



M.J. & A.R. Bamford
CONSULTING ECOLOGISTS
23 Plover Way,
Kingsley, WA, 6026
ph: 08 9309 3671 mo: 0400 802692
em: bamford.consulting@iinet.net.au
ABN 84 926 103 081

20th January 2022

INFINITE BLUE ENERGY; Arrowsmith Hydrogen Project Black-Cockatoo Assessment

BACKGROUND

Infinite Blue Energy is proposing to develop a hydrogen production facility, based upon wind and solar power, near Arrowsmith in the Mid-West region of Western Australia (Figure 1). Investigations to inform Environmental Impact Assessment have been carried out, and a key significant species in the area is Carnaby's Black-Cockatoo *Calyptorhynchus latirostris*. The investigations concluded that most of the native vegetation was of limited value as foraging habitat for the species, and found no suitable nesting areas and did not report any roosting site (ecoscape 2021). Some areas in the south, however, were noted as having some *Banksia prionotes*, a known food plant for the species, and the report concluded that these areas '*may provide preferred forage habitat but are of limited extent and plant density, therefore, are considered unlikely to support large flocks of Carnaby's [Black-]Cockatoo or prolonged feeding activity.*'

Further information has been requested on the foraging quality of these areas and in particular to assign a foraging quality score to those areas of vegetation identified by ecoscape (2021) as having some foraging value. Bamford Consulting Ecologists (BCE) was commissioned to undertake this assessment, using a foraging value scoring system developed by BCE. In addition, it was requested that BCE assess the likelihood of roosting by Carnaby's Black-Cockatoo in the project area.

METHODS

The project area was visited on the 5th and 6th of December 2021. The initial visit was brief and in response to a sighting of a flock of Carnaby's Black-Cockatoos flying north across paddocks in the east in the late afternoon. The second visit involved five people visiting the project area for about three hours. The four personnel were:

- Dr Mike Bamford (BSc. Hons Ph.D. (Biol)); ca. 20 years in black-cockatoo assessments.
- Dr Wes Bancroft (BSc (Zool./Microbiol.), Hons (Zool.), PhD (Zool.)); ca. 20 years in black-cockatoo assessments.
- Mr Andy McCreery (BSc. Wild. and Cons. Biol.); ca. five years black-cockatoo assessments.
- Dr Jamie Wadey (BSc. Hons Ph.D. (Biol)); ca. two years black-cockatoo assessments.

- Ms Eliza-Joyce Mellersh (BSc. (Wild. and Cons. Biol.); ca. four years black-cockatoo assessments.

The second visit involved two phases. The first phase was a walk-through the main area identified as Carnaby's Black-Cockatoo foraging habitat in order to determine the type of vegetation present. The team broke into two parties to cover more ground (see tracks in Figure 2) and walked through part of this area. The remainder of the area was scanned from vantage points with binoculars; this enabled the more westerly parts of the foraging area to be inspected from high ground in the east. On these walks, notes were made of vegetation and foraging signs of Carnaby's were recorded. Some habitat photographs were also taken. The second phase was an evening observation from several points on high ground on farmland in the east of the project area. These high points gave clear views to the west with the intention of watching for flocks of Carnaby's that might be approaching a group of large eucalypt trees around a wetland in the north-east of the project area (Figure 1). Large trees close to wetlands are favoured roosting locations for black-cockatoos. The evening roost observation commenced about 18:40 hours with sunset about 19:10 hours. Observations ceased about 19:20 hours.

The foraging value of the study area was assessed by calculating a foraging score for areas of similar 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 government 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 therefore has three components as detailed in **Error! Reference source not found..** 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.

OBSERVATIONS

The vegetation identified as preferred forage habitat by Ecoscape (2021) was found to be a mosaic of:

1. *Banksia prionotes* Woodland/*Banksia sessilis* Thicket/Shrubland;
2. Acacia Shrubland. A complex heath/*Acacia* shrubland mosaic but generally with very low presence of *Banksia* species;
3. Heathland on shallow soil with exposed limestone; and
4. Eucalypt Woodland along drainage lines. Primarily *Eucalyptus camaldulensis*.

The banksia areas were mainly in the east with Heathland mostly to the west. Soils were sandy and underlain with limestone that was outcropping in the Heathland. These Vegetation and Substrate Associations (VSAs) are mapped in Figure 2.

Foraging habitat for the Carnaby's Black-Cockatoo was present but not uniform across the survey area. This is predominantly due to the presence of two *Banksia* species known to be mainstays of the Carnaby's Black-Cockatoo diet: *B. prionotes* and *B. sessilis* (Groom 2011). There were also other palatable species such as *Grevillea* spp. and *Hakea* spp.

A map of the vegetation foraging scores for Carnaby's Black-Cockatoo foraging within the survey area is presented in Figure 3. Vegetation, context, density and combined (foraging) scores for Carnaby's Black-Cockatoo in each VSA present in the survey area is presented in Table 1. The total areas (and proportions) of each foraging score in the survey area, for Carnaby's Black-Cockatoo, are presented in Table 2. Within the area identified by ecoscape (2021), there are 14.3ha of moderate to high quality foraging habitat (score of 6 out of 10), and about 80ha of low quality foraging habitat (score of 1 or 2 out of 10). About a further 10ha of moderate to high quality foraging habitat lie just to the east of the ecoscape area (Figure 3).

There was considerable evidence of foraging by Carnaby's Black-Cockatoos throughout the inspected area (50 records). This included foraging on *B. prionotes* (4 records), *B. sessilis* (44 records) and *G. leucopteris* (2 records), with recent, intermediate and old-aged signs noted. The locations of these records are shown in Figure 2.

The region around the survey area is known to support black-cockatoo roosting but prior to the current survey there were no records of roost sites within the lease area. Previously known roost locations from BirdLife Australia's Great Cocky Count and BCE records that are in the vicinity of the survey area are shown in Figure 4. The evening observations on 6th December are summarised below (observation locations and black-cockatoo sightings illustrated on Figure 5):

- 18:45. A single Red-tailed Black-Cockatoo (inland sub-species *Calyptorhynchus banksii esconditus*) was seen from the northern observation point (Figure 5), flew to planted paddock trees east of the highway and at 18:55, this bird flew to the west and disappeared amongst large trees around a wetland system within the lease area.
- 18:55. A flock of c. 80 Carnaby's Black-Cockatoos seen from the southern observation point, then flew over the central observation point and went east of the highway. They approached from the west so may have been coming from native vegetation on the southern edge of the lease area.
- 19:05. About 60 Carnaby's Black-Cockatoos flew from east of the highway and settled in large trees south of the wetlands on the lease area (see Figure 5). Location of roost estimated as: 310350E, 6735200N.

The presence of a single Inland Red-tailed Black-Cockatoo was unusual as in multiple previous field investigations by BCE in the general Arrowsmith region, this taxon has not previously been observed and the single bird appeared to be roosting in the same location as the Carnaby's Black-cockatoos. The Inland Red-tailed Black-Cockatoo is not of high conservation significance. The behaviour of the Carnaby's Black-Cockatoos suggests they were going to drink at a watering point on paddocks east of the highway. Some birds may have remained in trees near this presumed watering point to roost, but the majority of the flock did roost in large trees on the lease area.

CONCLUSIONS

Foraging habitat for Carnaby's Black-Cockatoo of moderate to high quality does lie in the area identified by ecoscape, and extends beyond this area (to the east). The majority of the area identified by ecoscape, however, is of low foraging value. No other potential foraging habitat was identified by ecoscape in the lease area but the current work did not involve revisiting other parts of the lease. Ecoscape identified the foraging area on the basis of the presence of *B. prionotes*, but *B. sessilis* was more extensive and was more heavily visited by Carnaby's Black-Cockatoo. It is possible that *B. sessilis* does occur elsewhere in the lease area.

Roosting by Carnaby's Black-Cockatoo in the lease area was confirmed, and large trees close to a wetland is very typical of a favoured roosting site. Roosting sites tend to be used most regularly and by the largest number of birds outside the breeding season, and particular in the March to May period. Therefore, the presence of roosting birds in early December, at the end of the breeding season, suggests that birds are present in the region and using that roost site for at least half the year. Larger numbers may be present in autumn and a roost count in April 2022, to coincide with the annual Great Cocky Count, would contribute both to knowledge of the value of the lease area for Carnaby's Black-cockatoo, and to broader knowledge of the species population size and distribution in the greater region.

The presence of a roost site within the lease area, and the evidence of foraging of varying ages on *B. sessilis*, indicates that Carnaby's Black-Cockatoo are likely to be more regular foraging visitors to the area than suggested by ecoscape. It is not known if large trees in the vicinity of the roost site have been assessed for their potential for nesting.

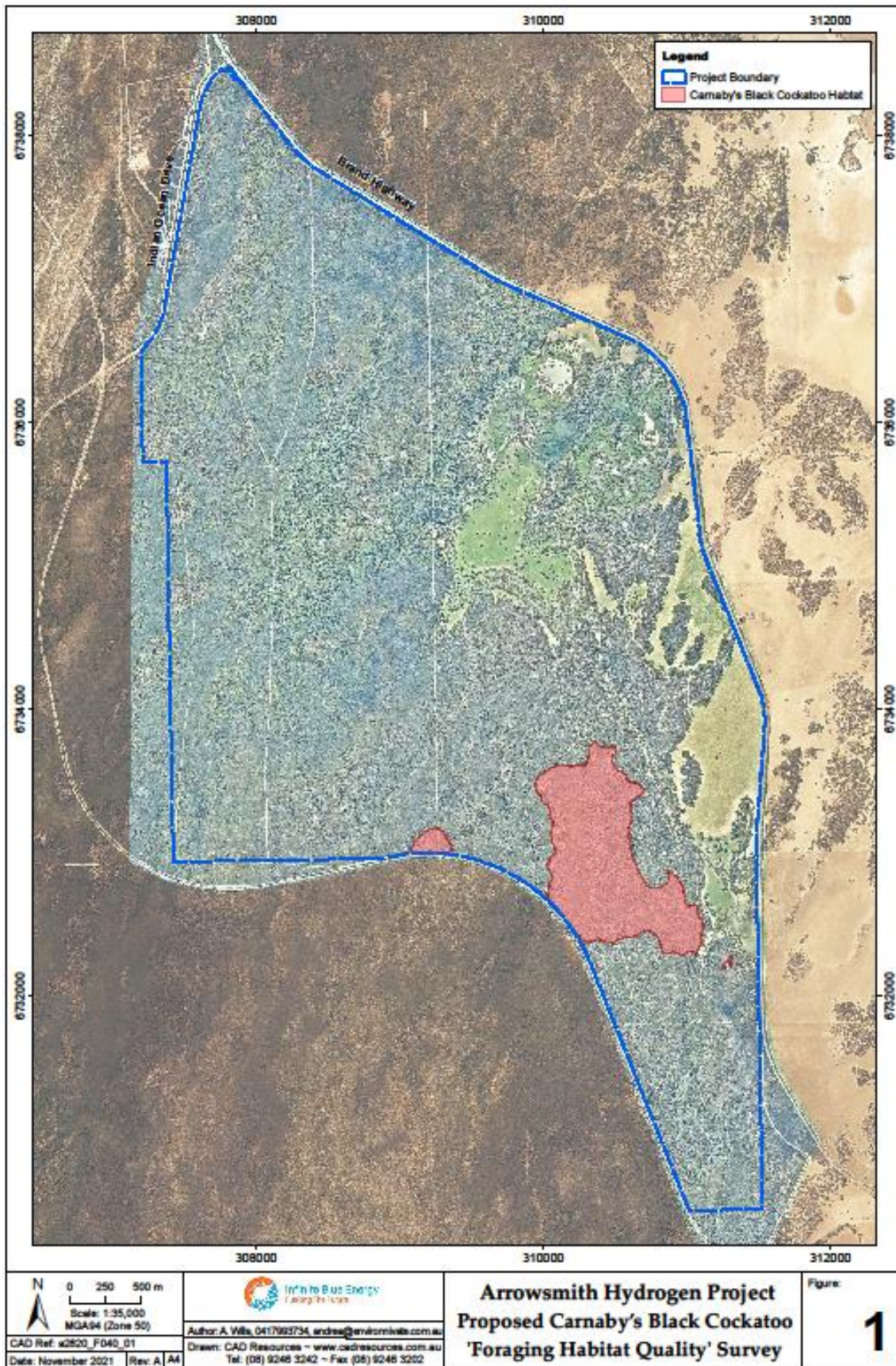


Figure 1. The project area, indicating location assessed as Carnaby's Black-Cockatoo foraging habitat by ecoscape (2021).

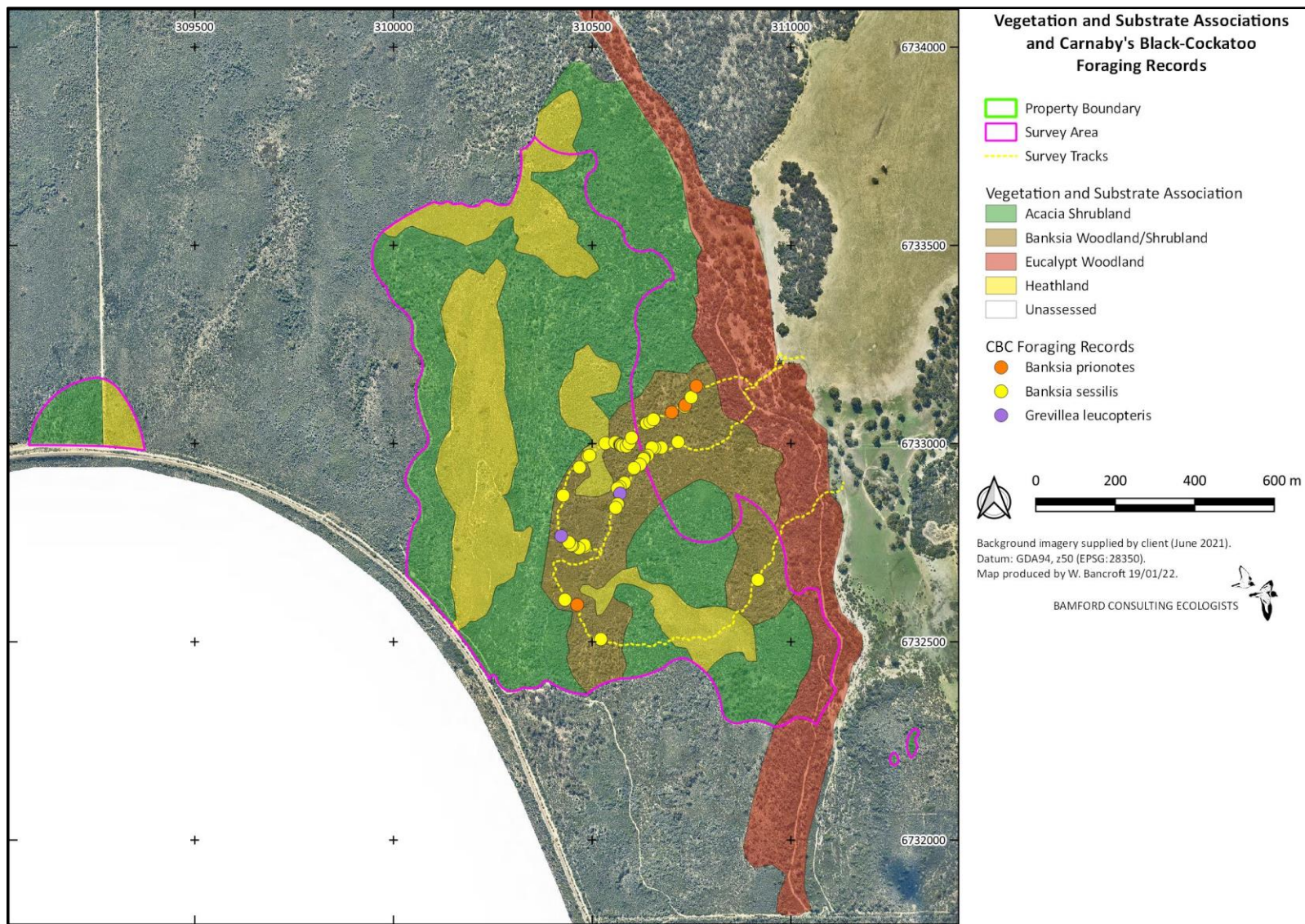


Figure 2. Vegetation and substrate associations and Carnaby's Black-Cockatoo foraging records in the vicinity of the survey area.

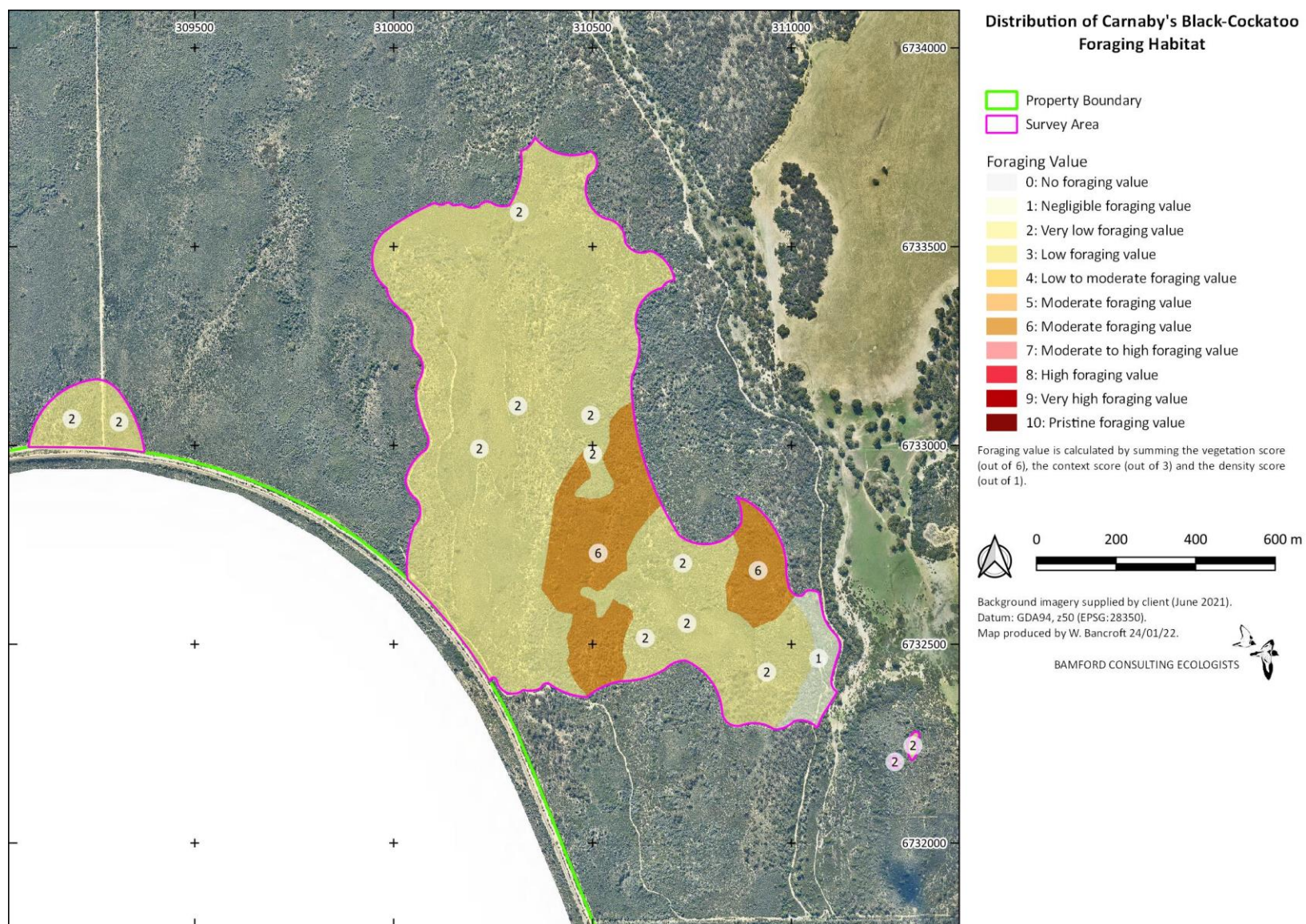


Figure 3. Distribution of Carnaby's Black-Cockatoo foraging habitat within the survey area.

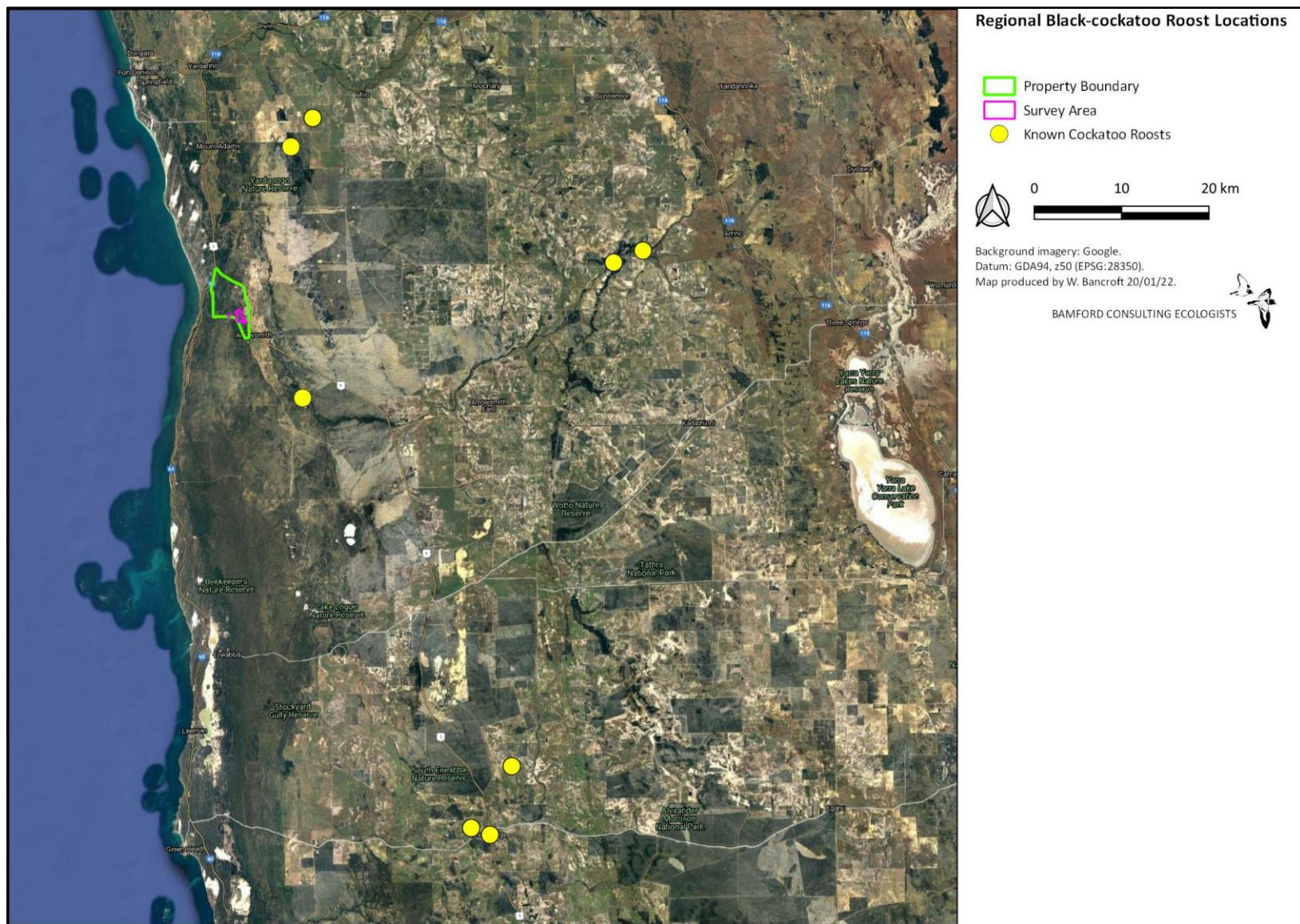


Figure 4. Known black-cockatoo roost locations within the region.

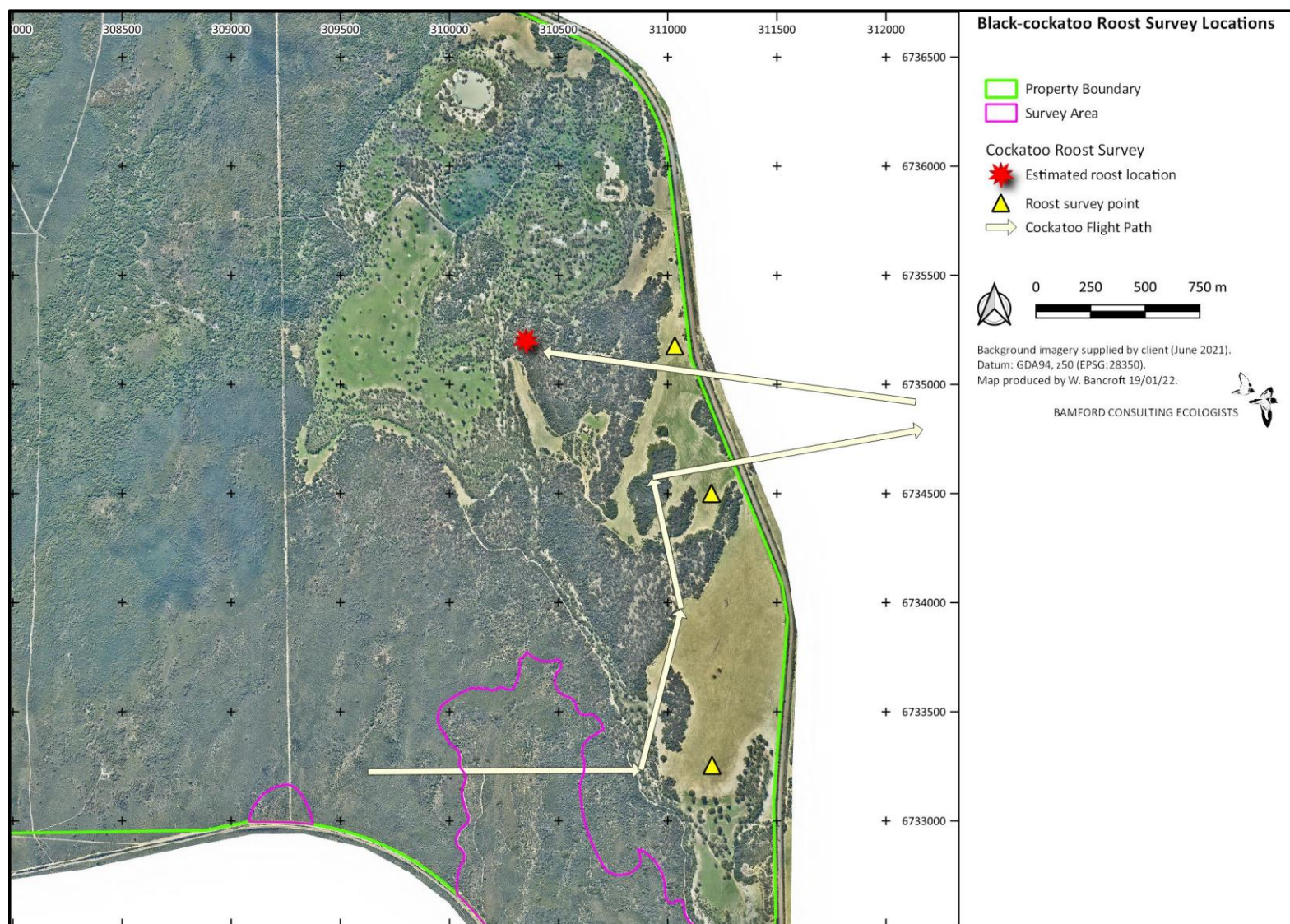


Figure 5. Roost survey locations, approximate cockatoo flight paths and estimated roost location within the lease area.

Table 1. Vegetation, context, density and combined (foraging) scores in each VSA present in the survey area.

VSA	Area (ha)	Carnaby's Black-Cockatoo			
		Vegetation	Context	Density	Total
Acacia Shrubland	49.13	1	1	0	2
Banksia Woodland/ Shrubland	14.26	3	2	1	6
Eucalypt Woodland	2.30	1	0	0	1
Heathland	27.87	1	1	0	2
<i>Total</i>	93.56				

Table 2. Total areas (ha) and proportions (%) of each (combined) foraging score in the survey area.

Foraging Score	Carnaby's Black-Cockatoo	
	Area (ha)	%
0	-	-
1	2.30	2.5
2	77.00	82.3
3	-	-
4	-	-
5	-	-
6	14.26	15.2
7	-	-
8	-	-
9	-	-
10	-	-
<i>Total</i>	93.56	100.0

Appendix 1. Scoring system for the assessment of foraging value of vegetation for Black-Cockatoos. Revised 5th November 2020

Bamford Consulting Ecologists

Introduction

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

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

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

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

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

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

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

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

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

A. Site condition. Vegetation composition, condition and structure scoring

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	Baudin's Black-Cockatoo	Forest Red-tailed Black-Cockatoo
0	<p>No foraging value. No Proteaceae, eucalypts or other potential sources of food. Examples:</p> <ul style="list-style-type: none"> • Water bodies (e.g. salt lakes, dams, rivers); • Bare ground; • Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits) or with vegetation of no food value, such as some suburban landscapes. • Mown grass 	<p>No foraging value. No eucalypts or other potential sources of food. Examples:</p> <ul style="list-style-type: none"> • Water bodies (e.g. dams, rivers); • Bare ground; • Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits). 	<p>No foraging value. No eucalypts or other potential sources of food. Examples:</p> <ul style="list-style-type: none"> • Water bodies (e.g. dams, rivers); • Bare ground; • Developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits).
1	<p>Negligible to low foraging value. Examples:</p> <ul style="list-style-type: none"> • Scattered specimens of known food plants but projected foliage cover of these is < 2%. This could include urban areas with scattered foraging trees; • Paddocks that are lightly vegetated with melons or other known food-source weeds (e.g. <i>Erodium</i> spp.) that represent a short-term and/or seasonal food source; • Blue Gum plantations (foraging by Carnaby's Black-Cockatoos has been reported but appears to be unusual). 	<p>Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these < 1%. This could include urban areas with scattered foraging trees.</p>	<p>Negligible to low foraging value. Scattered specimens of known food plants but projected foliage cover of these < 1%. Could include urban areas with scattered foraging trees.</p>

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	Baudin's Black-Cockatoo	Forest Red-tailed Black-Cockatoo
2	<p>Low foraging value. Examples:</p> <ul style="list-style-type: none"> Shrubland in which species of foraging value, such as shrubby banksias, have < 10% projected foliage cover; Woodland with tree banksias 2-5% projected foliage cover; Open eucalypt woodland/mallee of small-fruited species; Paddocks that are densely vegetated with melons or other known food-source weeds (e.g. <i>Erodium</i> spp.) that represent a short-term and/or seasonal food source. 	<p>Low foraging value. Examples:</p> <ul style="list-style-type: none"> Woodland with scattered specimens of known food plants (e.g. Marri and Jarrah) 1-5% projected foliage cover; Urban areas with scattered foraging trees. 	<p>Low foraging value. Examples:</p> <ul style="list-style-type: none"> Woodland with scattered specimens of known food plants (e.g. Marri, Jarrah or Sheoak) 1-5% projected foliage cover; Urban areas with scattered food plants such as Cape Lilac, <i>Eucalyptus caesia</i> and <i>E. erythrocorys</i>.
3	<p>Low to Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> Shrubland in which species of foraging value, such as shrubby banksias, have 10-20% projected foliage cover; Woodland with tree banksias 5-20% projected foliage cover; Eucalypt Woodland/Mallee of small-fruited species; Eucalypt Woodland with Marri < 10% projected foliage cover. 	<p>Low to Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> Eucalypt Woodland with known food plants (especially Marri) 5-20% projected foliage cover; Parkland-cleared Eucalypt Woodland/Forest with known food plants 10-40% projected foliage cover (poor long-term viability without management); Younger areas of (managed) revegetation with known food plants 10-40% projected foliage cover (establishing food sources with good long-term viability). 	<p>Low to Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> Eucalypt Woodland with known food plants (especially Marri and Jarrah) 5-20% projected foliage cover; Parkland-cleared Eucalypt Woodland/Forest with known food plants 10-40% projected foliage cover (poor long-term viability without management); Younger areas of (managed) revegetation with known food plants 10-40% projected foliage cover (establishing food sources with good long-term viability).

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	Baudin's Black-Cockatoo	Forest Red-tailed Black-Cockatoo
4	<p>Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> Woodland/low forest with tree banksias (of key species <i>B. attenuata</i> and <i>B. menziesii</i>) 20-40% projected foliage cover; Kwongan/ Shrubland in which species of foraging value, such as shrubby banksias, have 20-40% projected foliage cover; Eucalypt Woodland/Forest with Marri 20-40% projected foliage cover. 	<p>Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> Marri-Jarrah Woodland/Forest with 20-40% projected foliage cover; Marri-Jarrah Forest with 40-60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths. Eucalypt Woodland/Forest with diverse, healthy understorey and known food trees (especially Marri) 10-20% projected foliage cover. Orchards with highly desirable food sources (e.g. apples, pears, some stone fruits). 	<p>Moderate foraging value. Examples:</p> <ul style="list-style-type: none"> Marri-Jarrah Woodland/Forest with 20-40% projected foliage cover; Marri-Jarrah Forest with 40-60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; Sheoak Forest with 40-60% projected foliage cover.
5	<p>Moderate to High foraging value. Examples:</p> <ul style="list-style-type: none"> Banksia Low Forest (of key species <i>B. attenuata</i> and <i>B. menziesii</i>) with 40-60% projected foliage cover; Banksia Low Forest (of key species <i>B. attenuata</i> and <i>B. menziesii</i>) with > 60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths; Pine plantations with trees more than 10 years old (but see pine note below in moderation section). 	<p>Moderate to High foraging value. Examples:</p> <ul style="list-style-type: none"> Marri-Jarrah Forest with 40-60% projected foliage cover; Marri-Jarrah Forest with > 60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths. 	<p>Moderate to High foraging value. Examples:</p> <ul style="list-style-type: none"> Marri-Jarrah Forest with 40-60% projected foliage cover; Marri-Jarrah Forest with > 60% projected foliage cover but vegetation condition reduced due to weed invasion and/or some tree deaths. Sheoak Forest with > 60% projected foliage cover.

Site Score	Description of Vegetation Values		
	Carnaby's Black-Cockatoo	Baudin's Black-Cockatoo	Forest Red-tailed Black-Cockatoo
6	<p>High foraging value. Example:</p> <ul style="list-style-type: none"> Banksia Low Forest (of key species <i>B. attenuata</i> and <i>B. menziesii</i>) with > 60% projected foliage cover and vegetation condition good with low weed invasion and/or low tree deaths (indicating it is robust and unlikely to decline in the medium term). 	<p>High foraging value. Example:</p> <ul style="list-style-type: none"> 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). 	<p>High foraging value. Example:</p> <ul style="list-style-type: none"> 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 DEE, provides a *guide* to the assignment of site context scores. Note that 'local area' is defined as within a 15 km radius of the centre point of the study site. This is greater than the maximum distance of 12km known to be flown by Carnaby's Black-Cockatoo when feeding chicks in the nest.

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

The table above provides weighting for where nearby breeding is known (or suspected) and for the proportion of foraging habitat within 15km 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 (eg 0.5% of such habitat within 15km) could be upgraded to a context of 2 if it formed part of a critical movement corridor. In contrast, the same sized area of habitat, of the same local proportion, could be downgraded if it were so isolated that birds could never access it.

C. Species density (stocking rate).

Species stocking rate is described as "the usage and/or density of a species at a particular site" in the offsets guide. The description also implies that a site supports a discrete population, which is unlikely in the case of very mobile black-cockatoos. Assignment of the species density score (0 or 1) is based upon the black-cockatoo species being either abundant or not abundant. A score of 1 is used where the species is seen or reported regularly and/or there is abundant foraging evidence. Regularly is when the species is seen at intervals of every few days or weeks for at least several months of the year. A score of 0 is used when the species is recorded or reported very infrequently and there is little or no foraging evidence. Where information on actual presence of birds is lacking, a species density score can be assigned by interpreting the landscape and the site context. For example, a site with a moderate condition score that is part of a network of such habitat where a black-cockatoo species is known would get a species density score of 1 even without clear presence data, while a species density score of 0 can be assigned to a site where the level of usage can confidently be predicted to be low.

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

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

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

vegetation composition, condition and structure score (out of 6)	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. It could also get an elevated context score if it is the only foraging habitat in an area.

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.

Keighery (1994).

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(2)**, 421-430.

Stock, W.D., Finn, H., Parker, J. and Dods, K. (2013). Pine as Fast Food. Foraging Ecology of an Endangered Cockatoo in a Forestry Landscape. *PlosOne* 8: issue 4.