Tronox Cooljarloo
Level 1 Fauna and Targeted Black-Cockatoo Assessment of the Lone South and Osprey Survey Areas

Typical access track in the Osprey area, passing through *Banksia telmatiae* heath (VSA 5) (M. Bamford)

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Executive Summary

Introduction

Tronox Limited (Tronox) is proposing to expand operations at their Cooljarloo Mine. Bamford Consulting Ecologists (BCE) was commissioned by Tronox to conduct a Basic (sensu EPA, 2020) fauna assessment (desktop review, fauna habitat identification and a site inspection), including a targeted black-cockatoo assessment, of two survey areas: Lone South and Osprey. This report presents the results of that desktop review, site inspection and black-cockatoo assessment. The survey areas were visited on the 14th November 2023 (Lone South), and 19th January and 20th November 2024 (Osprey).

The purpose of impact assessment is to provide government agencies with the information they need to decide upon the significance of impacts of a proposed development, and to provide information to proponents to help them to develop appropriate strategies for avoiding and minimising impacts of their activities. This relies on information on the fauna assemblage and its environment, and BCE uses an approach with the following components:

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

Survey area description

Both survey areas are located in the Midwest region of WA, approximately 150-160 km north of Perth. The Lone South survey area is c. 55 ha in size and the Osprey survey area is c. 280 ha in size. Both survey areas consist primarily of native vegetation, intersected by narrow tracks of cleared vegetation. Th vegetation was long-unburnt at the time of site inspections, but was burnt in November 2024. The surrounding landscape is largely intact native vegetation, with existing Tronox developments to the south (Lone South), and north and east (Osprey), and areas of agricultural land about 1km to the north (Lone South) and 1km to the south (Osprey). Within 25 km of the survey areas there are several recognized sensitive sites including Threatened Ecological Communities, Environmentally Sensitive

Areas, Important Wetlands, protected terrestrial reserves, and a Key Biodiversity Area - the Cataby Important Bird Area (significant for Carnaby's Black-Cockatoo).

Key fauna values

Vegetation and Substrate Associations (VSAs). The survey areas encompass seven VSAs: VSA 1 (*Banksia attenuata* and *B. menziesii* Low Woodland), VSA 2 (*Banksia prionotes* Low Woodland), VSA 3 (*Banksia sessilis* Shrubland), VSA 4 (Dampland Shrubland/Open Woodland), VSA 5 (*Banksia telmatiaea* Heathland), VSA 6 (Mixed Heathland) and VSA 7 (Cleared areas). The Lone South survey area consists primarily of VSA 1, with small areas of VSA 2 and VSA 5. The Osprey survey area is composed primarily of VSA 5 and VSA 1, with small areas of VSAs 3, 4, 6 and 7.

Fauna assemblage. The desktop assessment identified 198 vertebrate fauna species as potentially occurring in the survey area: ten frogs, 46 reptiles, 120 birds, and 17 native and 5 introduced mammals. Fourteen vertebrate species that would historically have been present in the survey areas have been omitted from the expected species list because they are extinct or considered locally extinct. Overall, the assemblage of vertebrate fauna expected in the survey area is typical of the region, mostly complete for frogs, reptiles and birds, but incomplete for mammals. It is an assemblage rich in reptiles and small mammals, while the avian component is only moderately rich but notable for the large number and high abundance of nectarivores.

Species of conservation significance. Three broad levels of conservation significance are used in this report:

- Conservation Significance 1 (CS1) – species listed under State or Commonwealth Acts.
- Conservation Significance 2 (CS2) – species listed as Priority by DBCA but not listed under State or Commonwealth Acts.
- Conservation Significance 3 (CS3) – species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution.

Species of conservation significance. There are nine vertebrate species of conservation significance expected to occur in the survey area: five CS1, two CS2 and two CS3. An additional 11 species (one reptile, one bird and nine mammals) would be considered of conservation significance (CS1 or CS2) if they were not locally extinct in the area.

Three listed conservation significant invertebrates may be present in the survey area: the Moore River land snail (P1) and Spiny Katydid (Swan Coastal Plain) (P2) are both expected as residents, while the Graceful Sunmoth is only expected as an irregular visitor due to the low density of its host plant in the survey areas. Based on species collected in previous fauna surveys, the Cooljarloo area appears to be rich in short-range endemic (SRE) invertebrate species, particularly *Antichiropus* millipedes (four species collected by BCE) and mygalomorph spiders (six species collected by BCE). The Lone South and Osprey survey areas are likely to contain suitable habitat for these SRE species.

Black-cockatoo Assessment. Carnaby's Black-Cockatoo is expected to be a regular visitor to the survey area, but the area is out of range for the Forest Red-tailed and Baudin's Black-Cockatoos. No Carnaby's Black-Cockatoos were observed during the site inspection but evidence of foraging by this species was observed throughout both survey areas.

Foraging value – overall the Lone South survey area is of high foraging value and the Osprey survey area is of moderate foraging value for Carnaby's Black-Cockatoo. Throughout the sites, foraging scores ranged from 9/10 for areas with high *Banksia* spp. tree density (especially in VSA 1), to 4/10 for areas with lower density of these trees (such as VSA 5).

Breeding value – no trees were large enough to be assessed as potential nesting trees. The closest known and confirmed breeding sites are c. 15 km from the Osprey survey area and c. 21 km from the Lone South survey area.

Roosting value – No suitable areas for roosting sites were apparent within either survey area. The closest known and confirmed roost is less than 2 km from the closest boundary (Osprey), and it is expected that additional unknown roost sites will be present within the local area.

Patterns of biodiversity. The majority of each survey area contains vegetation with a complex structure in the understorey and/or midstorey, and these areas are therefore expected to support a high abundance and diversity of fauna across all taxa, including conservation significant species such as the Carpet Python, Jewelled Ctenotus (Swan Coastal Plain subpopulation) and Brush Wallaby. Sandy substrates, particularly in VSA 1 which is extensive in the Lone South survey area, are likely to support a variety of fossorial reptiles and frogs, including the conservation significant Black-striped Snake.

Black-cockatoo foraging habitat occurs throughout the survey areas, primarily in the form of *Banksia* spp. trees that vary in density between VSAs. VSA 1 (*Banksia attenuata* and *B. menziesii* Low Woodland) contains some of the highest value foraging habitat and is extensive in the Lone South survey area. In comparison, the Osprey survey area contains less VSA 1 and primarily consists of VSA 5 (*Banksia telmatiaea* Heathland) which contains a lower density of suitable foraging plants.

Key ecological processes. The ecological processes that are expected to influence the fauna assemblage include existing habitat loss, landscape connectivity, and the presence of feral species. Local hydrology may impact fauna as there are extensive areas of seasonally inundated damplands/swamps which may support certain fauna species. The recent (November 2024) fire across both areas will have altered the fauna assemblage and the abundance levels of many species, and will have triggered series of post-fire changes in abundance as the vegetation matures.

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1 Introduction

Tronox Limited (Tronox) is proposing to expand operations at their Cooljarloo Mine. Bamford Consulting Ecologists (BCE) was commissioned by Tronox to conduct a Basic (sensu EPA, 2020) fauna assessment (desktop review, fauna habitat identification and a site inspection), including a targeted black-cockatoo assessment and impact assessment, of two survey areas at Lone South and Osprey. This report presents the results of that desktop review, site inspection, black-cockatoo assessment and impact assessment.

1.1 Background information: fauna impact assessment

The purpose of impact assessment is to provide government agencies with the information they need to decide upon the significance of impacts of a proposed development, and to provide information to proponents to help them to develop appropriate strategies for avoiding and minimising impacts of their activities. This relies on information on the fauna assemblage and its environment, and BCE uses an approach with the following components:

- The identification of **fauna values:**
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  - Hydrological change;
  - Altered fire regimes; and
  - Disturbance (dust, light, noise).
- The **recommendation** of actions to mitigate impacts.

The objectives of the current assessment and report are as follows:

1. Conduct a literature review and searches of Commonwealth and State fauna databases to compile a comprehensive list of fauna expected to occur in the survey areas;
2. Review the list of fauna expected to occur in the survey areas in the light of fauna habitats present, with a focus on investigating the likelihood of significant species being present, including a targeted black-cockatoo assessment;
3. Identify significant or fragile fauna habitats within the survey areas;
4. Identify any ecological processes in the survey areas upon which fauna may depend;
5. Identify general patterns of biodiversity within or adjacent to the survey areas; and
6. Review impacting processes and provide recommendations for mitigation.

Descriptions and more background information on these values and processes can be found in Appendices 1 to 4.

1.2 Description of survey areas and background environmental information

1.2.1 Overview

Tronox is proposing developments in two new survey areas: Lone South and Osprey (Figure 1-1). As these are in close proximity, the current report encompasses both survey areas, with separate sections for each area when required. The survey areas are located in the south-western part of Western Australia's Midwest region (DBCA, 2024b), approximately 150-160 km north of Perth (Figure 1-1). The Lone South survey area is approximately 55 ha in size and consists of native remnant vegetation intersected by cleared tracks for access and exploration activities (Figure 1-2). The surrounding area is predominantly intact native vegetation, including the Wongonderrah Nature Reserve, aside from the existing Tronox development to the south. Cleared agricultural land lies about 1 km to the north. The Osprey survey area is approximately 280 ha in size and consists of native vegetation and seasonal damplands/wetlands intersected by cleared tracks (Figure 1-3). The surrounding landscape consists predominantly of native vegetation to the west and south, with agricultural land (Mullering Farm) about 1km to the south, and existing Tronox development to the north and east.

A range of terms is used through this report to refer to the spatial environment including and around the survey areas; these are defined below and illustrated in Figure 1-1, Figure 1-2 and Figure 1-3:

- Survey areas – the boundaries of each site were provided by Tronox. These are the areas to which the results of the desktop analysis are directed and the areas within which field investigations were conducted.
- Study area – the outermost boundary of the desktop assessment area that is almost always a specified buffer distance (see Section 2.3.1 below) around the *survey area*. The study area thus encompasses the *survey area* but includes the area from which database records are sourced for the desktop assessment. For the current report, this is an area that encompasses a 25km radius around the centroid of each survey area, combined to create an oval shape (see Figure 1-1). Database records from this search area were interpreted separately for each survey area, depending on the environments present.

Note that for the purposes of regional context and mapping, a 15 km buffer around the boundary was used for each survey area; this is based upon guidance for regional context from the EPA (EPA, 2016c).

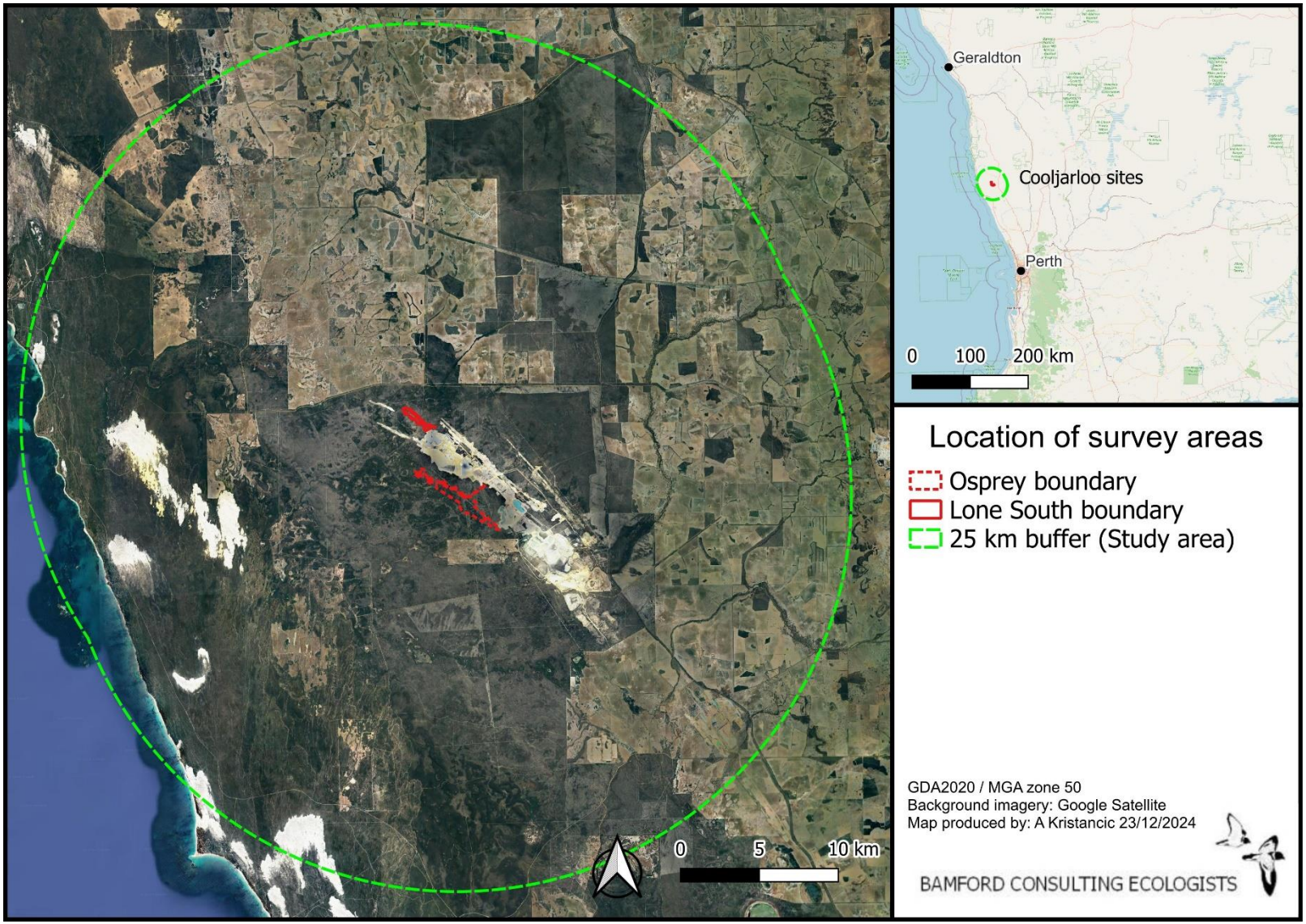

Figure 1-1. Locations of the project areas and the study area (used for database searches).

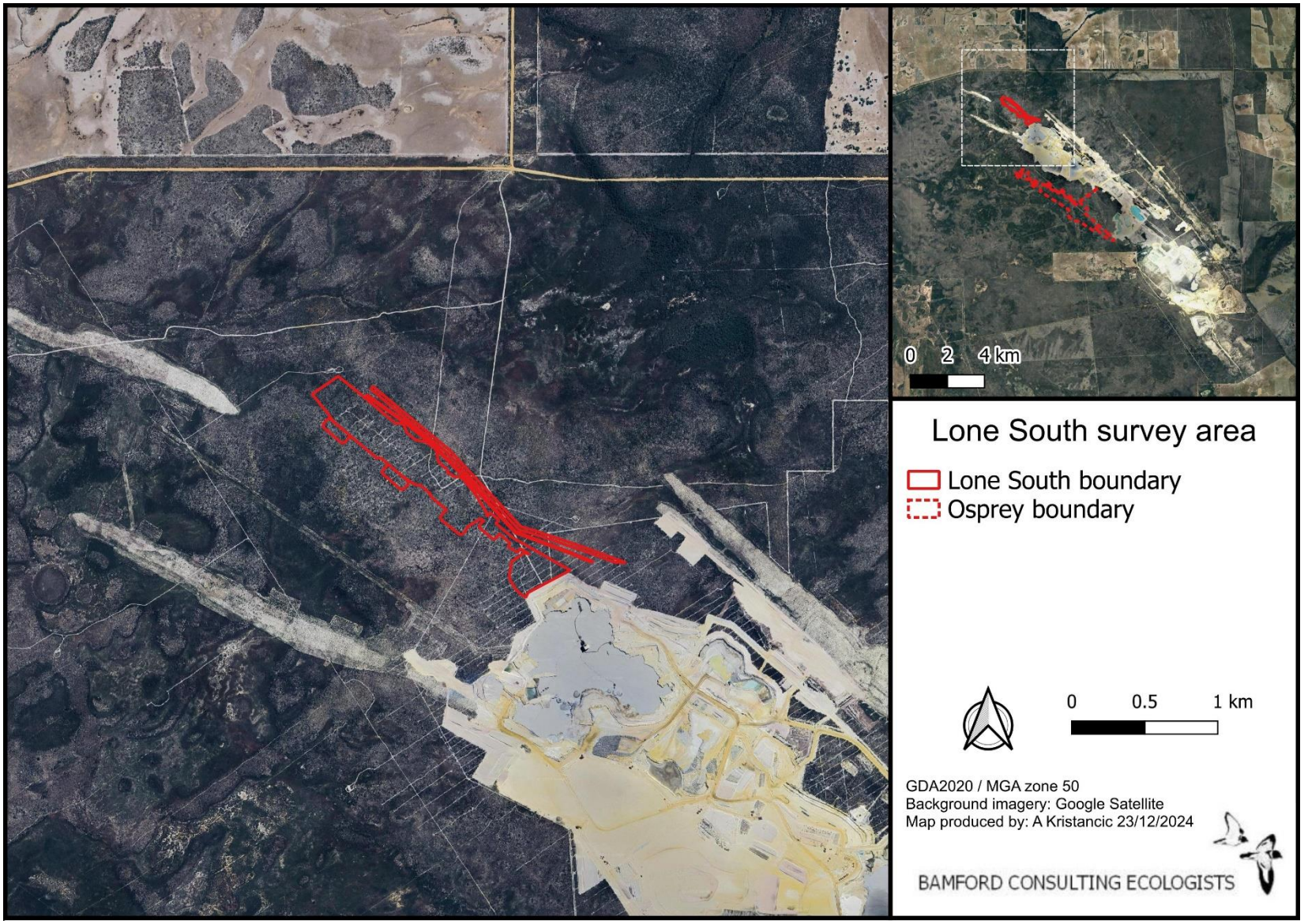

Figure 1-2. Location of Lone South survey area.

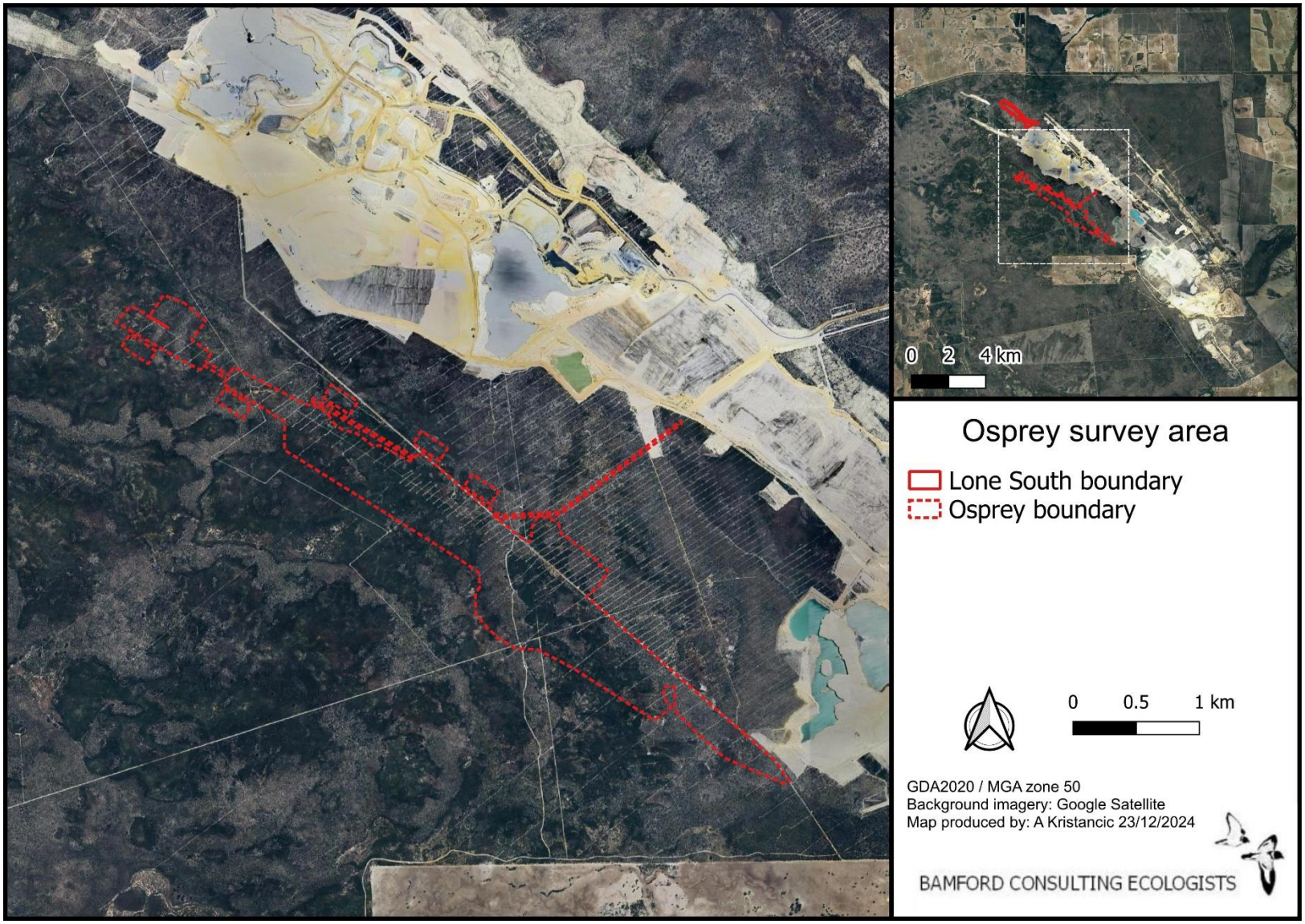

Figure 1-3. Location of Osprey survey area.

1.2.2 Interim Biogeographic Regionalisation of Australia (IBRA) and landscape characteristics

The Interim Biogeographic Regionalisation of Australia (IBRA) has identified 27 bioregions (IBRA v7) in Western Australia which are further divided into subregions (DCCEEW, 2023b). Bioregions are classified on the basis of climate, geology, landforms, vegetation and fauna (Thackway & Cresswell, 1995). IBRA bioregions are affected by a range of different threatening processes and have varying levels of sensitivity to impact (EPA, 2016c). The survey areas lie within the north-eastern portion of the Perth (SWA02) subregion of the Swan Coastal Plain bioregion, less than 5 km from the boundary with the Leseur Sandplain (GES02) subregion of the Geraldton Sandplain bioregion (Figure 1-4).

The Perth (SWA02) subregion was described by Mitchell *et al.* (2003) and a summary of their work follows here. The Swan Coastal Plain bioregion is a low lying coastal plain, with woodlands the predominant vegetation type, and dominant species comprising Banksia or Tuart on sandy soils, *Casuarina obesa* on outwash plains, and paperbark in swampy areas. The Perth subregion is made up of colluvial sands and alluvial river flats (dominated by Marri vegetation), aeolian sands/dunes (dominated by Banksia and Jarrah-Banksia woodlands), and coastal limestone (with heath and/or Tuart woodlands). This subregion also includes a complex series of seasonal wetlands and several offshore islands. The Swan Coastal Plain bioregion falls into the Southern Climatic Region (EPA, 2020) and the climate of the Perth subregion is Mediterranean (Mitchell *et al.*, 2003). Average rainfall for the station closest to and most representative of the survey area is 518 mm (Station: Badgingarra Research Station, Number 009037, BOM, 2023).

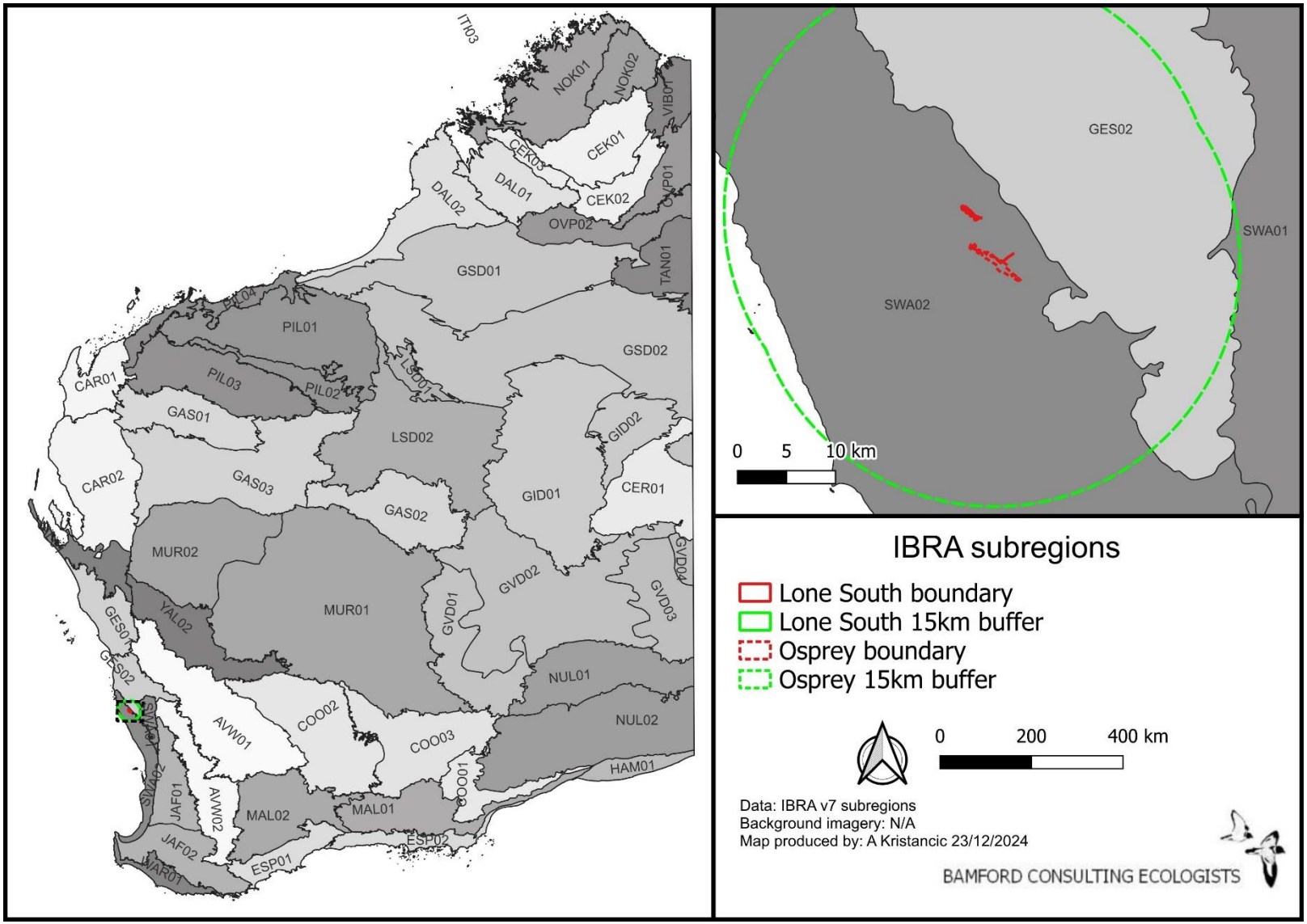

Figure 1-4. Location of survey areas within the Interim Biogeographic Regionalisation of Australia (IBRA) subregions.

1.2.3 Pre-European Vegetation and Soil-Landscape Mapping

Mapping of a survey area in relation to broad scale datasets can provide useful context regarding the current and historical landscape of the survey area and surrounds. A dataset of soil-landscape mapping across Western Australia is provided by DPIRD (2023). Beard *et al.* (2013) have described and mapped the original vegetation presumed to have existed across Western Australia prior to European settlement and this dataset is provided by DPIRD (2024b). The survey areas in relation to these datasets are shown in Figure 1-5 and Figure 1-7.

The landscape surrounding the survey areas is a complex mosaic of 33 soil-landscape subsystems (DPIRD, 2023); 33 of which are represented in the 15 km buffer around the Lone South survey area (Figure 1-5) and 32 of which are represented in the 15 km buffer around the Osprey survey area (Figure 1-6). Details are provided here only for soil-landscape subsystems which overlap with or are found within 1 km of each survey area.

The Lone South survey area lies almost entirely within the Bassendean 2 subsystem (Undulating sandplain with ironstone and occasionally poorly drained depressions), with a very small area in the north overlapping with the Bassendean 5 subsystem (Complex pattern of dunes or low sandy rises, poorly drained plains, saline depressions and swamps). The Osprey survey area lies mostly within the Bassendean 5 subsystem (Complex pattern of dunes or low sandy rises, poorly drained plains, saline depressions and swamps), with small areas overlapping with the Bassendean 3 subsystem (Low dunefields; deep, pale grey or white sands).

Prior to European arrival, the landscape within 15km of the survey area is thought to have included six vegetation types, as well as areas of unvegetated dune sand (Beard et al., 2013; DPIRD, 2024b)(Figure 1-7). Details are provided here only for vegetation types in the survey areas. Both survey areas are entirely within Vegetation type 9, described as follows:

- **Vegetation type 9 (Low woodland or open low woodland):** Low or open low woodland including *Acacia* spp., *Banksia* spp., *Agonis flexuosa* (Peppermint), *Callitris* spp. (cypress pine), *Allocasuarina* spp. (sheoak), and *Eucalyptus loxophleba* (York Gum)

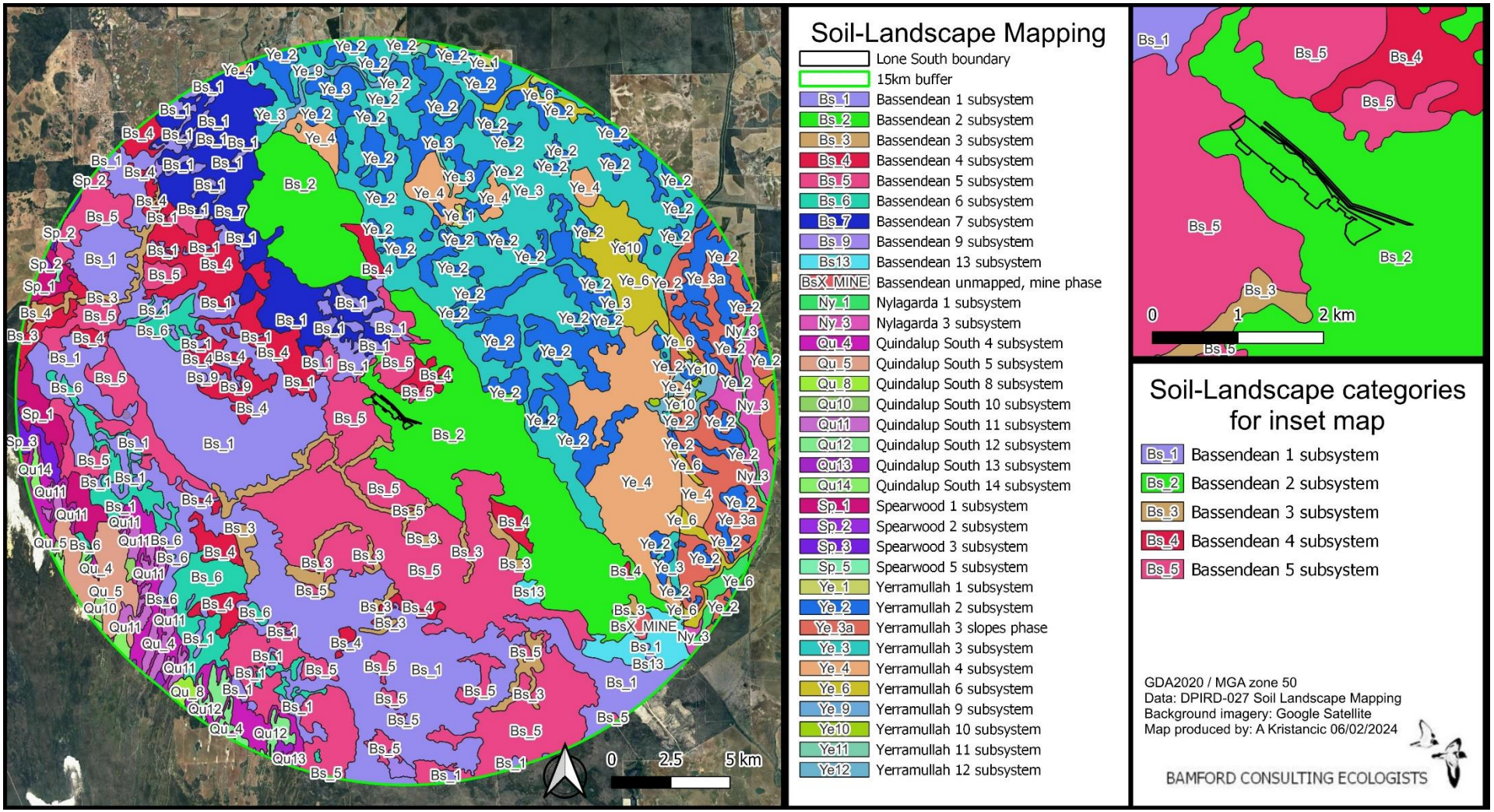

Figure 1-5. Soil-landscape mapping (DPIRD, 2023) within 15km of the Lone South survey area boundary.

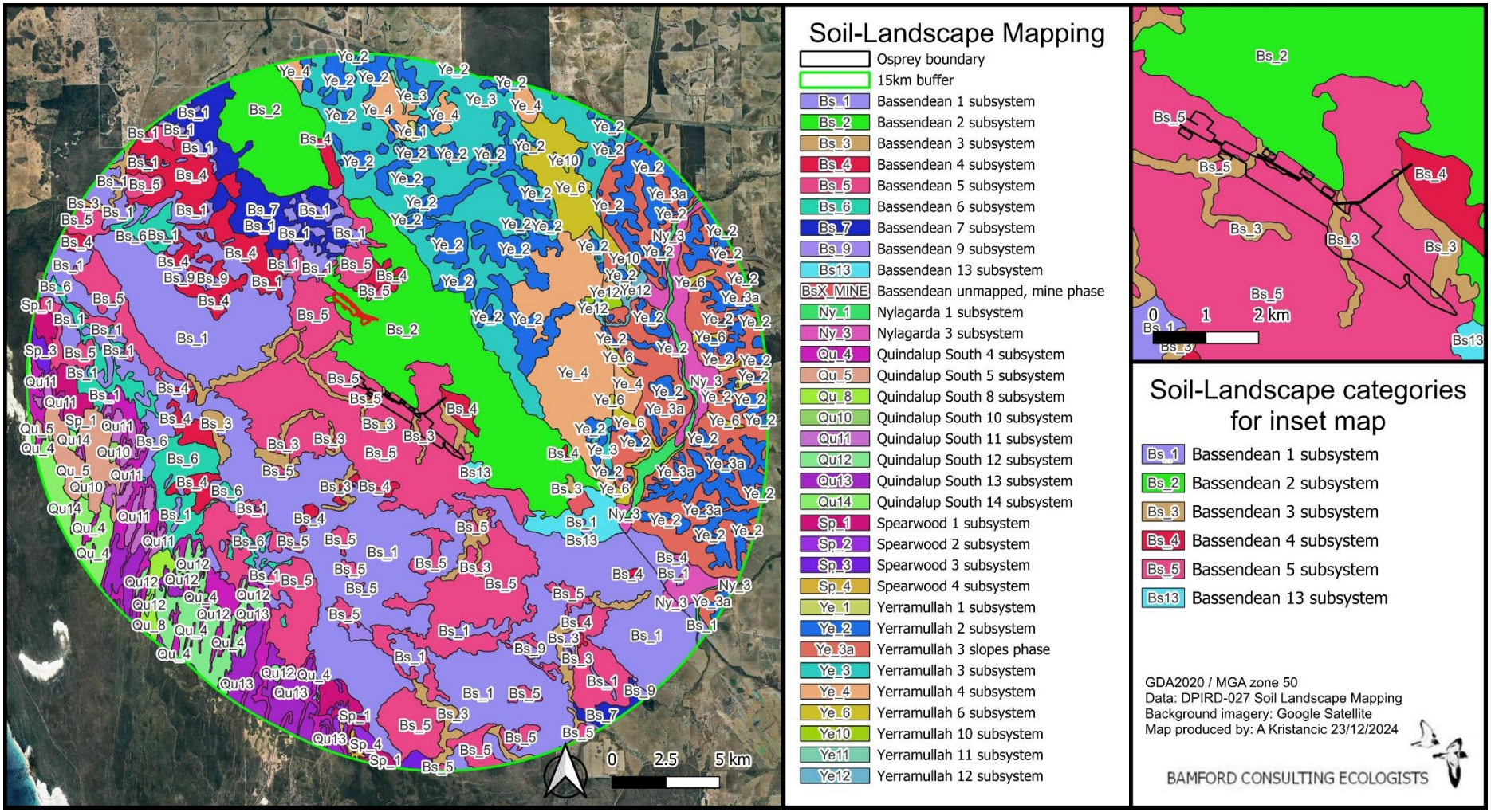

Figure 1-6. Soil-landscape mapping (DPIRD, 2023) within 15km of the Osprey survey area boundary.

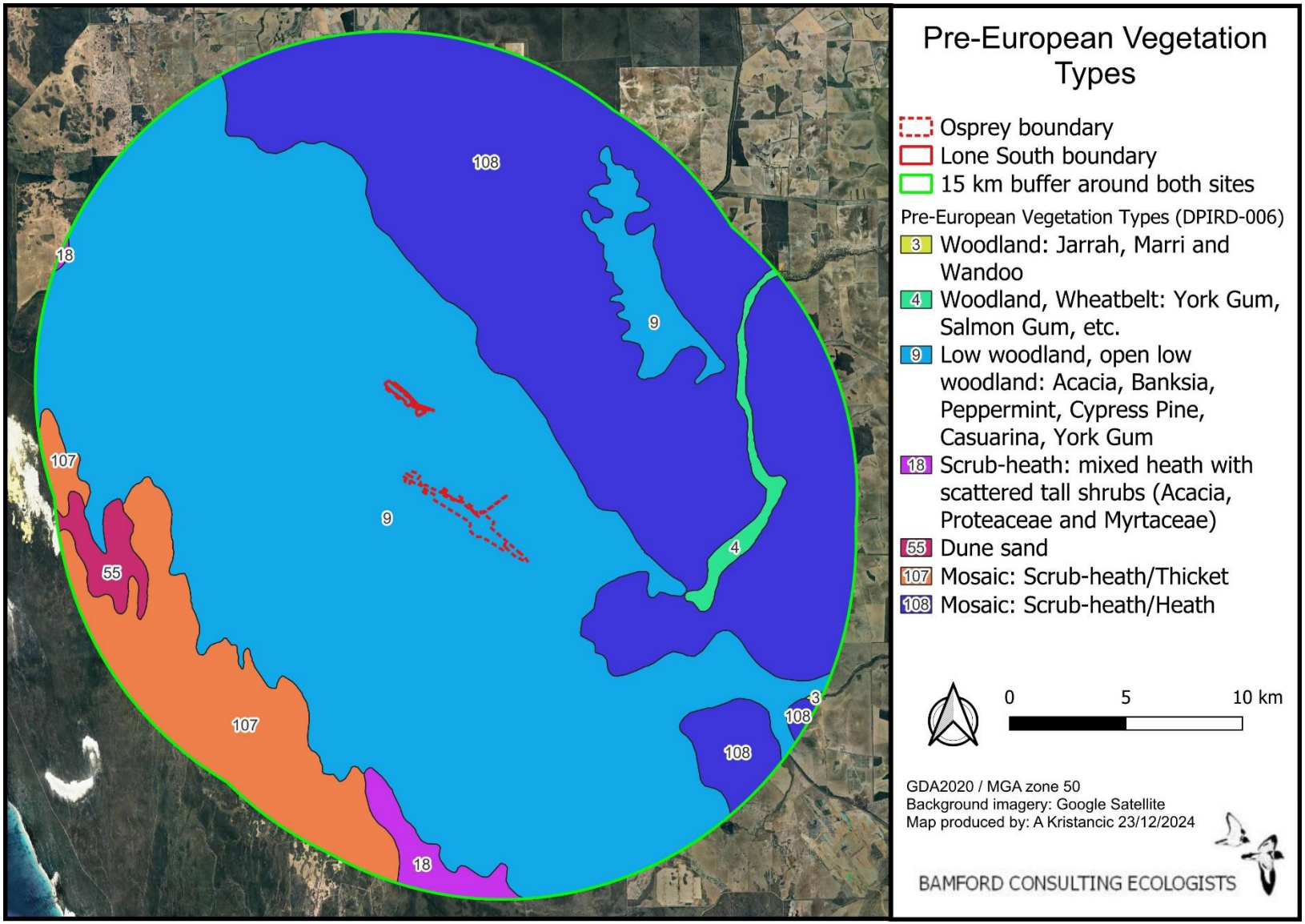

Figure 1-7. Pre-European vegetation types (DPIRD, 2024b) within 15km of the survey areas.

1.2.4 Land use and tenure

The dominant land uses within the Perth (SWA02) subregion are Cultivation (both dry land agriculture, and irrigated horticulture, agriculture and plantations), Conservation, UCL and Crown reserves, Urban, Rural residential, Forestry plantations, Roads and other easements and Grazing (improved pastures), with smaller areas of Mining and Defence lands. The southern half of the subregion is extensively cleared, comparable to the Avon Wheatbelt (Mitchell et al., 2003), while the northern third of the subregion (where the survey areas are located) contains a greater proportion of remnant vegetation (e.g. less extensive clearing) (Mitchell et al., 2003). At the local scale, the survey areas are surrounded predominantly by intact remnant vegetation, with existing Tronox developments to the immediate south and east, and areas of agricultural land to the north and south.

1.2.5 Recognised sensitive sites

There are no known Bush Forever sites (Dell & Banyard, 2000) or Ramsar sites (DBCA, 2023c) within 25 km of the survey areas. A large swathe of Threatened Ecological Communities (TECs) (DBCA, 2023e) runs north-south through the middle of the 25 km buffer around the survey areas, and both survey areas lie within this swathe. The TECs are not continuous. Based on cross-referencing with PMST, this appears to be the Endangered 'Banksia Woodlands of the Swan Coastal Plain ecological community', which is 'likely to occur' in the same area shown by DBCA mapping in Figure 1-8 (DCCEEW, 2023e). Two other Critically Endangered ecological communities may occur within 25 km of the survey areas (DCCEEW, 2023e): 'Tuart Woodlands and Forests of the Swan Coastal Plain ecological community' (which may occur in the survey area and surrounds) and 'Honeymyrtle shrubland on limestone ridges of the Swan Coastal Plain Bioregion' (which may occur 20 km south of the survey areas and is therefore unlikely to be of relevance for this report). There are four large areas and c. 70 small points within 25 km that are categorised as Environmentally Sensitive Areas (ESAs; DWER, 2023b, 2023a), the closest of which are c. 1 km east of the Lone South survey area and on the northern boundary of the Osprey survey area (Figure 1-8). One of these large areas, near Cervantes, is also categorised as a Priority Ecological Community by DBCA (2023e). Three of these large areas encompass Nambung National Park, Badgingarra National Park, Wanagarren Nature Reserve and Unnamed WA41986 Conservation Park, all of which are also considered protected terrestrial areas (DCCEEW, 2020). An additional six protected terrestrial areas are present within 25 km of the survey areas (Figure 1-9). A large area of Important Wetlands (DBCA, 2023a) spans from 20 km south to c. 1 km north of the survey areas, and overlaps with the Osprey survey area. This is known as the Lancelin Defence Training Area wetlands and is associated with Carnaby's Black-Cockatoo (DBCA, 2023a). There is one Key Biodiversity Areas (KBA, 2023) within 25 km of the survey areas; this is the Cataby Important Bird Area, which is significant in that it supports more than 1% of the breeding population of Carnaby's Black-Cockatoo (Key Biodiversity Areas Partnership, 2024). In this area, nesting trees and foraging habitat are distributed throughout remnant vegetation and isolated paddock trees (Key Biodiversity Areas Partnership, 2024). Important Wetlands and Key Biodiversity Areas are shown along with protected terrestrial areas on Figure 1-9.

A summary of these sensitive sites and the distances to each survey area boundary is provided in Table 1-1.

Table 1-1. Summary of sensitive sites and distance from each survey area.

Sensitive Site	Distance from Lone South	Distance from Osprey
Threatened Ecological Communities	Within survey area	Within survey area
Priority Ecological Communities	c. 20 km north-west	c. 22 km north-west
Environmentally Sensitive Areas	c. 1 km	On northern boundary
Protected terrestrial areas	Closest is Wongonderrah NR, <100 m east	Closest is Wongonderrah NR, c. 3-6 km north
Important Wetlands	<100 m west	Within survey area
Cataby Important Bird Area (KBA)	c. 29 km south-east	c. 22 km south-east

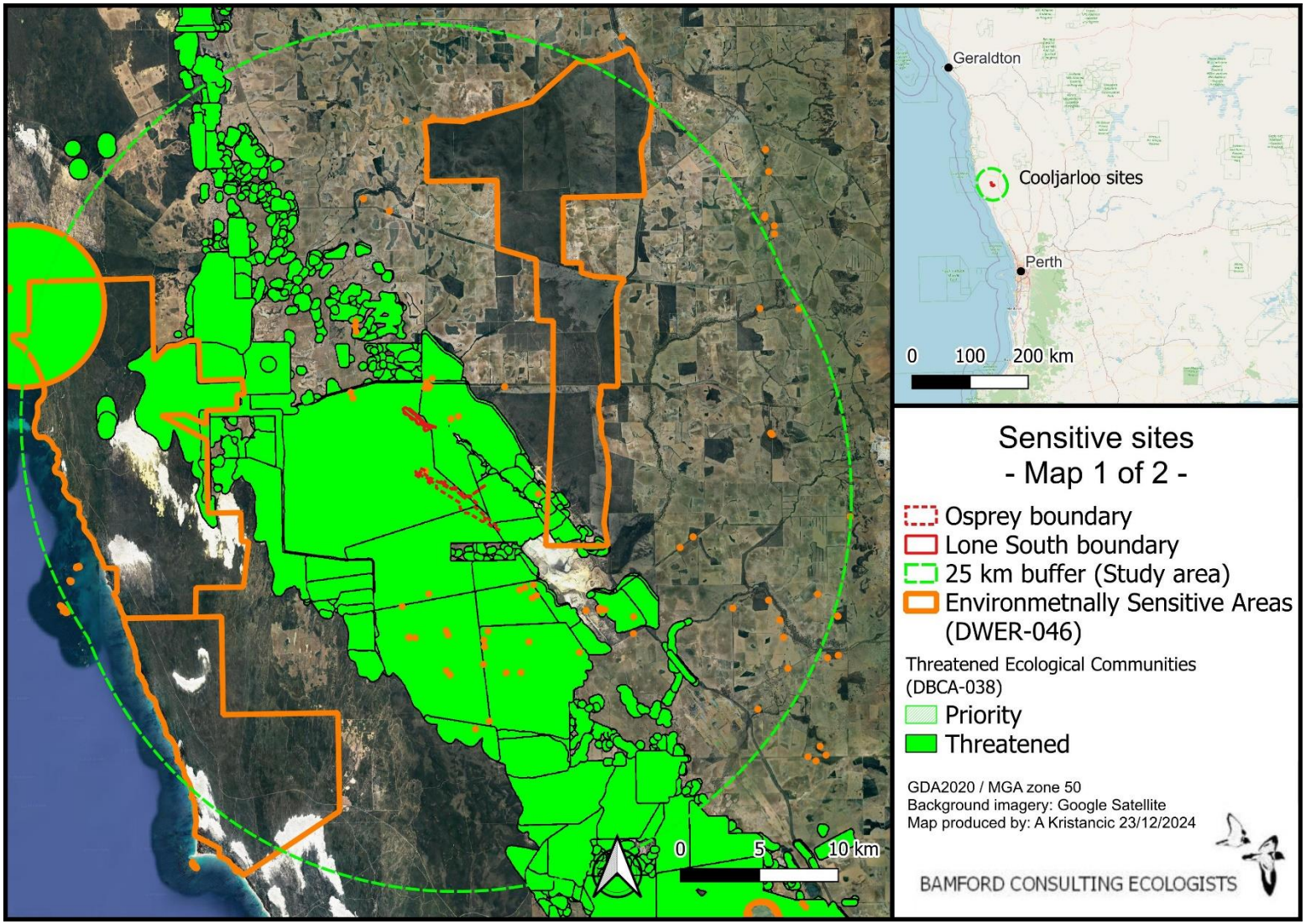

Figure 1-8. Environmentally Sensitive Areas (DWER, 2023a), and Priority and Threatened Ecological Communities (DBCA, 2023e) within 25km of the survey area.

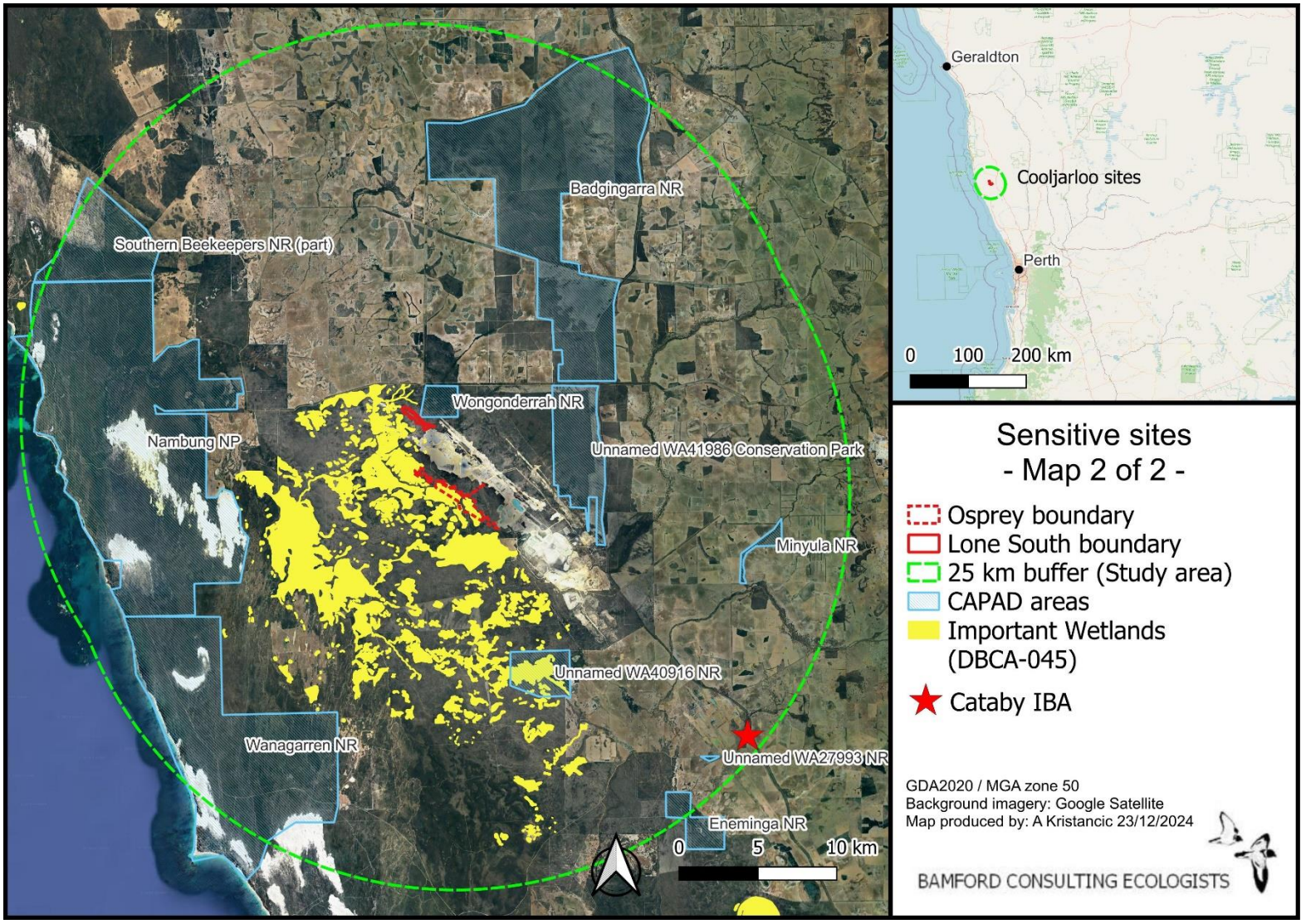

Figure 1-9. Protected areas, as per the Collaborative Australian Protected Areas Database (CAPAD; DCCEEW, 2020), Important Wetlands (DBCA, 2023a) and KBAs (KBA, 2023) within 25 km of the survey areas.

1.2.6 Regional development

The survey areas are surrounded predominantly by remnant vegetation, aside from existing Tronox developments to the south and east, and agricultural land to the north (extensive) and south (isolated). A network of roads also exists in the surrounding landscape, and existing development includes the Cataby (Iluka) Mineral Sands Mine c. 20 km south-east of the survey areas. Figure 1-10 illustrates the existing extent of land clearing and development in a 15 km buffer around both survey areas combined. Both areas are mapped for simplicity but are treated separately for the sake of the below calculations. These calculations are based on the Native Vegetation Extent dataset provided by DPIRD (2024a) which gives a broad indication of vegetation remaining in the survey area and surrounding landscape. To provide more detail concerning areas that provide habitats for fauna, BCE describes and provides maps of vegetation and substrate associations (VSAs) observed during site inspections. This is described in more detail in Sections 2.2 and 3.1.

1.2.6.1 Lone South

The land area within a 15 km buffer around the boundary of the Lone South survey area is c. 78,824 ha. Within this buffer, c. 51,505 ha of native vegetation remains (DPIRD, 2024a); therefore existing land clearing or development (c. 27,319 ha) impacts c. 35% of the total land area within 15 km. According to the native vegetation extent dataset from DPIRD (2024a), the majority of the survey area consists of native vegetation, with small areas of cleared land coinciding with existing tracks (Figure 1-10). The native vegetation within the survey area (c. 52 ha) comprises 0.1 % of the remaining vegetation within the 15 km buffer.

1.2.6.2 Osprey

The land area within a 15 km buffer around the boundary of the Osprey survey area is c. 92,771 ha. Within this buffer, c. 60,215 ha of native vegetation remains (DPIRD, 2024a); therefore existing land clearing or development (c. 32, 556 ha) impacts c. 35% of the total land area within 15 km. According to the native vegetation extent dataset from DPIRD (2024a), the majority of the survey area consists of native vegetation, with very small areas of cleared land coinciding with existing tracks (Figure 1-10). The native vegetation within the survey area (c. 267 ha) comprises 0.4 % of the remaining vegetation within the 15 km buffer.

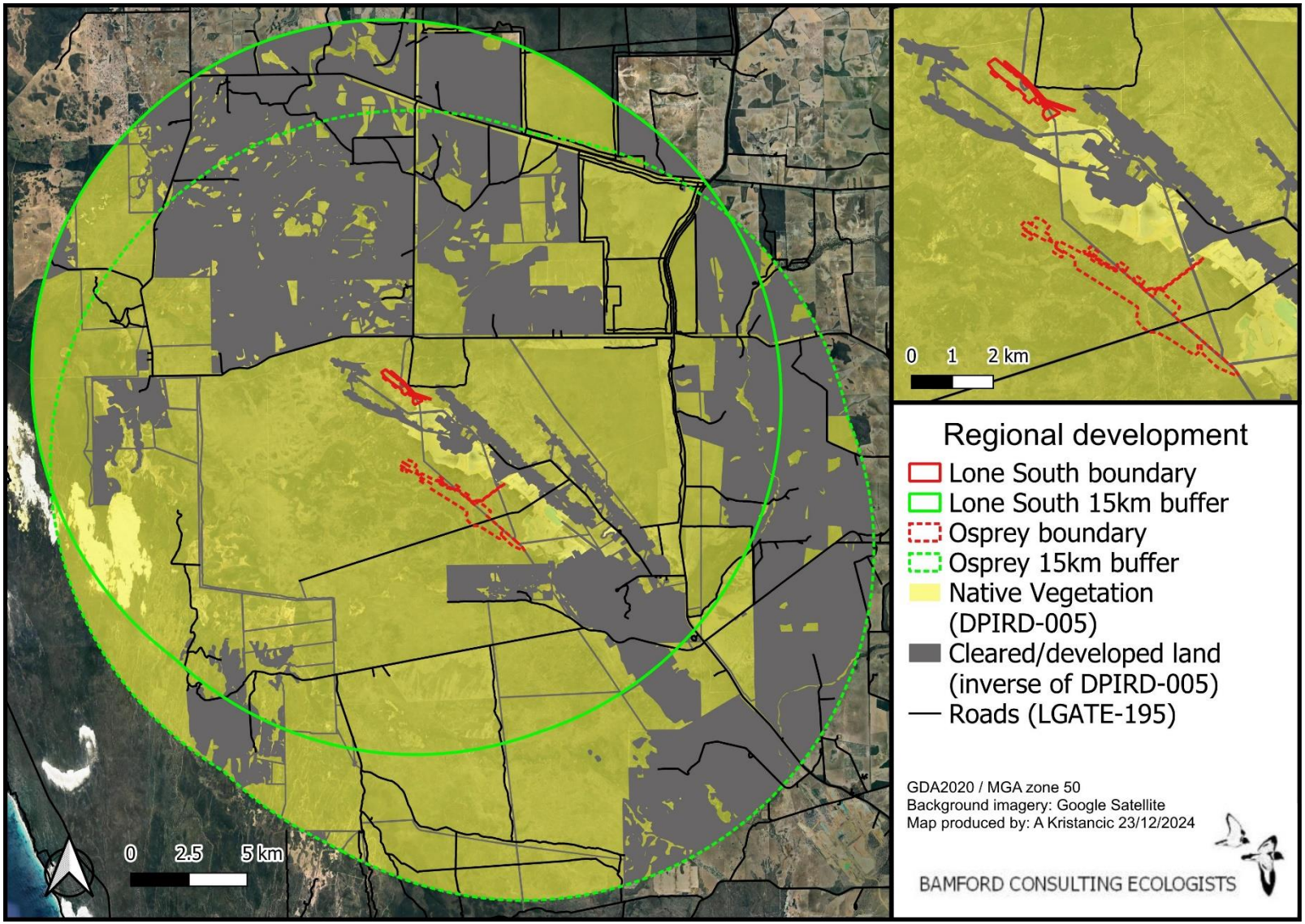

Figure 1-10. Estimated existing development within the region. Native vegetation extent is from DPIRD (2024a).

2 Methods

2.1 Overview

This approach to fauna impact assessment has been developed with reference to guidelines and recommendations set out by the Western Australian Environmental Protection Authority (EPA) on fauna surveys and environmental protection (EPA, 2002, 2016a, 2016b, 2020), and Commonwealth biodiversity legislation (DotE, 2013; DSEWPaC, 2013). The EPA (2020) recommends three levels of investigation that differ in their approach for field investigations:

- Basic – a low-intensity survey, conducted at the local scale to gather broad fauna and habitat information (formerly referred to as 'Level 1'). The primary objectives are to verify the overall adequacy of the desktop study, and to map and describe habitats. A basic survey can also be used to identify future survey site locations and determine site logistics and access. The results from the basic survey are used to determine whether a detailed and/or targeted survey is required. During a basic survey, opportunistic fauna observations should be made and low-intensity sampling can be used to gather data on the general faunal assemblages present. While referred to as 'basic', this level of survey is involved and powerful, and should be considered the primary level of assessment. Other levels of assessment (where deemed necessary) add information to inform this primary level.
- Detailed – a detailed survey to gather quantitative data on species, assemblages and habitats in an area (formerly referred to as 'Level 2'). A detailed survey requires comprehensive survey design and should include at least two survey phases appropriate to the biogeographic region (bioregion). Surveys should be undertaken during the seasons of maximum activity of the relevant fauna and techniques should be selected to maximise the likelihood that the survey will detect most of the species that occur, and to provide data to enable some community analyses to be carried out.
- Targeted – to gather information on significant fauna and/or habitats, or to collect data where a desktop study or field survey has identified knowledge gaps. Because impacts must be placed into context, targeted surveys are not necessarily confined to potential impact areas. A targeted survey usually requires one or more site visits to detect and record significant fauna and habitats. For areas with multiple significant species there may not be a single time of year suitable to detect all species. In these cases, multiple visits, each targeting different species or groups, should be conducted.

The level of assessment recommended by the EPA (2020) is determined by geographic position, with a generic statement that detailed surveys are expected across all of the state except the south-west, but also recommending that site and project characteristics be considered, such as the survey objectives, existing available data, information required, the scale and nature of the potential impacts of the proposal and the sensitivity of the surrounding environment in which the disturbance is planned. These aspects should be considered in the context of the information acquired by the desktop study. When determining the type of survey required, the EPA (2020) suggested that the following be considered:

- level of existing regional knowledge;
- type and comprehensiveness of recent local surveys;
- degree of existing disturbance or fragmentation at the regional scale;
- extent, distribution and significance of habitats;

- significance of species likely to be present;
- sensitivity of the environment to the proposed activities; and
- scale and nature of impact.

The survey area lies in a region where the fauna assemblage is well-documented, and a 'basic' level survey (desktop review, fauna habitat identification and a site inspection) with targeted investigations for relevant significant species is considered an appropriate level of investigation. Guidance for field investigation methods for vertebrate fauna is provided by the EPA (2016c, 2020) and by Bamford *et al.* (2013).

The approach and methods utilised in this report for the Basic assessment are divided into two sections, which differ in their objectives, and are used in combination to summarise the fauna values of the survey area:

- **Desktop assessment.** The purpose of the desktop assessment is to produce species lists that can be considered to represent the vertebrate fauna assemblage of the survey areas, and the conservation significant invertebrate species likely to occur in the survey areas, based on unpublished and published data and using a precautionary approach.
- **Field investigations.** The purpose of the field investigations is to gather information on the vegetation and substrate associations ('VSAs') that support the fauna assemblage and place the list generated by the desktop assessment into the context of the environment of the survey area. The brief field investigations that form part of a Basic assessment also allow for some fauna observations to be made and assist the consultant to develop an understanding of the ecological processes that may be operating in the survey areas.

2.2 Identification of vegetation and substrate associations (VSAs)

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.

For the current assessment, VSAs were identified based on the consultant's previous experience in the area, a previous vegetation assessments of the site (Umwelt, 2023), and on observations made during the field investigations.

2.3 Desktop assessment of expected species

2.3.1 Sources of information

As per the recommendations of EPA (2020), information on the fauna assemblage of the survey areas was drawn from a range of sources including databases (as listed in Table 2-1). Information from these sources was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns are listed in Table 2-2. For the current assessment, fish were excluded from all database outputs aside from the BCE database for Cooljarloo, in order to simplify the compilation of the species list. Therefore, a small number of freshwater fish recorded nearby were included in the potential species list, but records relating to marine fish were excluded.

Table 2-1. Databases searched for the desktop review; accessed January 2024.

Database	Type of records held in database	Area searched
BCE Database	Fauna recorded by BCE in the vicinity of the survey areas; extensive 30-year monitoring data available for Cooljarloo mine	Cooljarloo mine and surrounding areas.
Atlas of Living Australia (ALA, 2023)	Fauna records from Australian museums and conservation/research bodies.	Search area encompassing 25 km buffer around centroid of each survey area.
NatureMap (DBCA, 2023b)	Records from the Western Australian Museum (WAM) and Department of Biodiversity, Conservation and Attractions (DBCA) databases, including historical data.	Search area encompassing 25 km buffer around centroid of each survey area.
DBCA Threatened and Priority Fauna (DBCA, 2023d)	Records from the DBCA Threatened and Priority species database, including black-cockatoo nesting/roosting data.	Search area encompassing 25 km buffer around centroid of each survey area.
BirdLife Australia databases (BirdLife Australia, 2023c, 2023a, 2023b)	Records from Bird Life Australia, including birdata and black-cockatoo datasets	Search area encompassing 25 km buffer around centroid of each survey area.
EPBC Protected Matters Search Tool (DCCEEW, 2023e)	Records on MNES protected under the EPBC Act.	Search area encompassing 25 km buffer around centroid of each survey area.

Database	Type of records held in database	Area searched
Index of Biodiversity Surveys for Assessment (IBSA) (DWER, 2023c)	Flora and fauna data contained in EIA biodiversity survey reports.	Search area encompassing 25 km buffer around centroid of each survey area.

Table 2-2. Sources of information used for general patterns of fauna distribution.

Taxa	Sources
Fish	Morgan *et al.* (1998), Allen *et al.* (2003), Morgan *et al.* (2014), DoF (2023).
Frogs	Tyler and Doughty (2009), Anstis (2017).
Reptiles	Storr *et al*. (1983, 1990, 1999, 2002) , Bush *et al.* (2010), Wilson and Swan (2021).
Birds	Johnstone and Storr (1998, 2005), Menkhorst *et al*. (2017).
Mammals	Van Dyck and Strahan (2008), Churchill (2009), Menkhorst and Knight (2011).

2.3.1.1 Conservation significant invertebrates

A list of potentially occurring conservation significant invertebrates was compiled. This was based on the threatened and priority fauna database for the Midwest region (DBCA, 2023f), DBCA threatened species search (DBCA, 2023d), Naturemap CS search (DBCA, 2023b) within 25 km, and significant invertebrates identified during previous surveys in Cooljarloo (M. J. Bamford *et al*., 2012; Bennelongia, 2013 and BCE database). These previous surveys included records of several short-range endemic (SRE) species. Species from this initial list were omitted if they were clearly out of range and any remaining species possibly within range and potentially occurring in the survey areas was cross-checked against ALA and Naturemap search results (within 25 km). In addition, selected genera known to contain high numbers of SRE species (e.g. *Antichiropus, Buddelundia)* were cross-checked against ALA and Naturemap invertebrate records.

2.3.2 Previous fauna surveys

There were five previous vertebrate fauna surveys listed within a 30 km radius of the survey areas in the Index of Biodiversity Surveys for Assessments (IBSA) (DWER, 2023c; listed in Table 2-3). Resources (data and/or report) were only available for one of these surveys: a black-cockatoo habitat assessment for a potential offset site near Cataby, 18-25 km from the survey areas.

Table 2-3. Terrestrial fauna studies returned from IBSA search during desktop review. Studies in italics did not have any resources publicly available and are not included in reference list.

Author	Title	Distance to site
Eco Logical Australia (2020)	Black Cockatoo Habitat Assessment of Part of Lot 3333 Mimegarra Road, Cataby. Prepared for Public Transport Authority.	25 km (Lone South), 18 km Osprey
AECOM (2014)	*Indian Ocean Drive Passing Lanes. Unpublished report prepared for Main Roads Western Australia*	*n/a*
Ecologia Environment (2016)	*Waddi Wind Farm Project - Cataby Supplementary Flora, Vegetation and Fauna Survey. Conducted for Waddi Wind Farm Pty Ltd, for the Waddi Wind Farm Project.*	*n/a*
Outback Ecology (2014)	*Spring Flora and Vegetation Survey and Black Cockatoo Habitat Survey. Conducted for RPS Australia Asia Pacific, for the Waddi Wind Farm Project.*	*n/a*
GHD (2016)	*Brand Highway, Western Australia - Various Sections: SLK 74 to 150 Biological Survey. Unpublished report prepared for Main Roads Western Australia.*	*n/a*

2.3.3 Nomenclature and taxonomy

As per the recommendations of the EPA (2020), the nomenclature and taxonomic order presented in this report are generally based on the Western Australian Museum's (WAM) Checklist of the Fauna of Western Australia 2020. The authorities used for each vertebrate group were: fish (Morgan et al., 2014), frogs (Doughty, 2022a), reptiles (Doughty, 2022b), birds (F. Gill et al., 2023), and mammals (Travouillon, 2022). In some cases, more widely-recognised names and naming conventions have been followed, particularly for birds where there are national and international naming conventions in place (e.g. the BirdLife Australia working list of names for Australian Birds (BirdLife Australia, 2022), and the International Ornithological Congress' 'World Bird List'). Similarly, the group name 'black-cockatoo' is consistently used for all three taxa in the South-West. English common names of species, where available, are used throughout the text; Latin names are presented with corresponding English names in tables in the appendices. The use of subspecies is limited to situations where there is an important (and relevant) geographically distinct population, or where the taxonomic distinction has direct relevance to the conservation status or listing of a taxon.

2.3.4 Interpretation of species lists

2.3.4.1 Expected occurrence

Species lists generated from the review of sources of information are generous as they include records drawn from a large region (the study area, see Figure 1-1) and possibly from environments not represented in the survey areas. Therefore, some species that were returned by one or more of the database and literature searches have been excluded because their ecology, or the environment within the survey area, determined that it is highly unlikely that these species will be present. Such species can include, for example, seabirds that might occur as extremely rare vagrants at a terrestrial, inland site, but for which the site is of no importance. For the current assessment, given that there is no suitable habitat in either survey area for freshwater fishes, all records of fish from databases were excluded and are not shown in any Appendix. Freshwater fish that have been observed by BCE during

other surveys in the Cooljarloo area have been included in the overall list of potential species, but have been excluded based on lack of habitat (and are shown in the relevant Appendix).

Species returned from the databases and not excluded on the basis of ecology or environment are therefore considered potentially present or expected to be present in the survey areas at least occasionally, whether or not they were recorded during field surveys, and whether or not the survey areas are likely to be important for them. This list of expected species is therefore subject to interpretation by assigning each a predicted status, the expected occurrence, in the survey areas. For the current assessment, the species list has been interpreted for both survey areas combined, as they are of similar environments and the same fauna assemblage is expected at each. The status categories used are:

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

These status categories make it possible to distinguish between vagrant species, which may be recorded at any time but for which the survey area is not important in a conservation sense, and species which use the survey area in other ways but for which the site is important at least occasionally. This is particularly useful for birds that may naturally be migratory or nomadic, and for some mammals that can also be mobile or irruptive, and further recognises that even the most detailed field survey can fail to record species which will be present at times. The status categories are assigned conservatively based on the precautionary principle. For example, a lizard known from the general area is assumed to be a resident unless there is very good evidence the survey area will not support it, and even then, it may be classed as a vagrant rather than assumed to be absent if the site might support dispersing individuals. It must be stressed that these status categories are predictions only and that often very intensive sampling would be required to confirm a species' status. It should be noted that the aim of the desktop assessment and field investigations is not to confirm the presence or absence of species in the survey area. By using a precautionary approach, the expected species assemblage represents a conservative estimate of the species assemblage that may use the survey area, with errors of inclusion rather than exclusion.

The results of the database searches were reviewed and interpreted, and obvious errors and out of date taxonomic names were deleted.

2.3.4.2 Conservation significance

All expected species were assessed for conservation significance as detailed in Appendix 1. Three broad levels of conservation significance are used in this report:

- Conservation Significance 1 (CS1) – species listed under State or Commonwealth Acts such as the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the Western Australian *Biodiversity Conservation Act 2016* (BC Act);
- Conservation Significance 2 (CS2) – species listed as Priority by DBCA but not listed under State or Commonwealth Acts; and
- Conservation Significance 3 (CS3) – species not listed under Acts or in publications, but considered of at least local significance because of their pattern of distribution. In the wheatbelt region, a large proportion of what might otherwise be considered common species are of local significance as they are reliant on the very small areas of remnant native vegetation. In a different context, this principle was used by Dell and Banyard (2000) to recognise species of conservation significance in urban landscapes.

See Appendix 1 for an expanded discussion of these categories and Appendix 2 for a description of the categories used in the legislation (EPBC and BC Acts) and by the DBCA.

2.4 Field investigations

2.4.1 Overview

The site visit involved BCE personnel walking across as much of the survey area as possible. GPS tracks are indicated on Figure 2-1. Within the survey area, field investigations included:

- identification of VSAs (that provide fauna habitats);
- targeted black-cockatoo assessment; and
- opportunistic fauna observations (birds and other fauna, including signs such as diggings, scats and tracks).

2.4.2 Dates and Personnel

The Lone South survey area was visited on 14th November 2023, and the Osprey survey area was visited on 19th January 2024, and again on 20th November 2024 due to a slight revision in the Osprey project area boundary. Personnel involved in the field investigations and report preparation (including desktop review) are listed in Table 2-4.

Table 2-4. Personnel involved in the field investigations and report preparation.

Personnel	EIA/Wildlife Survey Experience	Field Investigations	Report Preparation
Dr Wes Bancroft *BSc (Zool/Microbiol, Hons (Zool), PhD (Zool)*	26 years	+	+
Natalia Huang *BEnvSc (Zool, Hons (Cons Biol, MBA*	16 years	+	+
Dr Mike Bamford *BSc (Biol), Hons (Biol), PhD (Biol)*	40 years	+	+
Dr Amanda Kristancic *BSc (Zool/Biochem), Hons (Zool), PhD (Parasitol)*	3 years		+

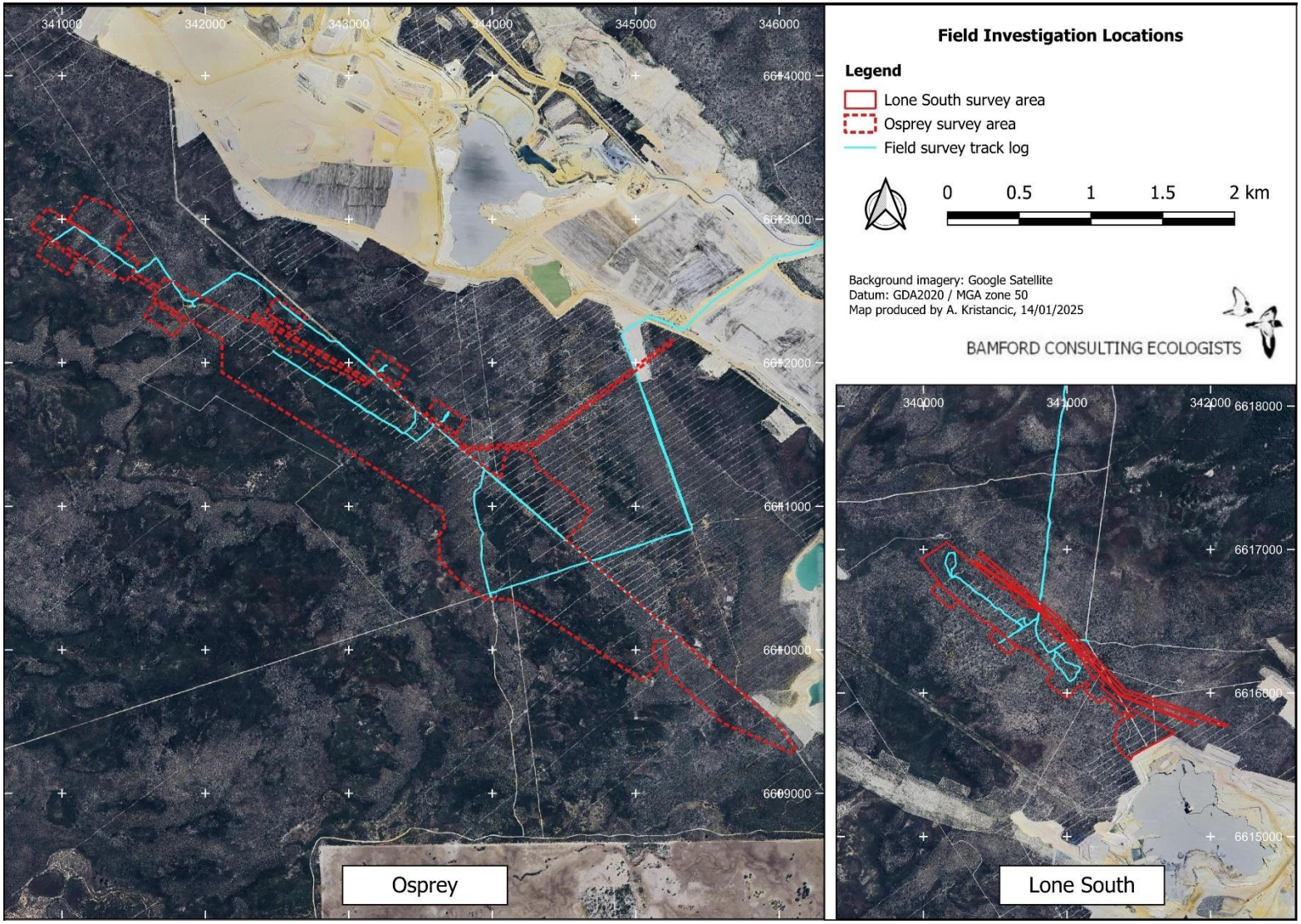

Figure 2-1. GPS tracks of BCE personnel during the field investigations (November 2023). Tracks in Osprey in November 2024 were not recorded.

2.4.3 Black-cockatoo habitat analysis

2.4.3.1 Guidelines

The Commonwealth Department of Climate Change, Energy, the Environment 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 to both the existing guidelines (DAWE, 2022) as well as the previous guidelines (DEE, 2017). In addition, survey methodology followed the recommendations listed on the DCCEEW's Species Profile and Threats Database (DCCEEW, 2024a, 2024c, 2024d). 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 (DAWE, 2022).

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

2.4.3.2 Breeding

The aim of breeding surveys is to sample a survey area for potential hollow-bearing trees (suitable for black-cockatoo nesting). In the case of both the Lone South and Osprey projects, the lack of large trees mean that the survey areas were not examined systematically for potential nest trees but any notable trees were recorded opportunistically as the foraging survey was undertaken. The following information was recorded for any suitable trees[1] with a diameter at breast height (DBH) equal to or greater than 500 mm (or equal to or greater than 300 mm for *Eucalyptus accedens* and *E. wandoo*):

- tree location;
- tree species;
- life status;
- DBH; and
- nest-tree rank: trees were assessed (from the ground) for the potential presence/quality of nest-hollows and allocated a nesting rank (developed by BCE) as described in Table 2-5.

The DBCA database of black-cockatoo breeding sites (DBCA, 2024a) was also searched for relevant local records (see also Peck, 2019).

[1] the revised EPBC Act referral guidelines (DAWE, 2022) note that "any species of tree may develop suitable hollows for breeding" however there are some species that are much more likely to provide breeding sites. These species are listed on the DCCEEW SPRAT database and were the focus of the field investigations here.

Table 2-5. Ranking system for the assessment of potential nest-trees for black-cockatoos (revised 08/01/2021).

As per DCCEEW (2024d, 2024a, 2024c) guidance, a potential nest-tree is any tree with a diameter at breast height >500 mm (or >300 mm for *Eucalyptus accedens, E. 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. The tree may be dead or alive.

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.
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.

2.4.3.3 Foraging

The foraging value of the study area was assessed by calculating a foraging score for areas of similar vegetation type/condition (see Appendix 5). The foraging score provides a numerical value that reflects the significance of vegetation as foraging habitat for black-cockatoos, and this numerical value is designed to provide the sort of information needed by DCCEEW, 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 5. These three components are drawn from the DCCEEW 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 5. Foraging value scores are calculated differently for the three black-cockatoo species (Appendix 5) depending upon the vegetation present; thus a separate score is given for each VSA for each species when multiple species are potentially present in an area.

For comparison, the foraging quality scoring tool of DAWE (2022) was also used to assess the foraging value of the site to black-cockatoos. The template for this tool is provided in Appendix 6. In addition, BCE was recently provided an unpublished draft 'habitat scoring system for WA black-cockatoo foraging habitat' by DCCEEW which takes a very similar approach to the BCE method (described above and in Appendix 5). The Draft DCCEEW Habitat Scoring System is provided in Appendix 7 and was also used to assess the survey area.

Black-cockatoo foraging signs were also recorded opportunistically as part of the general site inspection. When observed, the location, tree species and approximate age of the foraging evidence were recorded. Black-cockatoo foraging evidence may persist for some months or years after the foraging event. There is currently no published evidence documenting the deterioration process of forage. Factors that help to establish the time since foraging include: the colour of nuts/foliage, the degree of weathering or decay of debris, the presence of small fragments of nut debris, the position/compression of the foraging debris relative to surrounding vegetation and leaf litter, and the strength of the eucalyptus 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.

2.4.3.4 Night roosting

As per the guidance of DAWE (2022), areas likely to be used as night roosting sites were noted based on the topographical, physical and vegetation characteristics present (such as sites adjacent to watercourses with large trees) and/or indirect evidence of roosting (e.g. guano deposits, discarded feathers).

The BirdLife Australia Great Cocky Count (GCC) database of roost sites (last updated in 2022) was searched for relevant local records (see Peck et al., 2019).

2.5 Survey limitations

The EPA Guidance Statement 56 (2004) and the EPA (2020) outline a number of limitations that may arise during field investigations for Environmental Impact Assessment. These survey limitations are discussed in the context of the BCE investigation of the survey area in Table 2-6.

The lack of detailed survey (i.e. intensive sampling of the fauna assemblage) is not considered a limitation as this assemblage is well-understood in the area from previous field investigations in similar landscapes. Furthermore, EPA guidance does not consider limitations related to the effectiveness of field sampling for fauna but appears to make an assumption that the purpose of such sampling is to confirm the fauna assemblage. This is implicit in the EPA (2020) technical guidance that does provide suggestions for sampling techniques, but the level of field investigations suggested cannot confirm the presence of an entire assemblage, or confirm the absence of a species. This requires far more work than is possible (or recommended) for studies contributing to the EIA process because fauna assemblages vary seasonally and annually, and often have high levels of variation even over short distances (Beta diversity). For example, in an intensive trapping study, How and Dell (1990) recorded in any one year only about 70% of the vertebrate species found over three years. In a study spanning over two decades, Bamford *et al.* (2010) found that the vertebrate assemblage varies over time and space, meaning that even complete sampling at a set of sites only defines the assemblage of those sites at the time of sampling. In that study, it took 24 to 26 years of annual sampling for species richness of small, terrestrial vertebrates to asymptote (M. Bamford unpubl. analysis). The limited effectiveness of short periods of fauna sampling is not a limitation for assessing the fauna values of a survey area *per se*, as long as database information is interpreted effectively and field investigations are targeted appropriately. That is the approach taken by BCE.

Table 2-6. Survey limitations as outlined by EPA (2020).

EPA Survey Limitations	BCE Comment
Availability of data and information	Sufficient information from databases (see Section 2.3.1). Not a limitation.
Competency/experience of the survey team, including experience in the bioregion surveyed	The ecologists have had extensive experience in conducting desktop reviews and Basic level field investigation and site inspections for environmental impact assessment fauna studies, and have undertaken a number of studies within the region. Not a limitation.
Scope of the survey (e.g. were faunal groups excluded from the survey)	The survey focused on terrestrial vertebrate fauna and fauna values. Some information on threatened invertebrates was available from databases. Not a limitation.
Timing, weather and season	Timing is not of great importance in this region for the type of field investigations covered in this report. Not a limitation.
Disturbance that may have affected results	None. Not a limitation.
The proportion of fauna identified, recorded or collected	All fauna observed were identified. Not a limitation.
Adequacy of the survey intensity and proportion of survey achieved (e.g. the extent to which the area was surveyed)	Fauna database searches covered a 25 km radius around the survey areas and were interpreted based on the environments present in the survey areas. The Basic level assessment and targeted black-cockatoo assessment were completed. Not a limitation.
Access problems	None. Not a limitation.
Problems with data and analysis, including sampling biases	There were no data problems. Not a limitation.

2.6 Presentation of results for Impact Assessment

While some impacts are unavoidable during a development, of concern are long-term, deleterious impacts upon biodiversity. This is reflected in documents such as the Significant Impact Guidelines provided by DotE (2013) (see Appendix 4). Significant impacts may occur if:

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

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

The presentation of this assessment follows the general approach to impact assessment as given in Section 1.1, but modified to suit the characteristics of the site. Key components to the general approach to impact assessment are addressed as follows:

Fauna values

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

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

Impact assessment

This section reviews impacting processes (as described in detail in Appendix 3) with respect to the proposed development and examines the potential effect these impacts may have on the faunal biodiversity of the project area. It thus expands upon Section 1.1 and discusses the contribution of the project to impacting processes, and the consequences of this with respect to biodiversity. A major component of impact assessment is consideration of threats to species of conservation significance as these are a major and sensitive element of biodiversity. Therefore, the impact assessment section includes the following:

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

The impact assessment concludes with recommendations for impact mitigation, based upon predicted impacts. Note that the terms direct and indirect impacts are not used in this report; for further explanation see Appendix 2.

2.6.1 Criteria for impact assessment

Impact assessment criteria are based on the severity of impacts on the fauna assemblage and conservation significant fauna, and quantified on the basis of predicted population change (Table 2-7). Population change can be the result of direct habitat loss and/or impacts upon ecological processes.

The significance of population change is contextual. The EPA (2016c) have suggested that the availability of fauna habitats within a radius of 15 km can be used as a basis to predict low, moderate or high impacts. In this case, a high impact is where the impacted environment and its component

fauna are rare (less than 5% of the landscape within a 15 km radius or within the Bioregion), whereas a low impact is where the environment is widespread (e.g. >10% of the local landscape). Under the Ramsar Convention, a wetland that regularly supports 1% of a population of a waterbird species is considered to be significant. These provide some guidance for impact assessment criteria. In the following criteria (Table 2-7), the significance of impacts is based upon percentage population decline within a 15 km radius (effectively local impact) and upon the effect of the decline upon the conservation status of a recognised taxon (recognisably discrete genetic population, sub-species or species). Note that percentage declines can usually only be estimated on the basis of the distribution of a species derived from the extent of available habitat while for a few species, such as the black-cockatoos, there is guidance for the assessment of impact significance.

The impact assessment concludes with recommendations based upon predicted impacts and designed to mitigate these.

Table 2-7. Assessment criteria for impacts upon fauna.

Impact Category	Observed Impact
Negligible	Effectively no population decline; at most few individuals impacted and any decline in population size within the normal range of annual variability.
Minor	Population decline temporary (recovery after end of project such as through rehabilitation) or permanent, but < 1% within 15 km radius of centre-point of impact area (or within bioregion if this is smaller). No change in viability or conservation status of taxon.
Moderate	Permanent population decline 1-10% within 15 km radius. No change in viability or conservation status of taxon.
Major	Permanent population decline 10-50% within 15 km radius. No change in viability or conservation status of taxon.
Critical	Taxon decline > 50% (including local extinction) within 15 km and/or change in viability or conservation status of taxon.

3 Fauna values

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

- Recognition of ecotypes or vegetation/substrate associations (VSAs);
- Assemblage characteristics (uniqueness, completeness and richness);
- Targeted black-cockatoo habitat assessment results;
- Information on species of conservation significance;
- Patterns of biodiversity across the landscape; and
- Ecological processes affecting fauna.

3.1 Vegetation and substrate associations (VSAs) ['Habitat assessment']

Vegetation and substrate associations within the survey areas are a mosaic, largely reflecting soil types and topography. Umwelt (2023) provided a detailed assessment of the vegetation within much of the Osprey survey area, including a list of species recorded and vegetation type mapping. From this and observations made during the field investigations here, seven major vegetation and substrate associations (VSAs) were identified in relation to fauna in the survey areas (described below). Not all VSAs were present in each survey area: Lone South consisted of VSA 1, VSA 2 and VSA 5, while Osprey consisted of VSA 1 and VSAs 3-7.

- **VSA 1. *Banksia attenuata* and *B. menziesii* Low Woodland.** Low woodland to isolated trees of *Banksia attenuata* and *Banksia menziesii*, occasionally with *B. prionotes*, *Eucalyptus todtiana* and *Nuytsia floribunda*, over diverse mixed shrubland on grey, yellow-brown or brown deep sands or sandy loam on plains or flats within undulating plains and slopes of low dunes. This VSA corresponds to vegetation types D-A and D-B of Umwelt (2023). See Plate 1 and Plate 2.
- **VSA 2. *Banksia prionotes* Low Woodland.** Low woodland dominated by *Banksia prionotes* with occasional *B. attenuata* and *B. menziesii*, over diverse mixed shrubland on yellow sands on low dune crests. This VSA does not directly correspond to a vegetation type of Umwelt (2023) but may form a sub-type of D-B. See Plate 3.
- **VSA 3. *Banksia sessilis* Shrubland**. Shrubland dominated by *B. sessilis* over mixed shrubland on red-brown clay loam with ironstone surface stones and outcropping on low rocky hills. This VSA corresponds to vegetation type D-C of Umwelt (2023). See Plate 4.
- **VSA 4. Dampland Shrubland/Open Woodland.** Sparse mixed shrubland, often dominated by *Acacia saligna* with occasional low isolated trees of *Melaleuca rhaphiophylla*, *Eucalyptus rudis* and *Banksia littoralis* on brown or grey clay loam or sandy loam on damp to wet flats or plains. This VSA corresponds to vegetation type W-E of Umwelt (2023).
- **VSA 5. *Banksia telmatiaea* Heathland.** Heathland dominated by *Banksia telmatiaea* with *Regelia ciliata*, *Hakea obliqua*, and occasionally low isolated *Bankisa* spp., *Melaleuca preissiana* and *Nuytsia floribunda* trees on grey, brown or yellow sandy loam or sand on seasonally damp to wet low-lying plains, flats, open depressions and swamps. This VSA corresponds to vegetation type W-C of Umwelt (2023). See Plate 5 and Plate 6.
- **VSA 6. Mixed Heathland.** Mixed, diverse heathland on sandy clay loam or clay loam of various colours on seasonally damp undulating plains, damp to wet plains, seasonally damp to wet lower slopes, open depressions and clay pans. This VSA corresponds to vegetation types W-A, W-B and W-D of Umwelt (2023). See Plate 7.

- **VSA 7. Cleared. Cleared areas.** This VSA corresponds to vegetation type 'Cleared' of Umwelt (2023).

The extent of the VSAs in the survey areas is mapped in Figure 3-1 (Lone South) and Figure 3-2 and Figure 3-3 (Osprey).

Plate 1. VSA 1: *Banksia attenuata* and *B. menziesii* Low Woodland – Lone South.

Plate 2. VSA 1: *Banksia attenuata* and *B. menziesii* Low Woodland – Osprey.

Plate 3. VSA 2. *Banksia prionotes* Low Woodland – Lone South.

Plate 4. VSA 3. *Banksia sessilis* Shrubland - Osprey.

Plate 5. VSA 5. *Banksia telmatiaea* Heathland – Lone South.

Plate 6. VSA 5. *Banksia telmatiaea* Heathland – Osprey.

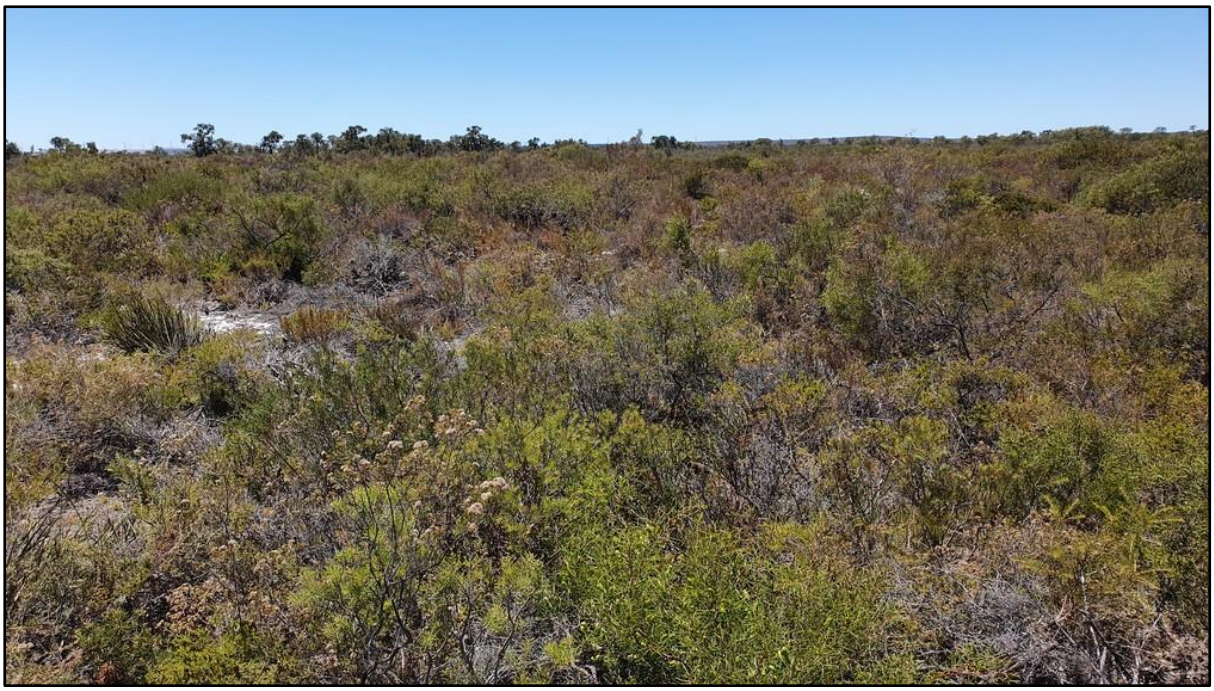

Plate 7. VSA 6. Mixed Heathland – Osprey

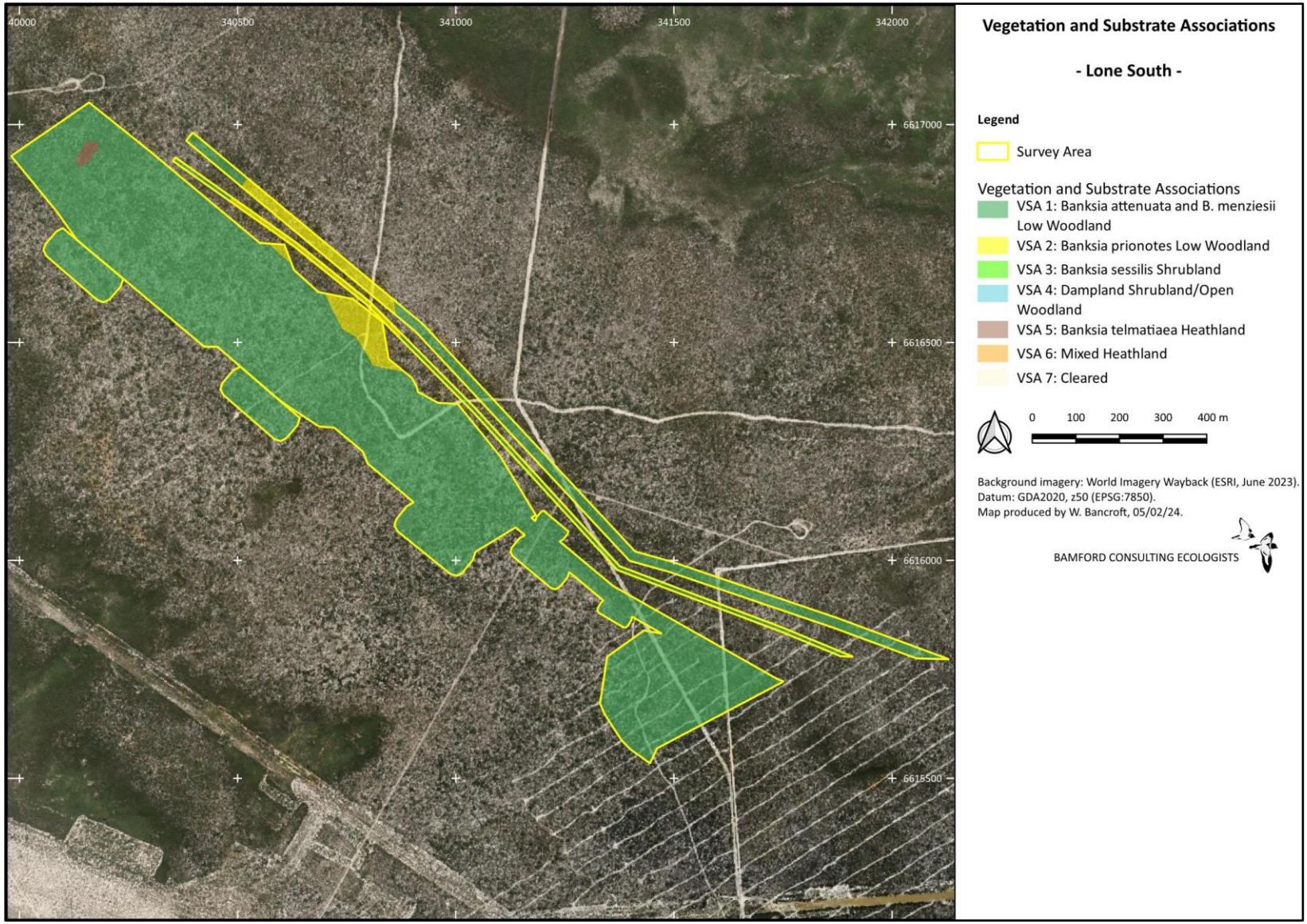

Figure 3-1. The distribution of VSAs in the Lone South survey area.

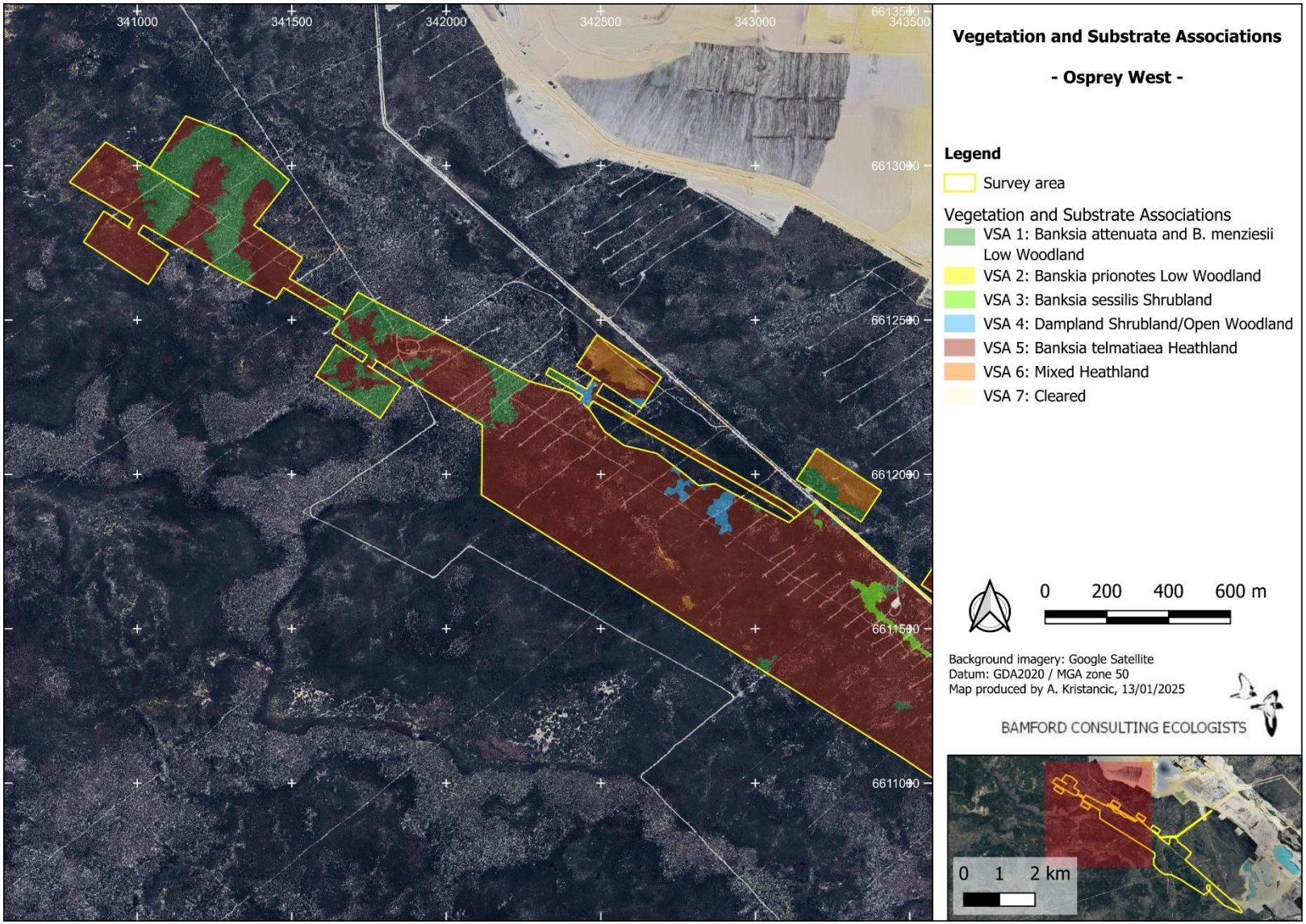

Figure 3-2. The distribution of VSAs in the Osprey survey area (map 1 of 2).

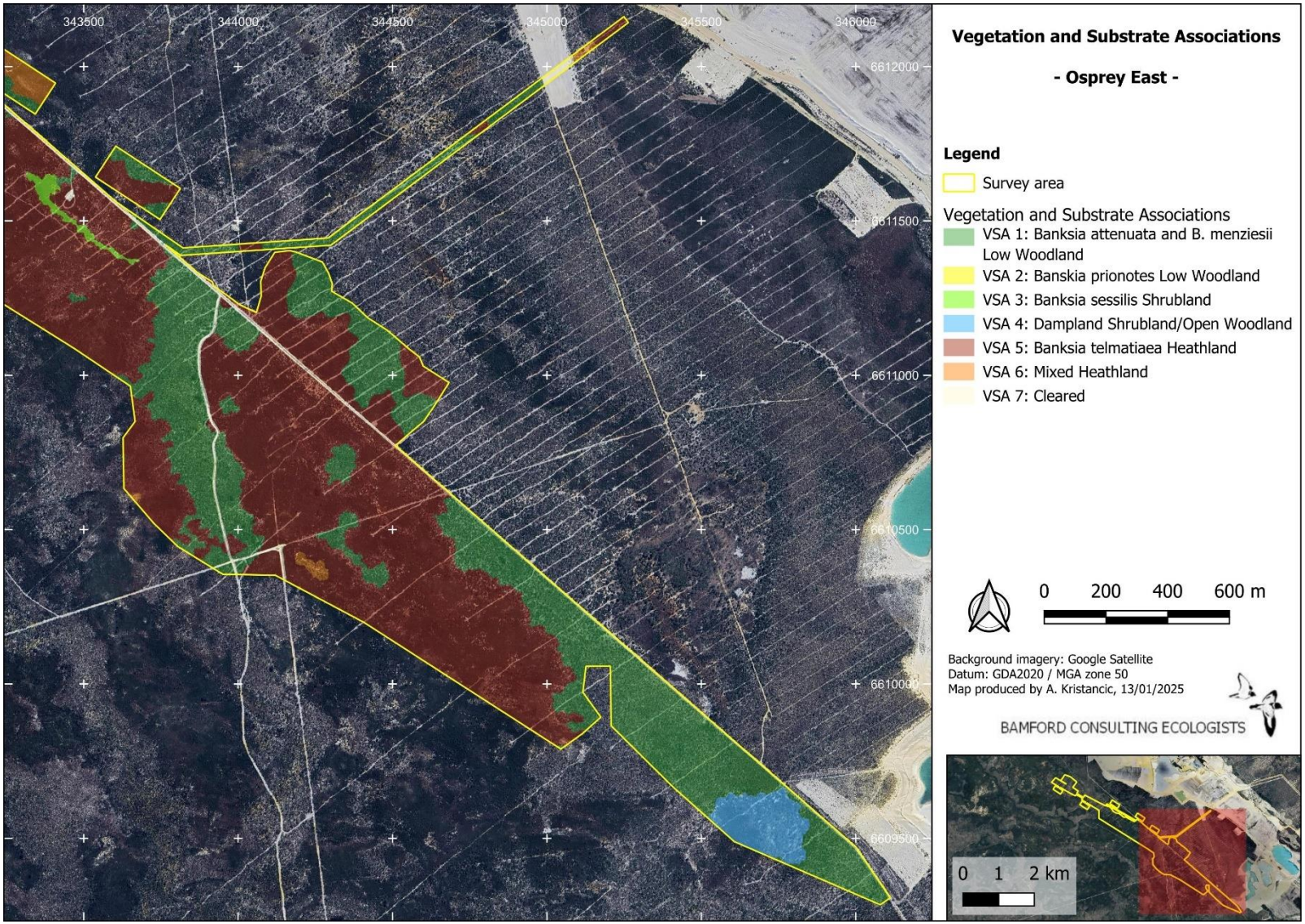

Figure 3-3. The distribution of VSAs in the Osprey survey area (map 2 of 2).

3.2 Fauna assemblage

3.2.1 Overview of vertebrate fauna assemblage

The desktop assessment identified 198 vertebrate fauna species as potentially occurring in the survey area: ten frogs, 46 reptiles, 120 birds, 17 native and 5 introduced mammals. These species are listed in Appendix 8. Thirteen birds and one mammal were observed during field investigations; these are presented in Appendix 12 and indicated in Appendix 8. The composition of the expected vertebrate fauna assemblage is summarised in Table 3-1.

Twelve vertebrate species that would historically have been present in the survey areas have been omitted from the expected species list because they are extinct (one mammal) or considered locally extinct (one bird and 10 mammals). These species are listed in Appendix 9 and summarised in Table 3-1.

An additional 139 species (including five freshwater fish recorded nearby by BCE) were omitted due to habitat or range limitations, or because they are domesticated species. These are listed in Appendix 10. The large number of omitted species reflects differences between the environments of the survey areas compared with those represented in the study area from which database results were obtained. For example, the database search returned several pelagic birds, as well as marine reptiles and mammals, which are not relevant to the survey areas. About a fifth of the omitted species are waterbirds or shorebirds that have been observed nearby during previous BCE surveys in Cooljarloo, but for which there is no suitable habitat in the Lone South and Osprey survey areas. These species may fly over or very occasionally visit the survey areas but are considered unlikely to be affected by the proposed development and have therefore been omitted on the basis of no suitable habitat.

Table 3-1. Composition of expected vertebrate fauna assemblage of the survey area.

Taxon	Total	Number of species in each status category			
		Resident	Regular visitor	Irregular visitor	Vagrant
Frogs	**10**	6	4	0	0
Reptiles	**46**	44	0	1	1
Birds	**120**	26	44	25	25
Native mammals	**17**	12	3	2	0
Introduced mammals	**5**	4	1	0	0
Total	**198**	**92**	**52**	**28**	**26**

3.2.2 Expected vertebrate fauna

The expected fauna assemblage presented in the expected species list and described here is a conservative estimate of the fauna that may use the sites, taking a precautionary approach. BCE has been conducting trapping and censussing of fauna near Cooljarloo since 1986, and a summary of observations from this dataset is provided below for each fauna group.

Frogs

The ten frog species include six which are expected to be resident to the survey areas and four that are expected as regular visitors. All frog species are terrestrial frogs that spend most, or all, of their life-cycle away from wetlands/damplands. Nine of the ten frog species have been recorded by BCE during studies in the Cooljarloo area.

Reptiles

The 46 reptile species consist of one tortoise, 33 lizards and 12 snakes. All are expected as residents except for the South-West Long-necked Tortoise (Vagrant) and Leopard Ctenotus (Irregular Visitor). Three of the expected reptile species are of conservation significance and are discussed in Section 3.2.5: the Jewelled Ctenotus (Swan Coastal Plain subpopulation) (CS2 (P3)), Black-striped Snake (CS2 (P3)) and Carpet Python (CS3). Almost all of these reptiles (42 species) have been recorded by BCE during their studies at Cooljarloo, including the three reptiles of conservation significance. The reptile assemblage is rich and the survey areas lies in a region recognised for high reptile species richness (Maryan 2005).

Birds

The expected bird assemblage of 120 species is moderately rich, but only about 20% of these (26 species) are expected as residents. The majority (69 species) are expected as visitors to the survey areas; 44 as regular visitors and 25 as irregular visitors, while 25 species are expected as vagrants. In addition to the 120 bird species expected, one species is considered locally extinct; the Barking Owl. Three bird species are introduced and are expected as irregular visitors (Rock Dove, Laughing Dove and Laughing Kookaburra). Introduced species may negatively impact native bird species via predation or competition for food and nesting resources. Five bird species are of conservation significance: four CS1 and one CS3. One of these is expected as a regular visitor (Carnaby's Black-Cockatoo), three as irregular visitors (Fork-tailed Swift, Peregrine Falcon and Australian Bustard) and one as a vagrant (Malleefowl). All conservation significant birds are discussed in Section 3.2.5. Ninety-one bird species have been recorded by BCE during bird censussing at Cooljarloo, including the conservation significant Carnaby's Black-Cockatoo and Australian Bustard.

Mammals

The mammal assemblage is incomplete, with 17 native mammals expected in the survey areas and eleven mammals considered extinct or locally extinct. The majority of the native mammal species are expected as residents (12 species), with the remainder expected as regular visitors (3 species) or irregular visitors (2 species). Most of these native mammals have been recorded by BCE at Cooljarloo, including the conservation significant Brush Wallaby (CS2 (P4)). The assemblage is notable for a near-complete suite of small mammals (four dunnarts, two native rodents and the Honey Possum). One of these may be an undescribed form of *Sminthopsis dolichura*, as it has a much shorter tail than the

nominate form, but BCE has recorded it from as far south as Muchea to as far north as the Mt Adams area (just inland from Dongara), so it is moderately widespread on the coastal plain. Five introduced mammal species are expected in the survey area (four as residents and one as a regular visitor). An additional introduced mammal (the Common Dog) may be present in the survey areas but is excluded from the expected assemblage as it is domesticated. One mammal in the expected species assemblage is of conservation significance (Brush Wallaby, CS2 (P4)) and is discussed in Section 3.2.5.

Summary

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

- **Uniqueness:** The assemblage is likely to be represented elsewhere within nearby native vegetation, but this assemblage has a restricted distribution in remnant patches of Banksia woodland on the already-fragmented coastal plain. The assemblage is notable for high reptile species richness, a large number of small mammal species, and a high proportion of nectar-dependent species (many birds and one small mammal).
- **Completeness:** The assemblage is substantially complete for frogs, reptiles and birds, and incomplete for mammals which are depauperate in medium-sized species.
- **Richness:** The assemblage is likely to be relatively rich in a regional context, particularly for reptiles, as it is located in intact Banksia woodland within an increasingly fragmented landscape.

3.2.3 Locally extinct vertebrate fauna

There are fourteen vertebrate species that would be expected to be present in the survey area if they were not locally extinct or extinct; this includes one reptile, two birds and eleven mammals. The locally extinct species are still present in other areas of Western Australia and would have once been present in the survey areas, but have not been recently recorded in the local area and therefore are almost certainly no longer present in the survey areas. Locally extinct and extinct species are listed in Appendix 9.

For the majority of species, the likely causes of extinction or local extinction are habitat loss and introduced predators (e.g. cats and foxes).

3.2.4 Conservation significant fauna

3.2.4.1 Vertebrate fauna of conservation significance

Of the 198 species of vertebrate fauna expected to occur in the survey area, nine are considered to be of conservation significance: four CS1, three CS2 and two CS3. A summary of the numbers in each vertebrate class is presented in Table 3-2. These species of conservation significance are indicated in the complete species list (Appendix 8) but are also listed with details of their conservation significance in Table 3-3. The CS1 species are all birds, and none is expected as resident; one is expected as a regular visitor (Carnaby's Black-Cockatoo), two as irregular visitors (Fork-tailed Swift and Peregrine Falcon), and one as a vagrant (Malleefowl). The CS2 species consist of two reptiles (Jewelled Southwest Ctenotus (Swan Coastal Plain subpopulation)) and Black-striped Snake) and one mammal (Brush Wallaby), and all are expected as residents. The CS3 species consist of one bird (Australian

Bustard, irregular visitor) and one reptile (Carpet Python, resident). More details regarding CS species are given under conservation significant species accounts in Section 3.2.5.

Locations of records of expected CS1 and CS2 vertebrates within 25 km of the survey area (from the DBCA threatened and priority fauna database) are illustrated in Figure 3-4. Locations of records of omitted CS1 and CS2 vertebrates are illustrated in Figure 3-5.

There is only one mammal expected in the survey areas that is listed under state or federal legislation or publications (CS1 and CS2 categories). This reflects the high level of local extinction in the region; there are nine mammal species that are of conservations significance (CS1 or CS2) and would historically have been present in the survey areas but are now considered locally extinct. These are shown in Appendix 9. Two of these locally extinct species (Quenda and Tammar Wallaby) were the subject of a trial relocation into Nambung National Park (c. 25km to the west; indicated on Figure 3-5) in the early 2000s (P. Orell pers. comm.). Neither species has been confirmed in the Cooljarloo area, but an unconfirmed sighting of a small wallaby was made in December 2006 (M. Bamford pers. obs.). There were no subsequent sightings. The translocations are reported to have ultimately been unsuccessful due to predation by Feral Cats and Red Foxes (DBCA personnel). There is also one reptile (Woma, CS2 (P1)) and one bird (Western Ground Parrot, CS1 (CR, S2D1)) that are of conservation significance but locally extinct in the survey areas.

Table 3-2. The number of conservation significant species in each vertebrate class expected to occur within the survey area.

See Appendix 1 for full explanation of Conservation Significance (CS) levels: CS1 = listed under WA State and/or Commonwealth legislation; CS2 = listed as Priority by DBCA; CS3 = considered locally significant. Number in parentheses in Mammals row indicate locally extinct species.

		CONSERVATION SIGNIFICANCE		
CLASS	**Total**	**CS1**	**CS2**	**CS3**
Frogs	**0**	0	0	0
Reptiles	**3**	0	2	1
Birds	**5**	4	0	1
Mammals	**1 *(9)***	0 *(7)*	1 *(2)*	0
Total	**9**	**4**	**3**	**2**

Table 3-3. Conservation significant fauna species expected to occur within the survey area.

Species are listed in taxonomic order.
CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 1 for full explanation.
EPBC Act listings: CR = Critically Endangered, EN = Endangered, VU = Vulnerable, MI = Migratory (see Appendix 2).
Biodiversity Conservation Act 2016 listings: S1 to S3 = Schedules 1 to 3, D1 to D3 = Divisions 1 to 3 (see Appendix 2).
DBCA Priority species: P1 to P4 = Priority 1 to 4 (see Appendix 2).

Latin Name	Common Name	Expected Occurrence	Status
REPTILES			
Ctenotus gemmula (Swan Coastal Plain subpopulation)	Jewelled Southwest Ctenotus (Swan Coastal Plain subpopulation)	Resident	CS2 (P3)
Morelia spilota imbricata	Carpet Python	Resident	CS3
Neelaps calonotos	Black-striped Snake	Resident	CS2 (P3)
BIRDS			
Leipoa ocellata	Malleefowl	Vagrant	CS1 (VU, S2D3)
Apus pacificus	Fork-tailed Swift	Irregular visitor	CS1 (MI, S1D2)
Ardeotis australis	Australian Bustard	Irregular visitor	CS3
Falco peregrinus	Peregrine Falcon	Irregular visitor	CS1 (S1D3)
Zanda latirostris	Carnaby's Black-Cockatoo	Regular visitor	CS1 (EN, S2D2)
MAMMALS			
Notamacropus irma	Brush Wallaby	Resident	CS2 (P4)

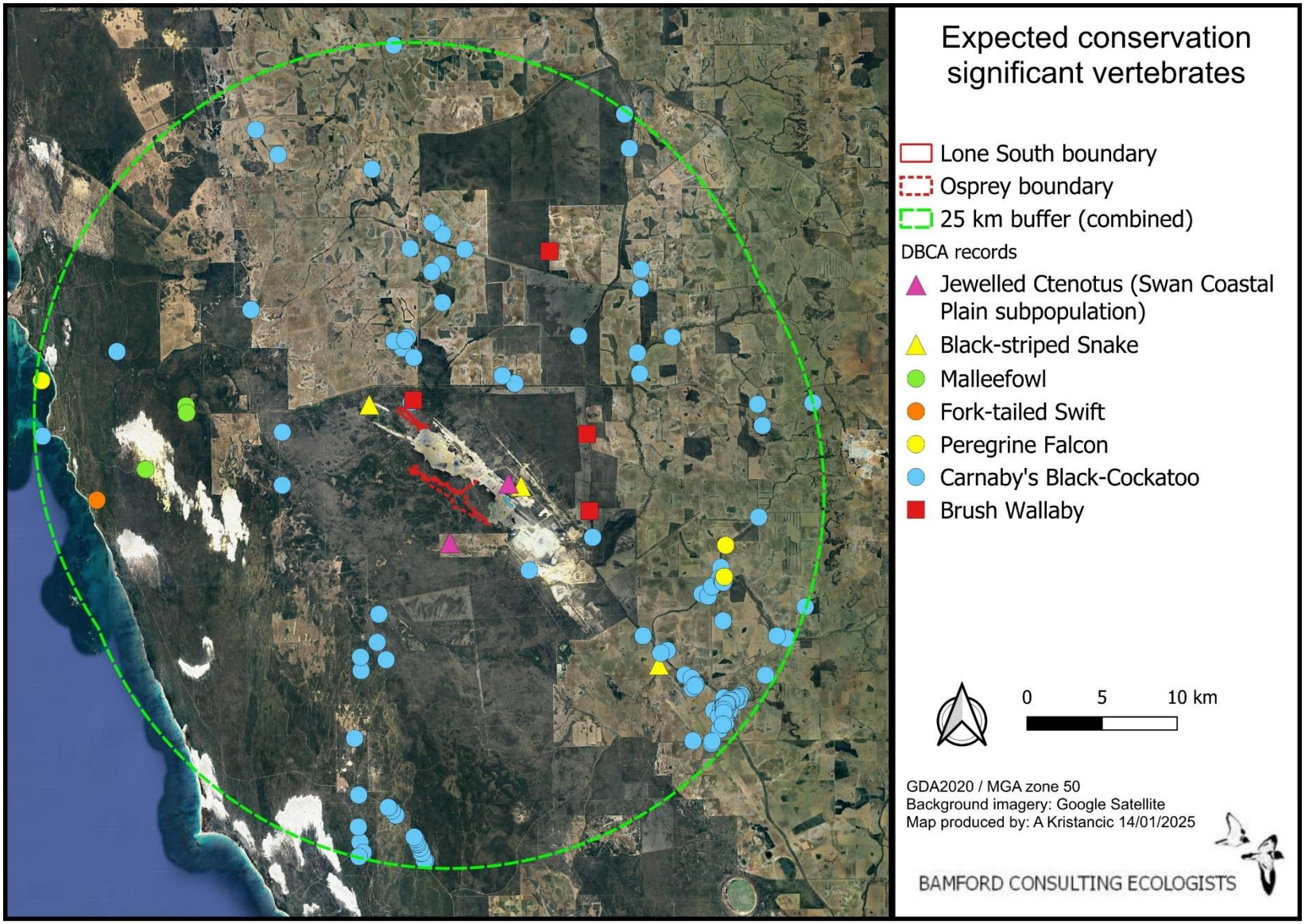

Figure 3-4. Locations of records of expected conservation significant vertebrates within 25 km of the survey areas. Records are from DBCA (2023d).

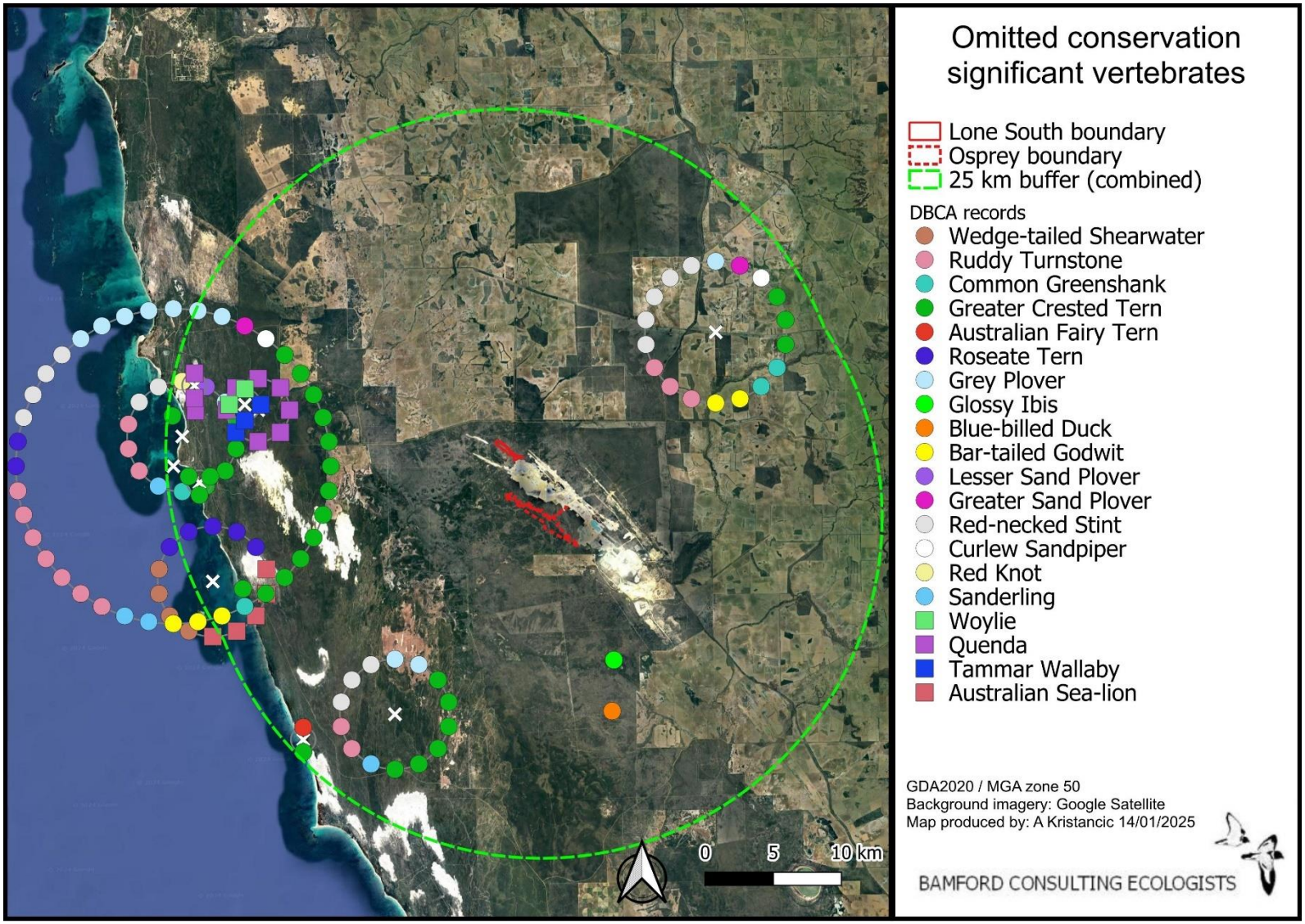

Figure 3-5. Location of records of omitted conservation significant vertebrates within 25 km of the survey area. Records are from DBCA (2023d). Point displacement around a central white X has been used to display overlapping records.

3.2.4.2 Invertebrate fauna of conservation significance

Invertebrate fauna of conservation significance includes listed threatened species and short-range endemic (SRE) (or potential SRE) species, although it should be noted that SRE and potential SRE species are often not well-documented. A compiled list of potential conservation significant invertebrates, along with their expected occurrence in the survey areas, is provided in Appendix 11.

3.2.4.2.1 Listed invertebrates

The database searches returned records of three listed threatened invertebrate species:

- *Bothriembryon perobesus*, a bothriembryontid land snail (Moore River) - Priority 1 (also considered SRE);
- *Synemon gratiosa*, Graceful Sunmoth - Priority 4; and
- *Austrosaga spinifer*, Spiny Katydid (Swan Coastal Plain)- Priority 2

Two of these species were recorded in Cooljarloo West by Bennelongia (2013): the Graceful Sunmoth and the Moore River Land Snail). The Graceful Sunmoth is found in association with *Lomandra hermaphrodita* or *Lomandra maritima* and is therefore expected as only an irregular visitor to the survey areas due to the low density of these species in these areas. Known records of CS invertebrates within 25 km of the survey area are shown on Figure 3-6.

This figure also shows the location of the Graceful Sunmoth specimens collected by Bennelongia, the majority of which were found on a reference transect to the west of the Cooljarloo West proposal area (in association with *L. hermaphrodita*). The specimen of the Moore River Land Snail attributed to DBCA records in Figure 3-6 is almost certain to be the specimen collected by Bennelongia in 2012. Based on these records it is considered likely that the Moore River Land Snail occurs as a resident in the current survey areas. The Spiny Katydid is a type of cricket and considered likely to be present in the survey areas due to nearby records and the mobility of these type of invertebrates.

3.2.4.2.2 Short range endemic (SRE) invertebrates

SRE invertebrates are significant because they have “naturally small distributions” (Harvey, 2002) and are therefore sensitive to habitat loss and degradation where they do occur. It should be noted that the ecology and distribution of short-range endemic invertebrates is often poorly understood or documented, and databases are unlikely to provide comprehensive information about these species. Previous surveys in Cooljarloo have recorded several SRE or potential SRE species, which are shown in Table 3-4.

Table 3-4. SRE or potential SRE species collected in Cooljarloo during previous fauna surveys.

Source: 4 = Bennelongia (2013), 5 = Bamford *et al.* (2012), 6 = BCE database

Latin Name	Comments	Status	Source
Arachnida			
Cercophonius sp.		not likely SRE	6
Eucyrtops sp.		not SRE	6
Euryolpium ‘sp.’	pseudoscorpion	potential SRE R1	4
Aname 'MYG223'	undescribed spider (3 males collected)	possible SRE	6

Latin Name	Comments	Status	Source
Kwonkan sp.	one juvenile collected	not identified to species	6
Aganippe 'MYG221'	undescribed spider (1 male collected)	possible SRE	6
Aganippe 'MYG222'	undescribed spider (1 male collected)	possible SRE	6
Euoplos mcmillani	two males collected	possible SRE	6
Missulena sp.	one male collected	not identified to species	6
Chilopoda			
Mecistocephalus sp. B07		potential SRE R1	4
Mollusca			
?*Bothriembryon* sp. indet.		potential SRE	6
Diplopoda			
Antichiropus Cooljarloo 1		SRE	5 6
Antichiropus Cooljarloo 2		SRE	5 6
Antichiropus Eneabba 2		SRE	5 6
Antichiropus USB2?		SRE	5 6
Podykipus sp.		unresolved	6
Isopoda			
Acanthodillo sp. B09		potential SRE (Rank 1)	4
Trichorhina sp. B14		potential SRE (Rank 1)	4
Oligochaeta			
Oligochaeta sp.		potential SRE (Rank 1)	4

Aside from the Moore River Land Snail, a confirmed SRE species, Bennelongia (2013) found five potential SRE species: one pseudoscorpion, one centipede, two isopods and one oligochaete worm. Full details are provided in Table 3-4 and Appendix 11. Based on available evidence, all these species were considered potential SRE species (Rank 1), but it was noted that this rank is extremely precautionary and is assigned mostly due to a lack of life-history information about the species in question, rather than a high likelihood of these species being SRE. Bennelongia (2013) concluded that it is unlikely that these species are in fact SREs. Bennelongia (2013) identified two prospective habitats for SRE invertebrates in the vicinity of the proposed development at Cooljarloo West; these were *Melaleuca rhaphiophylla/Eucalyptus camaldulensis* forests on drainage basin/flats and *Melaleuca rhaphiophylla* forests associated with mound springs. The Cooljarloo West development area is c. 10-15 km south of the Lone South and Osprey survey areas covered in the current report. These environments are not represented in the current survey areas although there were a few very small patches of VSA 4 (which includes some scattered specimens of *M. rhaphiophylla*) in the Lone South area, and scattered individual specimens of *M. rhaphiophylla* in the Osprey area.

During previous surveys near Cooljarloo, BCE has found 12 invertebrate species that may be SRE species. These records are captured in published reports (Bamford *et al*., 2012) as well as the BCE database. In 2011 BCE found four species of Antichiropus millipede that were considered to be SRE species based on available evidence (M. J. Bamford *et al*., 2012). Two of these were found in banksia woodland habitat (similar to the habitat that is extensive in the Lone South and Osprey survey areas). Another millipede was collected that may be an SRE species; this was a *Podykipus* species. Across

previous surveys in Cooljarloo, BCE has collected eight species of mygalomorph spider. Based on available evidence, four of these may be SRE species, two are not or unlikely to be SRE species, and two were not able to be identified (Table 3-4). BCE also collected a specimen thought to be a *Bothriembryon* species, which may be the Moore River Land Snail described above. The large number of new species collected in Cooljarloo probably reflects a general lack of collection of invertebrate fauna, but also suggests that the sandplain country around Cooljarloo is rich in mygalomorph spiders and *Antichiropus* millipedes, both of which are groups that contain a high proportion of SRE species. These millipedes have been recorded in rehabilitation sites in Cooljarloo as part of BCE's long-term monitoring program so are considered likely to be present in the survey areas.

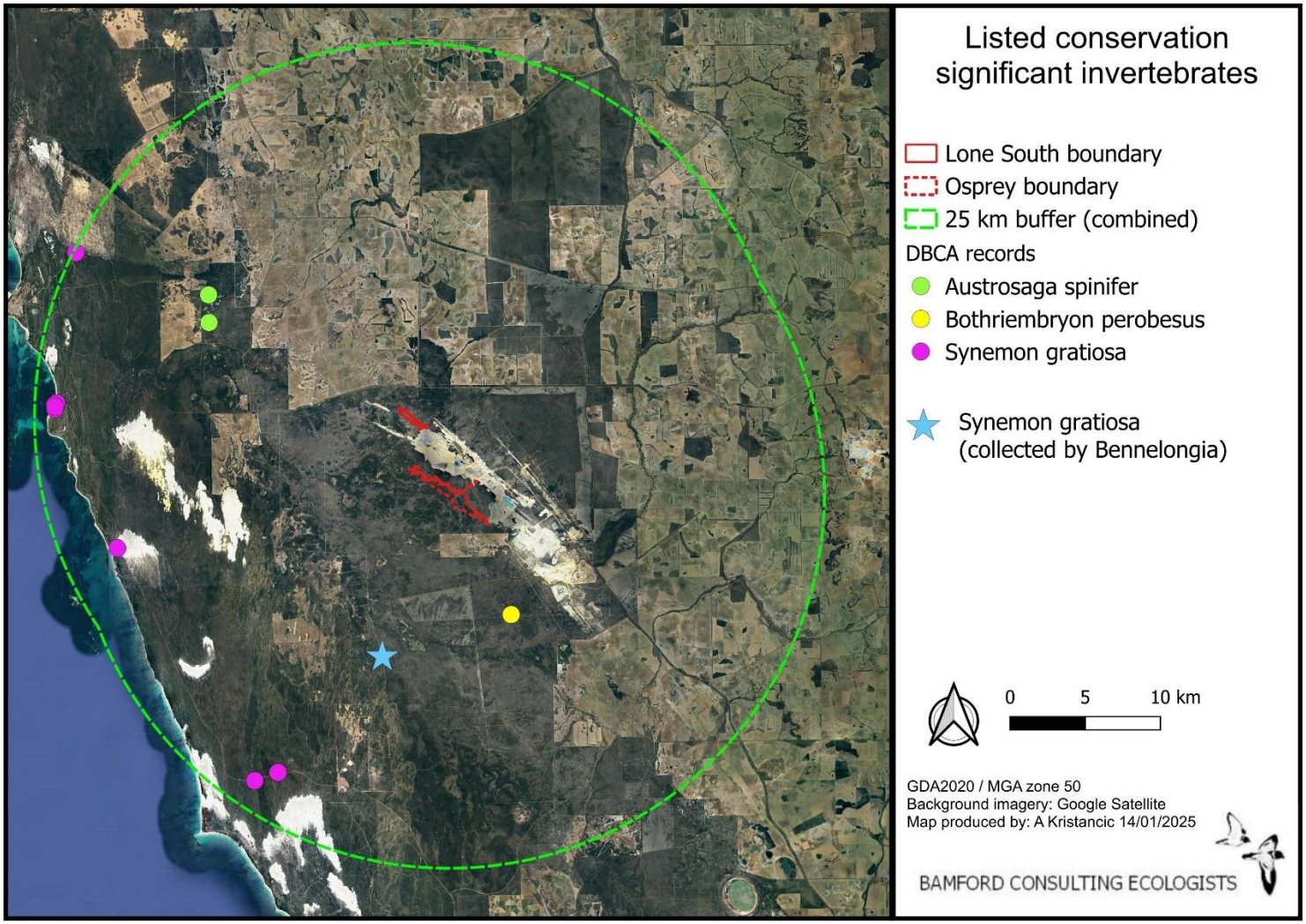

Figure 3-6. Records of listed conservation invertebrates (does not include potential SRE species) from the DBCA threatened and priority fauna database and previous fauna surveys. The blue star indicates the broad location in which Bennelongia (2013) collected 55 *Synemon gratiosa* (Graceful Sunmoth) specimens in the vicinity of the Cooljarloo West proposal area. These were all found in association with habitats containing *Lomandra hermaphrodita*, the moth's host plant.

3.2.5 Conservation significant species accounts

A list of all conservation significant species expected within the survey area is provided in Table 3-3; these comprise three reptiles, five birds, and one mammal (see Section 3.2.4.1). Information on the conservation status, distribution and habitat, salient ecology and expected occurrence within the survey area is provided below for all conservation significant species.

3.2.5.1 Conservation Significance 1

Malleefowl (*Leipoa ocellata*) CS1 (V, S2D3)

Conservation status:	Vulnerable under the EBPC Act and Schedule 2 Division 3 under the BC Act.
Distribution and habitat:	The Malleefowl lives within scrubland and woodland dominated by mallee eucalypts and wattle species (Burbidge, 2004; DCCEEW, 2023c). The species is distributed throughout the southern third of Australia in suitable, predominantly inland, semi-arid habitats (Menkhorst et al., 2017).
Ecology:	A diurnal, ground-foraging and usually solitary omnivore, the Malleefowl has a preference for long-unburnt sites (Benshemesh, 2007). Although not flightless, this species spends the vast majority of its time on the ground. In the breeding season, males construct large nest mounds out of soil and vegetation into which their female mates lay eggs (DCCEEW, 2023c). The males tend the nests during the incubation period, where they adjust mound height and composition to control the internal temperature and, hence, egg development (Benshemesh, 2007; DCCEEW, 2023c). No parental care is provided to emergent fledgelings. Major threatening processes for this species include habitat loss, fragmentation, grazing, fire and predation by foxes (Benshemesh, 2007; Burbidge, 2004).
Expected occurrence:	**Vagrant.** There are three records in the DBCA database within c. 15 km of the survey areas. The habitat within the survey areas is not typical of that associated with Malleefowl, but the species is known from the general region and individuals may very occasionally visit the survey areas. Given the over 30 years of annual surveys to the Cooljarloo area, it is extremely unlikely that the species is present with any regularity, and the likelihood of breeding is very low.

Fork-tailed Swift (*Apus pacificus*) CS1 (M, S1D2)

Conservation status: Migratory under the EPBC Act and Schedule 1 Division 2 under the BC Act.

Distribution and habitat: The swift is a largely aerial species of unpredictable occurrence in Western Australia. There are scattered records from the south coast, widespread in coastal and subcoastal areas between Augusta and Carnarvon, scattered along the coast from south-west Pilbara to the north and east Kimberley region. Sparsely scattered inland records, especially in the Wheatbelt, but more common in the north and north-west Gascoyne Region, north through much of the Pilbara Region, and the south and east Kimberley (DCCEEW, 2023a; Higgins, 1999). Aerial, usually flying from as low as one metre to more than 300 m above the ground.

Ecology: A diurnal, aerial insectivore, this species often forages along the edge of low pressure systems in flocks of ten to 1000 birds (DCCEEW, 2023a; Higgins, 1999). Breeds in Siberia (April to July) and spends the non-breeding season (October to mid-April) in Australia. Being aerial, it is effectively independent of terrestrial ecosystems when in Australia.

Expected occurrence: **Irregular visitor.** There is one record in the DBCA database within c. 25 km of the survey areas. This species may occasionally fly over the survey areas but is unlikely to utilise them in any significant manner.

Peregrine Falcon (*Falco peregrinus*) CS1 (S1D3)

Conservation status: Schedule 1 Division 3 under the BC Act.

Distribution and habitat: More or less cosmopolitan throughout Australia (Menkhorst *et al.* 2017). This species occurs in a variety of habitats but is usually reliant on cliff faces or tall trees for nesting (Debus, 2019).

Ecology: A highly adept aerial predator that predominantly forages on birds, although will also occasionally take invertebrates, fish, reptiles and mammals (Debus, 2019). Mostly diurnal or crepuscular.

Expected occurrence: **Irregular visitor.** The Peregrine Falcon is known from the general region, although there are only three records in the DBCA database within 25 km of the survey areas. The small number of records probably reflects the fact that this species is widespread but not common (Western Australian Museum, 2019). The survey area is possibly within the home range of a pair but the lack of sightings after over 30 years of annual surveys suggests the birds are not present regularly. The two survey areas do not contain suitable nesting sites such as tall trees or cliff faces.

Carnaby's Black-Cockatoo (*Zanda latirostris*) CS1 (E, S2D2)

Conservation status: Endangered under the EPBC Act and Schedule 2 Division 2 under the 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 (DCCEEW, 2024b; Johnstone & Storr, 1998). 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 (DCCEEW, 2024b). Heavily reliant on areas of Banksia woodland and proteaceous shrubland/heath for foraging (DCCEEW, 2024b; Johnstone & Storr, 1998).

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 (DCCEEW, 2024b; DPaW, 2013; Groom, 2011; Johnston et al., 2016; Valentine & Stock, 2008). Reliant on large tree-hollows in eucalypts (especially smooth-barked species such as Wandoo and Salmon Gum) for breeding (DCCEEW, 2024b; Johnstone & Storr, 1998; Saunders, 1974). 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; DCCEEW, 2024b).

Expected occurrence: **Regular visitor.** Carnaby's Black-Cockatoo is known from the general region and there are more than 200 records in the DBCA database within 25 km of the survey areas. It has been recorded regularly (almost every survey) in the ongoing studies by BCE in the Cooljarloo area, with a roost site known along Mullering Brook and breeding sites along Cataby Brook. The project areas do not appear to provide suitable roosting sites or potential nest trees, but contain extensive foraging habitat. More information on the species is provided below.

3.2.5.2 Conservation Significance 2

Spiny Katydid (Swan Coastal Plain) (*Austrosaga spinifer*) CS2 (P2)

Conservation status: Listed as Priority 2 by DBCA.

Distribution and habitat: The distribution of this species is poorly defined due to the low number of records of this species; there are records in the Perth Hills and near Cervantes (ALA, 2023). Suitable habitat is thought to consist of Banksia woodland and associated heaths (Bamford & Knowles, 2019).

Ecology: A species of predatory bush cricket (Rentz, 1993); likely to hide within shrubs during the day and emerge to sing at night (Rentz, 2010).

Expected occurrence: **Resident.** There are two old records in the DBCA database within c. 25 km of the survey areas. The survey areas contain suitable habitat in the form of Banksia Woodland and Heaths; therefore, the species is assumed to be resident.

Moore River Land Snail (*Bothriembyron perobesus*) CS2 (P1)

Conservation status: Listed as Priority 1 by DBCA. Confirmed SRE species.

Distribution and habitat: Known mainly from the Moore River area but extending at least as far north as Cooljarloo based on collection by Bennelongia (2013). The Cooljarloo specimens were found in Banksia Low Woodland.

Ecology: *Bothriembryon* land snails are herbivores that feed on biofilms, bark and decaying wood (Stanisic *et al.*, 2022). They often seal their shell aperture (opening) with a thick epiphragm to prevent them drying out in dry conditions (Stanisic *et al*., 2022).

Expected occurrence: **Resident.** There is one record in the DBCA database within c. 25 km of the survey areas, almost certainly the specimen collected by Bennelongia (2013).

Graceful Sunmoth (*Synemon gratiosa*) CS2 (P4)

Conservation status: Listed as Priority 4 by DBCA. Formerly listed as Endangered under the EPBC Act.

Distribution and habitat: The Graceful Sunmoth is found only in the south-west of Western Australia, from Kalbarri in the north to Binningup in the south (TSSC, 2013). Within this range, it is restricted to a narrow corridor of suitable coastal habitat, and this habitat is highly fragmented (TSSC, 2013; Williams et al., 2012). This species has specific habitat requirements and is found in strong association with one of two closely related host plants, *Lomandra hermaphrodita* or *Lomandra maritima* (TSSC, 2013).

Ecology: Adults usually emerge between mid-February to March each year, depending on climate and weather conditions (TSSC, 2013). Graceful sun moths have short adult lives, estimated at between 4-10 days and do not feed, instead relying on nutrients stored while in the larval stage (TSSC, 2013). Females lay eggs in the soil or near the base of the host plant; when hatched larvae feed on roots, rhizomes and leaves of this plant (TSSC, 2013).

Expected occurrence: **Irregular visitor.** There are 17 records in the DBCA database within c. 25 km of the survey areas, mostly in more coastal areas. The Wanagarren National Park (c. 15-20 km away on the coast) is considered a location of particular importance for Graceful Sunmoth conservation (Williams *et al*., 2012). The two project areas, however, have very low occurrence of the species' favoured food plants, hence the moths are not expected to be resident or even to occur regularly.

Jewelled Ctenotus (Swan Coastal Plain subpopulation) (*Ctenotus gemmula*) CS2 (P3)

Conservation status: Listed as Priority 3 by DBCA.

Distribution and habitat: The Jewelled Ctenotus occurs in two isolated subpopulations in Western Australia: one on the Swan Coastal Plain from Cataby south to Perth, and another along the south coast (IUCN, 2017). The Swan Coastal Plain subpopulation is listed as Priority 3 by DBCA, and is threatened by habitat loss associated with mining and urbanisation (IUCN, 2017). Typical habitat for this species includes *Banksia* and Mallee woodlands and heath on sandplains (Wilson & Swan, 2021).

Ecology: A fossorial skink that shelters in leaf litter (Huang, 2009).

Expected occurrence: **Resident.** There are two records in the DBCA database within c. 2-3 km of the survey areas, and suitable habitat occurs within the survey areas. These records are probably from the BCE sampling (BCE records are lodged with DBCA as a permit condition). All the BCE records of this species come from a section of Banksia Low Woodland on level ground (therefore VSA 1).

Black-striped Snake (*Neelaps calonotos*) CS2 (P3)

Conservation status: Listed as Priority 3 by DBCA.

Distribution and habitat: Restricted to coastal sandplains from near Dongara to Mandurah (Bush *et al*., 2010). Appears to be absent from the eastern coastal plain (M. Bamford pers. obs.). Within the Perth Metropolitan area this species may be restricted to large reserves (How & Shine, 1999).

Ecology: A fossorial species that preys upon small, fossorial skinks in the upper layers of loose sand (Bush *et al.*, 2010).

Expected occurrence: **Resident.** There are three records in the DBCA database within c. 15 km of the survey areas (some within 2-3 km), and suitable habitat occurs within the survey areas. The nearby records are likely to be BCE specimens as the species is very occasionally caught in the ongoing sampling. All records are from VSA 1 (Banksia Low Woodland on sand).

Brush Wallaby (*Notamacropus irma*) CS2 (P4)

Conservation status: Listed as Priority 4 by DBCA.

Distribution and habitat: Endemic to the South-West more or less south of line from Geraldton to Esperance, although it has disappeared from much of the Wheatbelt due to clearing. Occurs in a wide range of vegetation types from Eucalypt Woodland to Banksia Woodland, Shrublands and Kwongan. Locally common in dry sclerophyll forest and woodland in the south-west however it has declined in recent decades due to predation and habitat destruction (Menkhorst & Knight, 2011).

Ecology: Based on detailed radio-tracking study in Banksia Woodland in Whiteman Park (M. J. Bamford & Bamford, 1999), a largely solitary species that browses on shrubs and bushes; rarely on grass. Rarely drinks free-standing water and rarely ventures from dense vegetation. Individuals occupy home ranges of up to c. 10ha; larger in males than females and those of females overlap.

Expected occurrence: **Resident.** There are four records in the DBCA database within c. 15 km, and all are restricted to relatively large or well-connected areas of remnant vegetation (including National Parks and Nature Reserves). Suitable habitat exists within both survey areas. The Brush Wallaby is seen regularly during BCE surveys in the area and it typically favours areas of dense shrubland, including where this is the understorey of low woodland. It therefore is likely to occur across almost all VSAs present in the survey areas.

3.2.5.3 Conservation Significance 3

There are two species considered to be of local significance (CS3) - one bird and one reptile. The Carpet Python is expected as a resident, and the Australian Bustard is expected as an irregular visitor.

Carpet Python (southwest) (*Morelia spilota imbricata*) CS3 (LS)

Conservation status: This subspecies was formerly listed under the Western Australian *Wildlife Conservation Act 1950* as 'other specially protected fauna' but that status has, more recently, been removed in the WA *Biodiversity Conservation Act 2016* (DBCA, 2023d). It is likely to remain uncommon or at risk in the proximity of development. It is also sensitive to predation by the Red Fox.

Distribution and habitat: Patchily distributed through south-west Western Australia in a wide range of habitats including woodlands, heaths and rock outcrops (Bush et al., 2010; Wilson & Swan, 2021). It is particularly common in areas of exposed limestone, including offshore islands (Bush et al., 2010).

Ecology: Predominantly a nocturnal carnivore, the Carpet Python preys mainly on birds and mammals, although reptiles are occasionally taken (Bush et al., 2010).

Expected occurrence: **Resident.** Known from the region, with one record in ALA (2023) within c. 12 km of the survey areas. However, the species has been observed by BCE personnel on several occasions, including twice in rehabilitation sites, and is occasionally reported (and photographed) by Tronox personnel. Suitable habitat exists in both survey areas in the form of dense understorey vegetation that is extensive in both areas.

Australian Bustard (*Ardeotis australis*) CS3 (LS)

Conservation status: Considered locally significant due to declining populations

Distribution and habitat: The Australian Bustard can be found across most of mainland Australia, but is mostly restricted to inland northern Australia (Menkhorst *et al*., 2017). Typical habitat is open country such as dry grasslands, savanna, open woodland, spinifex sand plains, low semi-arid heath, pasture, stubble and ploughed fields (Menkhorst *et al*., 2017).

Ecology:	A large nomadic ground bird, usually found in pairs or family groups, but known to gather in larger groups in areas with ample food supply (Menkhorst *et al*., 2017). This species is omnivorous, with the diet consisting of small animals, seeds, buds, fruits and leaves (Menkhorst *et al*., 2017).
Expected occurrence:	**Irregular visitor.** This species is known from the region and there are two records within 25 km in ALA (2023). The species is occasionally seen by BCE personnel, usually in summer, with all records of single birds. Birds tend to be seen along tracks and in clearings rather than in native vegetation, which is probably too dense.

3.3 Black-cockatoo habitat analysis

3.3.1 Black-cockatoo presence

The survey areas are out of range for the Forest Red-tailed and Baudin's Black-Cockatoos While no black-cockatoos were observed within the Lone South and Osprey survey areas during the site inspection, there was evidence of foraging by Carnaby's Black-Cockatoo throughout the sites (see Section 3.3.3 below). Carnaby's Black-Cockatoos have been regularly recorded directly in the surrounding area (e.g. see Bancroft & Bamford, 2022, 2023b) and are known to forage extensively in similar VSAs throughout the region (Bancroft & Bamford, 2023a). Given this, the roosting data (see Section 3.3.4 below) and the literature review (including current species distributions), it is considered that, currently:

- Carnaby's Black-Cockatoo is likely to be a regular breeding migrant to the general region and, as such, is a regular foraging migrant to both survey areas. It is possible that birds also visit the survey areas as regular non-breeding migrants.

3.3.2 Black-cockatoo breeding habitat

No trees that met the potential black-cockatoo nest-tree criteria of DCCEEW (2024d, 2024a, 2024c) were recorded within either survey area.

The woodlands within the survey areas comprise tree species (*Banksia* spp.) that do not readily provide breeding sites for black-cockatoos. Occasional Flooded Gum (*Eucalyptus rudis*), Stout Paperbark (*Melaleuca preissiana*) or Swamp Paperbark (*M. rhaphiophylla*) trees were noted in the vicinity by Umwelt (2023), but the two Paperbarks do not form hollows and were small trees, while the Flooded Gums were also too small to provide hollows of a suitable size.

There are 73 known breeding sites (all natural hollows) within the 25 km buffer used for the database search; the closest known breeding sites are c. 15 km away from the Osprey survey area and c. 21 km from the Lone South survey area (Figure 3-7). Note that BCE has undertaken searching for breeding sites along Mullering Brook, about 12km south-east of the Osprey survey area, but no breeding activity was observed.

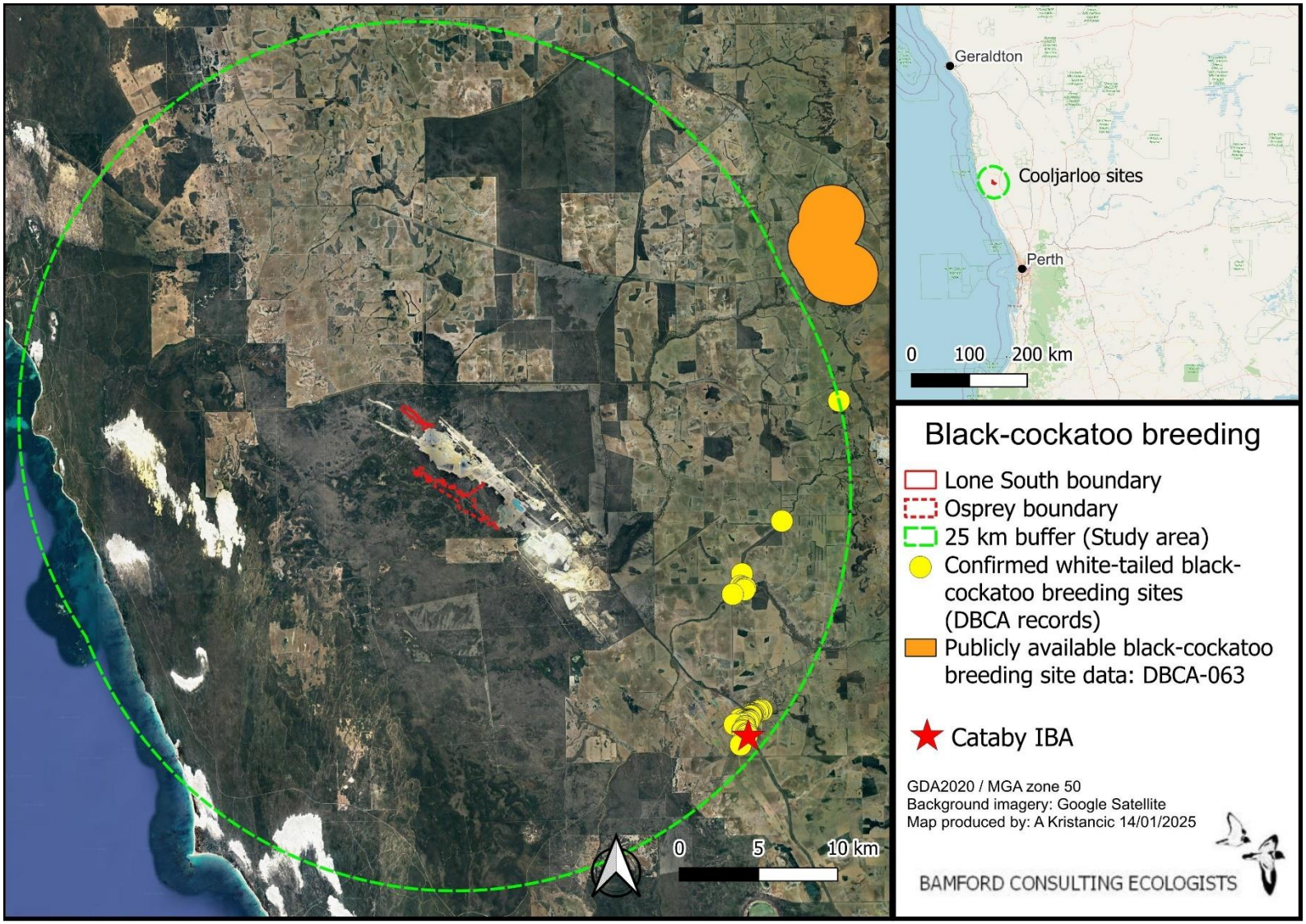

Figure 3-7. Known breeding sites for black-cockatoos within 25 km of the survey areas. Yellow dots indicate data from the DBCA threatened and priority fauna database (DBCA, 2023d), while the orange areas show publicly available data from DBCA (2024a).

3.3.3 Black-cockatoo foraging habitat

3.3.3.1 Carnaby's Black-Cockatoo

Foraging habitat for Carnaby's Black-Cockatoo was present throughout the Osprey and Lone South survey areas. This is predominantly due to the presence of three tree species (*Banksia attenuata*, *B. menziesii* and *B. prionotes*) known to be mainstays of the Carnaby's Black-Cockatoo diet (Groom, 2011). There were also some proteaceous shrub species such as *B. telmatiaea* and *Hakea* spp. that are known to be palatable for this species. *Banksia* spp. tree density was variable across the survey areas (ranging from patches of very high density, especially in VSA 1 areas, to scattered individual trees in VSA 5). The areas (and percentages) of each vegetation score within the Osprey and Lone South survey areas are shown for the Carnaby's Black-Cockatoo in Table 3-5.

There are approximately 34,624 ha of remnant native vegetation (as assessed by DPIRD, 2024a) within 12 km of the Lone South survey area, which itself has c. 51.7 ha of native vegetation. Therefore, the site comprises c. 0.14% of the native vegetation in the 'local area' (as per the methods outlined in Appendix 5). It is expected that Carnaby's Black-Cockatoo breeds within the local area (DCCEEW, 2024d, 2024a, 2024c). Therefore, for vegetation scores of 3 or above (out of 6), a 'context' score of 1 (out of 3) has been assigned to the survey areas for this species (see Appendix 5). For vegetation scores of 2 and below (out of 6), a 'context' score of 0 (out of 3) has been assigned.

There are approximately 45,370 ha of remnant native vegetation (as assessed by DPIRD, 2024a) within 12 km of the Osprey survey area, which itself has c. 267 ha of native vegetation. Therefore, the site comprises c. 0.58% of the native vegetation in the 'local area' (as per the methods outlined in Appendix 5). 'Context' scores were assigned as described for the Lone South area, above.

There was evidence of foraging by Carnaby's Black-Cockatoo within both the Lone South and Osprey survey areas: foraged cones (infructescences) and/or flowers (inflorescences) of *Banksia attenuata*, *B. menziesii* and *B. prionotes* were noted across the sites (although no specific location records were made in this instance). As a result, the survey areas were assigned a species 'density' score for Carnaby's Black-Cockatoo of 1 (out of 1; see Appendix 5), except for areas with a vegetation score of 0 (which received a 'density' score of 0).

The context and density values have been added on to the vegetation scores to yield the overall foraging value scores (with areas and percentages) that are also presented in Table 3-5. A breakdown of the vegetation, context, density and foraging scores for each VSA for Carnaby's Black-Cockatoo is shown in Table 3-6 (for Lone South) and Table 3-7 (for Osprey). A map of foraging scores for Carnaby's Black-Cockatoo foraging within the Lone South survey area is presented in Figure 3-8, and for the Osprey survey area in Figure 3-9 to Figure 3-12.

The Lone South survey area is, generally, of high value for foraging by the Carnaby's Black-Cockatoo and the Osprey survey area is, generally, of moderate value for foraging by the Carnaby's Black-Cockatoo. Osprey has more extensive moderate foraging value VSAs than Lone South.

Table 3-5. Areas (ha) and proportions (%) of each category (vegetation score, combined foraging score) of foraging habitat in the survey areas for Carnaby's Black-Cockatoo.

See Section 2.4.3.3 and Appendix 5 for explanation of vegetation, context, species density and (combined) foraging scores.

	Carnaby's Black-Cockatoo			
	LONE SOUTH		OSPREY	
Vegetation Score/Value	**Area (ha)**	**%**	**Area (ha)**	**%**
6: High	9.9	*17.9*	0.0	*0.0*
5: Moderate to High	37.8	*68.6*	60.8	*21.7*
4: Moderate	7.3	*13.2*	20.7	*7.4*
3: Low to Moderate	0.2	*0.3*	189.6	*67.7*
2: Low	0.0	*0.0*	4.9	*1.7*
1: Negligible	0.0	*0.0*	0.0	*0.0*
0: Nil	0.0	*0.0*	4.0	*1.4*
TOTAL	55.2	*100.0*	279.9	*100.0*
Context Score	2 when VS > 3 1 when 1 ≤ VS ≤ 3 0 when VS = 0			
Species Density Score	1 when VS > 0 0 when VS = 0			
Foraging Score	**Area (ha)**	**%**	**Area (ha)**	**%**
10: Pristine	-	-	-	-
9: Very high	9.9	*17.9*	-	-
8: High	37.8	*68.6*	-	-
7: Moderate to High	7.3	*13.2*	60.8	*21.7*
6: Moderate	-	-	20.7	*7.4*
5: Moderate	0.2	*0.3*	189.6	*67.7*
4: Low to moderate	-	-	-	-
3: Low	-	-	4.9	*1.7*
2: Very Low	-	-	-	-
1: Negligible	-	-	-	-
0: None	-	-	4.0	*1.4*
TOTAL	55.2	*100.0*	279.9	*100.0*

Table 3-6. Areas (ha) and proportions (%) of each VSA, and their respective vegetation, context, density and (combined) foraging scores for Carnaby's Black-Cockatoo within the Lone South survey area.

VSA	Area (ha)	%	Vegetation Score (out of 6)	Context (out of 3)	Density (out of 1)	Foraging Score (out of 10)
VSA 1: *Banksia attenuata* and *B. menziesii* Low Woodland	7.3	*13.2*	4	1	1	6
	35.0	*63.4*	5	1	1	7
	9.9	*17.9*	6	1	1	8
VSA 2: *Banksia prionotes* Low Woodland	2.8	*5.1*	5	1	1	7
VSA 5: *Banksia telmatiaea* Heathland	0.2	*0.3*	3	1	1	5
Total	**55.2**	***100.0***		**Rounded *weighted* overall site foraging score:**		**7** (out of 10)

Table 3-7. Areas (ha) and proportions (%) of each VSA, and their respective vegetation, context, density and (combined) foraging scores for Carnaby's Black-Cockatoo within the Osprey survey area.

VSA	Area (ha)	%	Vegetation Score (out of 6)	Context (out of 3)	Density (out of 1)	Foraging Score (out of 10)
VSA 1: *Banksia attenuata* and *B. menziesii* Low Woodland	20.7	*7.4*	4	1	1	6
	59.5	*21.3*	5	1	1	7
VSA 3: *Banksia sessilis* Shrubland	1.2	*0.4*	5	1	1	7
VSA 4: Dampland Shrubland/Open Woodland	6.7	*2.4*	3	1	1	5
VSA 5: *Banksia telmatiaea* Heathland	182.9	*65.3*	3	1	1	5
VSA 6: Mixed Heathland	4.9	*1.7*	2	0	1	3
VSA 7: Cleared	4.0	*1.4*	0	0	0	0
Total	**279.9**	***100.0***		**Rounded *weighted* overall site foraging score:**		**6** (out of 10)

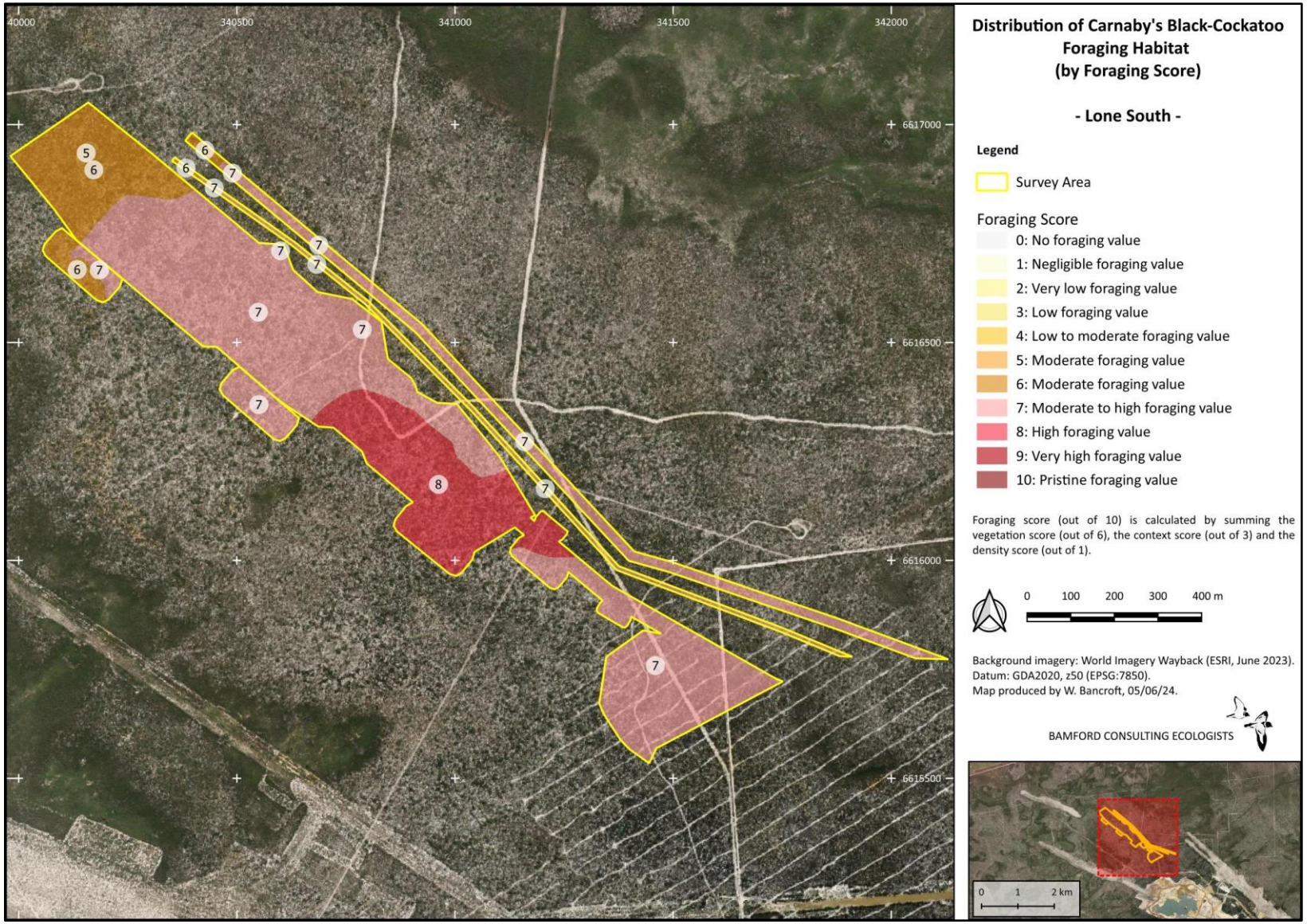

Figure 3-8. Distribution of Carnaby's Black-Cockatoo foraging habitat in the Lone South survey area.

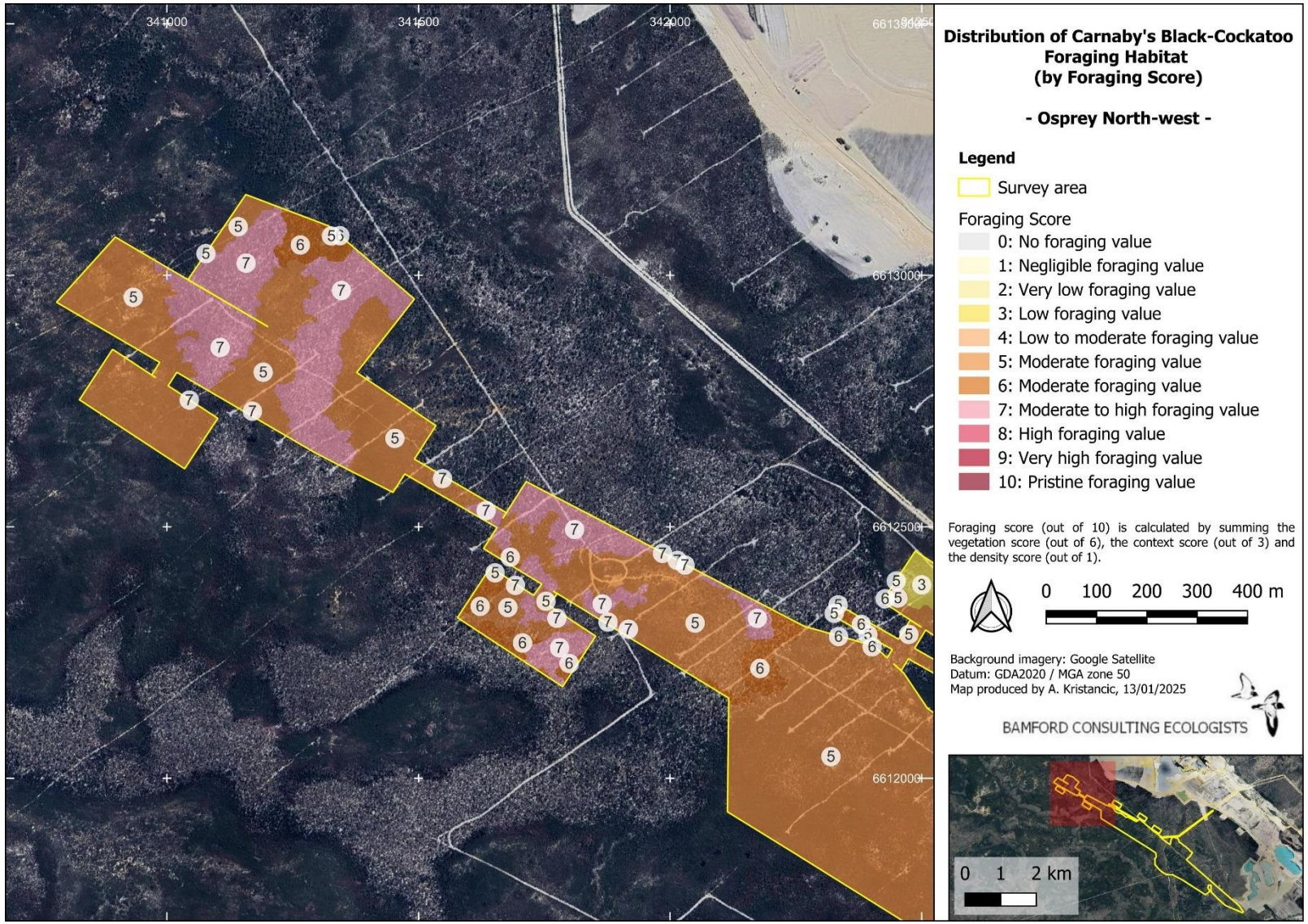

Figure 3-9. Distribution of Carnaby's Black-Cockatoo foraging habitat in the Osprey survey area: north-west map (1 of 4).

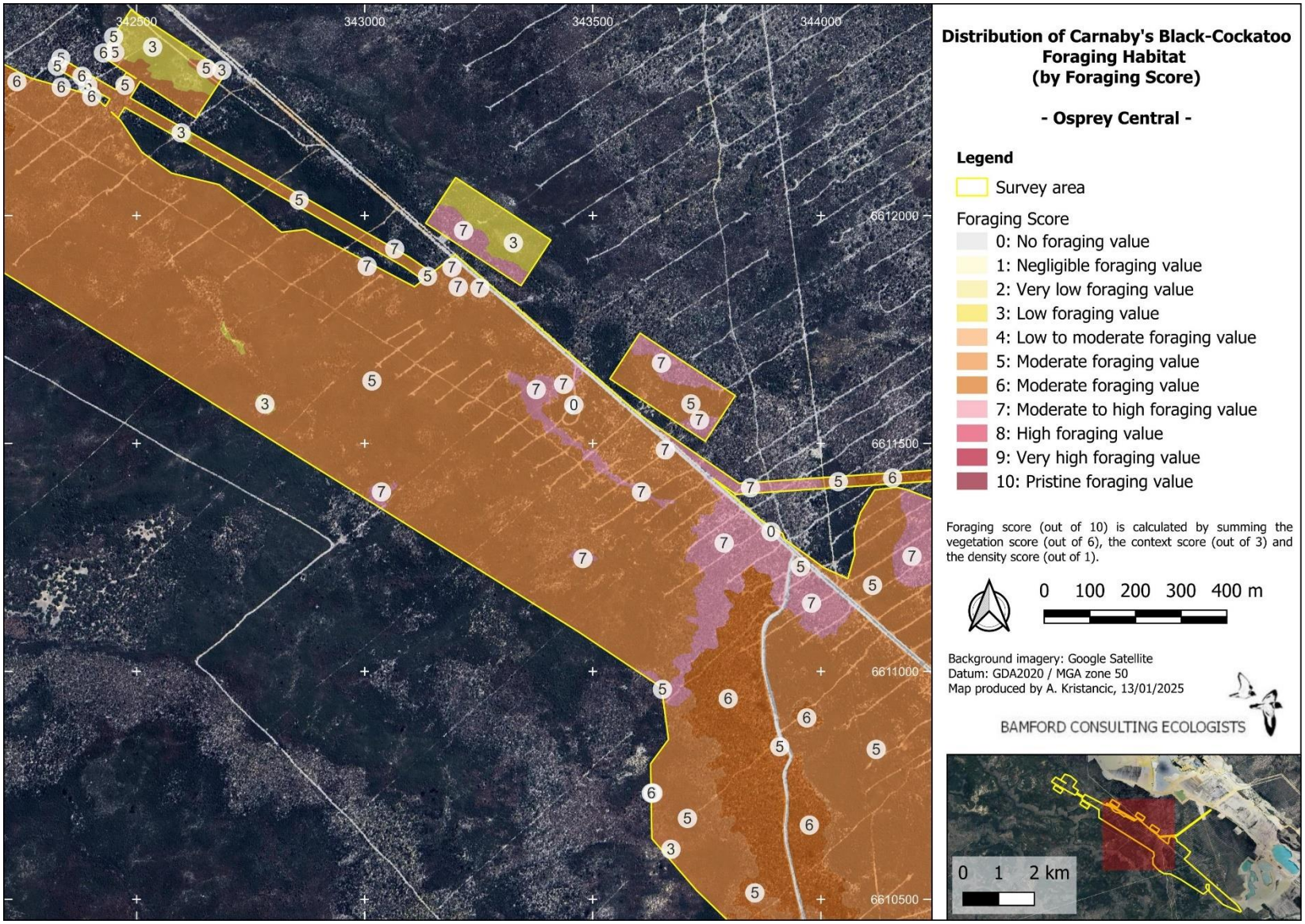

Figure 3-10. Distribution of Carnaby's Black-Cockatoo foraging habitat in the Osprey survey area: central map (2 of 4).

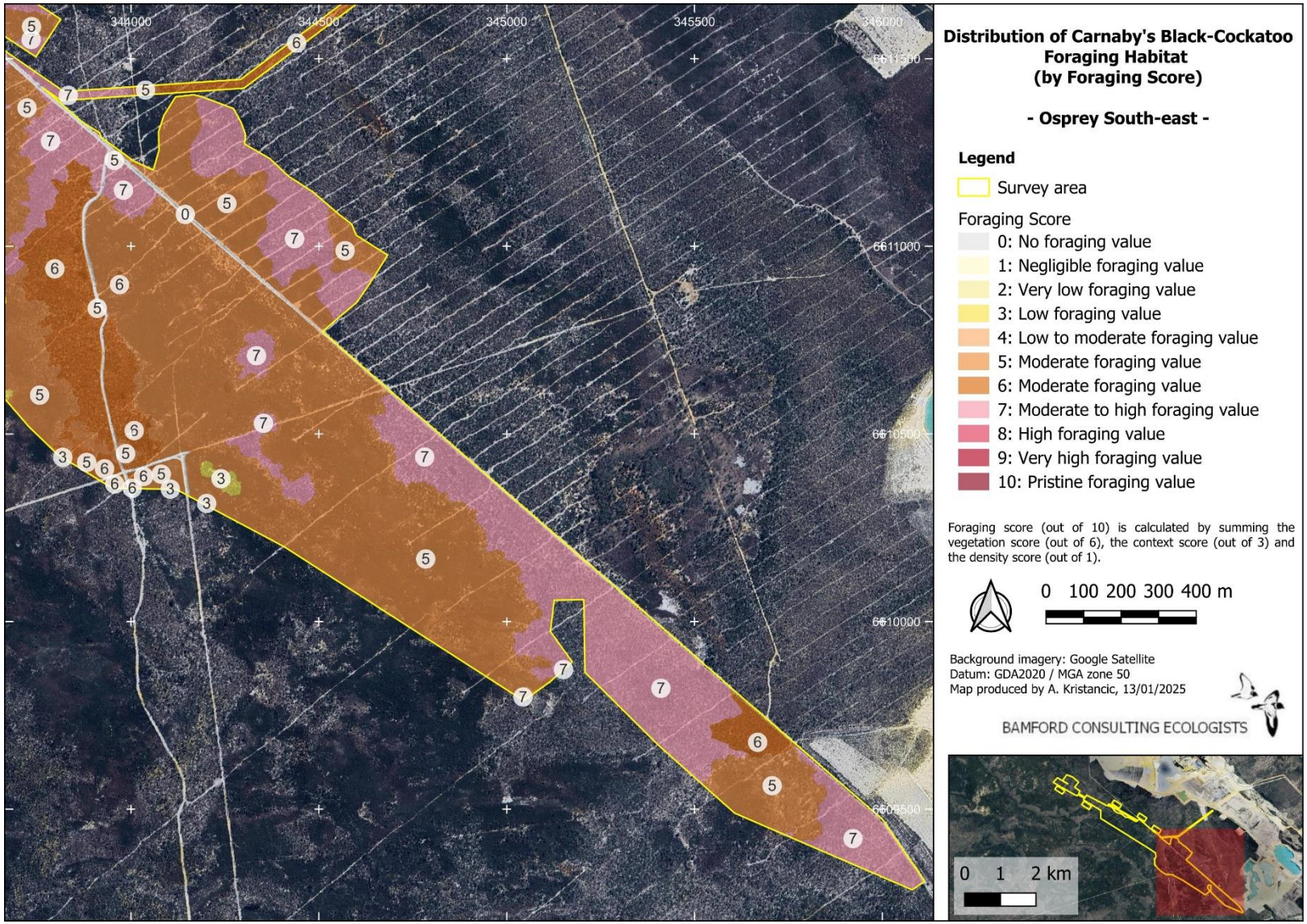

Figure 3-11. Distribution of Carnaby's Black-Cockatoo foraging habitat in the Osprey survey area: south-east map (3 of 4).

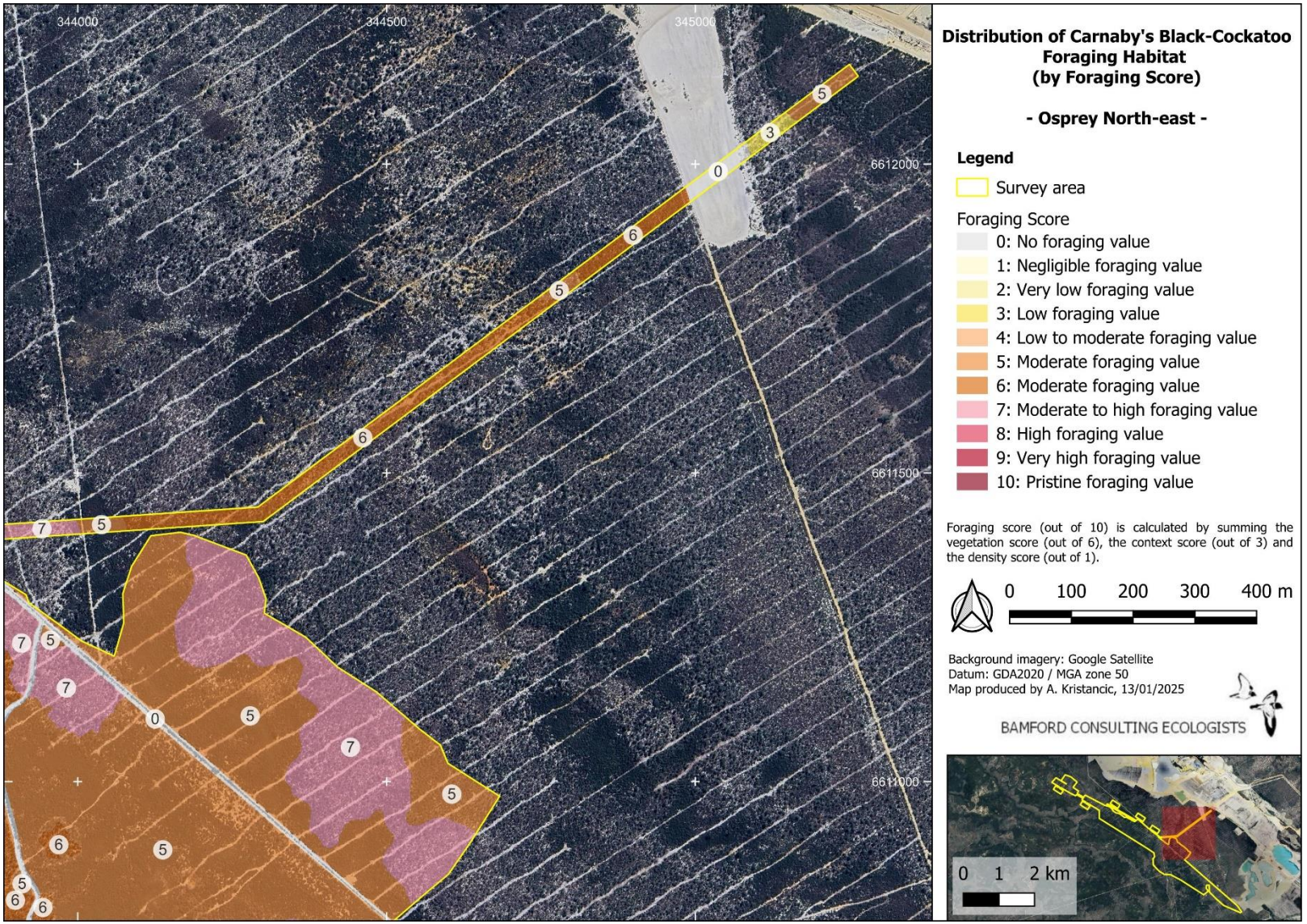

Figure 3-12. Distribution of Carnaby's Black-Cockatoo foraging habitat in the Osprey survey area: north-east map (4 of 4).

3.3.3.2 DCCEEW foraging quality scoring tool

The DCCEEW foraging quality scoring tool (provided by DAWE, 2022) was used to assess each survey area as a whole. The calculations are presented in Table 3-8 and these generated a total score (out of 10). Both the Lone South and Osprey survey areas scored 10 (out of 10) for Carnaby's Black-Cockatoo.

Table 3-8. DCCEEW foraging quality scoring tool calculations for the survey area.

	Carnaby's Black-Cockatoo	
Attribute	**LONE SOUTH**	**OSPREY**
Starting score	10	10
Foraging potential	0 (Foraging debris present.)	0 (Foraging debris present.)
Connectivity	0 (Foraging habitat within 12 km.)	0 (Foraging habitat within 12 km.)
Proximity to breeding	0 (Breeding habitat within 12 km.)	0 (Breeding habitat within 12 km.)
Proximity to roosting	0 (Likely night roosting habitat within 20 km.)	0 (Likely night roosting habitat within 20 km.)
Impact from significant plant disease	0 (*Phytophthora* spp. or Marri canker affects less than 50% of preferred food plants.)	0 (*Phytophthora* spp. or Marri canker affects less than 50% of preferred food plants.)
Total Score	**10**	**10**

3.3.3.3 Draft DCCEEW habitat scoring system

The draft DCCEEW habitat scoring system (DCCEEW pers. comm.) was used to assess each survey area as a whole. The calculations are presented in Table 3-9 and these generated a total score (out of 10). Both the Lone South and Osprey survey areas scored 9 (out of 10) for Carnaby's Black-Cockatoo.

Table 3-9. Draft DCCEEW habitat scoring system calculations for the survey area.

	Carnaby's Black-Cockatoo	
Attribute	**LONE SOUTH**	**OSPREY**
SITE CONDITION: Vegetation condition and structure. (Score out of 7)	6 High projected foliage cover but some tree deaths (c. 5-10%).	6 High projected foliage cover but some tree deaths (c. 5-10%).
SITE CONTEXT: Proximity of the site in relation to other habitat. (Score out of 3)	3 Site is within 12 km of other foraging resources with site condition of at least '3' for all three black-cockatoo species.	3 Site is within 12 km of other foraging resources with site condition of at least '3' for all three black-cockatoo species.
STOCKING RATE: Confirm presence or absence of species.	Present	Present
TOTAL SCORE	**9**	**9**

3.3.4 Black-cockatoo night roosting habitat

The region around the survey areas is known to support black-cockatoo roosting, however there are no known records of roost sites within the Lone South and Osprey survey areas themselves. Known roost locations (from BirdLife Western Australia's Great Cocky Count database and the BCE database) in the region are mapped in Figure 3-13. The nearest of these confirmed roosts is less than 2 km from the Osprey boundary and c. 9 km from the Lone South boundary. There are almost certainly additional (unknown) night-roost sites within the local area.

No signs of night-roosting activity were noted during the field investigations at either of the two survey areas. There did not appear to be any locations within either survey area that appeared suited to black-cockatoo roosting (e.g. taller trees, such as *Eucalyptus* spp., in proximity to water).

Given the lack of suitable night-roost habitat, night-roosting by black-cockatoos is not expected to occur within either the Lone South or Osprey survey areas.

3.3.5 Black-cockatoo watering points

No potential water sources for black-cockatoos were noted within either the Lone South or Osprey survey areas.

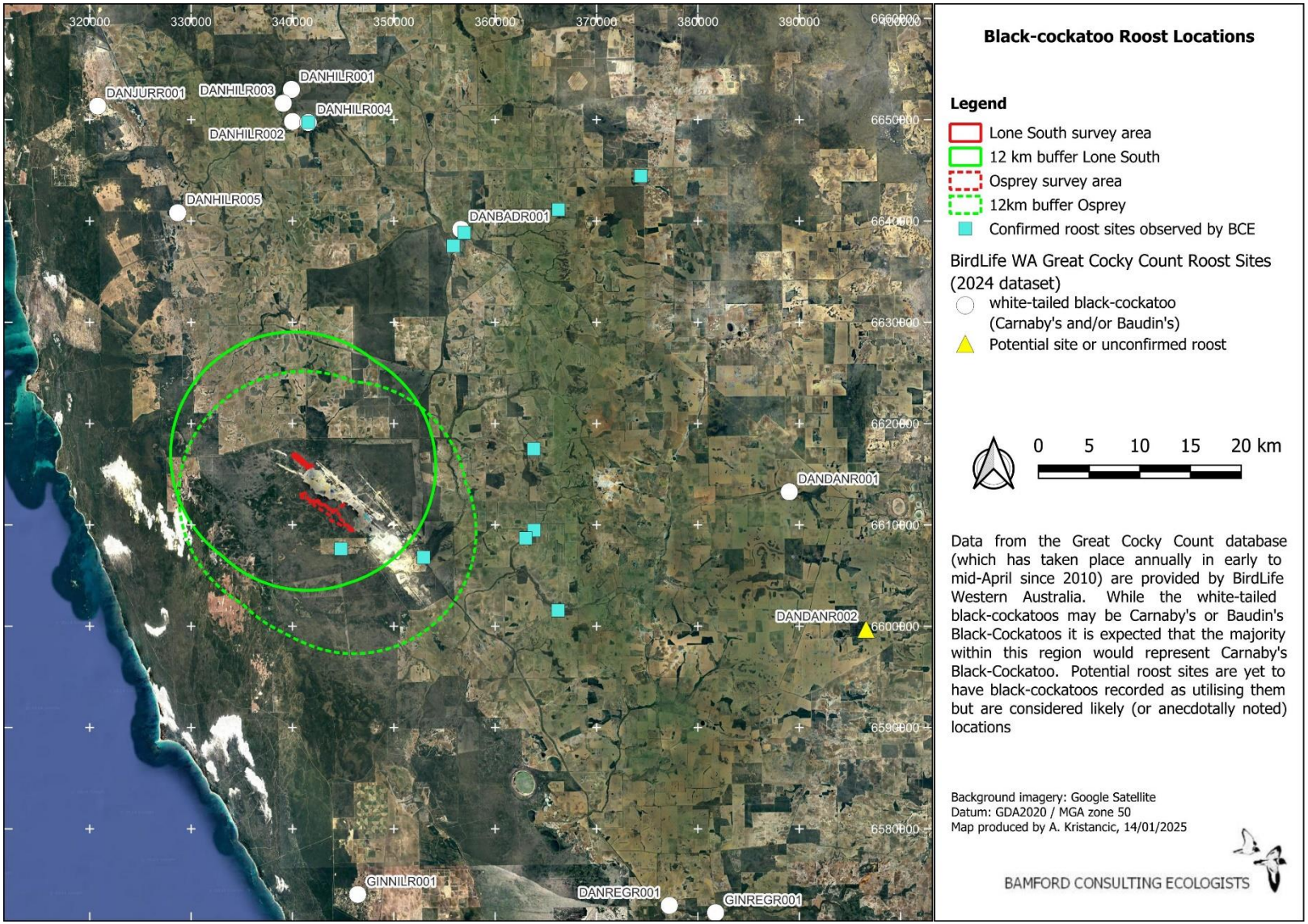

Figure 3-13. Known black-cockatoo roost locations within the region.

3.4 Patterns of biodiversity

Investigating patterns of biodiversity can be complex and are often beyond the scope even of detailed or targeted investigations (see Section 2.1 above), but it is possible to draw some general conclusions based upon the different VSAs in the survey areas.

3.4.1 Lone South

The vegetation within the Lone South survey area is mostly intact and in excellent condition. The area consists primarily of VSA 1 (*Banksia attenuata* and *B. menziesii* Low Woodland), which makes up 94.5% of the survey area, with very small sections of VSA 2 (*Banksia prionotes* Low Woodland, 5% of survey area) and VSA 5 (*Banksia telmatiaea* Heathland, 0.5% of survey area). All VSAs have a complex vegetation structure in the understorey and midstorey, and the area therefore provides an environment that in general is likely to support a large number and high diversity of fauna species. This will include potentially all the conservation significant species. The two Low Woodland VSAs (VSA 1 and VSA 2) provide higher value foraging habitat for Carnaby's Black-Cockatoo compared to the heathland of VSA 5; this is due to the higher density of foraging trees in VSAs 1 and 2. As VSA 1 makes up such a large proportion of the Lone South survey area, the overall foraging quality of this survey area is high for Carnaby's Black-Cockatoos, compared with moderate for the Osprey survey area (described below). No trees in the Lone South area were large enough to be assessed as potential nest trees or suitable night-roosting sites.

Differences in the density of the taller banksia trees across the VSAs will affect the abundance of Carnaby's Black-Cockatoo and of nectar-dependent fauna, while there are likely to be movements of such fauna between VSAs, such as when the *Banksia telmatiaea* of VSA 5 flowers. The sandy substrates of VSA 1 are likely to provide suitable habitat for a variety of fossorial (burrowing) reptiles and frogs, including the conservation significant Black-striped Snake (listed as P3 by DBCA). VSA 5 provides unique habitats, not represented in other VSAs, in the form of seasonally damp low-lying plains, flats, open depressions and swamps. This environment may be seasonally important for some frog species (e.g. during breeding) if flooding occurs.

3.4.2 Osprey

Aside from existing tracks, the vegetation within the Osprey survey area is mostly intact and in excellent condition. The Osprey survey area consists of five VSAs (listed in order of decreasing prevalence): VSA 5 (*Banksia telmatiaea* Heathland, 65% of survey area), VSA 1 (*Banksia attenuata* and *B. menziesii* Low Woodland, 29% of survey area), VSA 4 (Dampland Shrubland/Open Woodland, 2.4% of survey area), VSA 6 (Mixed heathland, 1.7% of survey area), VSA 7 (Cleared, 1.4% of survey area), and VSA 3 (*Banksia sessilis* Shrubland, 0.4% of survey area). The vast majority of the Osprey survey area contains vegetation with a complex, dense understorey; this is likely to support a high abundance and diversity of birds and provide shelter and protection for ground dwelling fauna such as small mammals, reptiles and frogs. As for the Lone South survey area, the entire suite of conservation significant fauna is expected to be present. Foraging habitat for Carnaby's Black-Cockatoo is of lower value than in Lone South but the species will still be present regularly, while the prevalence of VSA 5 and the much smaller area of VSA 1 will affect the abundance of nectar-dependent species. VSA 5 has very dense vegetation and slightly loamy soil, so the reptile assemblage may be slightly smaller in

Osprey compared with Lone South (many reptiles favour sandy soil while very dense vegetation can create too much shade for reptiles to thermoregulate. As noted for Lone South, VSA 5 may occasionally be of value for frog breeding.

The Osprey survey area contains two VSAs that are absent or very limited in the Lone South area, and are generally uncommon across the region: VSA 3 (which has rocky (strictly lateritic capstone) substrates) and VSA 6 (which has areas of occasionally inundated claypan). These unusual environments may support species absent or uncommon elsewhere, which potentially includes SRE invertebrates.

3.5 Ecological processes

The nature of the landscape and the fauna assemblage indicate some of the ecological processes that may be important for ecosystem function (see Appendix 1 for descriptions and other ecological processes). The main ecological processes which have affected and continue to affect the fauna assemblage are likely to be: (i) ongoing habitat loss; (ii) the presence and abundance of feral species, and (iii) landscape connectivity, because of the fragmented nature of vegetation in the area. These and additional ecological processes which are affecting fauna are discussed here:

Ongoing habitat loss

The survey areas are in a region which has experienced and continue to experience land clearing, particularly of banksia woodlands which are rich in fauna. This results in mortality of fauna and the decline of local populations. While clearing for agriculture has largely ceased, there is ongoing clearing (with some restoration) for mining elsewhere in the Tronox leases.

Landscape connectivity

Compared with other regions where land is cleared for agriculture, the landscape connectivity surrounding the survey areas is relatively good (on a local scale). However, more broadly, the native vegetation is highly fragmented by clearing and this will have impacted the persistence of some fauna in the region, and therefore in the survey areas. This is especially relevant to fauna species that require a large home range or to travel large distances during dispersal. In addition, although there are corridors remaining to provide connectivity between vegetation, there are a number of potential issues with relatively narrow corridors (such as increased influence of edge effects), and they do not necessarily allow unimpeded movement for all fauna species. Therefore, the level of fragmentation in the surrounding landscape is still likely to have contributed to the loss and decline of several fauna species.

For other fauna, such as many reptiles which can persist in small remnants (M. J. Bamford & Calver, 2012), the amount of landscape connectivity remaining may be sufficient to have allowed populations to persist.

Feral species and interactions with over-abundant native species

Feral species occur throughout Western Australia and are a considerable component of the expected mammal fauna of the survey area; five of the 17 mammals expected in the survey areas are introduced species. In addition to the introduced mammals, there are also three introduced bird species expected

in the survey areas. Feral species are likely to have contributed to local mammal extinctions in the area and are likely to currently be affecting populations of extant species in the survey area. For example, the locally significant Carpet Python is susceptible to predation by the introduced Red Fox. Grazing and trampling of vegetation by stray domestic livestock such as the feral Goat can have a considerable negative impact on native fauna due to habitat degradation. Most of the introduced mammals are expected as residents, including the Feral Cat, Red Fox and Rabbit which are all likely to be placing considerable pressure on the native fauna in the region - cats and foxes via predation, and rabbits via competition for resources and degradation of vegetation. The three birds are all expected as irregular visitors. The doves have only ever been recorded in small numbers and do not persist (BCE records) so are unlikely to pose any threat to native wildlife. The Laughing Kookaburra has also only been recorded infrequently but if it becomes established it may affect native birds via predation on smaller birds and competition with other predatory birds.

Local hydrology

The surveys areas are generally of low relief, consisting primarily of dunes or low sandy rises and poorly drained depressions and swamps. Seasonal inundation of these depressions and swamp areas may be important for some fauna species and will influence the flora and vegetation which in turn supports the fauna assemblage. Surface water in the area includes two significant streams – Mullering Brook c. 1.5 km south of the Osprey survey area and Mount Jetty Creek c. 500 m north of the Lone South survey area – and the Wongonderrah Swamp c. 1.5 km north-east of the Lone South survey area.

Fire

Native vegetation in the survey areas is subject to fire and while appropriate fire regimes can benefit biodiversity, inappropriate regimes can lead to a loss of biodiversity. The two survey areas were long unburnt at the time of the sit inspections, but were burnt in November 2024. Many species will be affected by this sequence of fires. For example, the Noodji (Ashy-grey Mouse) may have been virtually absent prior to the fire, but is a species that responds positively to fire elsewhere in the Cooljarloo region (BCE records). Therefore, it my now increase in abundance dramatically over the next three to five years. In contrast, the flowering of banksia increases with time after fire, with the result that nectar-dependent species may be very scarce for several years. A single, broad-scale fire such as occurred in November 2024 poses a risk to the fauna because it sets the entire to one post-fire stage, whereas a mosaic of fire ages will support more species.

3.6 Summary of fauna values

Vegetation and Substrate Associations (VSAs).

Overall, the survey areas support seven VSAs. The vast majority (94.5%) of the Lone South survey area is composed of VSA 1 (*Banksia attenuata* and *B. menziesii* Low Woodland), with small areas of VSA 2 (*Banksia prionotes* Low Woodland) and VSA 5 (*Banksia telmatiaea* Heathland), all of which provide complex vegetation structure in the midstorey and understorey which is likely to support a high abundance and diversity of fauna. The high density of Banksia trees in VSA 1, combined with the very high coverage of this VSA, means the Lone South survey area is generally of high value for foraging for Carnaby's Black-Cockatoo. The majority of the Osprey survey area consists of VSA 5 (*Banksia telmatiaea* Heathland, 65% of survey area) and VSA 1 (*Banksia attenuata* and *B. menziesii* Low

Woodland, 29% of survey area) resulting in an area that is generally of moderate foraging value for Carnaby's Black-Cockatoo, due to the relatively lower density of foraging species in VSA 5. Remaining VSAs in the Osprey survey area include VSA 3 (*Banksia sessilis* Shrubland), VSA 4 (Dampland Shrubland/Open Woodland), VSA 6 (Mixed Heathland) and VSA 7 (Cleared areas). As for Lone South, the majority of the Osprey survey area contains vegetation with a complex structure, likely to support a high abundance and diversity of fauna species.

Fauna assemblage. The desktop assessment identified 198 vertebrate fauna species as potentially occurring in the survey areas: ten frogs, 46 reptiles, 120 birds, 17 native mammals and five introduced mammals. Fourteen vertebrate species that would historically have been present in the survey area have been omitted from the expected species list because they are extinct (one mammal) or considered locally extinct (one reptile, two birds and 11 mammals). Overall, the assemblage of vertebrate fauna expected in the survey area is typical of intact remnant vegetation in this region and is likely to be represented elsewhere in the region. It is rich in reptiles, nectar-dependent species and while the mammal fauna has lost several species, the suite of small mammals is unusually complete for the South-West region.

Species of conservation significance. Nine vertebrate species that are of conservation significance are expected to occur in the survey area; four CS1, three CS2 and two CS3 species. The CS1 species are all birds and none is expected as a resident; Carnaby's Black-Cockatoo is expected as a regular visitor, the Fork-tailed Swift and Peregrine Falcon as irregular visitors, and the Malleefowl as a vagrant. The CS2 species are all expected as residents and include the Jewelled Southwest Ctenotus (Swan Coastal Plain subpopulation), Black-striped Snake and Brush Wallaby. The CS3 species consist of one bird (Australian Bustard, irregular visitor) and one reptile (Carpet Python, resident).

It is expected that two invertebrate species of listed conservation significance will be resident in the survey areas, the Moore River Land Snail (*Bothriembryon perobesus*) and the Spiny Katydid (Swan Coastal Plain) (*Austrosaga spinifer*). The Graceful Sun Moth *(Synemon gratiosa*) is expected only as an irregular visitor, due to the low density of its host plant (*Lomandra* spp.) in the survey areas. A relatively large number and variety of potential SRE species have been collected in Cooljarloo, and it is likely that several of these species will be present in the Lone South and Osprey survey areas. Many of these have been collected by BCE in ongoing studies and have been found to be more or less widespread across a variety of VSAs.

Black-cockatoo Assessment. The survey area is out of range for the Forest Red-tailed and Baudin's Black-Cockatoos. Carnaby's Black-Cockatoo is expected as a regular visitor. Carnaby's Black-Cockatoo was not recorded during the site inspection, but there was evidence of foraging by this species throughout both sites. Both survey areas contain significant amounts of suitable foraging habitat, with the Lone South survey area containing a higher density of suitable plants, and therefore representing higher value foraging habitat compared with the moderate value habitat present in the Osprey survey area. No suitable nesting hollows were observed during the site inspection; the vegetation consists primarily of Banksia woodland containing tree species that do not readily provide breeding sites for black-cockatoos. There are 73 known Carnaby's Black-Cockatoo breeding sites within 25 km of the survey areas, including a large cluster in the Cataby Important Bird Area. There did not appear to be any suitable roost-site locations within either survey area; night-roosting is not

expected to occur in either area. The area in general is known to support black-cockatoo roosting, with the closest known and confirmed roosting site less than 2 km from the closest boundary (Osprey).

Summary of black-cockatoo assessment

- Foraging value – overall the Lone South survey area is of high foraging value and the Osprey survey area is of moderate foraging value for Carnaby's Black-Cockatoo. Throughout the sites, foraging scores ranged from 9/10 for areas with high *Banksia* spp. tree density (especially in VSA 1), to 4/10 for areas with lower density of these trees (such as VSA 5).
- Breeding value – no trees were large enough to be assessed as potential nesting trees. The closest known and confirmed breeding sites are c. 15 km from the Osprey survey area and c. 21 km from the Lone South survey area.
- Roosting value – No suitable areas for roosting sites were apparent within either survey area. The closest known and confirmed roost is less than 2 km from the Osprey boundary and c. 9 km from the Lone South boundary.

Patterns of biodiversity. The majority of each survey area contains vegetation with a complex structure in the understorey and/or midstorey, and these areas are therefore expected to support a high abundance and diversity of fauna across all taxa, including the suite of conservation significant species. Sandy substrates, particularly in VSA 1 which is extensive in the Lone South survey area, may be rich in a variety of fossorial reptiles and frogs, including the conservation significant Black-striped Snake. VSA 1 is also important for Carnaby's Black-Cockatoo and is most extensive in Lone South. VSA 5, which is extensive in the Osprey survey area, may be slightly lower in reptile species than elsewhere and may be only seasonally important for nectarivores. VSAs 3 and 6 are uncommon and unusual across the region may support some different fauna, notably SRE invertebrates.

Key ecological processes. The ecological processes that are expected to influence the fauna assemblage include existing habitat loss, landscape connectivity, and the presence of feral species. Local hydrology may impact fauna as there are extensive areas of seasonally inundated damplands/swamps which may support certain fauna species. It is not expected that fire is currently having a significant impact on the fauna assemblage, but changes to natural fire regimes have the potential to negatively affect the fauna assemblage.

4 Impact assessment

Threatening processes have to be considered in the context of fauna values and the nature of the proposed action, and are examined below. Impact categories are defined in Table 2-7. The threatening processes are derived from the literature and guidance and are described in Appendix 3. The notes below include some recommendations.

Habitat loss leading to population decline. *Minor*

If the entire survey areas are cleared, the proposed actions will result in a moderate loss of native vegetation; an area of up to 52 ha for Lone South and 267 ha for Osprey. This represents 0.1 % (Lone South) and 0.4 % (Osprey) of the remaining native vegetation within a 15 km buffer (see Section 1.2.6). The proposed Lone South development occurs within the Bassendean 2 soil subsystem and the proposed Osprey development occurs within the Bassendean 5 and Bassendean 3 soil subsystems;

none of these subsystems is highly restricted in the broader region. The impact on significant species is expected to be minor, given that the proposed developments are not extensive and do not impact particularly sensitive or restricted environments.

Habitat loss leading to population fragmentation. *Negligible*

The proposed development still facilitates connectivity across the area so is considered unlikely to lead to population fragmentation.

Degradation of habitat due to weed invasion. *Minor*

There is potential for development to increase the spread of weeds but standard hygiene measures are likely to be in place to reduce this risk. Current levels of weed invasion re very low.

Mortality during construction *Minor*

This is a concern mostly on animal welfare grounds as the proportional impact on local populations will be small. Translocation of fauna from the impact area would reduce the risk of individual mortality. There are also standard practices for reducing fauna mortality during development, such as managing trenches (if applicable). Increased traffic during construction also poses an increased risk to fauna, and signage and education as part of inductions can reduce this risk.

Ongoing mortality. *Minor*

This results mainly from roadkill, fauna striking infrastructure and effects of lighting. The Carpet Python (CS3) and Brush Wallaby (CS2) are susceptible to vehicle strike, as is Carnaby's Black-Cockatoo (CS1) if there are any resources to bring this species to the ground (such as spilled food or pooling water). Roadkill can be reduced through education and signage. It is unlikely that any significant species will be impacted via striking infrastructure. Impacts of additional lighting upon invertebrates is largely unknown but Read *et al.* (2015) found a change in bird assemblages around remote mine sites that they considered to be linked to an increase in food supply (dead insects around lights) for predatory species.

Species interactions. *Minor*

Some of the fauna is sensitive to feral species such as cats and foxes. They are present already, but during construction in particular, feral species may be attracted to work-sites and may gain improved access into native vegetation via tracks and roads. Impacts can be kept to Minor through standard practices such as not feeding wildlife, managing waste and implementing feral species control.

Hydrological change. *Negligible*

There is a swamp in Wongonderrah National Park close to Lone South and much of both areas is low-lying so vegetation may be groundwater dependent at least to some extent. The impact to hydrology from the project is uncertain but should be monitored.

Altered fire regimes. *Negligible*

The vegetation of the survey area is generally fire-dependent and probably already subject to occasional fires. Th recent fire will have reduced the abundance of many fauna species, and while some may respond by increasing rapidly to levels higher than seen pre-fire, other species will take

several decades to return to pre-fire levels. The project may lead to an increase in fire frequency, but could also lead to improved fire management such as a reduction in the area of each fire.

Disturbance (dust, noise, light). *Negligible*

The level of dust, noise and light during construction and operation has the potential to result in some impacts, but there are standard management procedures to minimise these. As noted above, impacts of additional lighting upon invertebrates is largely unknown. Education of personnel as part of inductions can be an effective way of ensuring staff are familiar with the fauna of the area and how to avoid negative impacts.

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6 Appendices

Appendix 1. Explanation of fauna values.

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

Assemblage characteristics

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

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

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

Vegetation and substrate associations (VSAs)

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

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

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 Appendix 2.

<u>Conservation Significance (CS) 1: Species listed under State or Commonwealth Acts</u>.

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

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

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

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

This level of significance has no legislative or published recognition and is based on interpretation of distribution information, but is used here as it may have links to preserving biodiversity at the genetic level (EPA, 2002). If a population is isolated but a subset of a widespread (common) species, then it may not be recognised as threatened, but may have unique genetic characteristics. Conservation significance is applied to allow for the preservation of genetic richness at a population level, and not just at a species level. Species on the edge of their range, or that are sensitive to impacts such as habitat fragmentation, may also be classed as CS3, as may colonies of waterbirds. The Western Australian Department of Environmental Protection, now DBCA, used this sort of interpretation to identify significant bird species in the Perth metropolitan area as part of the Perth Bushplan (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)" (DEH, 2000). The EEZ extends to 200 nautical miles (approximately 350 kilometres) from the coast (DEH, 2006). 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 DEH, 2000) 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. Categories used in the assessment of conservation status.

IUCN (International Union for the Conservation of Nature) categories, as outlined by IUCN (2012), and as used for the *Environment Protection and Biodiversity Conservation Act 1999* and the Western Australian *Biodiversity Conservation Act 2016*.

Extinct	Taxa not definitely located in the wild during the past 50 years.
Extinct in the Wild (Ex)	Taxa known to survive only in captivity.
Critically Endangered (CR)	Taxa facing an extremely high risk of extinction in the wild in the immediate future.
Endangered (E)	Taxa facing a very high risk of extinction in the wild in the near future.
Vulnerable (V)	Taxa facing a high risk of extinction in the wild in the medium-term future.
Near Threatened	Taxa that risk becoming Vulnerable in the wild.
Conservation Dependent	Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened.
Data Deficient (Insufficiently Known)	Taxa suspected of being Rare, Vulnerable or Endangered, but whose true status cannot be determined without more information.
Least Concern.	Taxa that are not Threatened.

Schedules used in the WA *Biodiversity Conservation Act 2016, updated 2023*

Schedule 1	Specially protected fauna Division 1 – Species of special conservation interest (S1D1) Division 2 – Migratory species (S1D2) Division 3 – Species otherwise in need of special protection (S1D3)
Schedule 2	Threatened species Division 1 – Critically endangered species (S2D1) Division 2 – Endangered species (S2D2) Division 3 – Vulnerable species (S2D3)
Schedule 3	Extinct species (S3)

WA DBCA Priority species (species not listed under the *WA Biodiversity Conservation Act 2016*, but for which there is some concern).

Priority 1 (P1)	Taxa with few, poorly known populations on threatened lands.
Priority 2 (P2)	Taxa with few, poorly known populations on conservation lands; or taxa with several, poorly known populations not on conservation lands.
Priority 3 (P3)	Taxa with several, poorly known populations, some on conservation lands.
Priority 4. (P4)	Taxa in need of monitoring. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change.
Priority 5 (P5)	Taxa in need of monitoring. Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years (IUCN Conservation Dependent).

Appendix 3. Explanation of threatening processes.

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

Note that the terms direct and indirect impacts are used by the DotE (2013), DSEWPaC (2013) and EPA (2016a), but there is some inconsistency in how these are defined. The federal guidance does not define direct impact but has a very broad definition of indirect, and makes the statement (DotE, 2013) '*Consideration should be given to all adverse impacts that could reasonably be predicted to follow from the action, whether these impacts are within the control of the person proposing to take the action or not. Indirect impacts will be relevant where they are sufficiently close to the proposed action to be said to be a consequence of the action, and they can reasonably be imputed to be within the contemplation of the person proposing to take the action*.' Indirect impacts therefore can even include what the DotE (2013) calls facilitated impacts, which are the result of third party actions triggered by the primary action. In contrast, the EPA (2016a) defines direct impacts to '*include the removal, fragmentation or modification of habitat, and mortality or displacement of individuals or populations.*' This document then lists as indirect impacts what in many cases are the consequences of the removal, fragmentation or modification of habitat. For example, '*disruption of the dispersal of individuals required to colonise new areas inhibiting maintenance of genetic diversity between populations'* is a consequence of habitat fragmentation. Impacts of light, noise and even roadkill are defined as indirect but they are clearly the result of the action and in control of the person taking the action. Roadkill is as direct a form of mortality as can be observed, but it is considered as an indirect impact in the context of a development presumably because it is not directly linked to land clearing. The EPA (2016a) makes a strong distinction between removal of vegetation (direct impact) and the consequences of such clearing and other aspects of a development (indirect impacts). It is not obvious how this distinction between direct and indirect impacts is helpful in the EIA process, as the key aim is to ensure that all impacts that result from a project are addressed in this assessment process. Interestingly, Gleeson and Gleeson (2012), in a major review of impacts of development on wildlife, do not use the terms direct or indirect. In the following outlines of threatening processes that can cause impacts, the emphasis is upon interpreting how a threatening process will cause an impact. For example, loss of habitat (threatening process) can lead to population decline and to population fragmentation, which are two distinct impacts, with population decline considered a direct impact and fragmentation an indirect impact by the EPA (2016a).

Loss of habitat affecting population survival

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

Loss of habitat leading to population fragmentation

Loss of habitat can affect population movements by limiting movement of individuals throughout the landscape as a result of fragmentation (Gleeson & Gleeson, 2012; Soule et al., 2004). Obstructions associated with the development, such as roads, pipes and drainage channels, may also affect movement of small, terrestrial species. Fragmented populations may not be sustainable and may be sensitive to effects such as reduced gene flow.

Degradation of habitat due to weed invasion leading to population decline

Weed invasion, such as through introduction by human boots or vehicle tyres, can occur as a result of development and if this alters habitat quality, can lead to effects similar to habitat loss.

Increased mortality

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

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

Species interactions, including predation and competition

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

Changes in the abundance of some native species at the expense of others, due to the provision of fresh watering points, can also be a concern. Harrington (2002) found the presence of artificial fresh waterpoints in the semi-arid mallee rangelands to influence the abundance and distribution of certain bird species. Common, water-dependent birds were found to out-compete some less common, water-independent species. Similarly, Read *et al.* (2015) found a decline in some bird species but an increase in others in the vicinity of active mines and concluded this was due to the mine attracting large and aggressive species that displaced other species. Over-abundant native herbivores, such as kangaroos, can also adversely affect less abundant native species through competition and displacement.

Hydroecology

Interruptions of hydroecological processes can have major effects because they underpin primary production in ecosystems and there are specific, generally rare habitats that are hydrology-dependent. Fauna may be impacted by potential changes to groundwater level and chemistry and

altered flow regime. These changes may alter vegetation across large areas and may lead to habitat degradation or loss. Impacts upon fauna can be widespread and major.

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

Fire

The role of fire in the Australian environment and its importance to vertebrate fauna has been widely acknowledged (Fox, 1982; A. M. Gill et al., 1981; Letnic et al., 2004). It is also one of the factors that has contributed to the decline and local extinction of some mammal and bird species (Burbidge & McKenzie, 1989). Fire is a natural feature of the environment but frequent, extensive fires may adversely impact some fauna, particularly mammals and short-range endemic species. Changes in fire regime, whether to more frequent or less frequent fires, may be significant to some fauna. Impacts of severe fire may be devastating to species already occurring at low densities or to species requiring long unburnt habitats to survive. In terms of conservation management, it is not fire *per se* but the fire regime that is important, with evidence that infrequent, extensive and intense fires adversely affect biodiversity, whereas frequent fires that cover small areas and are variable in both season and intensity can enhance biodiversity. Fire management may be considered the responsibility of managers of large tracts of land, including managers of mining tenements.

Dust, light, noise and vibration

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

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

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

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

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

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

Threatening processes (EPBC Act)

Under the EPBC Act, a key threatening process is an ecological interaction that threatens or may threaten the survival, abundance or evolutionary development of a threatened species or ecological community. There are currently 22 key threatening processes listed by the federal Department of Climate Change, Energy, the Environment, and Water (DCCEEW, 2023d) :

- Aggressive exclusion of birds from potential woodland and forest habitat by over-abundant noisy miners (*Manorina melanocephala*).
- Competition and land degradation by rabbits.
- Competition and land degradation by unmanaged goats.
- Dieback caused by the root-rot fungus (*Phytophthora cinnamomi*).
- Fire regimes that cause declines in biodiversity.
- Incidental catch (bycatch) of Sea Turtle during coastal otter-trawling operations within Australian waters north of 28 degrees South.
- Incidental catch (or bycatch) of seabirds during oceanic longline fishing operations.
- Infection of amphibians with chytrid fungus resulting in chytridiomycosis.
- Injury and fatality to vertebrate marine life caused by ingestion of, or entanglement in, harmful marine debris.
- Invasion of northern Australia by Gamba Grass and other introduced grasses.
- Land clearance.
- Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants.
- Loss of biodiversity and ecosystem integrity following invasion by the Yellow Crazy Ant (*Anoplolepis gracilipes*) on Christmas Island, Indian Ocean.
- Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases.
- Novel biota and their impact on biodiversity.
- Predation by European red fox.
- Predation by exotic rats on Australian offshore islands of less than 1000 km^2 (100,000 ha).
- Predation by feral cats.
- Predation, Habitat Degradation, Competition and Disease Transmission by Feral Pigs.

- Psittacine Circoviral (beak and feather) Disease affecting endangered psittacine species.
- The biological effects, including lethal toxic ingestion, caused by Cane Toads (*Bufo marinus*).
- The reduction in the biodiversity of Australian native fauna and flora due to the red imported fire ant, *Solenopsis invicta* (fire ant).

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

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

In addition to the above processes, the federal Department of Agriculture, Water and the Environment (DAWE) produced Significant Impact Guidelines that provide criteria for the assessment of the significance of impacts. These criteria provide a framework for the assessment of significant impacts. The criteria are listed below.

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

Appendix 5. Scoring system for black-cockatoo foraging value.

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

Revised 6th February 2023

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 DCCEEW (formerly 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[2] 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

[2] https://www.agriculture.gov.au/sites/default/files/documents/offsets-how-use.pdf

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	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; • 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; • Urban areas with scattered foraging trees. • Paddocks with *Erodium* spp. and other weeds.	Low foraging value. Examples: • 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, *Eucalyptus caesia* and *E. erythrocorys*. • Paddocks with *Erodium* spp. and other weeds.
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; • Eucalypt Woodland with Marri 5- 10% projected foliage cover. • Eucalypt Woodland/Forest with known food plants such as Marri 10-40% projected foliage cover but badly degraded understorey (poor long-term viability without management);	Low to Moderate foraging value. Examples: • Eucalypt Woodland with known food plants (especially Marri) 5-10% projected foliage cover; • Eucalypt Woodland/Forest with known food plants such as Marri 10-40% projected foliage cover but badly degraded understorey (poor long-term viability without management); • 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; • Parkland-cleared Eucalypt Woodland/Forest with known food plants such as Marri 10-40% projected foliage cover but badly-degraded understorey (poor long-term viability without management); • 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; • Kwongan/ Shrubland in which species of foraging value, such as shrubby banksias, have 20-40% projected foliage cover; • Eucalypt Woodland/Forest with Marri 20-60% projected foliage cover. Depending on understorey condition (and thus long-term viability) and Marri density, may downgrade to 3 or upgrade to 5.	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. • 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).	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.
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; • 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.	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.

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).	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 DEE, provides a *guide* to the assignation of site context scores. Note that 'local area' is defined as within a 15 km radius of the centre point of the study site. 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. Adjustments to context score are further discussed below (moderation of scores).

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 (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 and birds are present, and also if it is immediately alongside at least moderately good foraging habitat, on the basis that birds are more likely to utilise it if they are nearby. Species density score might also be raised if there is a high likelihood of the birds actually being present. Context score can also be used to give a fine adjustment to the total score, such as if there are two vegetation types with the same vegetation composition score, but one may be slightly better foraging habitat and covers a larger area. Moderation is a means by which fairly subtle differences in overarching foraging value can be recognised.

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 & 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 6. The foraging quality scoring tool template from DAWE (2022).

Table A1 Foraging quality scoring tool template

Starting score		Baudin's Cockatoo	Carnaby's Cockatoo	Forest Red-tailed Black-Cockatoo
10		**Start at a score of 10** if your site is native eucalypt woodlands and forest, and proteaceous woodland and heath, particularly Marri, within the range of the species, including along roadsides and parkland cleared areas. Can include planted vegetation. **This tool only applies to sites equal to or larger than 1 hectare in size.**	**Start at a score of 10** if your site is native shrubland, kwongan heathland or woodland, dominated by proteaceous plant species such as *Banksia* spp. (including *Dryandra* spp.), *Hakea* spp. and *Grevillea* spp., as well as native eucalypt woodland and forest that contains foraging species, within the range of the species, including along roadsides and parkland cleared areas. Also includes planted native vegetation. **This tool only applies to sites equal to or larger than 1 hectare in size.**	**Start at a score of 10** if your site is Jarrah or Marri woodland and/or forest, or if it is on the edge of Karri forest, or if Wandoo and Blackbutt occur on the site, within the range of the subspecies, including along roadsides and parkland cleared areas. **This tool only applies to sites equal to or larger than 1 hectare in size.**
Attribute	Sub-tractions	Context adjustor (attributes reducing functionality of foraging habitat)		
Foraging potential	-2	**Subtract 2** from your score if there is no evidence of feeding debris on your site.	**Subtract 2** from your score if there is no evidence of feeding debris on your site.	**Subtract 2** from your score if there is no evidence of feeding debris on your site.
Connectivity	-2	**Subtract 2** from your score if you have evidence to conclude that there is no other foraging habitat within 12 km of your site.	**Subtract 2** from your score if you have evidence to conclude that there is no other foraging habitat within 12 km of your site.	**Subtract 2** from your score if you have evidence to conclude that there is no other foraging habitat within 12 km of your site.
Proximity to breeding	-2	**Subtract 2** if you have evidence to conclude that your site is more than 12 km from breeding habitat	**Subtract 2** if you have evidence to conclude that your site is more than 12 km from breeding habitat.	**Subtract 2** if you have evidence to conclude that your site is more than 12 km from breeding habitat.
Proximity to roosting	-1	**Subtract 1** if you have evidence to conclude that your site is more than 20 km from a known night roosting habitat.	**Subtract 1** if you have evidence to conclude that your site is more than 20 km from a known night roosting habitat.	**Subtract 1** if you have evidence to conclude that your site is more than 20 km from a known night roosting habitat.
Impact from significant plant disease	-1	**Subtract 1** if your site has disease present (e.g. *Phytophthora* spp. or Marri canker) and the disease is affecting more than 50% of the preferred food plants present.	**Subtract 1** if your site has disease present (e.g. *Phytophthora* spp. or Marri canker) and the disease is affecting more than 50% of the preferred food plants present.	**Subtract 1** if your site has disease present (e.g. *Phytophthora* spp. or Marri canker) and the disease is affecting more than 50% of the preferred food plants present.
Total score		*Enter score*	*Enter score*	*Enter score*
Appraisal		To support your habitat score, you should provide an overall appraisal of the habitat on the impact site and within 20km of the impact area to clearly explain and justify the score. It should include discussion on the foraging habitat's proximity to other resources (e.g. exact distance to proximate resources), frequency of use of proximate sites, the degree of evidence and description of vegetation type and condition.		

Appendix 7. Draft DCCEEW Habitat Scoring System.

Habitat Scoring System for WA black cockatoo foraging habitat

This habitat scoring system describes elements indicative of suitable foraging habitat[1] for the three WA black cockatoo species (Carnaby's Black Cockatoo, Baudin's Black Cockatoo and the Forest Red-tailed Black Cockatoo) in WA. Its use must be supported by survey information and reporting, undertaken by suitably qualified and experienced ecologists.

Appropriate scores will best fit a description. Where all components of the 'detail' column description are not met, this must be specified, and justification provided for that score to be accepted by the Department.

For an offset site to be considered by the Department, the offset site must have a start score of 1 for each indicator (e.g., there must be a species stocking rate score of at least 1).

Indicator	Score	Detail		Impact site	Offset start quality	Without offset	With offset
Site Condition							
		Foraging value	Details				
Vegetation condition and structure. Habitat features	7	Very High	Carnaby's Black Cockatoo				
			Native kwongan heath and shrubland (>30% projected foliage cover), banksia and eucalypt woodlands with >50% projected foliage cover. Low percentage (< 5%) of tree deaths[2].				
			Baudin's Black Cockatoo				
			Marri-Jarrah Forest and woodlands with >50% projected foliage cover. Low percentage (< 5%) of tree deaths.				
			Forest Red-tailed Black Cockatoo				
			Marri-Jarrah-Karri Forest, other eucalypt woodlands, or allocasuarina woodlands, with >50% projected foliage cover. Low percentage (< 5%) of tree deaths.				
	6	High	Carnaby's Black Cockatoo				
			Native kwongan heath and shrubland (>25% projected foliage cover), banksia and eucalypt woodlands with >40% projected foliage cover. Low percentage (< 10%) of tree deaths.				
			Baudin's Black Cockatoo				
			Marri-Jarrah Forest and woodlands with >40% projected foliage cover. Low percentage (< 10%) of tree deaths.				
			Forest Red-tailed Black Cockatoo				
			Marri-Jarrah-Karri Forest, other eucalypt woodlands, or allocasuarina woodlands, with >40% projected foliage cover. Low percentage (< 10%) of tree deaths.				

[1] In some cases, an impact or offset site may contain or require both foraging and breeding habitat for one or more black cockatoos. Breeding habitat is species of trees known to support breeding within the range of the species which either have a suitable nest hollow or are of a suitable diameter at breast height (DBH) to develop a nest hollow. For most species of trees, suitable DBH is 500 mm. For salmon gum and wandoo, suitable DBH is 300 mm.

[2] No tree deaths indicate robustness of habitat, unlikely for the habitat to decline in the medium-term. Tree deaths may be owing to disease, water stress, fire, etc.

1

Vegetation condition and structure. Habitat features	5	Moderate to high	Carnaby's Black Cockatoo				
			Native kwongan heath and shrubland (>20% projected foliage cover), banksia and eucalypt woodlands with 30-40% projected foliage cover; OR > 60% projected foliage cover but veg. condition reduced due to tree deaths (up to 20%).				
			Baudin's Black Cockatoo				
			Marri-Jarrah Forest or woodlands with 30-40% projected foliage cover; OR > 60% projected foliage cover but veg. condition reduced due to tree deaths (up to 20%).				
			Forest Red-tailed Black Cockatoo				
			Marri-Jarrah-Karri Forest, other eucalypt woodlands, or allocasuarina woodlands, with 30-40% projected foliage cover; OR > 60% projected foliage cover but veg. condition reduced due to tree deaths (up to 20%).				
	4	Moderate	Carnaby's Black Cockatoo				
			Native kwongan heath and shrubland, banksia or eucalypt woodlands with 20-30% projected foliage cover. Moderate percentage of tree deaths (30-40%).				
			Baudin's Black Cockatoo				
			Marri-Jarrah Forest or woodlands with 20-30% projected foliage cover; OR Marri-Jarrah Forest with 40-60% projected foliage cover but vegetation condition reduced due to tree deaths (up to 30-40%).				
			Forest Red-tailed Black Cockatoo				
			Marri-Jarrah-Karri Forest, other eucalypt woodlands, or allocasuarina woodlands with: 20-30% projected foliage cover; OR 40-60% projected foliage cover but veg. condition reduced due to tree deaths (up to 30-40%).				
	3	Low to moderate	Carnaby's Black Cockatoo				
			Native kwongan heath and shrubland, banksia or eucalypt woodlands with 10-20% projected foliage cover.				
			Baudin's Black Cockatoo				
			Marri-Jarrah Forest or woodlands with 5-20% projected foliage cover.				
			Forest Red-tailed Black Cockatoo				
			Marri-Jarrah-Karri Forest, other eucalypt woodlands, or allocasuarina woodlands with 5-20% projected foliage cover.				
	2	Low	Carnaby's Black Cockatoo				
			Native kwongan heath and shrubland, banksia and eucalypt woodlands with <10% projected foliage cover; OR Paddocks and/or urban areas with scattered foraging trees such as banksias, marri.				
			Baudin's Black Cockatoo				
			Marri-Jarrah Forest or woodlands with 1-5% projected foliage cover; OR Paddocks and/or urban areas with scattered foraging trees such as banksia, hakea, dryandra.				

2

Vegetation condition and structure. Habitat features			Forest Red-tailed Black Cockatoo				
			Marri-Jarrah-Karri Forest, other eucalypt woodlands, or allocasuarina woodlands with 1-5% projected foliage cover; OR Paddocks and/or urban areas with scattered food plants such as Cape Lilac, *Eucalyptus caesia* and *E. erythrocorys*.				
	1	Negligible to low	All species				
			Scattered specimens of known food plants but projected foliage cover of these is <2%. May include: paddocks or urban areas with scattered foraging trees.				
	0	None	All species				
			No Proteaceae, eucalypts or other potential sources of food. May include bare ground or developed sites devoid of vegetation (e.g. infrastructure, roads, gravel pits).				
			Totals				

Site Context								
Proximity of the site in relation to other habitat.	**3**	Site is within 6km of known breeding site.	or	Site is within 12km of other foraging resources with site condition of at least 3.				
	2	Site is within 12km of known breeding site.	or	Site is within 15km of other foraging resources with site condition of at least 4.				
	1	Site is within 15km of known breeding site.	or	Site is between 15km and 20km of other foraging resources with site condition of at least 5.				
	0	Site is further than 15km from known breeding site.	or	Site is further than 20km from other foraging resources.				
				Totals				

Final Totals				

Indicator		**Species Stocking Rate**[3]	**Impact Site**			**Offset Site**		
			CBC	**BBC**	**FRT**	**CBC**	**BBC**	**FRT**
Confirm presence/ absence of species.	**Yes**	Species is seen or reported regularly and/or there is abundant foraging evidence, e.g. chewed nuts can be identified as this species. Regularly is when the species is seen at intervals of every few days or weeks for at least several months of the year.						
	No	Species is recorded or reported very infrequently and there is little or no foraging evidence.						

[3] Species stocking rate is indicated by yes or no to confirm if any of the species is frequently present or not. If yes, the presence must be for the species being impacted by the proposal, not for a species that will not be impacted.

3

Legend	
	If the site scores between 0-2 (low to no value) for site condition, 0 for the site context score, or is **No** for species stocking rate, it is extremely unlikely to be considered as suitable habitat. This would not be appropriate to use as an offset site.

The metrics used to determine Site Condition, Site Context, and Species Stocking Rate were developed by the Department of Climate Change, Energy, the Environment, and Water in consultation with species experts in WA.

A standard habitat quality scoring system for a species allocates scores out of 3 for both site condition and site context, and out of 4 for species stocking rate. However, as black cockatoos are very mobile, this HQS uses a score out of 7 for site condition and a score out of 3 for site context. Site condition is considered the key factor in determining the quality of habitat for these black cockatoo species. Species stocking rate is considered only in terms of presence or absence of the species and does not add to the total score. Note that the species, or strong indicators of the species, must be present, consistent with the presence/usage description above, for an offset to be considered suitable.

4

Appendix 8. Expected fauna assemblage of the Lone South and Osprey survey areas.

Status codes:

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

EPBC Act listings: CR = Critically Endangered, EN = Endangered, VU = Vulnerable, MI = Migratory (see Appendix 2).

Biodiversity Conservation Act 2016 listings: S1 to S3 = Schedules 1 to 3, D1 to D3 = Divisions 1 to 3 (see Appendix 2).

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

CS3 = considered to be of local significance by Bamford Consulting Ecologists (see Appendix 1).

Int = introduced species.

See Section 2.3.4 for explanation of expected occurrence categories.

Species with expected occurrence in **bold** were observed during field investigations.

Source: 1 = BCE database, 2 = Birdata, 3 = Atlas of Living Australia, 4 = DBCA threatened and priority fauna search, 5 = previous reports (IBSA) , 6 = Naturemap, 7 = Protected Matters Search Tool, 8 = general literature

Latin Name	Common Name	Status	Expected Occurrence	Source
Pelodryadidae (Tree frogs)				
Litoria adelaidensis	Slender Tree Frog		Regular visitor	1 3
Litoria moorei	Motorbike Frog		Regular visitor	1 3 6
Limnodynastidae (Burrowing frogs)				
Heleioporus albopunctatus	Western Spotted Frog		Regular visitor	1 3 6
Heleioporus eyrei	Moaning Frog		Resident	1 3 6
Heleioporus psammophilus	Sand Frog		Resident	1 3 6
Limnodynastes dorsalis	Western Banjo Frog		Resident	1 3 6
Neobatrachus pelobatoides	Humming Frog		Resident	1 3 6
Myobatrachidae (Ground frogs)				
Crinia insignifera	Squelching Froglet		Regular visitor	1 3 6
Myobatrachus gouldii	Turtle Frog		Resident	1 3 6
Pseudophryne guentheri	Crawling Toadlet		Resident	1 3 6
Chelidae (Long-necked turtles)				
Chelodina oblonga	South-West long-necked Tortoise		Vagrant	1
Diplodactylidae (Diplodactylid geckoes)				
Crenadactylus ocellatus	South-western Clawless Gecko		Resident	1 6
Diplodactylus polyophthalmus	Spotted Sandplain Gecko		Resident	1 3 6

Latin Name	Common Name	Status	Expected Occurrence	Source
Lucasium alboguttatum	White-spotted Ground Gecko		Resident	1 3 6
Strophurus spinigerus	Soft Spiny-tailed Gecko		Resident	1 3 6
Gekkonidae (Gekkonid geckos)				
Christinus marmoratus	Marbled Gecko		Resident	1 3 6
Pygopodidae (Legless lizards)				
Aprasia repens	Sand-plain Worm-lizard		Resident	1 3 6
Delma concinna	Javelin Legless Lizard		Resident	1 3 6
Delma fraseri	Fraser's Legless Lizard		Resident	1 3 6
Delma grayii	Gray's Legless Lizard		Resident	1 3 6
Lialis burtonis	Burton's Legless Lizard		Resident	1 3 6
Pletholax gracilis	Keeled Legless Lizard		Resident	1 3 6
Pygopus lepidopodus	Common Scaly Foot		Resident	1 3 6
Agamidae (Dragons)				
Ctenophorus adelaidensis	Western Heath Dragon		Resident	1 3 6
Pogona minor	Western Bearded Dragon		Resident	1 3 6
Scincidae (Skinks)				
Cryptoblepharus buchananii	Buchanan's Snake-eyed Skink		Resident	1 6
Ctenotus australis	Western Limestone Ctenotus		Resident	1 3 6
Ctenotus catenifer	Chain-striped South-west Ctenotus		Resident	3 6
Ctenotus fallens	West Coast Ctenotus		Resident	1 6
Ctenotus gemmula (Swan Coastal Plain subpopulation)	Jewelled Southwest Ctenotus (Swan Coastal Plain subpopulation)	CS2 (P3)	Resident	1 3 4 6
Ctenotus impar	South-western Odd-striped Ctenotus		Resident	1 3 6
Ctenotus pantherinus	Leopard Ctenotus		Irregular visitor	1 3 6
Cyclodomorphus celatus	Western Slender Blue-tongue		Resident	1 3 6
Egernia napoleonis	Salmon-bellied Skink		Resident	1 3 6
Lerista christinae	Bold-striped Four-toed Lerista		Resident	1 3 6
Lerista elegans	West Coast Four-toed Lerista		Resident	1 3 6
Lerista praepedita	Western Worm Lerista		Resident	1 3 6
Liopholis multiscutata	Bull Skink		Resident	1 3 6

Latin Name	Common Name	Status	Expected Occurrence	Source
Menetia greyii	Common Dwarf Skink		Resident	1 3 6
Morethia lineoocellata	Western Pale-flecked Morethia		Resident	1 3 6
Morethia obscura	Dusky Morethia		Resident	1 3 6
Tiliqua occipitalis	Western Bluetongue		Resident	1 3 6
Tiliqua rugosa	Bobtail		Resident	1 3 6
Varanidae (Monitors and goannas)				
Varanus gouldii	Sand Goanna		Resident	1 3 6
Typhlopidae (Blind snakes)				
Anilios australis	Southern Blind Snake		Resident	1 3 6
Pythonidae (Pythons)				
Morelia spilota imbricata	Carpet Python	CS3	Resident	1 3 6
Elapidae (Venomous land snakes)				
Brachyurophis fasciolatus	Narrow-banded Shovel-nosed Snake		Resident	1 3
Brachyurophis semifasciatus	Southern Shovel-nosed Snake		Resident	1 6
Demansia psammophis	Yellow-faced Whipsnake		Resident	1 3 6
Echiopsis curta	Bardick		Resident	1 3 6
Neelaps bimaculatus	Black-naped Snake		Resident	1 3 6
Neelaps calonotos	Black-striped Snake	CS2 (P3)	Resident	1 3 4 6
Pseudechis australis	Mulga Snake		Resident	1 3 6
Pseudonaja mengdeni	Western Brown Snake		Resident	1 3 6
Simoselaps bertholdi	Jan's Banded Snake		Resident	1
Suta gouldii	Gould's Snake		Resident	1 3 6
Casuariidae (Emus and Cassowaries)				
Dromaius novaehollandiae	Emu		Resident	1 2 3 6
Megapodiidae (Mallefowl)				
Leipoa ocellata	Malleefowl	CS1 (VU, S2D3)	Vagrant	4 6 7
Phasianidae (Pheasants and Quail)				
Coturnix pectoralis	Stubble Quail		Regular visitor	1 3
Coturnix ypsilophora	Brown Quail		Irregular visitor	1 6
Columbidae (Pigeons and Doves)				

Latin Name	Common Name	Status	Expected Occurrence	Source
Columba livia	Rock Dove	Int	Irregular visitor	12 3
Ocyphaps lophotes	Crested Pigeon		Resident	1 2 3 6
Phaps chalcoptera	Common Bronzewing		Resident	1 2 3 6
Phaps elegans	Brush Bronzewing		Resident	1 2 3 6
Spilopelia senegalensis	Laughing Dove	Int	Irregular visitor	2 3 6
Podargidae (Frogmouths)				
Podargus strigoides	Tawny Frogmouth		Resident	1 2 3 6
Eurostopodidae (Eared Nightjars)				
Eurostopodus argus	Spotted Nightjar		Regular visitor	1 3
Aegothelidae (Owlet-nightjars)				
Aegotheles cristatus	Australian Owlet-nightjar		Vagrant	2 3 6
Apodidae (Swifts and Swiftlets)				
Apus pacificus	Fork-tailed Swift	CS1 (MI, S1D2)	Irregular visitor	2 3 4 6
Cuculidae (Cuckoos)				
Cacomantis flabelliformis	Fan-tailed Cuckoo		Regular visitor	1 2 3 6
Chalcites basalis	Horsfield's Bronze-Cuckoo		Regular visitor	1 2 3 6
Chalcites lucidus	Shining Bronze-Cuckoo		Regular visitor	1 2 3
Chalcites osculans	Black-eared Cuckoo		Vagrant	2 3
Heteroscenes pallidus	Pallid Cuckoo		Regular visitor	1 2 3 6
Otididae (Bustards)				
Ardeotis australis	Australian Bustard	CS3	Irregular visitor	12 3 6
Charadriidae (Plovers, Dotterel and Lapwings)				
Vanellus tricolor	Banded Lapwing		Irregular visitor	1 2 3 6
Turnicidae (Button-quail)				
Turnix varius	Painted Button-quail		Resident	1 2 3 6
Turnix velox	Little Button-quail		Regular visitor	16
Tytonidae (Masked Owls)				
Tyto alba (delicatula)	Barn Owl		Irregular visitor	12 3 6
Strigidae (Hawk-Owls)				
Ninox boobook	Southern Boobook		Regular visitor	1 2 3 6

Latin Name	Common Name	Status	Expected Occurrence	Source
Pandionidae (Osprey)				
Pandion haliaetus	Osprey		Vagrant	2
Accipitridae (Eagles, Kites, Goshawks)				
Accipiter cirrocephalus	Collared Sparrowhawk		Regular visitor	12 3 6
Accipiter fasciatus	Brown Goshawk		Regular visitor	1 2 3 6
Aquila audax	Wedge-tailed Eagle		Regular visitor	1 2 3 6
Circus approximans	Swamp Harrier		Irregular visitor	1 2 3 6
Circus assimilis	Spotted Harrier		Irregular visitor	1 2 3 6
Elanus axillaris	Black-shouldered Kite		Irregular visitor	1 2 3 6
Haliaeetus leucogaster	White-bellied Sea-Eagle		Vagrant	1 2 3 6
Haliastur sphenurus	Whistling Kite		Regular visitor	1 2 3 6
Hieraaetus morphnoides	Little Eagle		Irregular visitor	1 2 3 6
Lophoictinia isura	Square-tailed Kite		Irregular visitor	1 2 3 6
Milvus migrans	Black Kite		Vagrant	3
Meropidae (Bee-eaters)				
Merops ornatus	Rainbow Bee-eater		**Regular visitor**	1 2 3 6
Alcedinidae (Kingfishers)				
Dacelo novaeguineae	Laughing Kookaburra	Int	Irregular visitor	1 2 3 6
Todiramphus pyrrhopygius	Red-backed Kingfisher		Irregular visitor	1
Todiramphus sanctus	Sacred Kingfisher		Regular visitor	12 3 6
Falconidae (Falcons)				
Falco berigora	Brown Falcon		**Resident**	1 2 3 6
Falco cenchroides	Nankeen Kestrel		Regular visitor	1 2 3 6
Falco longipennis	Australian Hobby		Regular visitor	1 2 3 6
Falco peregrinus	Peregrine Falcon	CS1 (S1D3)	Irregular visitor	2 3 4 6
Cacatuidae (Cockatoos and Corellas)				
Cacatua pastinator	Western Corella		Regular visitor	1 2 3 6
Cacatua sanguinea	Little Corella		Vagrant	2 3 6
Calyptorhynchus banksii escondidus	Inland Red-tailed Black-Cockatoo		Vagrant	2
Eolophus roseicapilla	Galah		Regular visitor	1 2 3 6

Latin Name	Common Name	Status	Expected Occurrence	Source
Zanda latirostris	Carnaby's Black-Cockatoo	CS1 (EN, S2D2)	Regular visitor	1 2 3 4 5 6 7
Psittaculidae (Parrots, Lorikeets and Rosellas)				
Barnardius zonarius	Australian Ringneck		Regular visitor	1 2 3 6
Glossopsitta porphyrocephala	Purple-crowned Lorikeet		Irregular visitor	12 3 6
Melopsittacus undulatus	Budgerigar		Vagrant	1
Neophema elegans	Elegant Parrot		Irregular visitor	1 3
Polytelis anthopeplus	Regent Parrot		Irregular visitor	1 2 3 6
Purpureicephalus spurius	Red-capped Parrot		Vagrant	1
Maluridae (Fairy-wrens, Emu-wrens and Grasswrens)				
Malurus assimilis	Purple-backed Fairy-wren		**Resident**	1 2 3 6
Malurus leucopterus	White-winged Fairy-wren		Resident	1 2 3 6
Malurus pulcherrimus	Blue-breasted Fairy-wren		Resident	1 2 3 6
Malurus splendens	Splendid Fairy-wren		Resident	1 2 3 6
Stipiturus malachurus	Southern Emu-wren		Resident	1 2 3 6
Meliphagidae (Honeyeaters and Chats)				
Acanthorhynchus superciliosus	Western Spinebill		Resident	1 2 3 6
Anthochaera carunculata	Red Wattlebird		Regular visitor	1 2 3 6
Anthochaera lunulata	Western Wattlebird		Regular visitor	1 2 3 6
Certhionyx variegatus	Pied Honeyeater		Vagrant	1
Epthianura albifrons	White-fronted Chat		Irregular visitor	1 2 3 6
Epthianura tricolor	Crimson Chat		Vagrant	13 6
Gavicalis virescens	Singing Honeyeater		**Resident**	1 2 3 6
Gliciphila melanops	Tawny-crowned Honeyeater		Resident	1 2 3 6
Lichmera indistincta	Brown Honeyeater		**Resident**	1 2 3 6
Manorina flavigula	Yellow-throated Miner		Regular visitor	1 2 3 6
Melithreptus brevirostris	Brown-headed Honeyeater		Regular visitor	1 2 3 6
Phylidonyris niger	White-cheeked Honeyeater		**Resident**	1 2 3 6
Phylidonyris novaehollandiae	New Holland Honeyeater		Vagrant	1 2 3 6
Purnella albifrons	White-fronted Honeyeater		Vagrant	1 3

Latin Name	Common Name	Status	Expected Occurrence	Source
Sugomel niger	Black Honeyeater		Irregular visitor	1
Pardalotidae (Pardalotes)				
Pardalotus punctatus	Spotted Pardalote		Vagrant	2
Pardalotus striatus	Striated Pardalote		Irregular visitor	1 2 3 6
Acanthizidae (Thornbills and Gerygones)				
Acanthiza apicalis	Inland Thornbill		Resident	1 2 3 6
Acanthiza chrysorrhoa	Yellow-rumped Thornbill		**Resident**	1 2 3 6
Acanthiza inornata	Western Thornbill		**Resident**	1 2 3 6
Calamanthus montanellus	Western Fieldwren		Resident	1 2 3 6
Gerygone fusca	Western Gerygone		Regular visitor	1 2 3 6
Sericornis frontalis	White-browed Scrubwren		Resident	1 2 3 6
Smicrornis brevirostris	Weebill		Regular visitor	1 2 3 6
Neosittidae (Sittellas)				
Daphoenositta chrysoptera	Varied Sittella		Regular visitor	1 2 3 6
Oreoicidae (Australo-Papuan Bellbirds)				
Oreoica gutturalis	Crested Bellbird		Resident	1 2 3 6
Pachycephalidae (Whistlers, Shrike-thrushes and allies)				
Colluricincla harmonica	Grey Shrike-thrush		**Resident**	1 2 3 6
Pachycephala occidentalis	Western Whistler		Vagrant	12 3
Pachycephala rufiventris	Rufous Whistler		**Resident**	1 2 3 6
Campephagidae (Cuckoo-shrikes and Trillers)				
Coracina maxima	Ground Cuckoo-shrike		Vagrant	1
Coracina novaehollandiae	Black-faced Cuckoo-shrike		Regular visitor	1 2 3 6
Lalage tricolor	White-winged Triller		Regular visitor	1 2 3 6
Artamidae (Woodswallows, Currawongs, Butcherbirds and Magpie)				
Artamus cinereus	Black-faced Woodswallow		Regular visitor	1 2 3 6
Artamus cyanopterus	Dusky Woodswallow		Irregular visitor	1 2 3 6
Artamus personatus	Masked Woodswallow		Vagrant	1 3
Cracticus nigrogularis	Pied Butcherbird		Irregular visitor	1 2 3 6

Latin Name	Common Name	Status	Expected Occurrence	Source
Cracticus torquatus	Grey Butcherbird		Regular visitor	1 2 3 6
Gymnorhina tibicen	Australian Magpie		Regular visitor	1 2 3 6
Strepera versicolor	Grey Currawong		Vagrant	2 3 6
Rhipiduridae (Fantails)				
Rhipidura albiscapa	Grey Fantail		Regular visitor	1 2 3 6
Rhipidura leucophrys	Willie Wagtail		Regular visitor	1 2 3 6
Monarchidae (Monarch and Flycatchers)				
Grallina cyanoleuca	Magpie-lark		Regular visitor	1 2 3 6
Myiagra inquieta	Restless Flycatcher		Vagrant	3
Corvidae (Crows and Ravens)				
Corvus bennetti	Little Crow		Vagrant	1 2 3 6
Corvus coronoides	Australian Raven		Regular visitor	1 2 3 6
Corvus orru	Torresian Crow		Vagrant	3
Petroicidae (Australian Robins)				
Melanodryas cucullata	Hooded Robin		Regular visitor	1 2 3 6
Petroica boodang	Scarlet Robin		Vagrant	1 2 3 6
Petroica goodenovii	Red-capped Robin		Regular visitor	1 2 3 6
Quoyornis georgianus	White-breasted Robin		**Resident**	1 2 3 6
Locustellidae (Grassbirds)				
Cincloramphus cruralis	Brown Songlark		Vagrant	1 2 3 6
Cincloramphus mathewsi	Rufous Songlark		Irregular visitor	1 2 3 6
Hirundinidae (Swallows and Martins)				
Cheramoeca leucosterna	White-backed Swallow		Regular visitor	1 2 3 6
Hirundo neoxena	Welcome Swallow		Regular visitor	1 2 3 6
Petrochelidon ariel	Fairy Martin		Irregular visitor	1 3
Petrochelidon nigricans	Tree Martin		**Regular visitor**	1 2 3 6
Zosteropidae (White-eyes)				
Zosterops lateralis	Silvereye		**Regular visitor**	1 2 3 6
Dicaeidae (Flowerpeckers)				
Dicaeum hirundinaceum	Mistletoebird		Regular visitor	1 2 3 6

Latin Name	Common Name	Status	Expected Occurrence	Source	
Estrildidae (Munias)					
Taeniopygia guttata	Zebra Finch		Vagrant	1	
Motacillidae (Pipits and Wagtails)					
Anthus novaeseelandiae	Australasian Pipit		Regular visitor	1 2 3 6	
Tachyglossidae (Echidnas)					
Tachyglossus aculeatus	Short-beaked Echidna		Resident	1 3 6	
Dasyuridae (Dasyurids)					
Sminthopsis crassicaudata	Fat-tailed Dunnart		Resident	1 3 6	
Sminthopsis dolichura	Little Long-tailed Dunnart		Resident	1 3 6	
Sminthopsis fuliginosus	Grey-bellied Dunnart		Resident	1 3 6	
Sminthopsis granulipes	White-tailed Dunnart		Resident	1 3 6	
Tarsipedidae (Honey possum)					
Tarsipes rostratus	Honey Possum		Resident	1 3 6	
Macropodidae (Kangaroos)					
Macropus fuliginosus	Western Grey Kangaroo		**Resident**	1 3 6	
Notamacropus irma	Brush Wallaby	CS2 (P4)	Resident	1 3 4 6	
Muridae (Rats and mice)					
Mus musculus	House Mouse	Int	Resident	1 3 6	
Pseudomys albocinereus	Noodji/Ash-grey Mouse		Resident	1 3 6	
Rattus fuscipes	Moodit/Western Bush Rat		Resident	1 3 6	
Leporidae (Rabbits and hares)					
Oryctolagus cuniculus	Rabbit	Int	Resident	13 6	
Molossidae (Freetail bats)					
Austronomus australis	White-striped Free-tailed Bat		Regular visitor	1 6	
Ozimops kitcheneri	Western Free-tailed Bat		Irregular visitor		8
Vespertilionidae (Vespertillionid bats)					
Chalinolobus gouldii	Gould's Wattled Bat		Resident	1	
Chalinolobus morio	Chocolate Wattled Bat		Regular visitor		8
Nyctophilus geoffroyi	Lesser Long-eared Bat		Resident	1 3 6	
Scotorepens balstoni	Inland Broad-nosed Bat		Irregular visitor		8

Latin Name	Common Name	Status	Expected Occurrence	Source
Vespadelus regulus	Southern Forest Bat		Regular visitor	3 6
Canidae (Dogs)				
Vulpes vulpes	Fox	Int	Resident	1 3 6
Felidae (Cats)				
Felis catus	Cat	Int	Resident	1 3 6
Bovidae (Hooved ruminants)				
Capra hircus	Feral Goat	Int	Regular visitor	1

Appendix 9. Vertebrate species returned from the literature review and database search that have been omitted from the expected species list because they are extinct or considered locally extinct.

Status codes: CS1, CS2, CS3 = (summary) levels of conservation significance. See Appendix 1 for full explanation.
EPBC Act listings: CR = Critically Endangered, EN = Endangered, VU = Vulnerable, MI = Migratory, Ex = Extinct (see Appendix 2).
Biodiversity Conservation Act 2016 listings: S1 to S3 = Schedules 1 to 3, D1 to D3 = Divisions 1 to 3 (see Appendix 2).
DBCA Priority species: P1 to P4 = Priority 1 to 4 (see Appendix 2).
See Section 2.3.4 for explanation of expected occurrence categories.
Source: 1 = BCE database, 2 = Birdata, 3 = Atlas of Living Australia, 4 = DBCA threatened and priority fauna search, 5 = previous reports (IBSA) , 6 = Naturemap, 7 = Protected Matters Search Tool, 8 = general literature

Latin Name	Common Name	Status	Expected Occurrence	Source
Pythonidae				
Aspidites ramsayi	Woma	CS2 (P1)	Locally extinct	Maryan (2002)
Strigidae				
Ninox connivens	Barking Owl		Locally extinct	3
Psittaculidae				
Pezoporus wallicus flaviventris	Western Ground Parrot	CS1 (CR, S2D1)	Locally extinct	8
Dasyuridae				
Dasyurus geoffroii	Chuditch	CS1 (VU, S2D3)	Locally extinct	7
Parantechinus apicalis	Dibbler	CS1 (EN, S2D2)	Locally extinct	7
Peramelidae				
Isoodon fusciventer	Quenda	CS2 (P4)	Locally extinct	4 6
Perameles myosurus	Western Barred Bandicoot		Extinct	8
Thylacomyidae				
Macrotis lagotis	Greater Bilby	CS1 (VU, S2D3)	Locally extinct	8
Potoroidae				
Bettongia penicillata ogilbyi	Woylie	CS1 (EN, S2D1)	Locally extinct	4 6 7
Macropodidae				
Lagostrophus fasciatus	Banded Hare-Wallaby	CS1 (VU, S2D3)	Locally extinct	8
Notamacropus eugenii derbianus	Tammar Wallaby	CS2 (P4)	Locally extinct	4 6

Latin Name	Common Name	Status	Expected Occurrence	Source
Muridae				
Pseudomys fieldi	Djoongari/Shark Bay Mouse	CS1 (VU, S2D3)	Locally extinct	8
Megadermatidae				
Macroderma gigas	Ghost Bat	CS1 (VU, S2D3)	Locally extinct	7
Canidae				
Canis lupus dingo	Dingo		Locally extinct	8

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

Note that some birds could still occur as extremely rare vagrants, especially waterbirds known from the region and recorded during BCE surveys in other parts of Cooljarloo (Source 1 in following table). Source: 1 = BCE database, 2 = Birdata, 3 = Atlas of Living Australia, 4 = DBCA threatened and priority fauna search, 5 = previous reports (IBSA) , 6 = Naturemap, 7 = Protected Matters Search Tool, 8 = general literature

Family	Latin Name	Common Name	Expected Occurrence	Source
Freshwater fishes				
	Carassius auratus	Goldfish	No habitat	1
	Gambusia affinis	Mosquitofish	No habitat	1
	Nannoperca vittata	Western Pygmy-perch	No habitat	1
	Galaxias occidentalis	Western Minnow	No habitat	1
	Pseudogobius olorum	Swan River Goby	No habitat	1
Myobatrachidae				
	Crinia glauerti	Clicking Frog	Out of range	6
	Crinia pseudinsignifera	Bleating Froglet	Out of range	3 6
Cheloniidae				
	Caretta caretta	Loggerhead Turtle	No habitat - marine	7
	Chelonia mydas	Green Turtle	No habitat - marine	7
	Natator depressus	Flatback Turtle	No habitat - marine	7
Dermochelyidae				
	Dermochelys coriacea	Leatherback Turtle	No habitat - marine	3 7
Diplodactylidae				
	Diplodactylus granariensis		Out of range	6
Gekkonidae				
	Gehyra variegata	Tree Dtella	Out of range	3
Pygopodidae				
	Delma australis	Marble-faced Delma	Out of range	3 6
Agamidae				
	Ctenophorus maculatus	Spotted Military Dragon	Out of range	3
Scincidae				

Family	Latin Name	Common Name	Expected Occurrence	Source
	Cryptoblepharus plagiocephalus		Out of range	6
	Ctenotus inornatus	Bar-shouldered Ctenotus	Out of range	3
	Egernia kingii	King's Skink	Out of range	3 6
	Egernia stokesii badia	Western Spiny-tailed Skink, Baudin Island Spiny-tailed Skink	Out of range	7
	Lerista lineopunctulata	Dotted-line Robust Slider	Out of range	3 6
Typhlopidae				
	Anilios pinguis		Out of range	6
Elapidae				
	Pseudonaja affinis	Dugite	Out of range	3 6
Anatidae				
	Anas gracilis	Grey Teal	No habitat	12 3 6
	Anas rhynchotis	Australasian Shoveler	No habitat	13
	Anas superciliosa	Pacific Black Duck	No habitat	1 2 3 6
	Aythya australis	Hardhead	No habitat	13
	Biziura lobata	Musk Duck	No habitat	12 3 6
	Chenonetta jubata	Australian Wood Duck	No habitat	12 3 6
	Cygnus atratus	Black Swan	No habitat	12 3 6
	Malacorhynchus membranaceus	Pink-eared Duck	No habitat	3
	Oxyura australis	Blue-billed Duck	No habitat	13 4 6
	Stictonetta naevosa	Freckled Duck	No habitat	6
	Tadorna tadornoides	Australian Shelduck	No habitat	12 3 6
Podicipedidae				
	Podiceps cristatus	Crested Grebe	No habitat	3
	Poliocephalus poliocephalus	Hoary-headed Grebe	No habitat	12 3 6
	Tachybaptus novaehollandiae	Australasian Grebe	No habitat	12 3 6
Phaethontidae				
	Phaethon rubricauda westralis	Red-tailed Tropicbird (Indian Ocean), Indian Ocean Red-tailed Tropicbird	No habitat	7
Rallidae				
	Fulica atra	Eurasian Coot	No habitat	12 3 6

Family	Latin Name	Common Name	Expected Occurrence	Source
	Gallirallus philippensis	Buff-banded Rail	No habitat	13
	Porphyrio porphyrio	Purple Swamphen	No habitat	13
	Tribonyx ventralis	Black-tailed Native-hen	No habitat	12 3 6
	Zapornia tabuensis	Spotless Crake	No habitat	3
Diomedeidae				
	Diomedea amsterdamensis	Amsterdam Albatross	No habitat	7
	Diomedea epomophora	Southern Royal Albatross	No habitat	7
	Diomedea exulans	Wandering Albatross	No habitat	7
	Phoebetria fusca	Sooty Albatross	No habitat	7
	Thalassarche carteri	Indian Yellow-nosed Albatross	No habitat	7
	Thalassarche cauta	Shy Albatross	No habitat	7
	Thalassarche impavida	Campbell Albatross, Campbell Black-browed Albatross	No habitat	7
	Thalassarche melanophris	Black-browed Albatross	No habitat	7
	Thalassarche steadi	White-capped Albatross	No habitat	7
Procellariidae				
	Ardenna carneipes	Flesh-footed Shearwater	No habitat	3
	Ardenna pacifica	Wedge-tailed Shearwater	No habitat	3 4 6
	Daption capense	Cape Petrel	No habitat	3
	Macronectes giganteus	Southern Giant-petrel	No habitat	7
	Macronectes halli	Northern Giant-petrel	No habitat	3 7
	Pterodroma mollis	Soft-plumaged Petrel	No habitat	7
	Puffinus assimilis	Little Shearwater	No habitat	3
Threskiornithidae				
	Platalea flavipes	Yellow-billed Spoonbill	No habitat	12 3 6
	Plegadis falcinellus	Glossy Ibis	No habitat	2 3 4 6
	Threskiornis moluccus	Australian White Ibis	No habitat	2 3 6
	Threskiornis spinicollis	Straw-necked Ibis	No habitat	12 3 6
Ardeidae				
	Ardea alba	Great Egret	No habitat	2 3 6

Family	Latin Name	Common Name	Expected Occurrence	Source
	Ardea pacifica	White-necked Heron	No habitat	12 3
	Botaurus poiciloptilus	Australasian Bittern	No habitat	3
	Egretta novaehollandiae	White-faced Heron	No habitat	12 3 6
	Egretta sacra	Eastern Reef Egret	No habitat	3
	Nycticorax caledonicus	Nankeen Night-Heron	No habitat	12 3 6
Pelecanidae				
	Pelecanus conspicillatus	Australian Pelican	No habitat	12 3 6
Phalacrocoracidae				
	Microcarbo melanoleucos	Little Pied Cormorant	No habitat	12 3 6
	Phalacrocorax carbo	Great Cormorant	No habitat	2 3 6
	Phalacrocorax sulcirostris	Little Black Cormorant	No habitat	12 3 6
	Phalacrocorax varius	Great Pied Cormorant	No habitat	2 3 6
Anhingidae				
	Anhinga novaehollandiae	Australasian Darter	No habitat	12 3 6
Haematopodidae				
	Haematopus fuliginosus	Sooty Oystercatcher	No habitat	2 3
	Haematopus longirostris	Australian Pied Oystercatcher	No habitat	2 3 6
Recurvirostridae				
	Cladorhynchus leucocephalus	Banded Stilt	No habitat	2 3
	Himantopus leucocephalus	Pied Stilt	No habitat	12 3 6
	Recurvirostra novaehollandiae	Australian Red-necked Avocet	No habitat	3
Charadriidae				
				2 3 4 6
	Charadrius leschenaultii	Greater Sand Plover	No habitat	7
	Charadrius mongolus	Lesser Sand Plover	No habitat	2 3 4 6
	Charadrius ruficapillus	Red-capped Plover	No habitat	1 2 3 6
	Elseyornis melanops	Black-fronted Dotterel	No habitat	13
	Erythrogonys cinctus	Red-kneed Dotterel	No habitat	3
	Pluvialis fulva	Pacific Golden Plover	No habitat	3

Family	Latin Name	Common Name	Expected Occurrence	Source
	Pluvialis squatarola	Grey Plover	No habitat	2 3 4 6
	Thinornis cucullatus	Hooded Plover	No habitat	3
Rostratulidae				
	Rostratula australis	Australian Painted Snipe	No habitat	7
Scolopacidae				
	Actitis hypoleucos	Common Sandpiper	No habitat	12 3
	Arenaria interpres	Ruddy Turnstone	No habitat	2 3 4 6
	Calidris acuminata	Sharp-tailed Sandpiper	No habitat	2 3 7
	Calidris alba	Sanderling	No habitat	2 3 4 6
	Calidris canutus	Red Knot	No habitat	2 3 4 6 7
	Calidris ferruginea	Curlew Sandpiper	No habitat	2 3 4 6 7
	Calidris melanotos	Pectoral Sandpiper	No habitat	3
	Calidris ruficollis	Red-necked Stint	No habitat	2 3 4 6
	Calidris subminuta	Long-toed Stint	No habitat	3
	Calidris tenuirostris	Great Knot	No habitat	3
	Limosa lapponica	Bar-tailed Godwit	No habitat	2 3 4 6
	Limosa lapponica menzbieri	Northern Siberian Bar-tailed Godwit	No habitat	7
	Numenius madagascariensis	Eastern Curlew	No habitat	7
	Tringa brevipes	Grey-tailed Tattler	No habitat	2 3
	Tringa glareola	Wood Sandpiper	No habitat	3
	Tringa nebularia	Common Greenshank	No habitat	2 3 4 6 7
	Tringa stagnatilis	Marsh Sandpiper	No habitat	3
	Xenus cinereus	Terek Sandpiper	No habitat	3
Laridae				
	Anous tenuirostris melanops	Australian Lesser Noddy	No habitat	7
	Chlidonias hybrida	Whiskered Tern	No habitat	2

Family	Latin Name	Common Name	Expected Occurrence	Source
	Gelochelidon nilotica	Gull-billed Tern	No habitat	3
	Hydroprogne caspia	Caspian Tern	No habitat	2 3 6
	Larus novaehollandiae	Silver Gull	No habitat	2 3 6
	Larus pacificus	Pacific Gull	No habitat	2 3 6
	Onychoprion anaethetus	Bridled Tern	No habitat	3
	Onychoprion fuscatus	Sooty Tern	No habitat	3
	Sterna dougallii	Roseate Tern	No habitat	2 3 4 6
	Sternula nereis nereis	Australian Fairy Tern	No habitat	2 3 4 6 7
	Thalasseus bergii	Greater Crested Tern	No habitat	2 3 4 6
Cacatuidae				
	Nymphicus hollandicus	Cockatiel	Out of range	3
	Zanda baudinii	Baudin's Black-Cockatoo	Out of range	3
Psittaculidae				
	Neophema petrophila	Rock Parrot	Out of range	2 3 6
	Platycercus icterotis	Western Rosella	Out of range	2 3
	Psephotus haematonotus	Red-rumped Parrot	Out of range	3
Meliphagidae				
	Acanthagenys rufogularis	Spiny-cheeked Honeyeater	Out of range	2 3 6
	Epthianura aurifrons	Orange Chat	Out of range	2 3 6
	Melithreptus lunatus	Gilbert's Honeyeater	Out of range	2 3
Acanthizidae				
	Acanthiza uropygialis	Chestnut-rumped Thornbill	Out of range	2 3 6
	Aphelocephala leucopsis	Southern Whiteface	Out of range	7
	Pyrrholaemus brunneus	Redthroat	Out of range	2 3 6
Petroicidae				
	Microeca fascinans	Jacky Winter	Out of range	3
Acrocephalidae				
	Acrocephalus australis	Australian Reed-Warbler	No habitat	2 3 6

Family	Latin Name	Common Name	Expected Occurrence	Source
Locustellidae				
	Poodytes gramineus	Little Grassbird	No habitat	2 3 6
Oceanitidae				
	Pelagodroma marina	White-faced Storm Petrel	No habitat	3
Dasyuridae				
	Sminthopsis gilberti	Gilbert's Dunnart	Out of range	3 6
Peramelidae				
	Isoodon obesulus	Southern Brown Bandicoot	Out of range	6
Macropodidae				
	Osphranter rufus	Red Kangaroo	Out of range	3
Otariidae				
	Neophoca cinerea	Australian Sea-lion	No habitat	3 4 6 7
Canidae				
	Canis familiaris	Common Dog	Domestic	1 3 6
Balaenidae				
	Eubalaena australis	Southern Right Whale	No habitat - marine	7
Balaenopteridae				
	Balaenoptera musculus	Blue Whale	No habitat - marine	7

Appendix 11. Conservation significant invertebrate fauna species potentially present in the survey areas.

Status codes:

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

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

Biodiversity Conservation Act 2016 listings: S1 to S3 = Schedules 1 to 3, D1 to D3 = Divisions 1 to 3 (see Appendix 2). EX = extinct

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

Sources: 1 = DBCA threated and priority fauna list Midwest Region, 2 = DBCA threatened and priority fauna search 25 km buffer, 3 = Naturemap CS search (25 km buffer), 4 = Bennelongia report (Bennelongia, 2013), 5 = Bamford *et al.* (2012), 6 = BCE database, 7 = Atlas of Living Australia (25 km buffer), 8 = Naturemap (25 km buffer)

Latin Name	Common Name	Status	Expected Occurrence	Source
Insecta (Insects)				
Austrosaga spinifer	spiny katydid (Swan Coastal Plain)	P2	Likely Resident	1 2 3 7 8
Hemisaga vepreculae	thorny bush katydid (Moora)	P2	records along coast from Jurien Bay to Kalbarri. Out of range	1
Hylaeus globuliferus	woolybush bee	P3	Probable resident – associated with woolybush (*Adenanthos cygnorum*) which likely resident	1
Neopasiphae simplicior	a short-tongued bee	CR, EN	out of range	1
Phasmodes jeeba	springtime corroboree stick katydid (Eneabba)	P3	records c. 60km away. Out of range	1
Psacadonotus seriatus	a fan-winged katydid (Champion Bay)	P1	out of range	1
Synemon gratiosa	Graceful Sunmoth	P4	irregular visitor (habitat)	1 2 3 4 8
Throscodectes xederoides	Mogumber bush cricket, Northern Throsco	P3	records c. 50km away. Out of range	1
Arachnida (Spiders and Scorpions)				
Cercophonius sp.		not likely SRE	Likely resident	6
Eucyrtops sp.		not SRE	Likely resident	6
Euryolpium 'sp.'	Pseudoscorpion	potential SRE R1	Likely resident	4
Idiosoma arenaceum	Geraldton Sandplain shield-backed trapdoor spider	P3	out of range	1
Idiosoma castellum	tree-stem trapdoor spider	P4	out of range	1
Idiosoma dandaragan	Dandaragan Plateau shield-backed trapdoor spider	P2	records c. 60km away. Out of range	1
Idiosoma gutharuka	Gutha Pintharuka shield-backed trapdoor spider	P1	out of range	1
Idiosoma incomptum	Carnarvon shield-backed trapdoor spider	P3	out of range	1

Latin Name	Common Name	Status	Expected Occurrence	Source
Idiosoma kwongan	Kwongan heath shield-backed trapdoor spider	P1	records c. 50km away	1
Idiosoma nigrum	shield-backed trapdoor spider	VU, EN	out of range	1
Teyl sp. (MYG693)	Minnivale trapdoor spider	CR	out of range	1
Aname 'MYG223'	undescribed spider (3 males collected)	possible SRE	Likely resident	6
Kwonkan sp.	one juvenile collected	not identified to species	likely resident	6
Aganippe 'MYG221'	undescribed spider (1 male collected)	possible SRE	likely resident	6
Aganippe 'MYG222'	undescribed spider (1 male collected)	possible SRE	likely resident	6
Euoplos mcmillani	two males collected	possible SRE	likely resident	6
Missulena sp.	one male collected	not identified to species	likely resident	6
Mollusca (Snails and bivalves)				
?*Bothriembryon* sp. indet.		potential SRE	likely	6
Bothriembryon perobesus	a bothriembryontid land snail (Moore River)	P1, SRE	Resident	1 2 3 4 8
Bothriembryon whitleyi	Whitley's bothriembryontid land snail (Geraldton)	EX	out of range	1
Branchiopoda (Freshwater shrimp)				
Branchinella denticulata	a fairy shrimp (Carnavon to Kalgoorlie)	P3	out of range	1
Branchinella simplex	a fairy shrimp (inland WA)	P1	out of range	1
Branchinella wellardi	a fairy shrimp (Carnarvon and Murchison)	P3	out of range	1
Daphnia jollyi	a water flea (inland south west)	P1	out of range	1
Chilopoda (Centipedes)				
Mecistocephalus sp. B07		potential SRE R1	likely resident	4
Diplopoda (Millipedes)				
Antichiropus Cooljarloo 1		SRE	likely resident	5 6
Antichiropus Cooljarloo 2		SRE	likely resident	5 6
Antichiropus Eneabba 2		SRE	likely resident	5 6
Antichiropus sp. indet.		likely SRE	likely resident	6
Antichiropus USB2?		SRE	likely resident	5 6
Podykipus sp.		unresolved	likely resident	6
Antichiropus sulcatus		probable SRE	Likely out of range (not collected by BCE)	7 8
Antichiropus variabilis		not SRE	Likely out of range (not collected by BCE)	7

Latin Name	Common Name	Status	Expected Occurrence	Source
Antichiropus whistleri		confirmed SRE	possible	7 8
Isopoda (Slaters)				
Acanthodillo sp. B09		potential SRE R1	possible resident	4
Trichorhina sp. B14		potential SRE R1	possible resident	4
Buddelundia sp. B38		potential SRE	possible resident	8
Buddelundia sp. B39		no idea if SRE	possible resident	8
Oligochaeta (Earthworms and bristle worms)				
Oligochaeta sp.		potential SRE R1	possible resident	4

Appendix 12. Fauna observed during site inspections at Lone South and Osprey.

Latin Name	Common Name
BIRDS	
Merops ornatus	Rainbow Bee-eater
Falco berigora	Brown Falcon
Malurus assimilis	Purple-backed Fairy-wren
Lichmera indistincta	Brown Honeyeater
Phylidonyris niger	White-cheeked Honeyeater
Gavicalis virescens	Singing Honeyeater
Acanthiza chrysorrhoa	Yellow-rumped Thornbill
Acanthiza inornata	Western Thornbill
Pachycephala rufiventris	Rufous Whistler
Colluricincla harmonica	Grey Shrike-thrush
Quoyornis georgianus	White-breasted Robin
Petrochelidon nigricans	Tree Martin
Zosterops lateralis	Silvereye
MAMMALS	
Macropus fuliginosus melanops	Western Grey Kangaroo

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