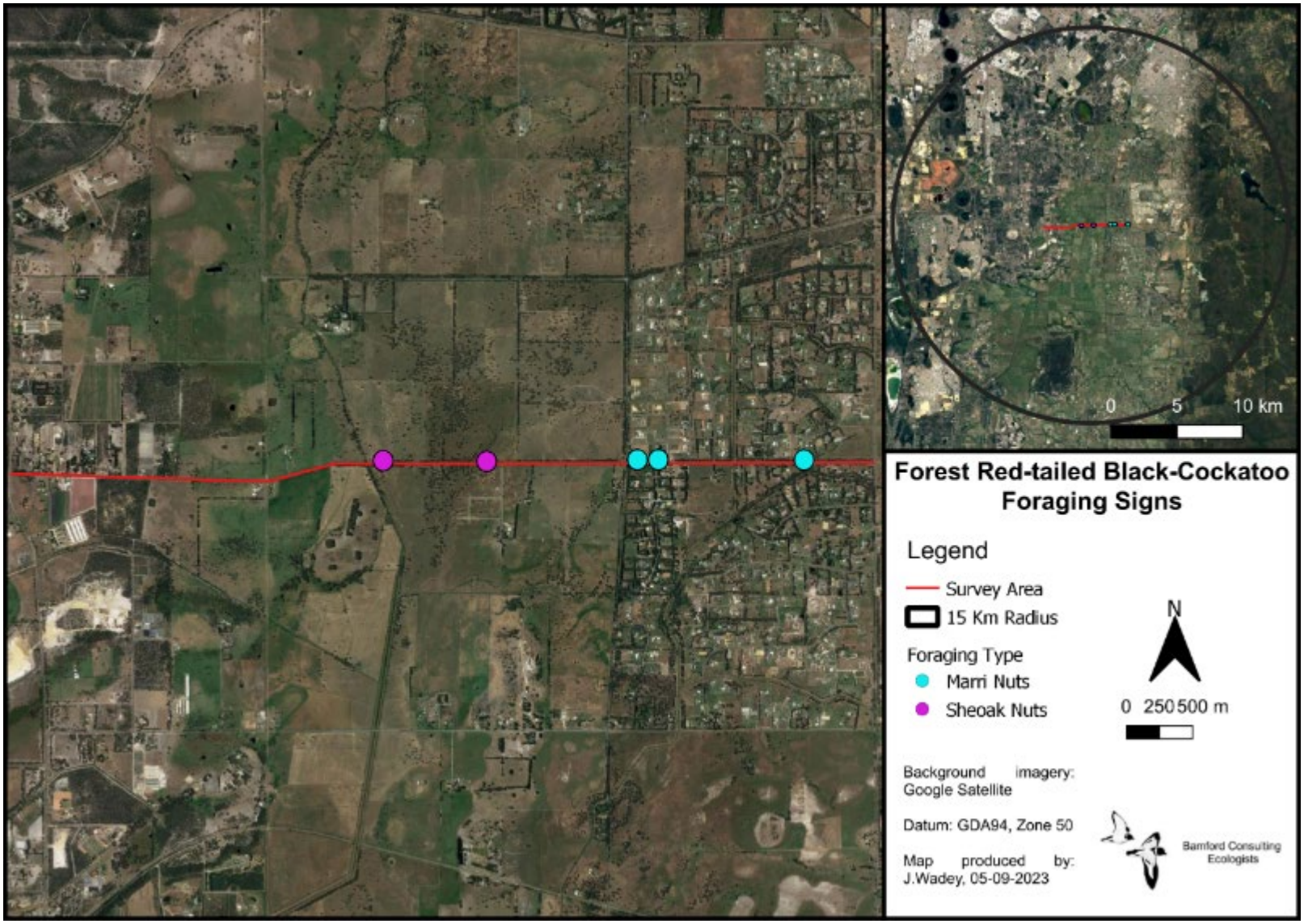

Figure 3-7. Distribution of Forest Red-tailed Black-Cockatoo foraging signs throughout the survey area.

Baudin's Black-Cockatoo

This species is reliant on Marri as its primary food source, followed by Jarrah (Johnstone and Kirkby 2008), but they will also feed on proteaceous shrubs/heath including Banksia species (DCCEEW 2023). It is considered likely to occur as an irregular visitor to the survey area.

3.2.2 Breeding habitat

There were 44 potential breeding trees (met minimum DBH) recorded in the survey area (Figure 3-8). Details of these trees are given in Appendix 3. Two trees were ranked Category 3 (trees that contained hollows considered suitable for black-cockatoos but which had no evidence that they were currently being used). These trees were both dead Marris and located within the Mixed Woodland towards the eastern part of the survey area (see Figure 3-8 and Figure 3-9).

There were seven trees ranked Category 4 (trees that contained large enough hollows but not at the angle known to be preferred by black-cockatoos) and 35 trees were ranked Category 5 (trees which met the minimum DBH but which contained no suitable hollows for black-cockatoos).

The closest records of known breeding are located c. 7 km northeast of the survey area in Lambert Lane Nature Reserve and Fletcher Park in Byford (Figure 3-10). These were recorded by BCE as part of the fauna assessment for the Byford Rail Extension project (Bamford *et al.* 2021). There were two rank 2 trees (with hollows with recent chew marks) and one rank 1 tree (with hollows with Forest Red-tailed Black-Cockatoo activity). Kirkby (2021) found an additional tree in the same study area which contained hollows which likely supported recent black-cockatoo breeding, though GPS coordinates for this are not available.

From BirdLife's Great Cocky Count database, the closest breeding site is located c. 5.1 km east of the survey area (Forest Red-tailed Black-Cockatoo; Figure 3-10). This database had seven breeding sites within a 15 km radius. Five of these were of Forest Red-tailed Black-Cockatoo and were all 'potential artificial' hollows and two sites were of white-tailed black-cockatoos (i.e., either Carnaby's or Baudin's Black-Cockatoo) and were both 'potential natural' hollows.

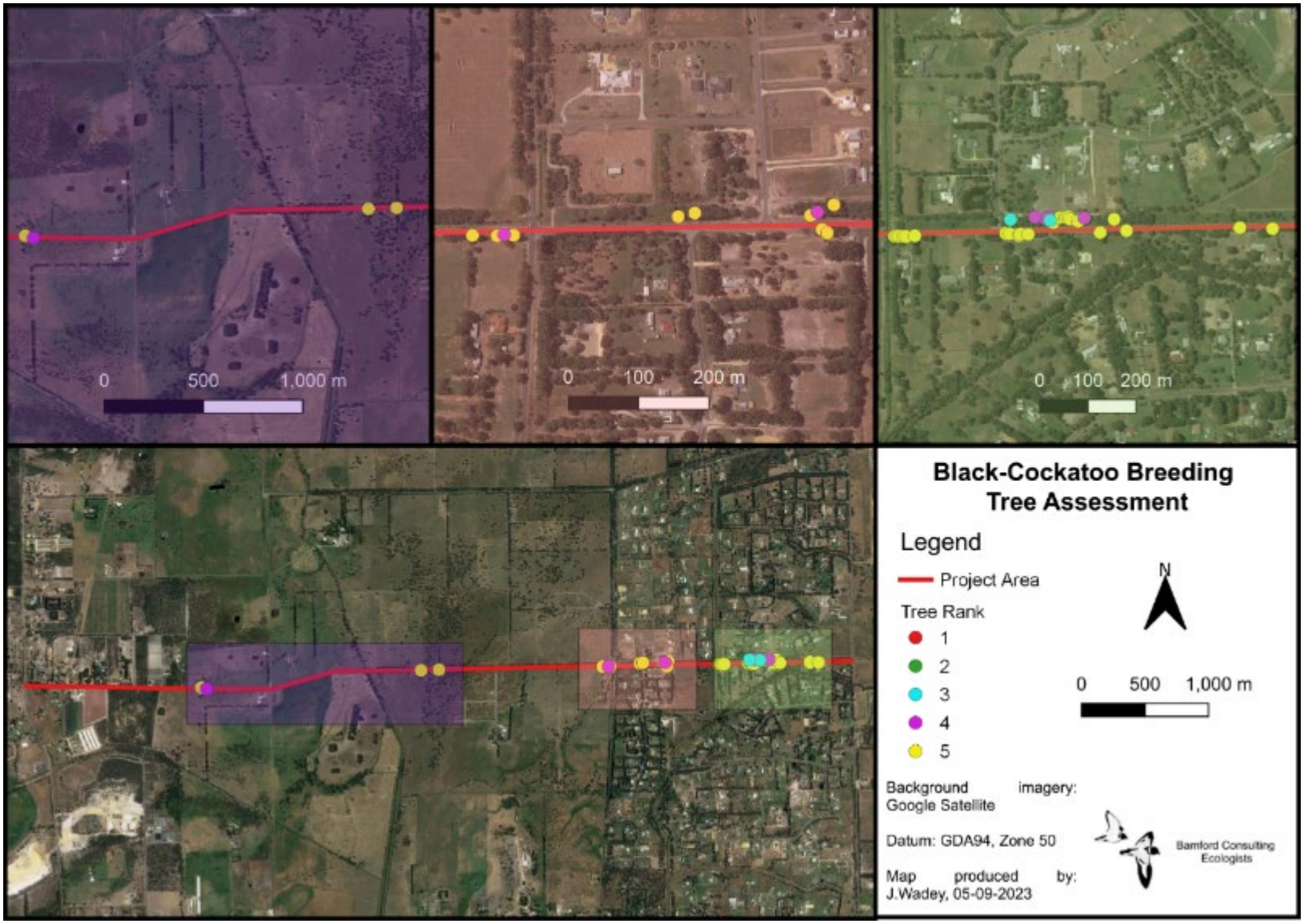

Figure 3-8. Locations and ranks of potential black-cockatoo nest trees.

Figure 3-9. A potential breeding tree ranked Category 3 showing whole tree with two vertical hollows considered suitable for black-cockatoos.

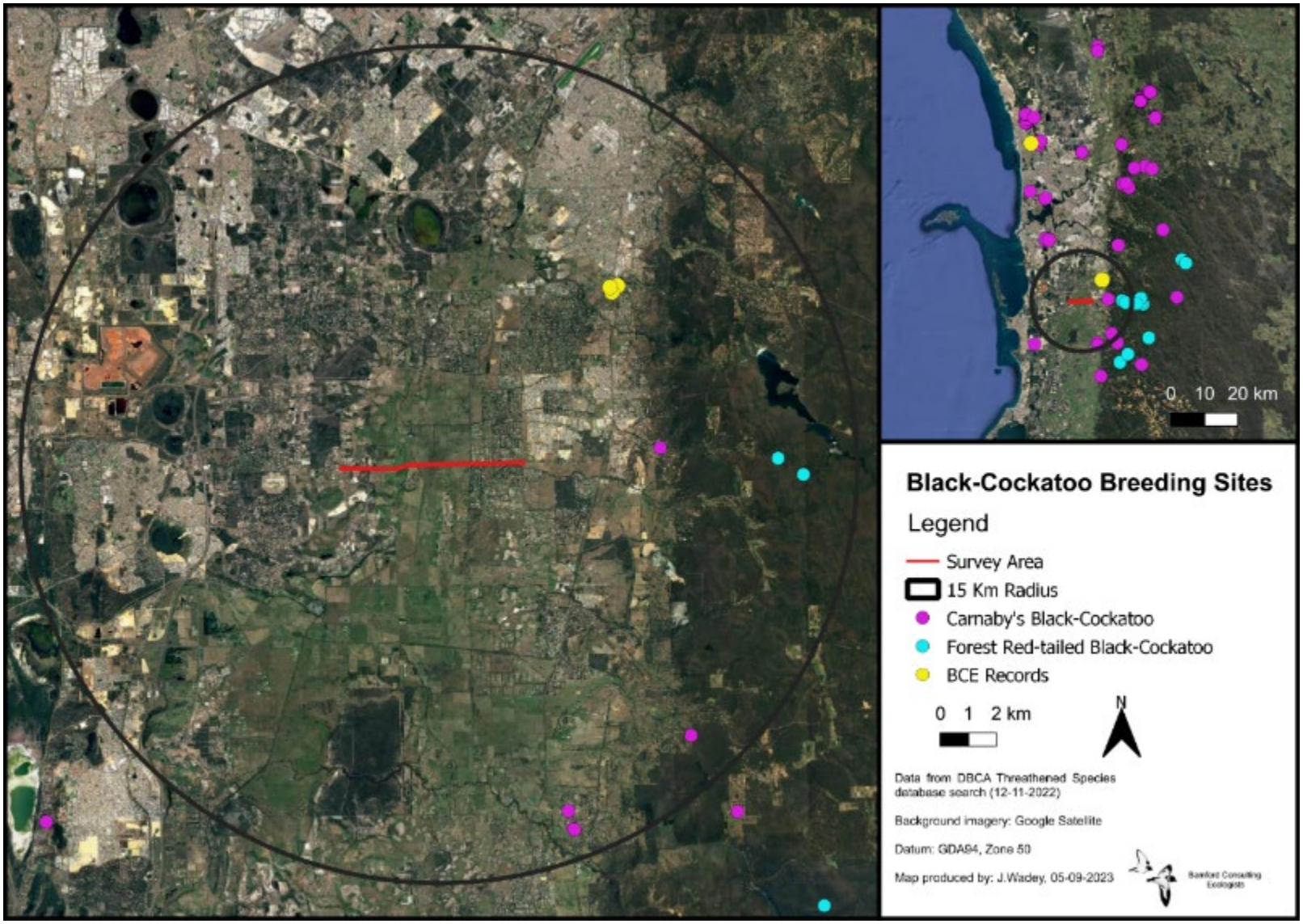

Figure 3-10. Black-cockatoo breeding sites (DBCA 2022) within 15 km of survey area, including nearby BCE records.

3.2.3 Foraging habitat

3.2.3.1 Carnaby's Black-Cockatoo

The survey area is likely to be an important foraging source for Carnaby's Black-Cockatoo given the fragmented and cleared nature of the Swan Coastal Plan. At a local scale the survey area will likely be utilised seasonally in conjunction with the remnant bush blocks that are present in the western portion of the survey area which extend to the roadside. These blocks are depicted in Figure 3-1 which are north and south of VSA 1 (Figure 3-1).

Foraging scores ranged from one to eight, with most of the VSAs scoring either two or three out of ten (Table 2). The Banksia Woodland scored the highest at 8 out of 10; a flock of Carnaby's Black-Cockatoo was recorded foraging in this Banksia Woodland (see previous section). Foraging values for each VSA are given in Table 2; foraging values by VSA are shown in Figure 3-11, Figure 3-12, and Figure 3-13.

Based on the foraging assessment outlined in the Methods section, approximately 81.2 % (12.76 ha) of the survey area is of low value (i.e., between 1 and 3), 16.2% (2.53 ha) is of moderate foraging values (i.e., 4 to 6) and 2.6 % (0.42 ha) is of high foraging value (i.e., 7 to 10).

The Banksia Woodland (VSA 1) was given a total score of 8 due to: i) the total number of foraging plants within the verge locale in the form of mature banksia and eucalypt species (*Banksia attenuata*, *Banksia menziesii*, and *Eucalyptus todtiana*) estimated at 5 -10 trees; ii) absence of foraging plant species in the midstorey and understorey; and iii) total area of the VSA being approximately 0.42 ha out of the total survey area of approximately 15.7 ha. Additional foraging opportunities for Carnaby's Black-Cockatoo exist in VSA 2 and VSAs 3 but are limited to a low number of trees scattered throughout the site (see previous section for locations of Marri trees). A site context score of 2 was applied to VSA 1 and VSA 2 due to the extent of surrounding clearing, and a stocking rate score of 1 was applied to VSA 2 and VSA 3; even though foraging evidence on Marri nuts was not recorded, it is highly likely these VSAs will be utilised in the future by this species.

Table 2. Carnaby's Black-Cockatoo foraging scores for each VSA

VSA	VSA Name	Site Condition (out of 6)	Site Context (out of 3)	Species Stocking Rate (0 or 1)	Total (out of 10)
1	Banksia Woodland	5	2	1	**8**
2	Marri Woodland	3	2	1	**6**
3	Mixed Woodland	2	1	1	**4**
4	Sheoak Stands	1	1	0	**2**
5	Melaleuca Dampland	1	1	0	**2**
6	Planted Eucalypts	1	1	0	**2**
7	Revegetated Shrubland	2	1	0	**3**
8	Open Areas	1	0	0	**1**

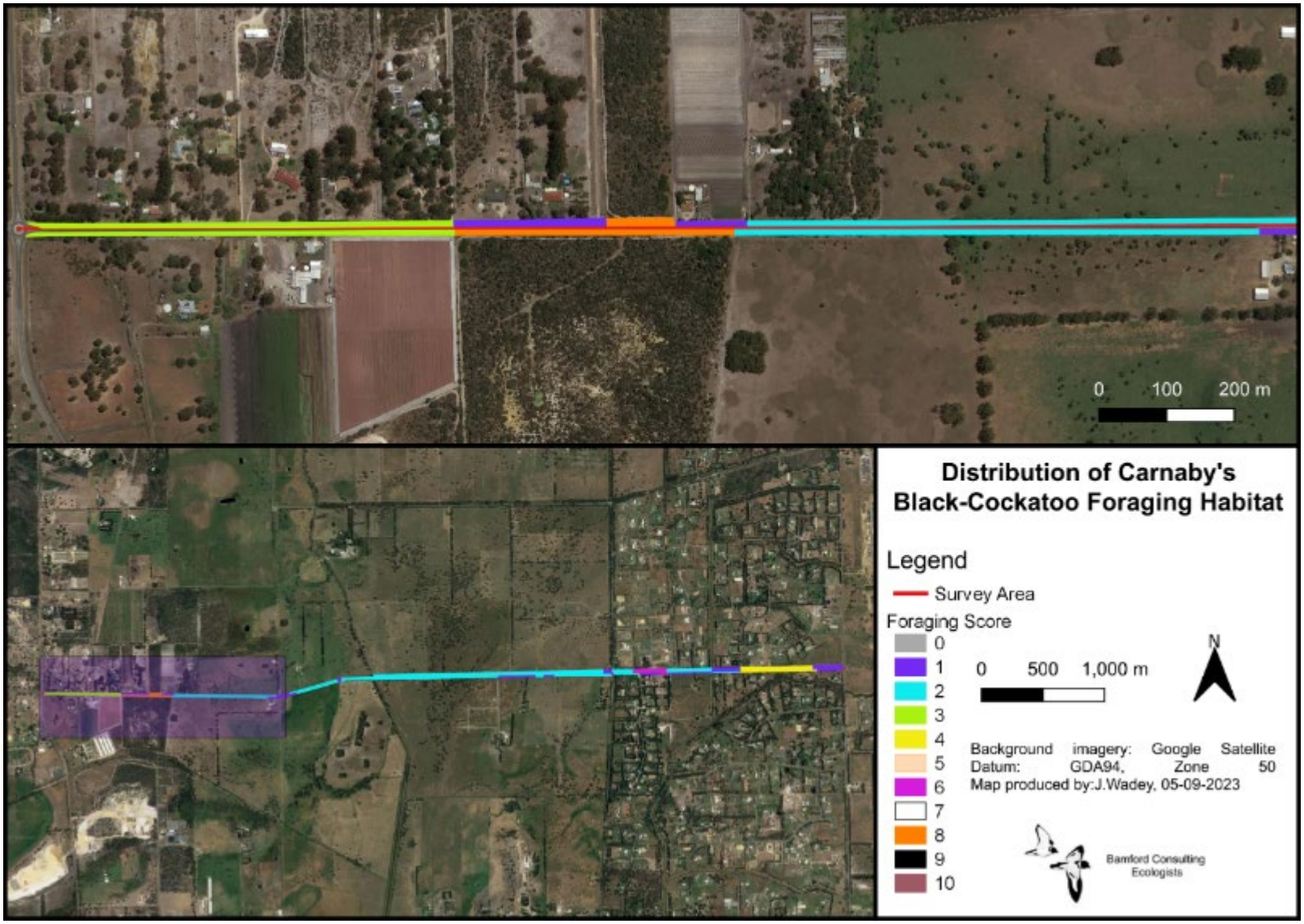

Figure 3-11.Distribution of Carnaby's Black-Cockatoo foraging scores within each VSA in the western portion of the survey area.

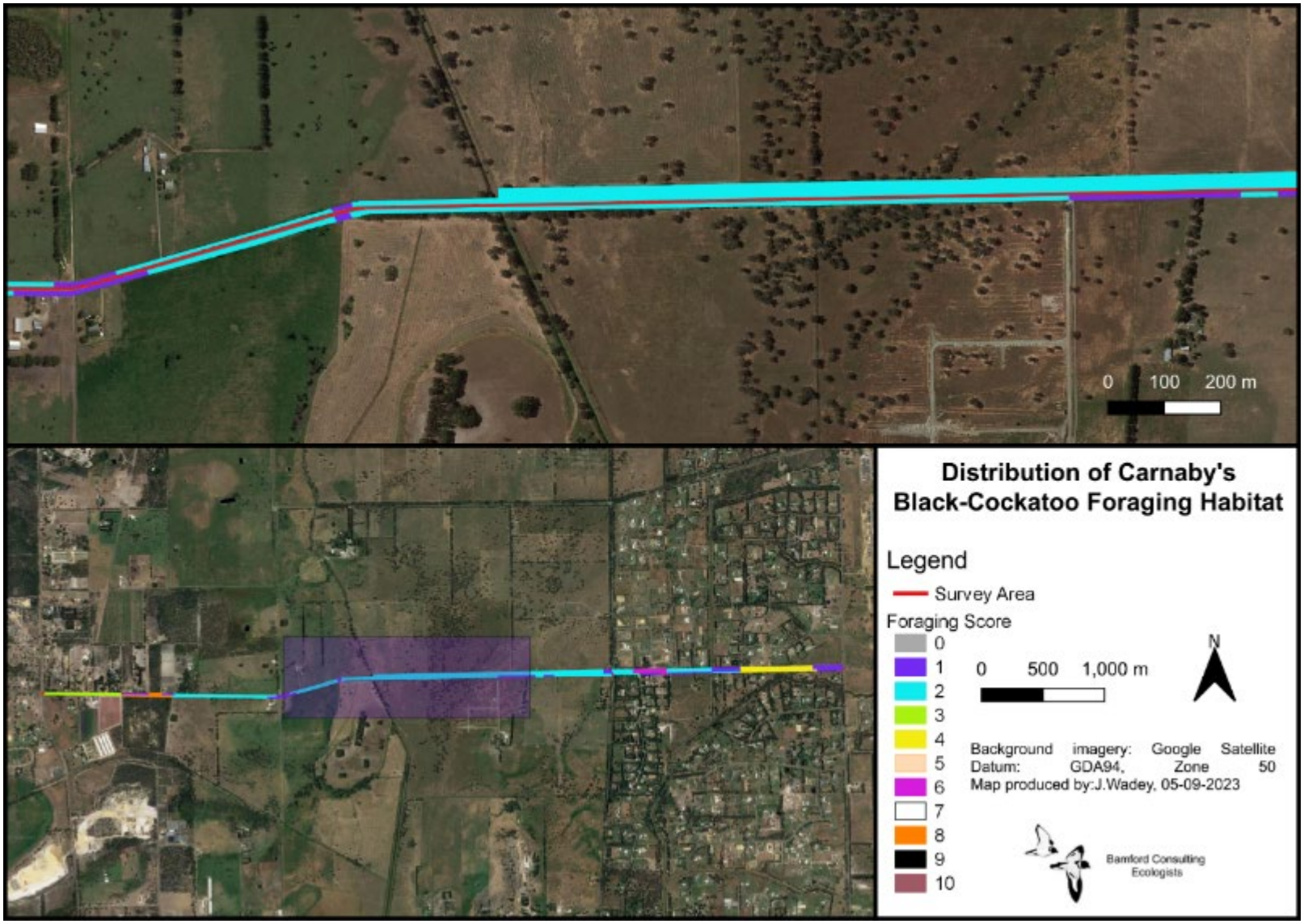

Figure 3-12. Distribution of Carnaby's Black-Cockatoo foraging scores within each VSA in the central portion of the survey area.

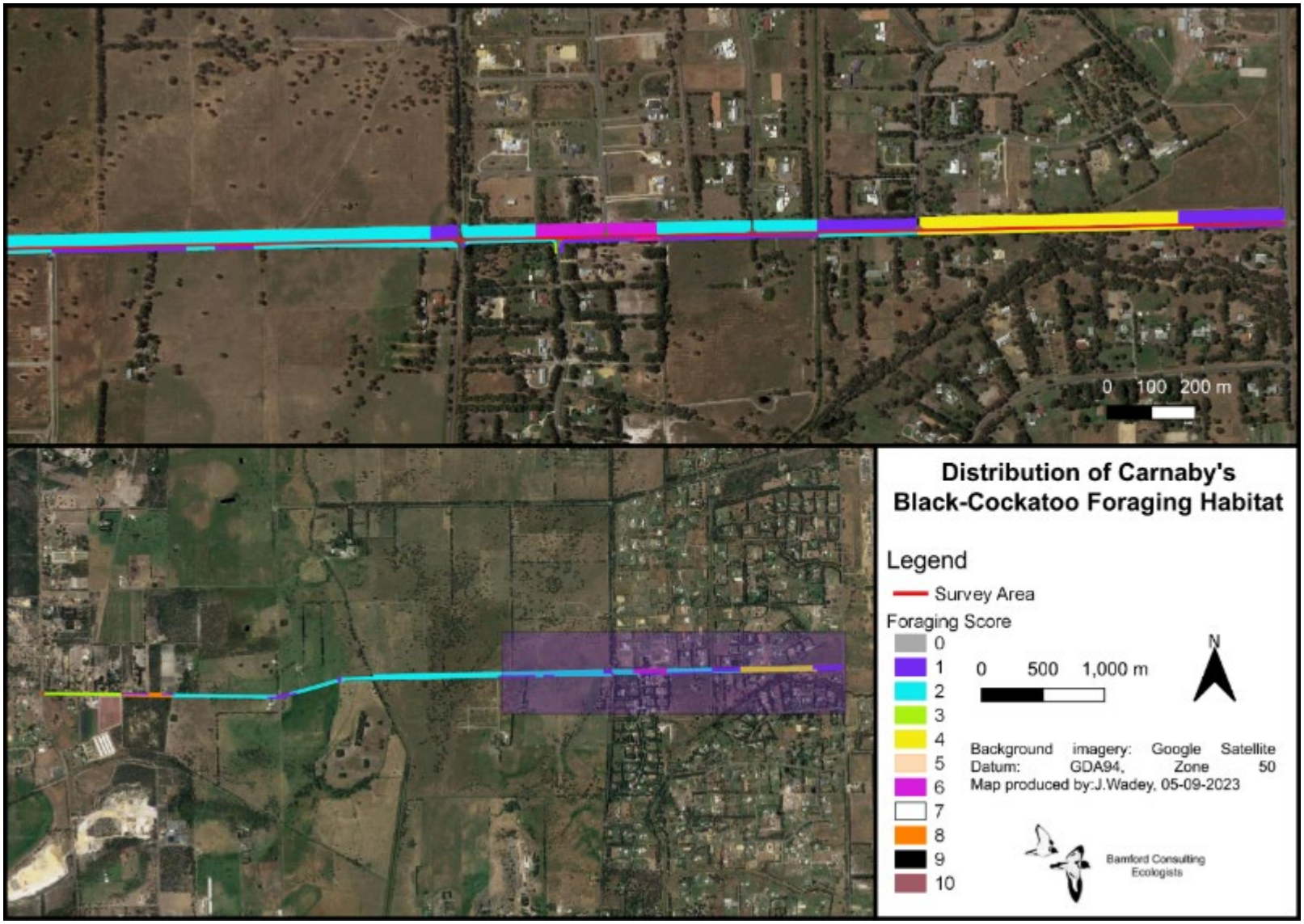

Figure 3-13.Distribution of Carnaby's Black-Cockatoo foraging scores within each VSA in the eastern portion of the survey area.

3.2.3.2 Forest Red-tailed Black-Cockatoo

As with Carnaby's Black-Cockatoo, the survey area is likely to be an important foraging source for Forest Red-tailed Black-Cockatoo given the fragmented and cleared nature of the Swan Coastal Plan. At a local scale the survey area will likely be utilised seasonally in conjunction with the patches of remnant Marri present throughout the area.

Foraging scores ranged from one to seven, with the Marri Woodland scoring the highest at 7 out of ten (Table 3). Foraging values for each VSA are given in Table 3; foraging values by VSA are shown in Figure 3-14, Figure 3-15 and Figure 3-16.

Based on the foraging assessment outlined in the Methods section, approximately 45 % (7.1 ha) of the survey area is of low value (i.e., scores of 1 to 3), 50.5% (7.9 ha) of the survey area is of moderate value (i.e., scores of 4 to 6) and 4.5 % (0.71 ha) of the survey area is of high foraging value (i.e., scores of 7 to 10). These foraging scores reflect the number of plant species known to be mainstays of the Forest Red-tailed Black-Cockatoo diet, such as Marri (in VSAs 2 and 3) and Sheoak (VSA 4) (Groom 2011). There were five records of foraging by Forest Red-tailed Black-Cockatoo within the survey area on both Marri and Sheoak nuts (see Figure 3-7).

Table 3. Forest Red-tailed Black-Cockatoo foraging scores for each VSA

VSA	VSA Name	Site Condition (out of 6)	Site Context (out of 3)	Species Stocking Rate (0 or 1)	Total (out of 10)
1	Banksia Woodland	2	1	0	**3**
2	Marri Woodland	4	2	1	**7**
3	Mixed Woodland	2	1	1	**4**
4	Sheoak Stands	3	2	1	**6**
5	Melaleuca Dampland	1	1	0	**2**
6	Planted Eucalypts	1	1	0	**2**
7	Revegetated Shrubland	2	1	0	**3**
8	Open Areas	1	0	0	**1**

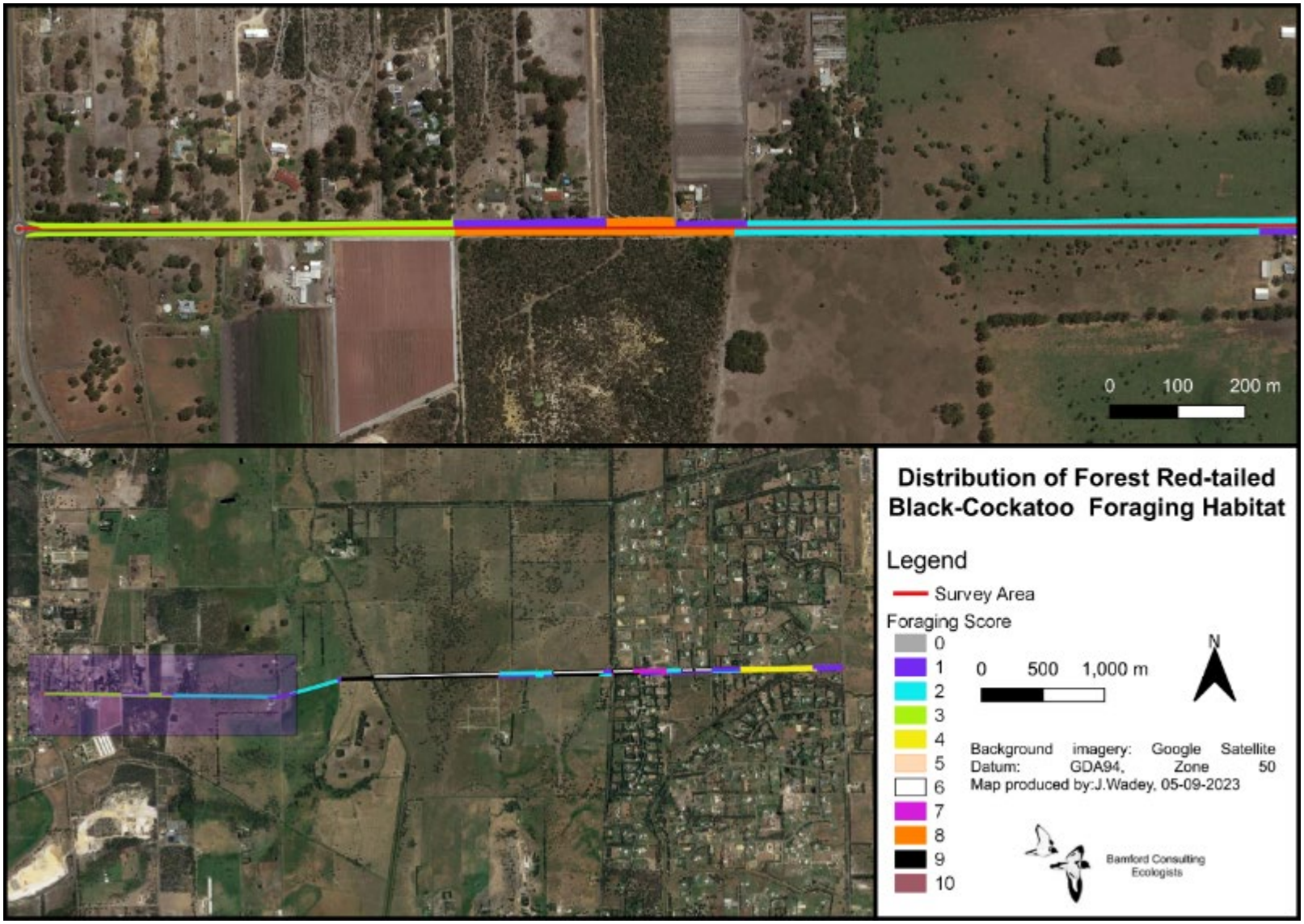

Figure 3-14. Distribution of Forest Red-tailed Black-Cockatoo foraging scores within each VSA in the western portion of the survey area.

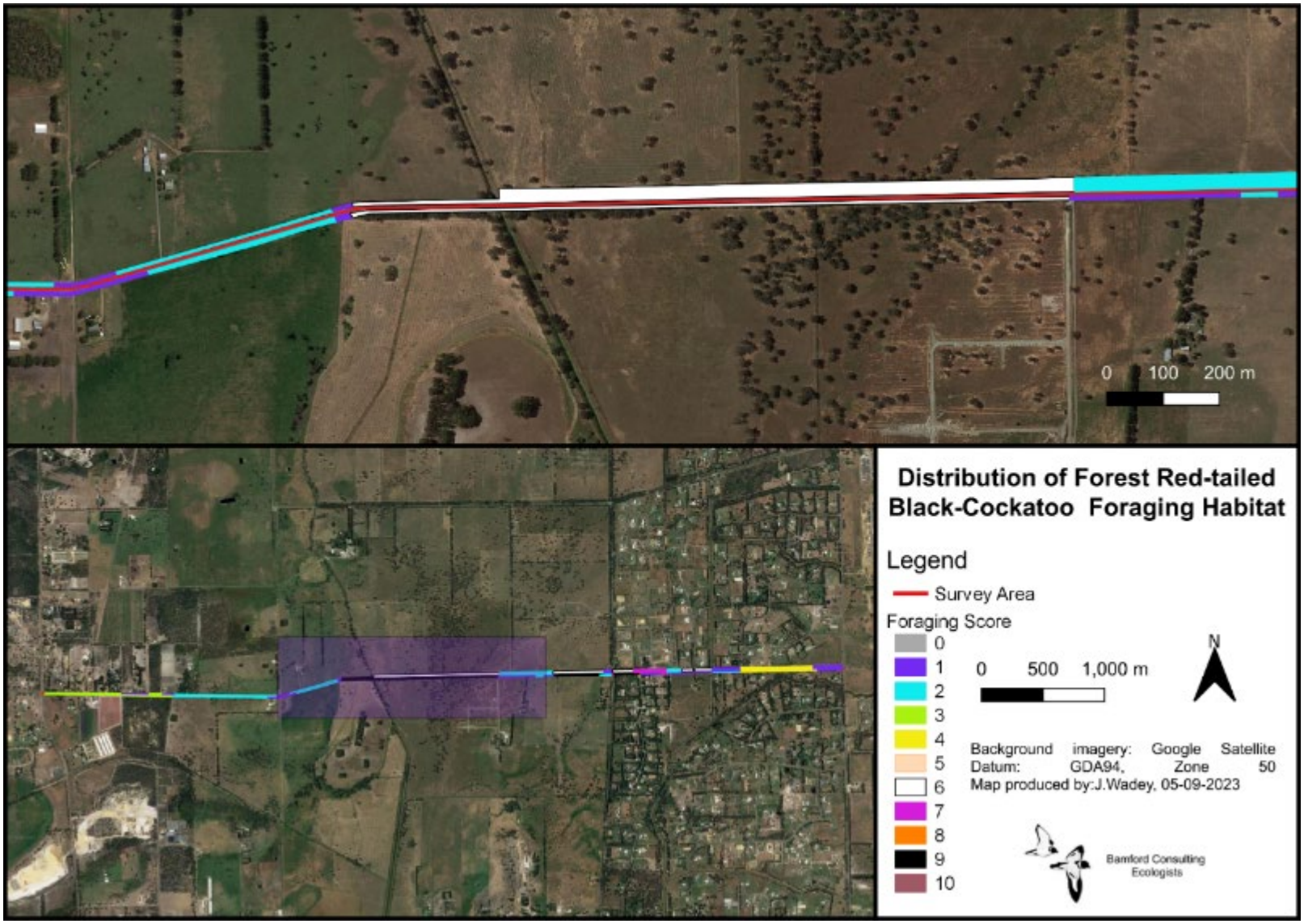

Figure 3-15. Distribution of Forest Red-tailed Black-Cockatoo foraging scores within each VSA in the central portion of the survey area.

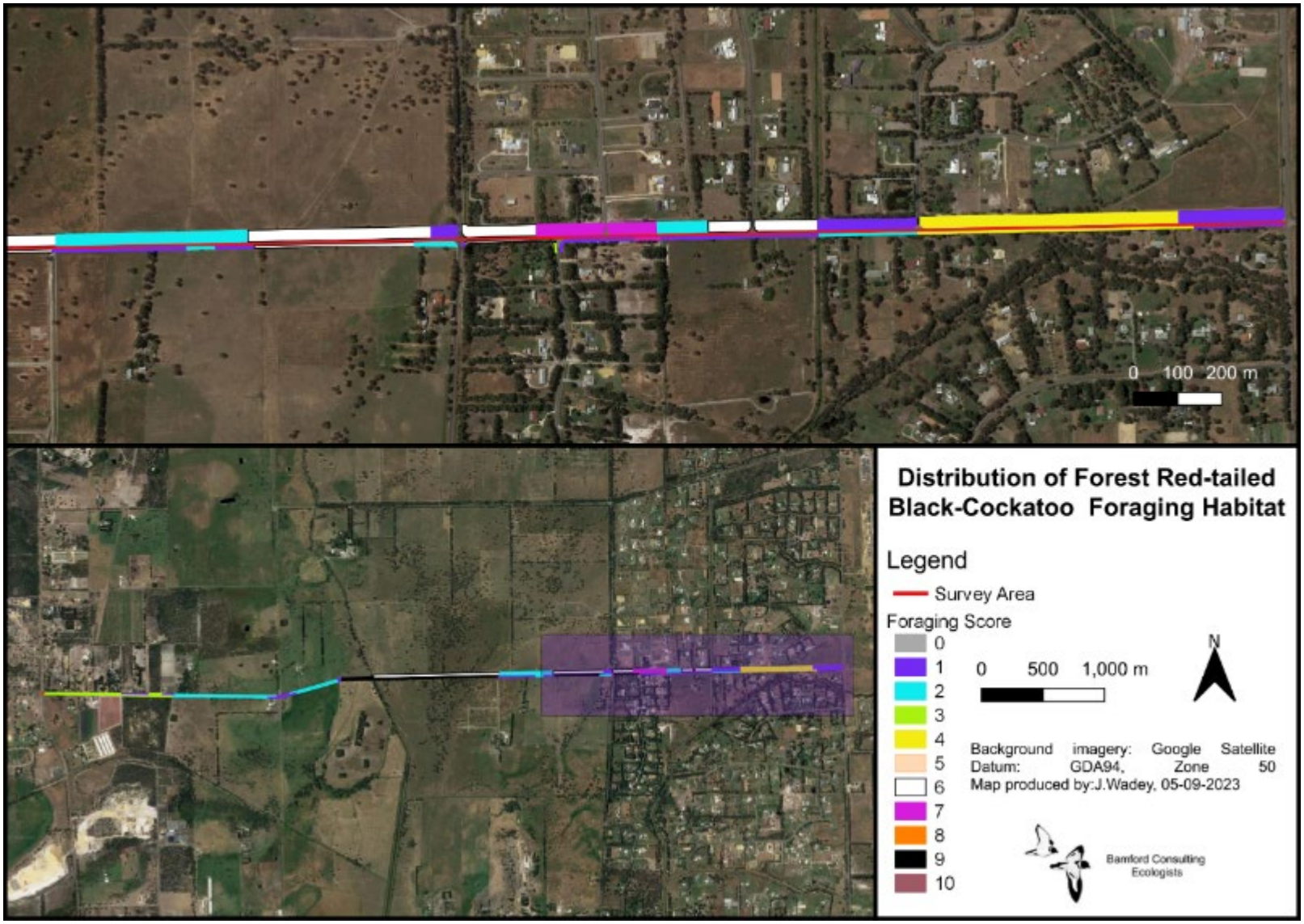

Figure 3-16. Distribution of Forest Red-tailed Black-Cockatoo foraging scores within each VSA in the eastern portion of the survey area.

3.2.3.3 Baudin's Black-Cockatoo

As with the other black-cockatoos, the survey area is likely to be an important foraging source for Baudin's Black-Cockatoo given the fragmented and cleared nature of the Swan Coastal Plan although less so than other black-cockatoo species as it is only an irregular visitor to the survey area. At a local scale the survey area will likely be utilised seasonally in conjunction with the patches of remnant Marri present throughout the area.

Foraging scores ranged from one to seven, with the Marri Woodland scoring the highest at 7 out of ten (Table 4) as Marri is known to be a mainstay of Baudin's Black-Cockatoo (Saunders 1979, Johnstone and Kirkby 2008). Foraging values for each VSA are given in Table 3; foraging values by VSA are shown in Figure 3-17, Figure 3-18 and Figure 3-19.

Table 4. Baudin's Black-Cockatoo foraging scores for each VSA

VSA	VSA Name	Site Condition (out of 6)	Site Context (out of 3)	Species Stocking Rate (0 or 1)	Total (out of 10)
1	Banksia Woodland	2	0	0	**2**
2	Marri Woodland	4	2	1	**7**
3	Mixed Woodland	2	1	1	**4**
4	Sheoak Stands	1	1	0	**2**
5	Melaleuca Dampland	1	1	0	**2**
6	Planted Eucalypts	1	1	0	**2**
7	Revegetated Shrubland	2	1	0	**3**
8	Open Areas	1	0	0	**1**

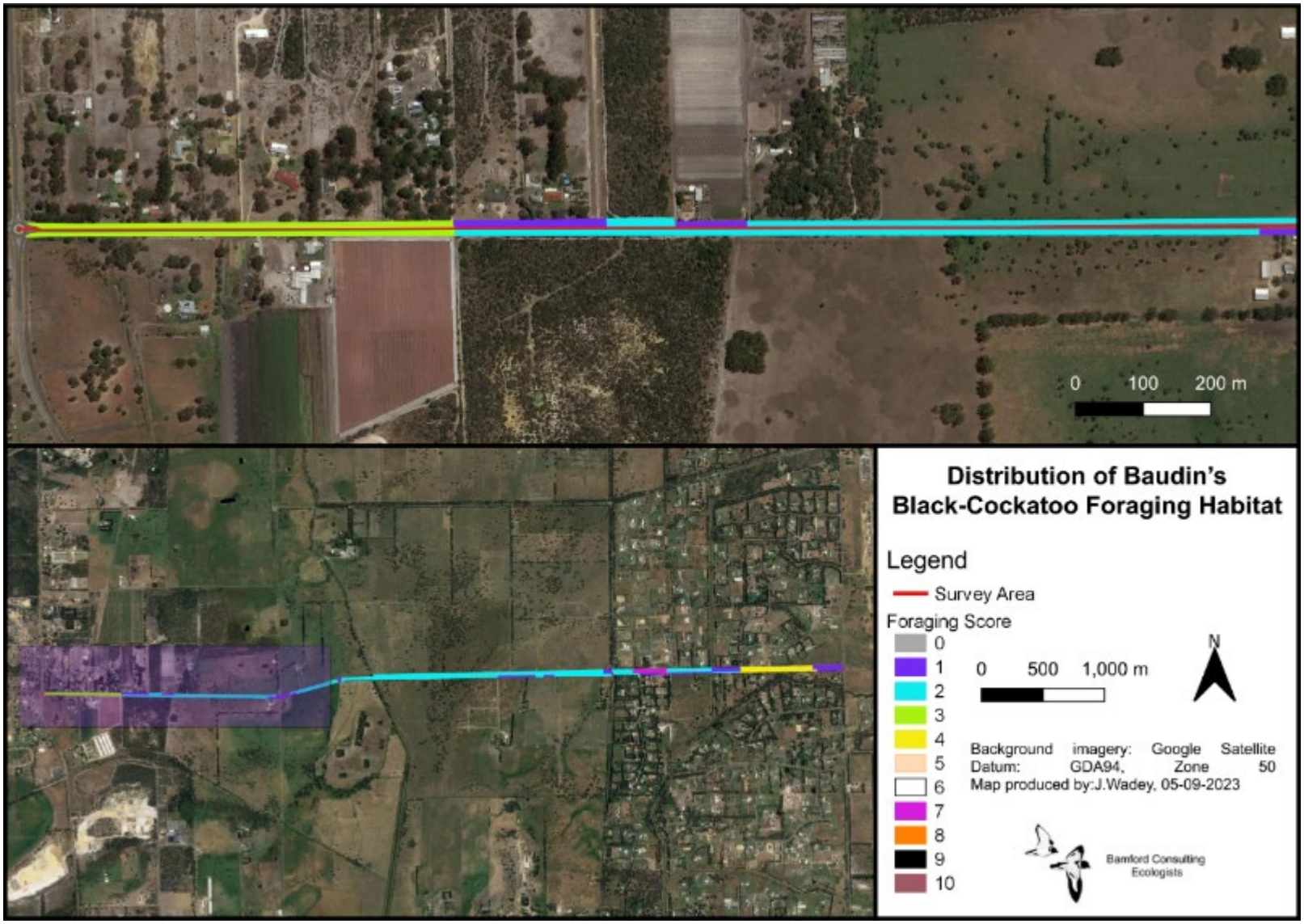

Figure 3-17. Distribution of Baudin's Black-Cockatoo foraging scores within each VSA in the western portion of the survey area.

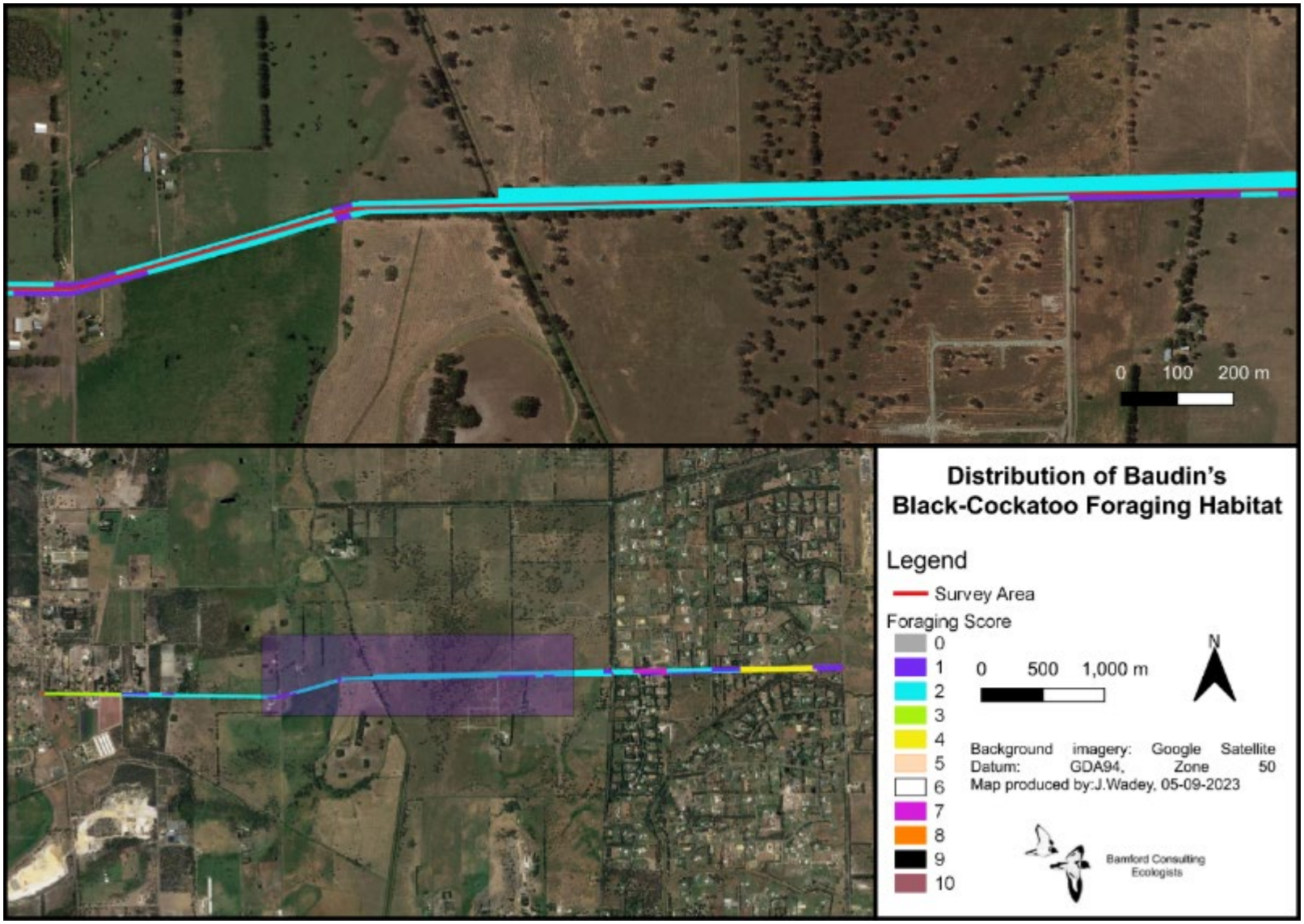

Figure 3-18. Distribution of Baudin's Black-Cockatoo foraging scores within each VSA in the central portion of the survey area.

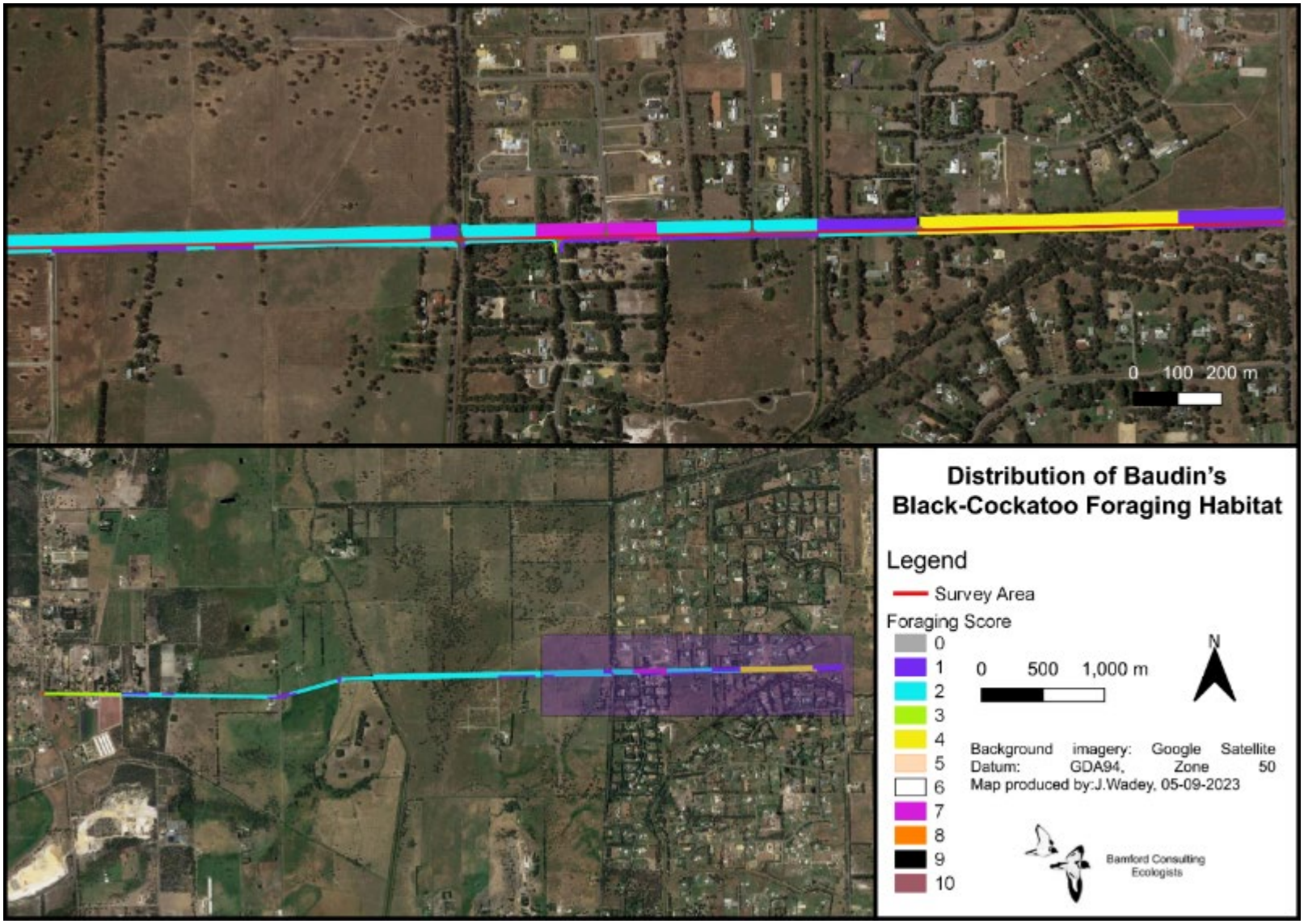

Figure 3-19. Distribution of Baudin's Black-Cockatoo foraging scores within each VSA in the eastern portion of the survey area.

3.2.4 Roosting habitat

BirdLife Australia provided descriptions of recorded roosts in the region. There are 48 known roost sites within 15 km of the survey area, with the closest recently-active roost located only 650 m north of the western part of the survey area (Figure 3-20). There are tall trees in the survey area suitable for roosting (planted eucalypts and Marri) and water sources within and adjacent to the survey area in the form of drainage lines and paddock dams. A nearby water source is considered an important feature of black-cockatoo roosts. This suggests the survey area provides suitable roosting habitat for black-cockatoo species.

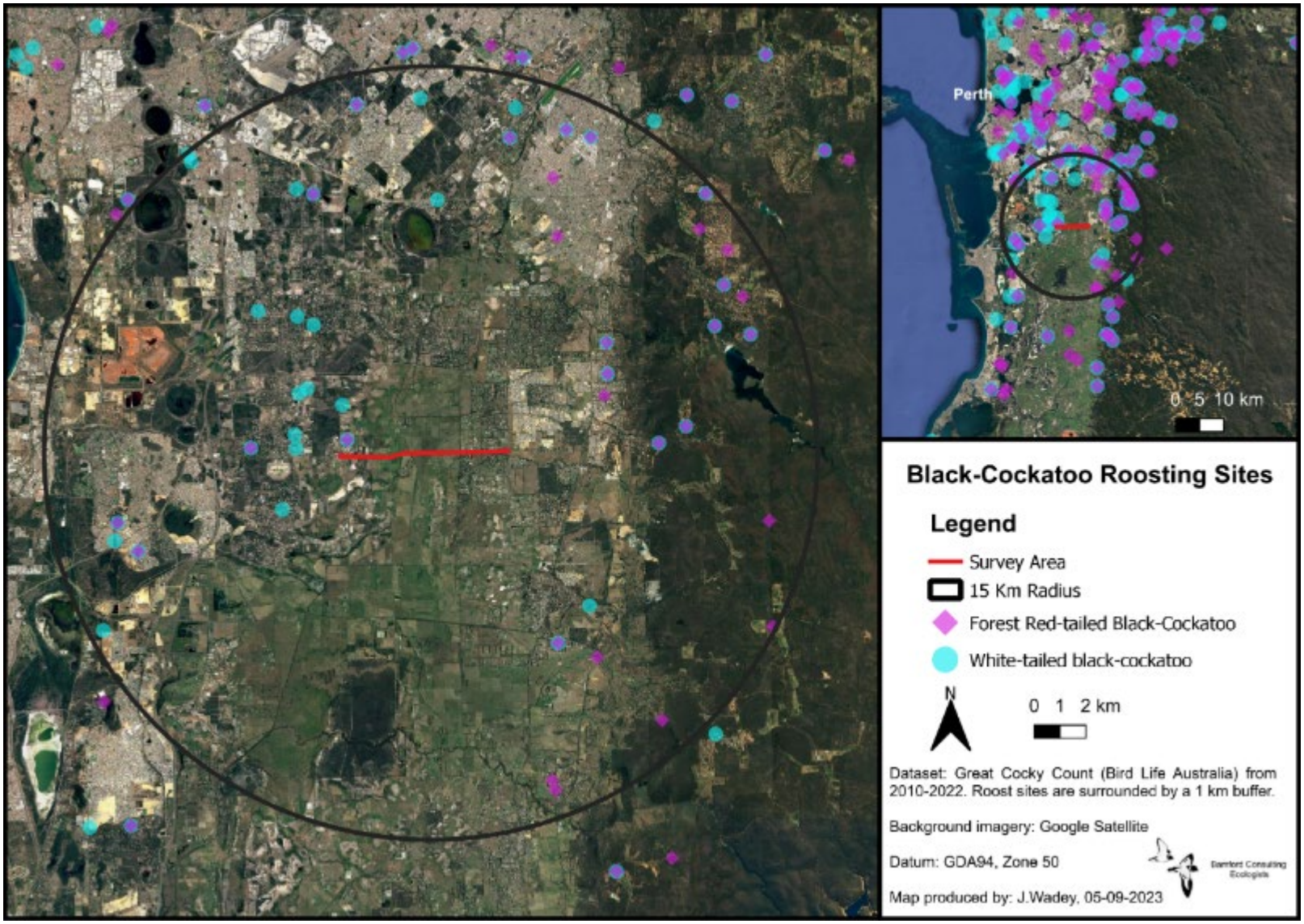

Figure 3-20. Known black-cockatoo roost locations around the survey area

3.3 Habitat loss and Connectivity

While ecological functions are usually discussed in higher level assessments involving the entire fauna assemblage, habitat loss and connectivity are considered particularly relevant to black-cockatoos and so are discussed briefly here.

3.3.1 Habitat loss

Habitat loss refers to both existing habitat loss and ongoing or cumulative habitat loss. Existing habitat loss refers to the loss of vegetation that has already occurred in the local area and region and which black-cockatoos are already affected by. The survey area is located on the Swan Coastal Plain where native vegetation has been previously cleared and few patches remain. This is relevant to black-cockatoos which rely on remnant (and in some cases planted) vegetation for foraging, roosting and breeding. Existing habitat loss has likely resulted in the decline of black-cockatoo abundance. Additional and ongoing habitat loss have the potential to lead to further population decline.

3.3.2 Connectivity

Connectivity is considered here due to the linear nature of the survey area and the critical ecological function such a linear strip of vegetation can provide in an otherwise highly-cleared rural environment. The area surrounding the survey area is rural and mostly cleared, and in most parts, the vegetation along the roads in the survey area represent the only vegetation present in the vicinity of the survey area. Figures throughout this report show vegetation in the local area and the connectivity the roadside vegetation of the survey area provides through the landscape. Although black-cockatoos are very mobile and will fly across paddocks to access foraging sites, BCE observations suggest that black-cockatoos are unlikely to regularly go over open ground for a distance of more than a few kilometres and prefer to follow tree-lines, suggesting the connectivity function provided by a linear strip of vegetation is important for black-cockatoos.

4 SUMMARY

The survey area contains a mix of VSAs with most having the potential to support roosting, breeding and/or foraging by black-cockatoos. VSAs with the highest foraging value for black-cockatoos were Banksia woodland, Marri woodland, Mixed woodland (of Marri and Flooded Gum) and Sheoak stands; these are scattered across the survey area. There were two Category 3 trees which contained vertical hollows suitable for black-cockatoo breeding, both located along the eastern part of the survey area. Carnaby's and Forest Red-tailed Black-Cockatoos are expected as regular visitors and Baudin's Black-Cockatoo is expected as an irregular visitor. A flock of Carnaby's Black-Cockatoo was recorded foraging in Banksia woodland within the survey area, and recent foraging evidence of Forest Red-tailed Black-Cockatoo was recorded in Marri woodland and along the Sheoak stands. The survey area provides a connectivity function for black-cockatoos through an otherwise-cleared landscape.

5 REFERENCES

Bamford, M., Bleby, K. and Chuk, K. (2021). Byford Rail Extension Fauna Assessment, Spring 2020. Unpublished report to Unpublished report to GHD Pty Ltd by Bamford Consulting Ecologists, Kingsley, Western Australia.

Burbidge, A. A. (2004). *Threatened Animals of Western Australia*. Department of Conservation and Land Management, Kensington, Western Australia.

DAWE. (2020a). List of marine species. Department of Agriculture, Water and the Environment. https://www.environment.gov.au/marine/marine-species/marine-species-list

DAWE. (2020b). Protected marine species - Identification guide. Department of Agriculture, Water and the Environment. https://www.environment.gov.au/marine/publications/protected-marine-species-identification-guide

DAWE. (2021a). *Calyptorhynchus latirostris* in Species Profile and Threats Database. Department of Agriculture, Water and the Environment. Available from: http://www.environment.gov.au/sprat

DAWE. (2021b). *Calyptorhynchus banksii naso* in Species Profile and Threats Database. Department of Agriculture, Water and the Environment. Available from: http://www.environment.gov.au/sprat

DAWE. (2022). Referral guideline for 3 WA threatened black cockatoo species: Carnaby's Cockatoo, Baudin's Cockatoo and the Forest Red-tailed Black-cockatoo. Department of Agriculture, Water and the Environment, Canberra, February.

DCCEEW. (2023). Calyptorhynchus baudinii in Species Profile and Threats Database. Department of Agriculture, Water and the Environment. Available from: http://www.environment.gov.au/sprat

DPaW. (2013). Carnaby's Cockatoo (*Calyptorhynchus latirostris*) Recovery Plan. Department of Parks and Wildlife, Perth, Western Australia.

DSEWPaC. (2012). EPBC Act referral guidelines for three threatened black cockatoo species: Carnaby's cockatoo (endangered) Calyptorhynchus latirostris, Baudin's cockatoo (vulnerable) Calyptorhynchus baudinii, Forest red-tailed black cockatoo (vulnerable) Calyptorhynchus banksii naso. Department of Sustainability, Environment, Water, Population and Communities, Canberra, Australian Capital Territory.

Groom, C. (2011). Plants Used by Carnaby's Black Cockatoo. Department of Environment and Conservation, Perth, Western Australia.

Johnston, T. R., Stock, W. D. and Mawson, P. R. (2016). Foraging by Carnaby's Black-Cockatoo in Banksia woodland on the Swan Coastal Plain, Western Australia. Emu 116: 284-293.

Johnstone, R. E. and Kirkby, T. (1999). Food of the Forest Red-tailed Black Cockatoo Calyptorhynchus banksii naso in south-west Western Australia. The Western Australian Naturalist 22: 167-177.

Johnstone, R. E., Kirkby, T. and Sarti, K. (2013a). The breeding biology of the Forest Red-tailed Black Cockatoo Calyptorhynchus banksii naso Gould in south-western Australia. I. Characteristics of nest trees and nest hollows. Pacific Conservation Biology 19: 121-142.

Johnstone, R. E., Kirkby, T. and Sarti, K. (2013b). The breeding biology of the Forest Red-tailed Black Cockatoo Calyptorhynchus banksii naso Gould in south-western Australia. II. Breeding behaviour and diet. Pacific Conservation Biology 19: 143-155.

Johnstone, R. E. and Storr, G. M. (1998). *Handbook of Western Australian birds. Volume 1: Non-passerines (Emu to Dollarbird)*. Western Australian Museum, Perth, Western Australia.

Keighery, B. J. (1994). Bushland Plant Survey: A guide to plant community survey for the community. Wildflower Society of Western Australia (Inc.), Nedlands, Western Australia

Kirkby, T. (2021). Byford Rail Extension: Assessment of Possible Black Cockatoo Breeding Hollows. Unpublished report to GHD Pty Ltd.

Peck, A. (2019). BirdLife Australia 2019 Black-Cockatoo breeding survey report. BirdLife Australia, Perth, Western Australia.

Saunders, D. A. (1974). Breeding biology of the Short-billed form of the White-tailed Black Cockatoo Calyptorhynchus baudinii latirostris (Carnaby). Emu 74: 292-293.

Saunders, D. A. (1979). Distribution and taxonomy of the White-tailed and Yellow-tailed Black-Cockatoos Carlyptorhynchus spp. Emu. 79: 215-227.

Saunders, D. and Ingram, J. (1995). Birds of Southwestern Australia. An atlas of changes in distribution and abundance of the wheatbelt fauna. Surrey Beatty & Sons; and CSIRO.

Scott, J.K. and Black, R. (1981) Selective predation by white-tailed black cockatoos on fruit of Banksia attenuata containing the seed-eating weevil Alphitopis nivea. Australian Wildlife Research, 8, 421-30.

Stock, W. D., Finn, H. C., Parker, J. and Dods, K. (2013). Pine as Fast Food. Foraging Ecology of an Endangered Cockatoo in a Forestry Landscape. *PlosOne* **8**.

Valentine, L. and Stock, W. (2008). Food Resources of Carnaby's Black-Cockatoo (Calyptorhynchus latirostris) in the Gnangara Sustainability Strategy study area. Unpublished report to Forest Products Commission by the Centre for Ecosystem Management, Edith Cowan University, and the Department of Environment and Conservation, Perth, Western Australia.

6 APPENDIX

Appendix 1. Explanation of fauna values.

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

Assemblage characteristics

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

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

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

Vegetation and substrate associations (VSAs)

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

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

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

- soil type and characteristics

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

Patterns of biodiversity across the landscape

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

Species of conservation significance

Species of conservation significance are of special importance in impact assessment. The conservation status of fauna species in Australia is assessed under Commonwealth and State Acts such as the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Western Australian *Biodiversity Conservation Act 2016* (BC Act). In addition, the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA) recognises priority levels, while local populations of some species may be significant even if the species as a whole has no formal recognition. Therefore, three broad levels of conservation significance can be recognised and are used for the purposes of this report, and are outlined below. A full description of the conservation significance categories, schedules and priority levels mentioned below is provided in **Error! Reference source not found.**.

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 *Wildlife Conservation Act 1950* 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 *Wildlife Conservation Act 1950* 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 (Dell & Banyard, 2000).

Marine-listed species

Some conservation significant species may also be listed as 'Marine' under the EPBC Act. This listing protects these species in 'Commonwealth areas' which include "marine areas beyond the coastal waters of each State and the Northern Territory, and includes all of Australia's Exclusive Economic Zone (EEZ)" (DAWE, 2020b). The EEZ extends to 200 nautical miles (approximately 350 kilometres) from the coast (DAWE, 2020b). This may mean that the 'Marine' listing does not apply to the project/survey area (depending on its location). Therefore, when a species is otherwise protected (under the EPBC Act or BC Act) or priority-listed (by the DBCA) then the Marine listing is also noted but it does not have site-specific relevance. In cases where a species is solely Marine-listed (for a list see DAWE, 2020a) and a project/survey area is not within a Commonwealth area then it is treated like all other fauna.

Invertebrates

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

Introduced species

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

Ecological processes upon which the fauna depend

These are the processes and conditions that apply to the existing environment and that affect and maintain fauna populations in an area. As such they are very complex; for example, populations are maintained through the dynamic of mortality, survival and recruitment being more or less in balance,

and these are affected by a myriad of factors. The dynamics of fauna populations in a survey area may be affected and effectively determined by processes such as:

- fire regime.
- landscape patterns (such as extent of existing habitat, fragmentation and/or linkage).
- the presence of feral species.
- hydrology.

Appendix 2. Scoring system for the assessment of foraging value of vegetation for black-cockatoos; developed by BCE and based on EPBC guidance.

Introduction

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

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

Note that the scoring system can only be applied within the range of the species or at least where the species could reasonably be expected to occur based upon existing information.

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

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

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

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

Species stocking rate is given a low weight (0 to 1) as it is a means only of recognising that a species may or may not be abundant at a site, but that abundance is dependent upon site condition and context and is thus not an independent variable. The abundance of a species is also sensitive to

sampling effort, and to seasonal and annual variation, and is therefore an unreliable indicator of actual importance of a site to a species.

Calculation of scores and the moderation process are described in detail below.

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

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

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

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

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

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

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

Vegetation structural class terminology follows Keighery (1994).

B. Site context.

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

The maximum score for site context is 3, and because it is effectively a function of presence/absence of nearby breeding and the distribution of foraging habitat across the landscape, the following table, developed by Bamford Consulting in conjunction with the DAWE (2022), provides a *guide* to the assignation of site context scores. Note that 'local area' is defined as within a 15 km radius of the centre point of the study site. This is greater than the maximum distance of 12km known to be flown by Carnaby's Black-Cockatoo when feeding chicks in the nest.

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

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

C. Species density (stocking rate).

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

moderate condition score that is part of a network of such habitat where a black-cockatoo species is known would get a species density score of 1 even without clear presence data, while a species density score of 0 can be assigned to a site where the level of usage can confidently be predicted to be low.

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

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

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

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

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

Pine plantations

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

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

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

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

B) also applies to pines. Thus, a context score of 3 can be given where pines are a significant proportion of foraging habitat (>5% if breeding occurs; >10% if no breeding), but where pines are a small part of the foraging landscape they will receive a context score of less than this.

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

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

Appendix 3. Details of potential breeding trees

Tree Species Name	DBH	Rank	Alive	Easting	Northing	Comment
Planted Eucalypt	500	5	Alive	401326	6432928	
Planted Eucalypt	500	4	Alive	401336	6432930	
Planted Eucalypt	600	5	Alive	401349	6432929	
Planted Eucalypt	500	5	Alive	401291	6432929	
Marri	500	5	Alive	401583	6432956	
Marri	500	5	Alive	401607	6432961	
Marri	500	5	Alive	401771	6432957	
Marri	700	4	Alive	401781	6432962	Galahs nesting
Marri	500	5	Alive	401805	6432972	
Marri	500	5	Alive	398130	6432764	
Melaleuca rhaphiophylla	900	4	Alive	398172	6432753	
Marri	500	5	Alive	401788	6432937	
Marri	500	5	Alive	401795	6432932	
Planted Eucalypt	500	5	Alive	402205	6432947	
Planted Eucalypt	500	5	Alive	402210	6432948	
Planted Eucalypt	500	5	Alive	402214	6432947	
Planted Eucalypt	500	5	Alive	402223	6432947	
Planted Eucalypt	500	5	Alive	402229	6432947	
Planted Eucalypt	500	5	Alive	402247	6432948	
Planted Eucalypt	500	5	Alive	402435	6432953	
Marri	500	5	Alive	402444	6432952	
Marri	700	5	Alive	402463	6432948	
Marri	800	5	Alive	402466	6432952	
Marri	600	5	Alive	402482	6432951	
Marri	700	3	Dead	402528	6432980	
Marri	700	4	Alive	402525	6432987	
Marri	700	4	Alive	402519	6432983	
Marri	700	4	Alive	402496	6432987	
Marri	600	3	Dead	402446	6432982	
Marri	500	5	Alive	402534	6432976	
Marri	900	5	Alive	402546	6432986	
Marri	500	5	Alive	402549	6432986	
Marri	700	5	Dead	402559	6432986	
Marri	600	5	Alive	402566	6432988	
Marri	500	5	Alive	402569	6432983	
Marri	500	5	Alive	402586	6432978	
Marri	500	4	Alive	402599	6432985	
Flooded Gum	800	5	Alive	402632	6432955	
Flooded Gum	500	5	Alive	402661	6432982	
Marri	500	5	Alive	402686	6432959	
Marri	600	5	Alive	402922	6432965	
Marri	700	5	Alive	402990	6432963	
Planted Eucalypt	600	5	Alive	400001	6432905	
Planted Eucalypt	600	5	Alive	399859	6432900	

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