ATLAS PROJECT DETAILED FAUNA ASSESSMENT

PREPARED FOR: PRESTON CONSULTING | IMAGE RESOURCES

Spectrum ECOLOGY & SPATIAL

© Spectrum Ecology Pty Ltd
ABN 68 615 115 243
PO Box 314 Leederville
Western Australia 6902
Ph: (08) 9317 8233
Email: info@spectrumecology.com.au

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EXECUTIVE SUMMARY

Image Resources are planning for the potential development of the Atlas Project, a mineral sands mine located approximately 18 km east of Cervantes in Western Australia (WA). Image Resources commissioned Spectrum Ecology to undertake a Detailed fauna assessment, including both vertebrate and short range endemic invertebrate fauna, which will be used as part of the environmental approvals process. The survey was designed to supplement previous Detailed survey work completed by 360 Environmental in 2012.

The project was completed over several stages with a Basic fauna assessment being conducted between 22 - 24 January 2020, a Detailed survey was completed between 14 – 24 October 2020 and a Basic fauna assessment of infrastructure corridors completed 20 – 24 September 2021. A one-phase Basic terrestrial fauna assessment of additional infrastructure areas was conducted on 28 July 2022. Short range endemic (SRE) invertebrates were sampled during both the initial Basic and the Detailed terrestrial fauna assessments. As part of the detailed terrestrial fauna survey, wet pitfall traps were installed on the 14 – 15 September, five weeks prior to being collected during the trapping survey. Long-term motion cameras were also installed at this time and were collected at the completion of the Detailed survey. All Basic and Detailed Surveys included targeted assessments for Carnaby's Cockatoo habitat. The surveys were completed in accordance with the EPA Technical Guidance (EPA 2016b, EPA 2020) during the period of peak fauna activity in the region.

The following survey effort was completed within the Atlas Project Survey Area (the Survey Area) during all assessments:

- Eight trapping grids were established for both the first and second phase for seven nights each.
- 123.6 hours were spent conducting bird surveys.
- 88.3 hours of diurnal searches were completed.
- 116 hours of bat recordings were analysed.
- 10 hours of nocturnal searches were completed.
- 1,210 camera trap nights were analysed from 30 camera point locations.
- 224 cage trap nights were completed.
- 1,088 nights of SRE wet pitfall trapping were completed at eight sites.
- 12 leaf litter samples were collected and sieved for SRE invertebrate fauna.

The key findings of the Atlas Project Detailed fauna assessment are as follows:

- Seven fauna habitat types were identified from the Survey Area: Banksia Woodland, Pasture / Cleared, Heath (Banksia), Samphire, Melaleuca, Ephemeral Wetland and Eucalypt Woodland.
- Two ecotone areas with mixed habitat characteristics and fauna assemblages were identified and defined: Banksia Woodland / Heath (Banksia) and Melaleuca / Samphire.
- 98 vertebrate fauna species were recorded during the Detailed survey, taking the total to 121 species when combined with the results of the Basic survey: 14 mammal, 83 bird, 19 reptile and five amphibian species. This total is comparable to those recorded during similar surveys completed in the region.
- Statistical analysis of systematically collected trapping and bird survey data recorded during the 2020 Detailed survey suggests that the majority of species potentially occurring within the Survey Area have been recorded. The total of 98 species is a combination of both systematically and opportunistically recorded species and exceeds the total species count predicted by the analysis.

- The following conservation significant fauna species have been recorded within the Survey Area:
  - Common Greenshank (*Tringa nebularia*) – EPBC/ BC Act Migratory (current survey)
  - Black-striped Snake (*Neelaps calonotos*) – DBCA Priority 3 (current survey)
  - Carnaby's Cockatoo (*Calyptorhynchus latirostris*) – EPBC/ BC Act Endangered (current survey)
  - Western Brush Wallaby (*Notamacropus irma*) – DBCA Priority 4 (360 Environmental, 2012a and current survey)
- A further two species of conservation significance were assessed to have a high likelihood of occurrence based on regional records and the habitat types present within the Survey Area:
  - Fork-tailed Swift (*Apus pacificus*; EPBC/ BC Act Migratory); and
  - Bothriembryontid Land Snail (Moore River) (*Bothriembryon perobesus*; DBCA Priority 1).
- Twenty-two potential SRE species were recorded during the surveys, 20 from within the Survey Area. Of the 20, twelve are currently only known from the Atlas Project; one araneomorph spider and 11 pseudoscorpions. Two others, both isopods, align morphologically with species known from 10 km southeast.
- Genetic sequencing was used in an attempt to align five potential SRE morphospecies specimens recorded within the proposed impact area with species recorded outside. Two morphospecies were found to align with known described species found well outside the Survey Area. Two morphospecies did not align with specimens found elsewhere and are only known from the Atlas Project Area. The remaining specimen aligns morphologically with animals recorded 10 km southeast though genetic sequencing of the regional comparison animals failed.
- The Melaleuca fauna habitat type was assessed to be the most likely habitat to host SRE species due to the mesic microhabitats it supports and its limited coverage within the Survey Area.

The desired objectives and outcomes were successfully reached during the current assessment. There were no significant limitations to the survey work, and the level of survey effort and number of species recorded is considered adequate for the Survey Area. All field work was completed in accordance with relevant government legislation, guidance, and standard operating procedures.

1. INTRODUCTION

1.1. Project Background

Image Resources (Image) are planning for the potential development of the Atlas Project, a mineral sands mine located approximately 18 km east of Cervantes in Western Australia (Map 1.1). Current project information is as follows:

- Dry mining of a portion of the southern section of the defined Ore Resource, using conventional earthmoving equipment;
- Mining will progress in stages followed by progressive backfilling and rehabilitation;
- The ore body is 1.4 km from an eastern extension of Nambung National Park;
- The northern quarter of the Ore Resource is located on freehold land currently used for stock grazing. The rest of the Ore Resource is located on land predominately covered with native vegetation;
- Clearing of some of this native vegetation will be required for construction and operation of the Project;
- Development of areas for infrastructure including roads and pipelines;
- There is a high water table in the vicinity of the ore body (approximately 2 – 10 m depth).

A single-phase Level 2 vertebrate fauna survey was completed by 360 Environmental in 2012, utilising eight trapping sites across five fauna habitat types (360 Environmental, 2012a). Spectrum Ecology completed a Level 1 fauna assessment in 2020 to update the previous fauna assessment and to determine if the previous surveys meet current guidelines (EPA 2016a, EPA 2020). This assessment included a targeted Black Cockatoo and reconnaissance SRE invertebrate fauna survey. Based on the results of this assessment a second phase of Level 2 vertebrate and SRE invertebrate fauna survey was recommended. In June 2020, the EPA released an updated Technical Guidance providing advice on appropriate survey methodology for vertebrate fauna surveys conducted for Environmental Impact Assessment (EIA) purposes (EPA 2020). Within this document, the various levels of survey have been revised and are referred to as Basic (previously Level 1) and Detailed (previously Level 2). The work undertaken during the current survey will be referred to as Detailed as per the Guidance in this report though the objective and survey methods are consistent with those utilised during the previous Level 2 survey.

1.2. Scope of Work

Image commissioned Spectrum Ecology to undertake a terrestrial (vertebrate and SRE invertebrate) fauna assessment, which will be used to support relevant environmental impact assessments and EPA referral. The scope of works included the completion of the following:

- Basic terrestrial fauna survey;
- Detailed vertebrate fauna survey; and
- Detailed SRE invertebrate survey.

The survey included as a minimum:

- A desktop assessment;
- Field Surveys:
  - Basic fauna survey;
  - An initial SRE wet pitfall trap set up trip (including long-term motion camera set up); and
  - Detailed fauna survey;

- Reporting.

1.3. Legislation & Guidance

1.3.1. Threatened Fauna (EPBC Act)

Nationally threatened species (flora and fauna) and ecological communities are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The EPBC Act provides for the identification and listing of species and ecological communities as threatened, development of conservation advice and recovery plans, development of a register of critical habitat, recognition of key threatening processes and the development of threat abatement plans. Listed threatened species and ecological communities are recognised under the EPBC Act as matters of national environmental significance and must be referred to the Minister and undergo an environmental assessment and approval process if they are likely to be significantly impacted. The categories for listing under the EPBC Act are outlined in Appendix A.

1.3.2. Threatened Fauna (BC Act)

The Western Australian *Biodiversity Conservation Act 2016* (BC Act) provides for the conservation, protection and ecologically sustainable use of biodiversity and biodiversity components in Western Australia. Threatened species (both flora and fauna) and ecological communities that meet the conservation categories listed within the BC Act are protected and require authorisation by the Minister to take or disturb. Species listed as Threatened under the BC Act are publicly listed in the WA Government Gazette with the current list published on the 11 September 2018.

Fauna species may also be listed as being of special conservation interest if they have a naturally low population, restricted natural range, are subject to or recovering from a significant population decline or reduction of range or are of special interest, and the Minister considers that taking may result in depletion of the species. These are known as Specially Protected Species in the BC Act. The conservation categories covering State-listed threatened fauna species are aligned with those listed under the EPBC Act and are outlined in Appendix A.

1.3.3. Priority Fauna (DBCA)

Conservation significant species are listed by the Department of Biodiversity, Conservation and Attractions (DBCA) as Priority species where populations are geographically restricted or threatened by local processes, or where there is insufficient information to formally assign them to threatened fauna categories. Whilst Priority species are not specifically listed in the BC Act, they have a greater level of significance than other native species. The categories covering Priority Fauna species (DBCA 2019) are outlined in Appendix A.

1.3.4. Assessment Guidance

The terrestrial fauna assessment was conducted in accordance with the following Commonwealth and State legislation, as well as the Environmental Protection Authority (EPA) requirements for environmental surveys as outlined below.

- *Biodiversity and Conservation Act 2016 (BC Act);*
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- Technical Guidance: Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA 2020)
- Technical Guidance: Sampling Methods for Terrestrial Vertebrate Fauna (EPA 2016a); and
- Technical Guidance: Sampling of Short Range Endemic Invertebrate (EPA 2016b).

Updated guidance for terrestrial vertebrate fauna surveys was released following the completion of some of the field surveys for this report (Terrestrial vertebrate fauna phase 1 (360 Environmental, 2012a) and Basic terrestrial fauna survey). Due to the update being released after the completion of those field surveys, both guidance documents (EPA 2016a, EPA 2020) were considered relevant. Changes to the terminology for terrestrial fauna assessments detailed in the recent guidelines from "Level 1 and Level 2" to "Basic and Detailed" (EPA 2020) have been adopted in this report.

Relevant species-specific survey and assessment guidelines include:

- Survey Guidelines for Australia's Threatened Birds (DEWHA 2010b);
- Survey Guidelines for Australia's Threatened Mammals (DSEWPaC 2011b);
- Survey Guidelines for Australia's Threatened Reptiles (DSEWPaC 2011c);
- Survey Guidelines for Australia's Threatened Bats (DEWHA 2010a);
- Survey Guidelines for Australia's Threatened Frogs (DEWHA 2010c);
- Survey Guidelines for Australia's Threatened Fish (DSEWPaC 2011a);
- EPBC Act referral guidelines for three threatened black cockatoo species: Carnaby's Cockatoo (endangered) *Calyptorhynchus latirostris*, Baudin's Cockatoo (vulnerable) *Calyptorhynchus baudinii*, Forest Red-tailed Black Cockatoo (vulnerable) *Calyptorhynchus banksii naso* (DSEWPaC 2012); and
- Revised draft referral guidelines for three threatened black cockatoo species: Carnaby's Cockatoo (Endangered) *Calyptorhynchus latirostris*, Baudin's Cockatoo (Vulnerable) *Calyptorhynchus baudinii*, Forest Red-tailed Black Cockatoo (Vulnerable) *Calyptorhynchus banksia naso* (DoEE 2017).

The most recent Black Cockatoo guidelines (DAWE 2022) were published after the completion of all field assessments for this project, therefore the previous referral guidelines and draft referral guidelines were considered for this report.

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Jurien Bay

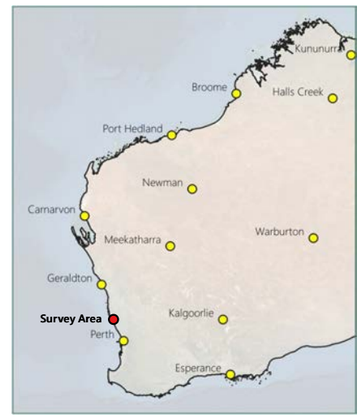
Cervantes

Grey

Badgingarra

Legend

Survey Area



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Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum

Author: JV Approved: DC Date: 12-09-2022

Survey Area Location

Atlas Project

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MAP
1.1

2. EXISTING ENVIRONMENT

2.1. IBRA Bioregion

The Interim Biogeographic Regionalisation for Australia (IBRA) classifies Australia into regions based on dominant landscape, climate, lithology, geology, landform and vegetation (Thackway and Cresswell, 1995). The Survey Area is located within the northern part of Swan Coastal Plain IBRA region (Figure 2.1). The region consists of two subregions, the Perth subregion which is situated along the coast and the Dandaragan Plateau which is located inland and to the northeast.

The Perth subregion (within which the Survey Area is located) is a low-lying coastal plain covered by woodland. The vegetation of this subregion is characterised by Banksia woodland, Tuart woodland and heath on sandy soils.

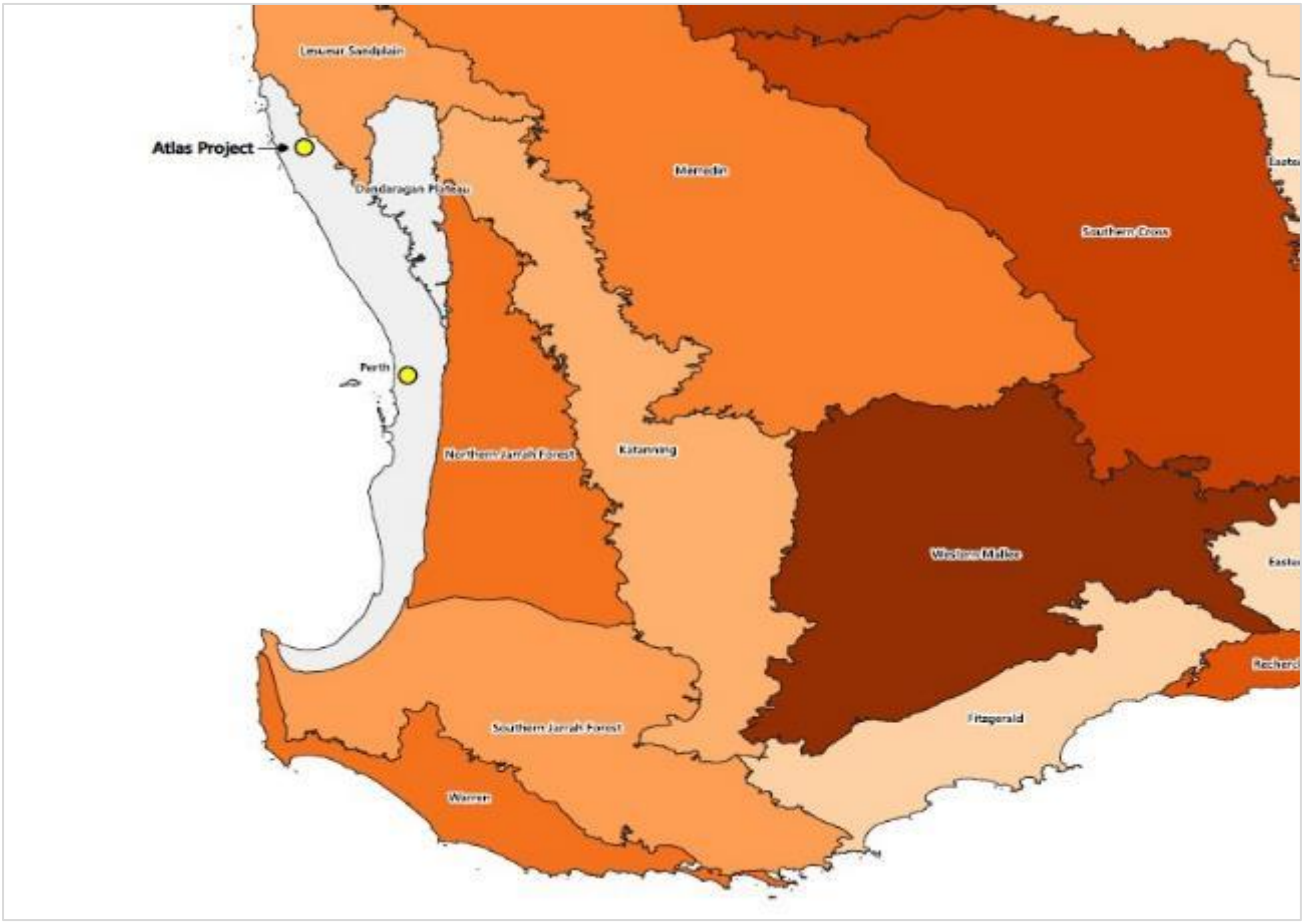


Figure 2.1: IBRA Classification

2.2. Climate

The climate of the Swan Coastal Plain is described as warm Mediterranean (warm wet winters and hot dry summers) with rainfall ranges between 600mm and 1000mm annually. Nyoongar climatic information describes six seasons which include long hot dry periods from October to April (Kambarang, Birak & Bunuru) with cooler periods in April-May (Djeran) and August-September (Djilba) on either side of a short wet cold period in June-July (Makuru).

Climate data recorded from the nearest Bureau of Meteorology (BOM) stations (Jurien Bay #9131 and Nambung #9276 BOM station) indicates that in the 12 months prior, the Survey Area experienced a cool wet winter and early spring, with high rainfall recorded from May to September (Figure 2.2). The mean annual rainfall for the 12 months prior to the field survey was 359mm which is well below the annual mean of 545mm. February 2020 recorded unusually high rainfall well above the long-term average (27mm) with below average rainfall recorded the rest of the year. Jurien Bay long-term temperature data is considered more accurate than the Nambung weather station which has sporadic records from 2005. Rainfall data from Nambung weather Station is included as Jurien Bay records higher rainfall due to its coastal location.

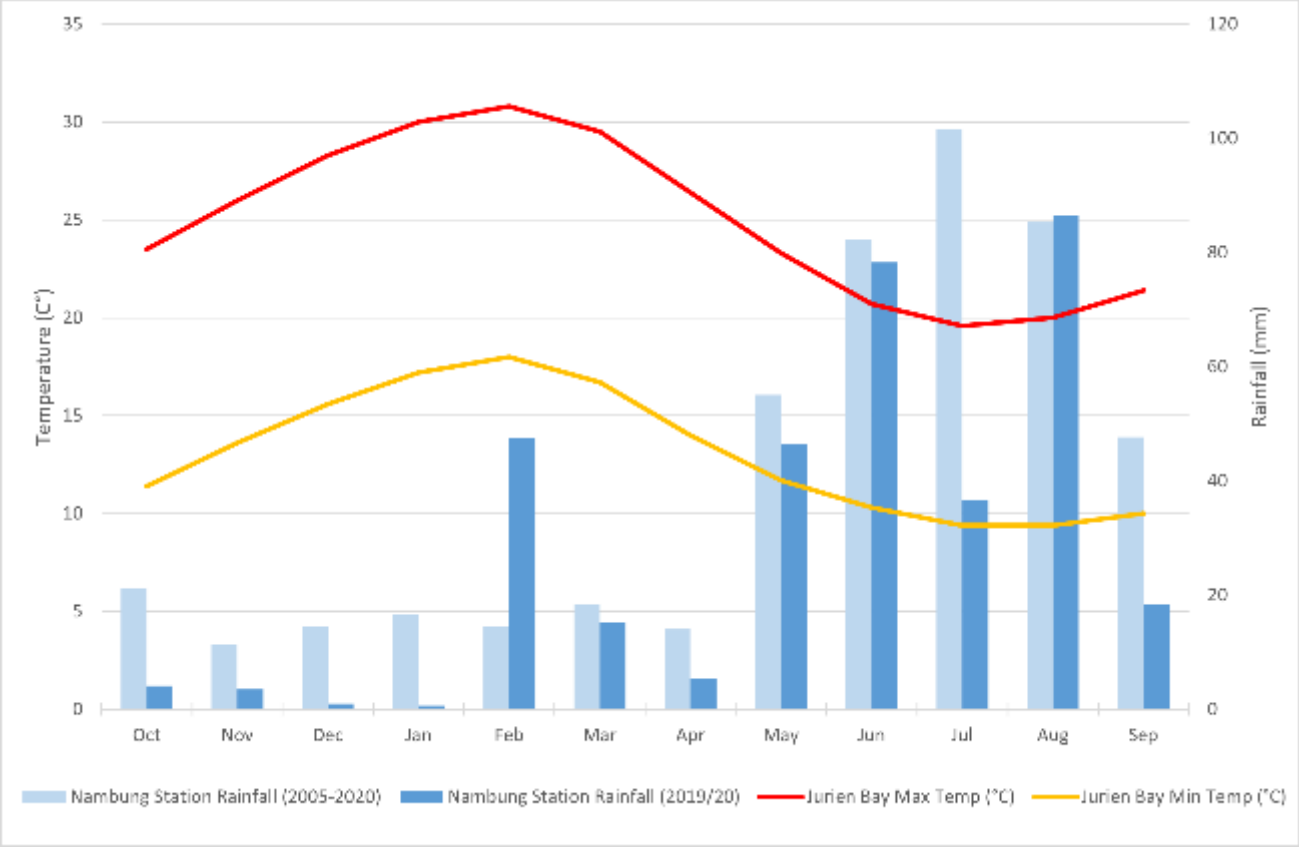


Figure 2.2: Climate Data Associated with the Survey Area

2.3. Pre-European Vegetation

Pre-European vegetation mapping was originally undertaken by Beard at various scales across the state and has since been updated to be consistent with the National Vegetation Information System (NVIS) descriptions at a scale of 1:250,000 (DPIRD 2019).

The majority of the Survey Area occurs within one vegetation unit (1030.2) which is described as low Banksia dominated woodland (*Banksia attenuata* & *B. menziesii*) (Government of Western Australia, 2019). Two small sections of the infrastructure corridor occur in two additional vegetation units; 1029.1 - Banksia mixed open shrubland and 1031.1 – Banksia Shrubland. The vegetation association, including any mosaics are summarised in Table 2.1 and the occurrence in the region is shown on Map 2.1.

Table 2.1: Vegetation Association Mapped within the Survey Areas

Sub-association	Area in Survey Area (ha)	% of Survey Area	Pre-European Whole State (ha)	Current Extent State (ha)	% Remaining	% of Current Extent in DBCA Land
1029.1	1.33	0.1	68,131.5	48,882.6	71.75	28.38
1030.2 (Mosaic)	1237.37	99.8%	122,166.9	81,519.7	66.73	15.2
1031.1 Mosaic	0.69	0.1	225,533.1	73,570.5	32.62	13.16
NVIS Level V descriptions						
1029.1 Banksia mixed open shrubland M+ ^*Banksia sessilis*,^*Calothamnus quadrifidus*, *Acacia heteroclita*\^shrub, *xanthorrhoea*\4\i;G *Conospermum stoechadis*, *Lechenaultia linarioides*, *Hibbertia hypericoides*\shrub,forb\2\c						
1030.2 Banksia mixed shrubland U+ ^*Banksia 13ttenuate*, *Banksia menziesii*, *Eucalyptus todtiana* \^tree \ 6 \i; M *Adenanthos cygnorum*, *Allocasuarina humilis*, *Jacksonia furcellata* \ shrub, *xanthorrhoea* \ 4\ r; G *Anigozanthos humilis*, *Conostylis aculeata*, *Eremaea fimbriata* \ forb, shrub, *xanthorrhoea*, cycad \ 2 \ i M+ ^^ *Banksia sphaerocarpa*, *Acacia lasiocarpa*, *Melaleuca acerosa* \ ^shrub, *xanthorrhoea* \ 3 \ c; G *Frankenia* sp., *Halosarcia* sp., *Byblis gigantea* \ chenopod shrub, samphire shrub, forb \ 2 \ bi U+ ^*Melaleuca rhaphiophylla*, *Banksia littoralis*, *Eucalyptus rudis* \ ^tree \ 6 \ i; M *Acacia rostellifera*, *Hypocalymma angustifolium*, *Melaleuca thyoides* \ shrub \ 3 \ i. 1031.1 Banksia shrubland M+ ^*Banksia bipinnatifida*, *Hakea auriculata*, *Banksia shuttleworthiana*\^shrub\3\c;G *Banksia* sp.,*Burchardia umbellata*, *Calectasia cyanea*\shrub,forb\2\i. U *Eucalyptus johnsoniana*, *Eucalyptus lane-poolei*, *Eucalyptus pendens*\tree mallee,tree\6\bi;M *Hakea obliqua*, *Allocasuarina humilis*, *Adenanthos cygnorum*\^shrub,*xanthorrhoea*\4\i;G+ *Anigozanthos humilis*, *Andersonia heterophylla*, *Beaufortia heterophylla*\forb,shrub,s						

2.4. Geology

The geology of Western Australia has been mapped at a scale of 1:50,000, 1:100,000, 1:250,000 and 1:500,000. The Survey Area occurs in the northern edge of the Wedge Island 1:100,000 scale geological mapping. The Survey Area consists of five geological units; Qa, Qe, Qp, Qt, and Czls. The Qa and Qp units are associated with the drainage system that runs across the northern half of the Survey Area and includes finer alluvium soils associated with the drainage features and ephemeral lakes. The Qe unit consists of accumulated sand forming broad dune features and is associated with areas of Banksia woodland. The Qt units are coastal limestone deposits and the Czls unit corresponds with sandplains associated with low Banksia woodland. The units are listed in Table 2.2 and shown in Map 2.2.

Table 2.2: Geological Units of the Survey Area (1:100,000)

Code	Description	Area in Survey Area (ha)	% of Survey Area
Qa	Alluvium-sand, silt, and clay	471.60	32.66
Qe	Non-calcareous sand reworked by eolian processes	958.97	66.42
Qp	Swamp and lacustrine deposits-clay, silt, and diatomite 1164.71	8.60	0.60
Qt	TAMALA LIMESTONE: eolian limestone and sandstone with secondary concretionary and residual calcareous deposits; minor fossilferous limestone	3.87	0.27
Czls	Leached quartz sand associated with laterite	0.80	0.06

325000 330000 335000 340000 345000 350000 355000

6635000 6630000 6625000 6620000 6615000 6610000

1029.1

1031.1

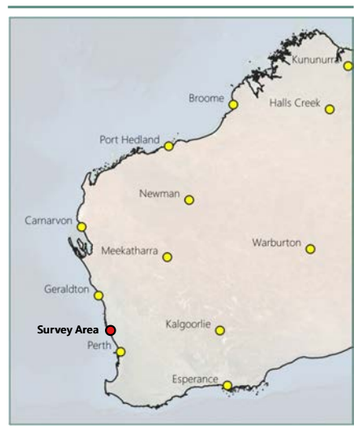
1030.2

Legend

Survey Area

Pre-European Vegetation Units

- 129
- 1026.1
- 1029.1
- 1030.2
- 1031.1



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Scale 1:100,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

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Author: MH Approved: DC Date: 12-09-2022

Pre-European Vegetation Units

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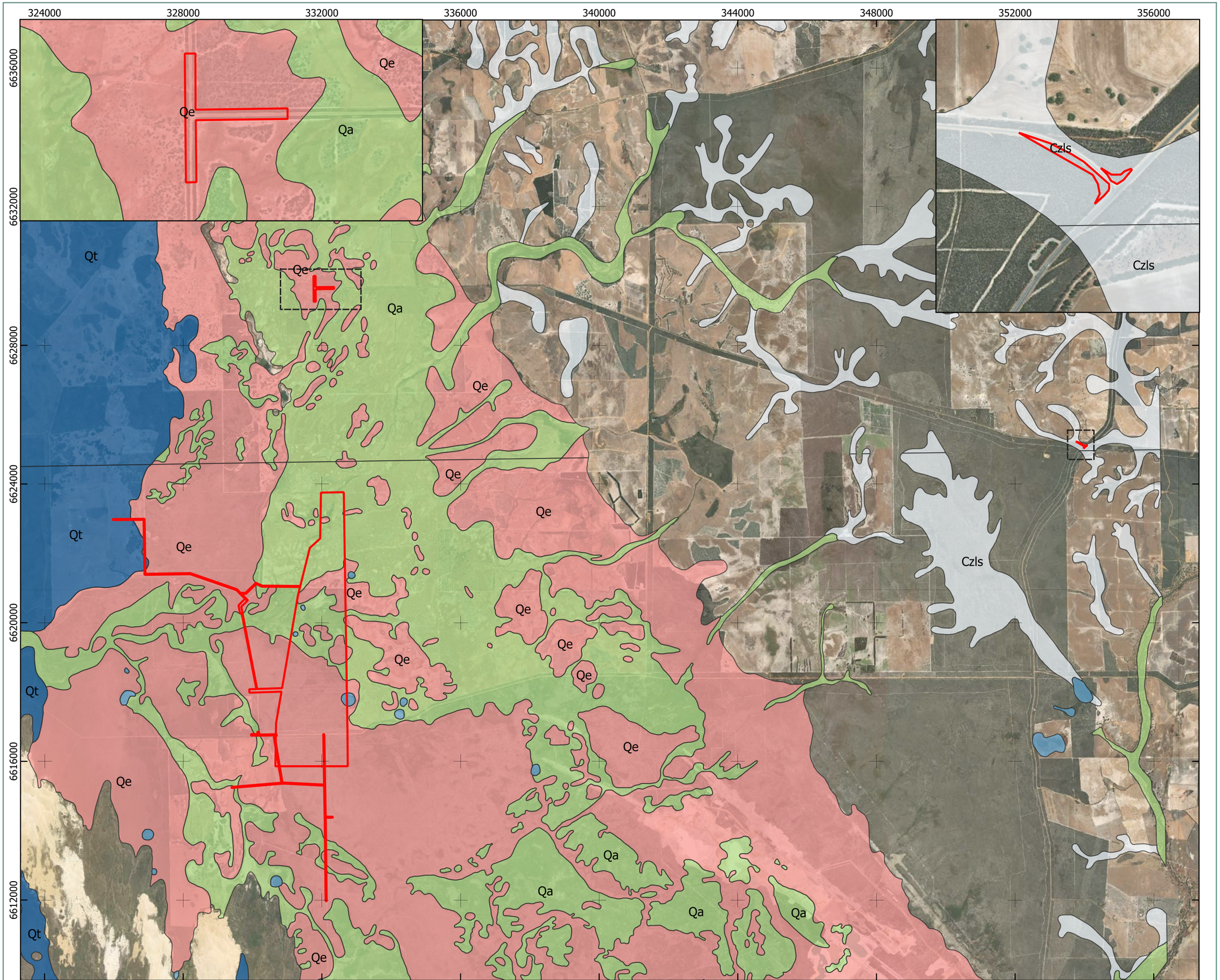
MAP
2.1

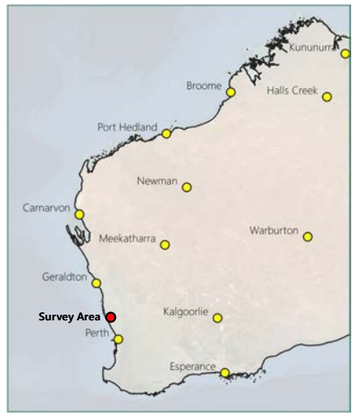


Legend

- Survey Area

Geological Units

- Czls
- Qa
- Qe
- Qp
- Qt



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Units: Meter

Spectrum

Author: JV Approved: DC Date: 15-09-2022

Geological Units

Atlas Project

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MAP 2.2

2.5. Environmentally Significant Areas

2.5.1. Conservation Estate

The Western Australian conservation estate includes land and waters vested in the Conservation and Parks Commission under the Conservation and Land Management Act (1984). The conservation estate is generally managed by the Parks and Wildlife Service of DBCA to protect Western Australia's biodiversity, and includes National Parks, Nature Reserves, Conservation Reserves, and other areas managed primarily for biodiversity conservation (DoEE 2016).

A search of the Collaborative Australian Protected Area Database (CAPAD) returned 10 conservation estates located within 30 km of the Survey Area. These protected areas and their approximate distance from the Survey Area are listed in Table 2.3. The Survey Area is not located within any Conservation Estates however it is located within proximity of four large conservation areas: Nambung National Park, Badgingarra National Park, Southern Beekeepers Nature Reserve and Wanagarren Nature Reserve.

Table 2.3: Environmentally Significant Areas in the Vicinity (30 km) of the Survey Area

Reserve Name (Protected Area ID)	Distance from Survey Area	Size (ha)
Conservation Estates		
Nambung National Park (WA_24522 & WA_37094)	1.2 km (west)	19,390
Badgingarra National Park (WA_31809)	16.5 km (east)	13,105
Wongonderrah Nature Reserve (WA_26248)	8.5 km (east)	439
Twyata Nature Reserve (WA_27277)	26 km (northeast)	152
Wanagarren Nature Reserve (WA_31675)	12.5 km (south)	11,082
Southern Beekeepers Nature Reserve (WA_36053)	8.0 km (northwest)	10,874
Unnamed WA40916 Nature Reserve (WA_40916)	20.2 km (southeast)	1,012
Unnamed WA41986 Conservation Park (WA_41986)	17.0 km (east)	2,369
Unnamed WA34039 5(1)(h) Reserve (WA_34039)	15.8 km (northwest)	1
Unnamed WA48205 5(1)(h) Reserve (WA_48205)	21.4 km (northwest)	14
Threatened Ecological Communities (TEC)		
Thetis-microbialite	18 km (west)	17
Wetlands		
Lancelin Defence Training Area (CR 729, 50297, 40916, 24522, 18294, 10525)	500 m (southeast)	9,930
Lake Thetis (CR 24522)	18 km (west)	17

2.5.2. Environmentally Sensitive Areas

Environmentally Sensitive Areas (ESA) are areas that are defined by the Department of Water and Environmental Regulation (DWER 2019) as:

- A declared World Heritage property as defined in s 13 of the EPBC Act 1999
- An area that is included on the Register of the National Estate, because of its natural heritage value under the *Australian Heritage Council Act 2003*
- A defined wetland and the area within 50 m of the wetland;
- The area covered by vegetation within 50 m of Threatened flora, to the extent to which the vegetation is continuous with the vegetation in which the Threatened flora is located;
- The area covered by a TEC;
- A Bush Forever site;
- Areas covered by the Gnangara Mound Crown Land Policy and Western Swamp Tortoise Policy;
- Areas covered by lakes, wetlands and fringing vegetation of the Swan Coastal Plain Lakes Policy, including South West Agricultural Zone Wetlands Policy and Swan and Canning Rivers Policy; and
- Protected wetlands as defined in the Environmental Protection (South West Agricultural Zone Wetlands) Policy 1998.

The Australian Wetlands Database includes nationally significant wetlands (as listed in the directory of important wetlands), wetlands listed under the Ramsar convention, wetlands that are representative, rare or unique, or wetlands that are considered of international importance (DoEE 2019).

The wetlands closest to the Survey Area include the Lancelin Defence Training Area (500m SE) and Lake Thetis (18 km W). The Lancelin Defence Training Area is part of a regionally significant group, the Bassendean group, is within close proximity of surrounding nature reserves and national parks and has a large area of freshwater wetlands. It is utilised for military purposes, including explosives, and is disturbed by weeds. Lake Thetis is a saline coastal lake and is one of only five sites within Western Australia featuring thrombolites and is also listed as a TEC. Neither of these wetland areas intersect directly with the Survey Area.

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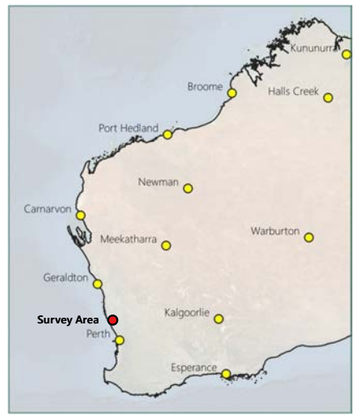
6610000
6600000
Southern Beekeepers
Badgingarra
Unnamed WA34039
Lake Thetis
Nambung
Wongonderrah
Unnamed WA41986
Lancelin Defence Training Area
Wanagarren
Unnamed WA40916

Legend

- Survey Area
- Important Wetlands

Reserve Name

- Badgingarra
- Nambung
- Southern Beekeepers
- Twyata
- Unnamed WA34039
- Unnamed WA40916
- Unnamed WA41986
- Unnamed WA48205
- Wanagarren
- Wongonderrah



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Scale 1:100,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY & SPATIAL

Author: MH Approved: DC Date: 12-09-2022

Significant Lands

Atlas Project

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MAP
2.3

3. METHODS

3.1. Desktop Assessment

Four public databases were accessed as part of the desktop assessment. One Level 2 vertebrate fauna survey, two targeted vertebrate fauna surveys and one SRE survey that were previously completed within the surrounding region were also reviewed to provide information to support the current assessment. Details of the completed database searches are listed in Table 3.1.

Table 3.1: Details of Database Searches

Custodian	Database	Species Group	Details
Department of Agriculture, Water and the Environment	Protected Matters Search	EPBC listed vertebrate and invertebrate fauna species	Date: 24/11/20 Buffer: 40 km
Department of Biodiversity, Conservation and Attractions	NatureMap	Vertebrate Fauna species	Date: 24/11/20 Buffer: 40 km Centre Point: 115° 15' 51'' E,30° 34' 22'' S
	Threatened Fauna Database Search	Threatened and Priority Vertebrate and Invertebrate Fauna species	Date: 15/01/20 Details: Polygon plus 40 km Reference: #6232
Western Australian Museum	Arachnida & Myriapoda Database	SRE invertebrate fauna species	Search Area: NW corner -29.5° 114.9° SE corner -31.5° 116.9° Date: 7/01/20
	Crustacea Database		
	Mollusc Database		

The following survey reports were reviewed as part of the literature review. Three previous fauna assessments were completed within the Survey Area, the results of which have been included. Three assessments reviewed were associated with the local region, Cooljarloo West and Yandin Wind Farm project. The previous fauna survey details are listed in Table 3.2 with the results of these surveys listed in Table 4.1.

Table 3.2: Previous Survey Reports

Reference	Location	Details
Atlas Tenement Level 2 Vertebrate Fauna Survey (Single Phase) – North Perth Mineral Sands Project (360 Environmental, 2012a)	Within Survey Area	Single phase Level 2 vertebrate fauna survey
Atlas Tenement Graceful Sun-moth Survey & Site Based (*Lomandra*) Habitat Assessment (360 Environmental, 2012b)	Within Survey Area	Targeted Sun Moth survey
Cooljarloo West Proposal: Short Range Endemic Fauna, Pilot and Targeted Surveys (Bennelongia Environmental Consultants, 2013)	Cooljarloo	SRE targeted invertebrate survey
Cooljarloo West Development Envelope Fauna Assessment (Bamford, Bancroft and Turpin, 2015)	Cooljarloo	Two phase Level 2 vertebrate fauna survey
Yandin Wind Farm – Flora, Vegetation and Avifauna Assessment (ecologia Environment, 2017)	Cataby	Avifauna survey
Bibby Road, Cooljarloo. Spring Biological Assessment (360 Environmental, 2021)	Within Survey Area	Basic vertebrate fauna and targeted black cockatoo habitat assessment

3.2. Conservation Significant Fauna

The results of the literature review identified fauna species that are listed under current legislative frameworks. Three conservation lists have been developed at national (EPBC Act) and state level (BC Act and DBCA priority list) (Appendix A). The likelihood of a conservation significant fauna species being present within the Survey Area was determined by examining the following:

- Suitability of fauna habitats known to exist within the Survey Area;
- Distribution of previously recorded conservation significant species;
- Frequency of occurrence of conservation significant species records in the region;
- Detectability of conservation significant species based on specific behavioural and ecological characteristics, and;
- Temporal distribution of conservation significant species records, taking previous survey effort into consideration.

Each conservation significant species potentially occurring in the Survey Area was assigned a likelihood of occurrence based on the below categories (Table 3.3). In accordance with the precautionary principal, the level of available information for each species was also taken into consideration so that species are not allocated a low likelihood of occurrence because of insufficient survey information.

Table 3.3: Likelihood of Occurrence Criteria for Conservation Significant Species and Communities

Likelihood	Fauna Criteria
Recorded	Species recorded within the Survey Area within the previous ten years.
High	Species recorded within or in proximity to the Survey Area within the previous 20 years. Suitable habitat occurs in the Survey Area.
Medium	Species recorded within or in proximity to the Survey Area more than 20 years ago. Species recorded outside the Survey Area but within 50 km. Suitable habitat occurs in the Survey Area.
Low	Species rarely or not recorded within 50 km of the Survey Area. Suitable habitat does not occur within or in proximity to the Survey Area.
Very Low	Species not recorded within 50 km despite multiple recent surveys. Suitable habitat does not occur within the Survey Area. Species considered locally extinct.

3.3. Short Range Endemic Target Groups

Short range endemic invertebrate species are defined as species with naturally small distributions (<10,000 km^2) that possess ecological, morphological and life history characteristics that affect their range. Poor powers of dispersal, confinement to discontinuous habitats, slow growth rates and low levels of fecundity often result in fragmented or severely restricted distributions. Many species appear to be Gondwanan relicts now isolated in pockets of mesic habitat that was once more widespread and contiguous prior to the aridification of the Australian landscape. A low level of taxonomic resolution, lack of detailed ecological information and difficulties identifying many taxa via morphological means further complicates the assessment of potential SRE species. In many taxa, such as *Antichiropus* sp. millipedes, male only characters (e.g. gonopod morphology) are the primary diagnostic features used when identifying species (Wojcieszek, Harvey and Rix, 2010). If female or juvenile specimens are collected, identification to species level or alignment with known undescribed morphospecies using morphological characters is not possible. The use of DNA barcoding is gradually addressing this issue though the database of known sequences is still limited for many taxa (Western Australian Museum, 2014).

The combination of these factors make SRE species particularly vulnerable to threatening processes such as habitat loss, degradation and climate change (Harvey *et al.*, 2011). The taxa detailed in Table 3.4 have been identified as displaying one or more of the characteristics known to cause short range endemism (Harvey, 2002) and as such are targeted during field assessments.

Table 3.4: SRE Target Groups

Phylum or Subphylum	Class	Order	Details
Annelida	Oligochaeta	Haplotaxida	Earthworms.
Chelicerata	Arachnida	Araneae	Spiders, particularly those belonging to the infraorder Mygalomorphae (trapdoor spider).
		Opiliones	Harvestmen.
		Pseudoscorpiones	False scorpion or book scorpion.
		Schizomida	Micro whip scorpions, mostly known from troglobitic species.
		Scorpiones	Scorpions.
Crustacea	Malacostraca	Isopoda	Terrestrial Isopods, also known as slaters or woodlice.
Mollusca	Gastropoda	Stylommatophora	Land snails.
Myriapoda	Chilopoda	Geophilomorpha	Elongate soil centipedes.
		Scolopendromorpha	Centipedes from the family Cryptopidae.
	Diplopoda	Not specified	Millipedes
Onychophora	Udeonychophora	Euonychophora	Velvet worms, family Peripatopsidae.

3.3.1. SRE Habitat

Sheltered, isolated, and often relictual mesic habitats have an increased likelihood of hosting SRE taxa. The gradual aridification of the Australian continent that began in the early Miocene has resulted in the contraction and isolation of mesic habitats and by association those relictual faunal groups that utilise them (Harvey, 2002). The following are examples or habitat types that have been recognised as potentially harbouring SRE species (Harvey, 2002; Durrant, 2011; EPA 2016b):

- Deep gorges;
- Isolated ranges, mesas, and rock outcrops;
- Rainforest patches;
- Islands;
- Drainage systems;
- Vine thickets;
- Hillslopes with south west facing aspects; and
- Fire refuge areas such as cliffs and rock piles.

Many SRE species are associated with permanently moist, shaded, and sheltered microhabitats. In arid landscapes, these habitat types are typically limited and isolated by barriers of exposed, dry habitat not conducive to the dispersal of SRE species. This isolation restricts or eliminates gene flow between populations and may result in speciation via selective pressures, genetic drift, and mutation. Even where speciation has not yet occurred, the geographical distribution of these species has severely contracted and fragmented. Isolated gorges and gullies that host complex microhabitats (heavy vegetation, deep leaf litter beds and varied rock cover) and protect relictual mesic habitat characteristics are more likely to host SRE

taxa than simple widespread habitats exposed to climatic extremes. Isolated freshwater habitats associated with springs are also likely to provide conditions suitable for SRE taxa. Regionally extensive and exposed habitat types with high connectivity are unlikely to host SRE taxa (Durrant, 2011).

Vegetation, geological, land system, and topographic mapping as well as aerial imagery may be used as surrogates to estimate habitat connectivity and distributional boundaries of potential SRE species. This is to be considered in circumstances where further survey is deemed unlikely to yield more specimens and further taxonomic or distributional information is not available via the museum and subject matter specialists (EPA 2016b).

3.3.2. Determination of SRE Status

The SRE status of invertebrates is based on categories which were developed by the Western Australian Museum (WAM). In an effort to further clarify the status of specimens collected during field assessments, the system employed by the WAM has been expanded to include likely and unlikely SRE sub-categories that fall within the larger potential SRE category (Table 3.5). To assign a species to one of these sub-categories, the habitat associated with the record is assessed to determine its likelihood of hosting SRE species. Further to this, related species at a generic or family level are examined to identify any confirmed SRE species within the group. The combination of habitat preference and prevalence of short range endemism in closely related species can be indicators as to a species likelihood of being an SRE. Following the Precautionary Principle, all data deficient species from known SRE target groups are regarded as potential short range endemics.

Table 3.5: SRE Categories

<table>
<tr><th>Categories</th><th colspan="2">Defining Characteristics</th></tr>
<tr><td>Confirmed SRE</td><td colspan="2">• Known distribution of <10,000 km$^{2.}$
• Taxonomy is well understood.
• Species is well represented in collections.
• Region of occurrence has been comprehensively sampled.</td></tr>
<tr><td rowspan="2">Potential SRE</td><td rowspan="2">• Limited sampling has resulted in incomplete knowledge of the species distribution.
• Poor or limited taxonomic resolution.
• Species not well represented in collections.</td><td>Likely SRE
• Belongs to a group (infraorder, family, or genera) containing a high proportion of confirmed SRE species.
• Occurs within isolated, sheltered and/ or non-contiguous habitat types associated with SRE taxa.</td></tr>
<tr><td>Unlikely SRE
• Belongs to a group (infraorder, family, or genera) containing a low proportion of confirmed SRE species.
• Recorded from a single or multiple exposed, regionally extensive, and contiguous habitat type/s or from a habitat type not typically associated with SRE taxa.</td></tr>
<tr><td>Not SRE</td><td colspan="2">• Known distribution of >10,000 km$^{2.}$
• Taxonomy is well understood.
• Species is well represented in collections.
• Region of occurrence has been comprehensively sampled.</td></tr>
</table>

3.4. Determination of Survey Design

The level of existing fauna and fauna habitat knowledge was assessed for the region within which the Survey Area was located. A total of one single phase Level 2 vertebrate fauna survey, and three targeted vertebrate fauna surveys have previously been completed in the local region (Table 3.2). One previous SRE invertebrate fauna survey was completed at Cooljarloo West by Bennelongia Environmental Consultants (Bennelongia Environmental Consultants, 2013), approximately 18 km south-east of the Survey Area. Regional sites completed during the current survey were located adjacent to the Survey Area (Map 3.2).

To determine the requirements for additional surveys, a Basic terrestrial fauna assessment was completed in early 2020. Based on the results of this assessment it was determined that an additional phase of detailed vertebrate fauna and SRE invertebrate fauna survey was required to complement the previous assessment data. These data include the previous regional fauna surveys (Table 3.2), as well as the Level 2 vertebrate fauna survey that was completed within the Survey Area itself in 2012 (360 Environmental, 2012a). Previous terrestrial fauna survey sites in the region are shown in Map 3.2.

Several infrastructure corridors located outside of the area surveyed during the Detailed fauna assessment were assessed during a Basic fauna survey completed between 20 - 24 September 2021 and on 28 July 2022. These surveys looked to assess habitat types within the infrastructure corridors and record any fauna species observed during the assessment.

3.5. Detailed Fauna Survey

Based on the results of the Basic fauna assessment, Spectrum Ecology completed a second phase of detailed fauna survey to complement the first phase of surveying completed in 2012 (360 Environmental, 2012a). Detailed descriptions for each sampling method are described below, and all methods followed the state and federal legislations and guidelines listed in section 1.3. Systematic sampling methods include standardised repeatable survey techniques that provide data that can be statistically analysed. Opportunistic surveys include a selection of supplementary sampling techniques that allow the collection of additional fauna records that may not be collected during systematic sampling. The combination of sampling methods allows the accurate identification of the local fauna assemblage that is present at the time of sampling.

The survey methods used during the second (current) phase of the detailed survey were designed to align as much as possible with the methods used during the first phase of surveying in 2012 (360 Environmental, 2012a). Survey methods completed during the Basic fauna assessment follow the opportunistic methods as described in section 3.5.3.

3.5.1. Vertebrate Fauna Systematic Sampling

Fauna trapping sites include a suite of trapping techniques designed to detect the local terrestrial fauna assemblage. The trapping grids used during the field survey include the following:

- 20 L bucket and 50 cm PVC pipe pitfall traps: a trapping grid comprised of 5 alternating buckets and PVC pipes, dug into the ground to act as pitfall traps. A 10 m long, 30 cm high fence was also installed, passing across the top of each pit to direct fauna into it.
- Fraser-type funnel traps: similar to Yabbie traps, these were placed at the ends of each fence to capture fauna that are not readily caught in pitfall traps (10 per trapping grid). All funnel traps were covered with shades to reduce the likelihood of animals suffering from overheating.
- Elliott traps: aluminium box traps were baited with 'universal bait' to attract and capture smaller mammals (5 per trapping grid) and re-baited as required. All Elliott traps were covered by shades to reduce the likelihood of animals suffering from overheating.

- Cage traps: larger wire-frame box traps, also baited with 'universal bait', to capture medium-sized mammals (2 per trapping grid) and re-baited as required. All cage traps were covered by shades to reduce the likelihood of animals suffering from overheating.

The layout of each site is detailed diagrammatically in Figure 3.1. Trapping grids were set up in each major fauna habitat type where possible, with each trapping grid surveyed over a seven-night period.

Bird Surveys: Area searches (30 minute set-time searches of 2 ha areas) were used to document the bird assemblage present at each of the systematic fauna trapping sites. During each area search an ornithologist recorded the number of individuals of each species observed while actively searching similar habitat within a 2 ha area surrounding the trapping site. Survey effort was concentrated within three hours of dawn or dusk, as these times are considered optimal for recording most bird species. A minimum of 2 hours of survey were completed at each systematic site.

Bat Surveys: Bat echolocation calls were recorded from each fauna trapping site using Wildlife Acoustics SM4Bat ultrasonic recorders. The SM4Bat device records the full spectrum of calls allowing greater accuracy and sensitivity when identifying bat species. Each SM4Bat device was programmed to record from 30 minutes pre-dusk to 30 minutes post-dawn for each night surveyed. All sites were surveyed for 1-3 nights to identify the bat assemblage present.

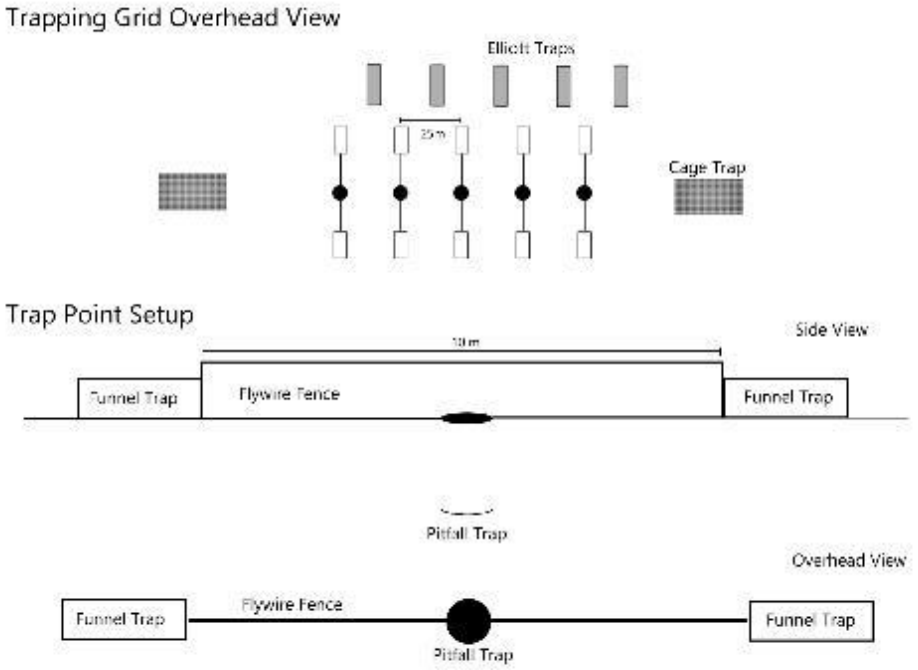


Figure 3.1: Systematic Trapping Grid Layout

3.5.2. SRE Invertebrate Fauna Systematic Sampling

SRE invertebrate fauna species were sampled using the below methods:

- Wet pitfall trapping: Wet pitfall traps consisted of a 1 L plastic jar containing 500-700 ml of mixed preserving solution (active ingredients; Propylene-Glycol and Ethanol). All wet pitfall traps were covered with a bucket lid, situated approximately 1-2 cm above the surface of the ground to prohibit vertebrate species from being trapped. Each wet pitfall site comprised four wet pitfalls which were established in suitable microhabitat and left in-situ for 6 weeks.

- Leaf litter collection: Three 1 m^2 quadrats were collected from each site containing suitable leaf litter or soil. The samples were initially processed using a leaf litter reducer, with the smaller leaf litter components placed into plastic zip-lock bags and transported back to Perth where they were placed under Tullgren funnels to extract the invertebrates.
- Dry pitfall trapping: Dry pitfalls used at systematic trapping sites for vertebrate fauna species (listed above) were concurrently utilised to collect SRE invertebrate species. The pitfalls were left open for seven nights and checked each morning.

3.5.3. Opportunistic Sampling

One limitation of systematic sampling sites is that some species and taxa are difficult to detect due to cryptic behaviours or other ecological considerations, such as fossorial or arboreal species. Systematic survey techniques were therefore supplemented with a suite of opportunistic sampling techniques that target specific species and habitats not normally covered by systematic trapping sites. These active survey techniques are listed below:

- Reptiles and Amphibians: Minimum 20-minute searches of 1 ha areas within the Survey Area by an experienced herpetologist. Microhabitats favored by reptiles and amphibians were searched using various techniques including the raking of leaf litter and soil under shrubs, searching amongst rock piles, and searching under and inside fallen timber. Nocturnal species searches were also performed (when safe access was available) using spotlights and recordings of frog calls, if present.
- Birds: Area searches (20-minute set-time searches of 2 ha areas) were used to document the bird assemblage present at bird-specific habitats, or habitats not already surveyed at systematic trapping sites. Bird species opportunistically observed inside the Survey Area that were not typically recorded during set time searches were also recorded, such as raptors, water birds and nocturnal species.
- Mammals: Mammals observed opportunistically within the Survey Area were also recorded. Tracks, scats and other traces of mammals were recorded and identified where possible. Suitable areas were targeted using additional SM4BAT acoustic devices to record the potential presence of bat species.
- SRE Invertebrate Fauna: Suitable microhabitats were foraged for invertebrates that potentially represent SRE species. Leaf litter and the underside of rocks and logs were closely searched for molluscs, millipedes, isopods, pseudoscorpions and arachnids. If encountered, live snails were also collected from vegetation and trapdoor spider burrows were excavated.
- Motion Cameras: Motion sensitive cameras capable of recording both normal (day) and infra-red (night) images were set up in areas of high fauna interest, such as permanent water features, to record cryptic species not typically observed during field surveys.

3.5.4. Conservation Significant Fauna

A number of species listed under the EPBC Act and/ or BC Act were identified by the literature review as having a medium to high likelihood of occurrence in the Survey Area. These were specifically targeted using the following field survey techniques, whilst all other species were targeted using the methods mentioned above.

- Quenda (*Isoodon fusciventer*) – DBCA Priority 4: Baited (non-food) long-term Motion Cameras (Reconyx HF2X & HP2X) were installed within suitable habitat across the Survey Area. Cameras were deployed 4 weeks prior to the Detailed survey in October. Any opportunistic sightings of the species were recorded including tracks, scats and other traces.

- Western Brush Wallaby (*Notamacropus irma*) – DBCA Priority 4: Baited (non-food) long-term Motion Cameras (Reconyx HF2X & HP2X) were installed within suitable habitat across the Survey Area. Cameras were deployed 4 weeks prior to the Detailed survey in October. Any opportunistic sightings of the species were recorded including tracks, scats and other traces.
- Carnaby's Cockatoo (*Calyptorhynchus latirostris*) – EPBC/ BC Act Endangered: Area searches were used to document the bird assemblage present at each systematic fauna trapping sites. All bird species were targeted during all surveys and any opportunistic sightings or secondary evidence were recorded.
- Malleefowl (*Leiopa ocellata*) – EPBC/ BC Act Vulnerable: All bird species were targeted during all surveys and any opportunistic sightings or secondary evidence were recorded. Suitable habitat within the Survey Area is limited to Heath (Banksia) and is also leaf litter dependent.
- Fork-tailed Swift (*Apus pacificus*) – EPBC/ BC Act Migratory: Area searches were used to document the bird assemblage present at each systematic fauna trapping sites. All bird species were targeted during all surveys and any opportunistic sightings or secondary evidence were recorded.
- Migratory Shorebirds, Seabirds and Waders – EPBC/ BC Act Migratory*: All migratory bird species present were targeted during all surveys and any opportunistic sightings were recorded. Area searches (20-minute set-time searches of 2 ha areas) were used to document the species within suitable habitat including wetland areas and dams.
- Hooded Plover (*Thinornis rubricollis*) – DBCA Priority 4: Area searches were used to document the bird assemblage present during all surveys and any opportunistic sightings or secondary evidence were recorded. Opportunistic surveys were completed in wetland and dam habitat that may be utilised by Hooded Plover.
- Black-striped Burrowing Snake (*Neelaps calonotos*) – DBCA Priority 3: The species was targeted through systematic vertebrate sampling sites and opportunistic sampling searches within suitable habitat. Opportunistic sampling involves searching and raking leaf litter and soil under shrubs, searching amongst rock piles, and searching under and inside fallen timber, within suitable habitat.
- Jewelled Southwest Ctenotus (*Ctenotus gemmula)* – DBCA Priority 3: The species was targeted through systematic vertebrate sampling sites and opportunistic sampling searches within suitable habitat. Opportunistic sampling involves searching and raking leaf litter and soil under shrubs, searching amongst rock piles, and searching under and inside fallen timber, within suitable habitat.

* Certain migratory shorebird species have additional conservation rankings under the EPBC and/or BC Act, see Table 5.1.

3.5.5. Site Selection

Prior to the selection of survey sites, all previous fauna assessments and habitat mapping within the Survey Area were consolidated to allow the identification of survey gaps. Previous survey information, pre-European vegetation mapping and aerial imagery were then utilised to identify fauna habitats expected to occur within the Survey Area. The number of previous survey sites located in each habitat type was also determined to allow further identification of survey gaps. Both systematic and opportunistic survey sites were established across all representative habitat types. Survey site locations are detailed in Appendix B and shown on Map 3.1.

3.5.6. Survey Effort

During the first phase of Detailed (previously known as Level 2) survey (360 Environmental, 2012a), eight systematic trapping sites incorporating bat recorders were installed for seven nights. For consistency, eight systematic trapping sites were also installed during the current (second phase) of survey, as close as possible to the original first phase site locations. The second phase survey included wet pitfall trapping and leaf litter sampling for SRE invertebrates and twenty motion camera sites.

The Basic fauna assessment completed between 22 - 24 January 2020 included 21 habitat assessment/ active search and foraging sites, five motion camera, three bat recorder and four leaf litter collection sites.

Two additional Basic fauna assessments were completed to survey the infrastructure corridors The Basic fauna assessment completed between 20 - 24 September 2021 included 39 habitat assessment sites with active searches completed at each site, and opportunistic observations made whilst walking transects through the infrastructure corridors. A further 18 sites, including habitat assessments and active searches, were completed during the Basic fauna assessment conducted on 28 July 2022.

Additional relevant sites completed during other fauna assessments outside of the Survey Area includes 144 traps, resulting in 1,054 trap nights as part of the Cooljarloo West Development Envelope Project Assessment (Bamford, Bancroft and Turpin, 2015). Previous survey site locations are shown on Map 3.2.

A summary of the survey effort undertaken within the Survey Area is detailed in Table 3.6. This included:

- Eight trapping grids were established for both the first and second phase for seven nights each.
- 123.6 hours were spent conducting bird surveys.
- 88.3 hours of diurnal searches were completed.
- 116 hours of bat recordings were analysed.
- 10 hours of nocturnal searches were completed.
- 1,210 camera trap nights were analysed from 30 camera point locations.
- 224 cage trap nights were completed.
- 1,088 nights of SRE wet pitfall trapping were completed at eight sites.
- 12 leaf litter samples were collected and sieved for SRE invertebrate fauna.

Table 3.6: Survey Effort Completed Within the Survey Area

Survey	Survey Timing	Trap Nights					No. Sites		Survey Effort (hrs)			Bat Recorders (nights)	Motion Cameras
		Person Days	Pit	Funnel	Elliott	Cages	SRE Wet Pitfall	Leaf Litter	Diurnal Searches	Bird Surveys	Nocturnal		
360 Environmental, 2012	15-24 Nov 2011	40*	161	175	560	112	-	-	18.3	≥80	4	48	-
Basic Fauna Assessment	22-24 Jan 2020	6	-	-	-	-	-	4	7	7	-	8	10
Detailed Fauna Assessment	14-24 Oct 2020	52	280	560	280	112	8	8	43	16.6	6	60	1,200
Basic Fauna Assessment	20-24 Sep 2021	4	-	-	-	-	-	-	14	14	-	-	-
Basic Fauna Assessment	28 July 2022	2	-	-	-	-	-	-	6	6	-	-	-
Total		102	441	735	840	224	8	12	88.3	123.6	10		1,210

*Not included in report, conservative estimate.

324000
327000
330000
333000
336000
339000
6624000
6621000
6618000
6615000
6612000

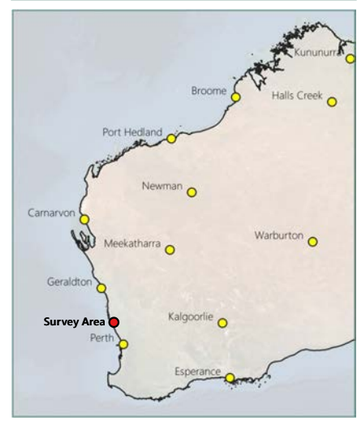
Legend

Survey Area

Survey Sites

- Bat recorder
- Habitat Assessment, Active search/Forage
- Motion Camera
- Nocturnal Site
- Opportunistic Site
- SRE leaf litter
- SRE wet pitfall
- Trapping Site

Survey Tracks



N

0 0.5 1 km

Scale 1:50,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY & SPATIAL

Author: JV Approved: DC Date: 16-09-2022

Survey Site Locations

Atlas Project

Prepared for
Preston Consulting |
Image Resources

MAP
3.1

315000 330000 345000 360000 375000

6645000 6630000 6615000 6600000

Legend

- Survey Area

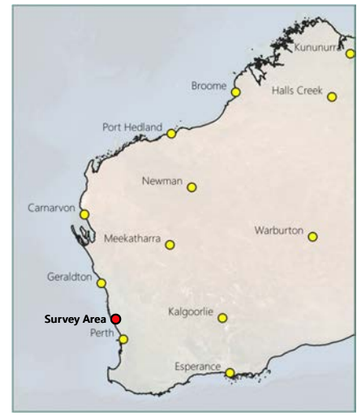
360 Environmental (2012)
- Fauna Trapping Site
- Opportunistic Site

Bennelongia (2012)
- Trapping
- Foraging
- Light trap

Bamford Consulting Ecologists (2015)
- Fauna Trapping Site
- Bird Survey Site

ecologia Environment (2017)
- Bird Survey Site

Spectrum Ecology (2020)
- Opportunistic Site
- Bat Recorder
- Motion Camera
- Habitat Assessment
- Leaf Litter Collection



N

0 2 4 6 8 km

Scale 1:220,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum

Author: JV Approved: DC Date: 15-09-2022

Previous and Regional Survey Sites

Atlas Project

Prepared for
Preston Consulting | Image Resources

MAP 3.2

3.5.7. Survey Timing

The field surveys completed within the Survey Area are summarised below with both trapping surveys being completed in Spring. SRE wet pitfall traps and motion cameras (Reconyx HF2X) were installed for five weeks before being collected during the trapping survey.

- Detailed terrestrial vertebrate fauna phase 1 (360 Environmental, 2012a): 15-24 November 2011.
- Basic terrestrial fauna survey: 22-24 January 2020.
- SRE wet pitfall trap/motion camera installation: 14-15 September 2020.
- Detailed terrestrial fauna survey phase 2: 14-24 October 2020.
- Basic terrestrial fauna survey: 20-24 September 2021.
- Basic terrestrial fauna survey: 28 July 2022

The Survey Area is located within the Southwest Botanical Province as described by Beard (Beard, 1980). The Technical Guidance (EPA 2016a, EPA 2020a) recommends terrestrial fauna surveys in this region be completed October – December to coincide with peak reptile, bird and mammal activity. Migratory bird species typically arrive in large numbers between November and March though early arrivals and juveniles that have over-wintered in Australia may be encountered in October. Peak periods of amphibian activity are highly variable, typically rainfall driven, and can occur at any time of year dependent on the individual species ecology.

Although the survey timing for the detailed survey fell just outside of the peak period of activity for autumn-winter breeding amphibians the timing allowed for potential records of early migratory bird species. The Technical Guidance also states that some compromise in timing may be required due to generally lower temperatures in spring pushing survey timing into late spring.

Generally, a two-season survey is preferred to coincide with peak fauna activity, where possible. Completing both phases of the field survey in October/November was effective due to relatively mild spring temperatures and recent winter rains, resulting in moderate species activity with reptiles entering periods of greater activity.

3.5.8. Taxonomy and Nomenclature

Nomenclature for mammals, birds, reptiles, and amphibians followed the Western Australian Museum Checklist of the Vertebrates of Western Australia (April 2020). Fauna species identifications were completed based on information provided in references listed in Table 3.7.

Table 3.7: Species Identification References

Fauna Group	Reference
Mammals	Churchill (2009), Menkhorst and Knight (2001), van Dyck and Strahan (2008)
Birds	Menkhorst *et al.* (2019)
Reptiles & Amphibians	Wilson and Swan (2021), Cogger (2014), Tyler and Doughty (2009)

3.5.9. Animal Ethics

Any disturbance of animals by the various capture or sampling methods involved followed the state and federal legislation and guidelines. The survey methods also followed the DBCA Standard Operating Procedures (SOPs) listed below (DBCA 2019):

- Aluminium Box Traps for Capture of Terrestrial Vertebrates.
- Cage Traps for Live Capture of Terrestrial Vertebrates.
- Dry Pitfall Trapping for Vertebrates.
- Funnel Trapping for Terrestrial Fauna.
- Animal Handling and Restraint using Soft Containment.
- Hand Capture of Wildlife.
- Hand Restraint of Wildlife.
- Transport and Temporary Holding of Wildlife.

Survey timing is also a significant factor when considering animal welfare. The survey must be completed at a time when the target fauna groups are active and detectable but not during a time of year when extreme weather events are likely. High temperatures and flooding can lead directly to fauna stress and/ or death or indirectly by restricting access to trapping sites. Vertebrate fauna was only handled as necessary for the purposes of species identification.

3.5.10. Survey Team and Licence

The field survey and assessment report were completed by the staff listed in Table 3.8 below. The field survey was conducted under DBCA Regulation 27 license BA27000302.

Table 3.8: Project team

Staff	Role	Years of Experience
Fauna		
Damien Cancilla	Principal Zoologist (field survey and reporting)	14 years
Astrid Heidrich	Principal Zoologist (field survey)	12 years
Jordan Vos	Senior Zoologist (field survey and reporting)	11 years
Jesse Harper	Senior Zoologist (field survey and reporting)	7 years
Nicola Palmer	Senior Zoologist (field survey and reporting)	8 years
Dr Floyd Holmes	Zoologist (field survey and reporting)	2 years
Melinda Henderson	Zoologist (field survey and reporting)	2 years
Susan Murrey	Ecologist (field survey)	2 years
Marcus Cosentino	Zoologist (field survey)	10 years
Geoffrey Schoonakker	Zoologist (field survey)	1 year
Lachlan Petersen	Zoologist (field survey)	1 year
Gabrielle Beca	Zoologist (reporting)	2 years

3.5.11. Survey Limitations

Survey limitations are unforeseen events that can limit the effectiveness of the field survey to achieve the required objectives. Overall, no significant limitations were experienced during the field survey. Specific potential limitations are addressed below in Table 3.9.

Table 3.9: Survey Limitations

Limitation	Constraint	Comment
Competency/experience of the consultant carrying out the survey.	No	The zoologists that completed the field survey were highly experienced conducting terrestrial fauna surveys in the south west region.
Scope (what faunal groups were sampled and were some sampling methods not able to be employed because of constraints such as weather conditions).	No	Sampling techniques were designed for a detailed terrestrial fauna assessment. All fauna groups were sampled, and no survey constraints were experienced that limited sampling of specific groups.
Proportion of fauna identified, recorded and/or collected.	No	All vertebrate fauna species encountered were identified in the field. Invertebrate fauna specimens were collected for identification by Bennelongia Environmental Consultants taxonomists.
Sources of information.	No	Database searches and previous survey reports provided a significant level of information, adequate to guide field survey design and effort.
The proportion of the task achieved and further work which might be needed.	No	All components of a detailed vertebrate fauna and SRE assessment were completed during the field survey. The combination of previous and current survey work gives a comprehensive understanding of the fauna values of the Survey Area.
Timing/weather/season/cycle.	No	The survey was conducted during suitable seasonal conditions for a detailed survey, and all dominant fauna groups, assemblages and major fauna habitat types were recorded.
Disturbances (e.g. fire, flood, accidental human intervention) which affected results of survey.	No	No disturbances were recorded during the survey.
Intensity (in retrospect, was the intensity adequate).	No	The completed detailed assessment was adequate to identify the fauna assemblages and habitats present within the Survey Area. Sufficient targeted searches for conservation significant fauna and SRE species were completed within areas of suitable habitat.
Completeness (was the relevant area fully surveyed.	No	All major fauna habitat types were sampled and defined. Habitat types that may host conservation significant fauna species were adequately surveyed.
Resources (degree of expertise available in animal identification to taxon level).	No	The experience level of the zoologists present was sufficient to identify all species accurately. Resources available were adequate and did not compromise the outcome of the survey.
Remoteness and/or access problems.	No	No issues were encountered in accessing the site and suitable access tracks were available throughout.
Availability of contextual (e.g. biogeographic) information on the region.	No	Background information about the region was available and sufficient.

3.6. Fauna Habitat Mapping

Fauna habitat mapping identifies areas of vegetation and land features that are distinguishable from other areas. Typically, each fauna habitat supports a characteristic fauna assemblage that is adapted to the features of the fauna habitat. Fauna habitat types are identified and mapped based on the following information:

- General vegetation type (Shepherd, Beeston and Hopkins, 2001);
- Vegetation Types mapped within the Survey Area;
- Vegetation structure;
- Landforms;
- Geological units;
- Soil substrate;
- Aerial imagery;
- Fauna assemblage; and
- Field observations.

The fauna habitat was recorded at each habitat assessment and survey site and opportunistically while traversing the Survey Area.

3.6.1. Black Cockatoo Habitat Assessment

The assessment of Black Cockatoo habitat followed the *Black Cockatoo referral guidelines* (DSEWPaC 2012) and the *revised draft referral guideline for three threatened black cockatoo species* (Commonwealth of Australia, 2017).

The scoring tool included in these documents (Table 3.10) was used to determine if the Survey Area contains quality foraging habitat. Information on the following was collected:

- The presence of all plant species that provide foraging, including non-native food sources used by black cockatoos;
- The presence of tree species used for breeding;
- Use as a roosting site;
- The vegetation present in the surrounding area, i.e. at least 12 km from the impact area, including proximity to any breeding habitat, roosting sites and watering points;
- Breeding habitat, such as an estimate of the number of trees with a diameter of ≥ 500 mm or ≥ 300 mm for salmon gum or wandoo at breast height (1.3 m from the ground);
- Numbers of any known nesting trees; and
- Presence of disease, such as *Phytophthora cinnamomi* or Marri canker (*Quambalaria coyrecup*).

Each potential breeding tree was also scored for suitability for breeding and the presence or absence of suitable tree hollows was noted.

Table 3.10: Commonwealth foraging quality scoring tool (DoEE 2017)

Starting Score	Foraging habitat for Carnaby's Black-Cockatoo	Foraging habitat for Baudin's Black-Cockatoo	Foraging habitat for Forest Red-tailed Black-Cockatoo
10 (very high quality)	Foraging habitat that is being managed for black cockatoos such as habitat that is the focus of successful rehabilitation, and/or has some level of protection from clearing, and/or is quality habitat described below with attributes contributing to meet a sore of ≥10.	Foraging habitat that is being managed for black cockatoos such as habitat that is the focus of successful rehabilitation, and/or has some level of protection from clearing, and/or is quality habitat described below with attributes contributing to meet a sore of ≥10.	Foraging habitat that is being managed for black cockatoos such as habitat that is the focus of successful rehabilitation, and/or has some level of protection from clearing, and/or is quality habitat described below with attributes contributing to meet a sore of ≥10.
7 (High quality)	Native shrubland, kwongan heathland and 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, including along roadsides. Does not include orchards, canola, or areas under a RFA.	Native eucalypt woodlands and forest, and proteaceous woodland and heath, particularly Marri, including along roadsides. Does not include orchards or areas under a RFA.	Jarrah and Marri woodlands and forest, and edges of karri forests, including wandoo and blackbutt, within the range of the subspecies, including along roadsides. Does not include areas under a RFA.
5 (Quality)	Pine plantation or introduced eucalypts.	Pine plantation or introduced eucalypts.	Pine plantation or introduced eucalypts.
1 (Low quality)	Individual foraging plants or small stand of foraging plants.	Individual foraging plants or small stand of foraging plants.	Individual foraging plants or small stand of foraging plants.
Additions	**Context adjustor – attributes improving functionality of foraging habitat**	**Context adjustor – attributes improving functionality of foraging habitat**	**Context adjustor – attributes improving functionality of foraging habitat**
+3	Is within the Swan Coastal Plain (important foraging area).	Is within the known foraging area (see guidelines).	Jarrah and/or Marri show good recruitment (i.e. evidence of young trees).
+3	Contains trees with suitable nest hollows.	Contains trees with suitable nest hollows.	Contains trees with suitable nest hollows.
+2	Primarily contains Marri.	Primarily contains Marri.	Primarily contains Marri and/or Jarrah.
+2	Contains trees with potential to be used for breeding (dbh ≥ 500 mm or ≥ 300 mm dbh for Salmon Gum and Wandoo).	Contains trees with potential to be used for breeding (dbh ≥ 500 mm or ≥ 300 mm dbh for Salmon Gum and Wandoo).	Contains trees with potential to be used for breeding (dbh ≥ 500 mm or ≥ 300 mm dbh for Salmon Gum and Wandoo).
+1	Is known to be a roosting site.	Is known to be a roosting site.	Is known to be a roosting site.
Subtractions	**Context adjustor – attributes reducing functionality of foraging habitat**	**Context adjustor – attributes reducing functionality of foraging habitat**	**Context adjustor – attributes reducing functionality of foraging habitat**
-2	No clear evidence of feeding debris.	No clear evidence of feeding debris.	No clear evidence of feeding debris.

Starting Score	Foraging habitat for Carnaby's Black-Cockatoo	Foraging habitat for Baudin's Black-Cockatoo	Foraging habitat for Forest Red-tailed Black-Cockatoo
-2	No other foraging habitat within 6 km.	No other foraging habitat within 6 km.	No other foraging habitat within 6 km.
-1	Is >12 km from a known breeding location.	Is >12 km from a known breeding location.	Is >12 km from a known breeding location.
-1	Is > 12 km from a known roosting location.	Is > 12 km from a known roosting location.	Is > 12 km from a known roosting location.
-1	Is >2 km from a watering point.	Is >2 km from a watering point.	Is >2 km from a watering point.
-1	Disease present (e.g. *Phytophthora cinnamomic* or Marri canker).	Disease present (e.g. *Phytophthora cinnamomic* or Marri canker).	Disease present (e.g. *Phytophthora cinnamomic* or Marri canker).

3.7. Data Analysis

Only systematically collected data can be analysed because any mathematical comparison requires standardised sampling effort between variables. As such, only the results of the trapping grids or set-time bird surveys can be used for habitat analysis and survey adequacy tests. In this case, the variables are the seven trapping grid nights and six to eight surveys at each of the bird sites. The difference in systematic survey methods used between the trapping grids and bird surveys means that each of these data sets were analysed separately. For both the habitat and SAC analyses, opportunistic records such as those from motion cameras or active searches were excluded because the variables and sampling effort between sites are not standardised.

3.7.1. Habitat Analysis

Fauna habitat mapping enables the categorisation of each survey site into different habitats, and analysis of this data provides insight into how distinct or similar the fauna assemblages in each habitat type are. One method is non-metric multidimensional scaling (non-metric MDS), which is based on a distance matrix computed with a range of distance measures, whereby an algorithm attempts to place the data points in a theoretical two- or three-dimensional coordinate system whilst preserving the ranked differences in terms of their Euclidean distance from others (Hammer and Harper and Ryan, 2001). In this case, the Bray-Curtis similarity algorithm was used because it appropriately quantifies the compositional similarity/dissimilarity between two sites with abundance data.

Another habitat comparison method is the use of cluster analysis, whereby a hierarchical clustering routine creates a dendrogram showing how survey site data are clustered and whether this matches the respective habitat types (Hammer and Harper and Ryan, 2001). The algorithm used (Bray-Curtis as an index) effectively joins clusters (or sites) together based upon the average distance between data in the two groups. A group can be a single site or several, and the level (or value) at which they join indicates how similar the two groups are, where an index value of 1 equals 100% similarity.

3.7.2. Survey Adequacy

Survey adequacy can, in part, be assessed by estimating species richness from sample data. Extrapolating Species Accumulation Curves (SACs), fitting parametric models or relative abundance and using non-parametric estimators (Bunge and Fitzpatrick, 1993; Colwell and Coddington, 1994; Gaston, 1996) are three generally accepted methods that achieve this. Species Accumulation Curves graphically illustrate the accumulation of species along a timeline and this method was used to analyse the data from the current

field survey. At the point the horizontal asymptote is reached, it is estimated that no new species are present. In an effort to eliminate the impact of random or periodic temporal variation, the sample order was randomised 1,000 times using EstimateS (Colwell, 2016). As a stopping-rule technique, a Michaelis-Menten enzyme kinetic curve was calculated to estimate the theoretical maximum number of species present at each systematic survey site.

Data for fauna groups sampled using the same systematic technique was used for the analyses. Firstly, for the mammals, reptiles and amphibians caught in trapping grids, and secondly for the set-time bird surveys. For both the habitat and SAC analyses, opportunistic records such as those from motion cameras or active searches cannot be included because the variables and sampling effort between sites are not standardised.

3.8. SRE Invertebrate Fauna Identification

All invertebrate fauna specimens collected during the current survey were provided to Bennelongia Environmental Consultants (Bennelongia), where they were identified to the highest possible taxonomic level. Leaf litter samples were handed over immediately following the field survey to ensure maximum survivorship before the samples were placed in Tullgren funnels. Invertebrate specimens from the wet and dry pitfall traps were also sorted and labelled by Spectrum staff before identification by Bennelongia taxonomists.

DNA analysis was completed for SRE taxa that required additional taxonomic clarification. Details of the analysis are present in Appendix D.

4. RESULTS

4.1. Desktop Assessment

4.1.1. Vertebrate Fauna

The literature review and database searches identified 19 non-volant native mammals, five introduced mammals, seven bats, 190 birds, 64 reptiles and 11 amphibians in the region surrounding the Survey Area (Appendix C). A summary of the total number of species identified during the desktop assessment is presented in Table 4.1.

The desktop assessment identified 48 significant vertebrate fauna species and four significant invertebrate fauna species: seven non-volant mammals, one bat, 34 birds, six reptiles and four invertebrates. Obligate marine species and seabirds have been excluded from the assessment due to no coastal or marine habitat being present within the Survey Area.

Consultancy 360 Environmental opportunistically recorded a single Western Brush Wallaby (*Notamacropus irma*; DBCA Priority 4*)* within the Survey Area during the previous Level 2 survey (360 Environmental, 2012a). Although also recording Western Brush Wallaby just outside the Survey Area, the Basic fauna assessment did not record any further conservation significant species inside the Survey Area.

The results of the regional DBCA Threatened Fauna Database search are shown on Map 4.1 and the location of all significant species recorded from the Survey Area are detailed in Table 4.4 and shown on Map 4.6.

Table 4.1: Summary of Vertebrate Fauna Species Previously Recorded

Data Source	Level of Survey	Non-volant Mammals (Native/ Introduced)	Birds	Bats	Reptiles	Amphibians	Total
Within Survey Area							
Atlas Tenement (360 Environmental, 2012a)	Level 2	3/5	54	6	22	7	**97**
Regional Surveys							
Cooljarloo West (Bamford, Bancroft and Turpin, 2015)	Level 2	7/1	36	-	19	6	**69**
Yandin Wind Farm (ecologia Environment, 2017)	Targeted	-	44	-	-	-	**44**
Database Searches							
DBCA Threatened Fauna Database	-	5/0	29	1	5	-	**40**
NatureMap	-	19/4	172	5	62	11	**273**
PMST	-	3	19	-	2	-	**24**
Total		**19/5**	**190**	**7**	**64**	**11**	**296**

290000 300000 310000 320000 330000 340000 350000 360000 370000 380000

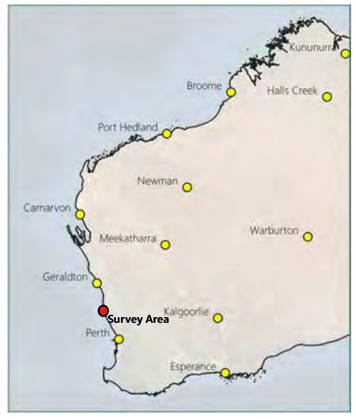
6660000 6650000 6640000 6630000 6620000 6610000 6600000 6590000 6580000

Legend

Survey Area

Database Results

- Woylie
- Dibbler
- Ghost Bat
- Quenda
- Western Brush Wallaby
- Tammar Wallaby
- Carnaby's Cockatoo
- Malleefowl
- Fork-tailed Swift
- Bar-tailed Godwit
- Curlew Sandpiper
- Great Knot
- Lesser Sand Plover
- Red Knot
- Common Greenshank
- Black-tailed Godwit
- Caspian Tern
- Long-toed Stint
- Pacific Golden Plover
- Pectoral Sandpiper
- Red-necked Stint
- Ruddy Turnstone
- Sanderling
- Sharp-tailed Sandpiper
- Glossy Ibis
- Wood Sandpiper
- Peregrine Falcon
- Hooded Plover
- Greater Sand Plover
- Fairy Tern
- Crested Tern
- Grey Plover
- Roseate Tern
- Blue-billed Duck
- Western Ground Parrot
- Black-striped Snake
- Jewelled Southwest Ctenotus
- Western Spiny-tailed Skink
- Jurien Bay Skink
- Lancelin Island Skink
- Bothriembryontid Land Snail
- Spiny Katydid
- Woolybush Bee
- Graceful Sunmoth



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Scale:300,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY & SPATIAL

Author: MH Approved: DC Date: 12-09-2022

DBCA Threatened Fauna Database Results

Atlas Project

Prepared for
PRESTON CONSULTING
IMAGE RESOURCES

MAP
4.1

4.1.2. SRE Invertebrate Fauna

The Western Australian Museum Invertebrate Database search identified a total of 24 potential short range endemic species in the region surrounding the Survey Area. The list is comprised of 10 Arachnids (a mite, eight spiders and a scorpion), 13 Diplopods (millipedes) and one Gastropod (snail). An additional Chilopod (centipede), two Isopods (wood lice) and an Oligochaeta (earthworm) were identified by the literature review. Many of the species identified were collected at Cooljarloo, approximately 18 km southeast of the Survey Area. The search results and their relevant details are listed in Table 4.2 and mapped in Map 4.2.

Table 4.2: WAM Invertebrate Database Results and Literature Review Records

Family and Species	Previous Records	Additional Information
ARACHNIDA		
Acari		
Erythraeidae		
Leptus minno	Multiple records from Coomallo Creek, 31 km north of the Survey Area.	Mite species recorded in 1991.
Araneae		
Anamidae		
Aname `MYG632`	Multiple specimens collected from Mt Lesueur National Park and the Coorow-Greenhead Rd. Nearest record is located 32 km north of the Survey Area.	Wishbone Trapdoor Spider (Mygalomorphae) collected in 2016.
Idiopidae		
Bungulla banksia	Multiple records both north and south of the Survey Area. The two nearest specimens were collected from Cooljarloo, 18 km southeast of the Survey Area.	Armoured Trapdoor Spider (Mygalomorphae). The specimen nearest to the Survey Area was collected in 2007.
Bungulla riparia	Recorded from both Mt Misery and Mt Lesueur, 37 km east and 38 km north respectively.	Armoured Trapdoor Spider (Mygalomorphae). Mt Misery specimens were collected in 1956, Mt Lesueur in 1989.
Euoplos mcmillani	Recorded from multiple locations both southeast and north of the Survey Area. The nearest record is located 18 km southeast of the Survey Area at Cooljarloo.	Armoured Trapdoor Spider (Mygalomorphae). The specimens nearest to the Survey Area were collected in the vicinity of Cooljarloo in both 2010 and 2014.
Idiosoma gardneri	Two records from Mt Lesueur, 38 km north of the Survey Area.	Mt Lesueur Shield-backed Trapdoor Spider (Mygalomorphae). Both specimens were collected in 1989. This species is also listed by the DBCA as Priority 2.
Idiosoma kwongan	Specimens collected from three locations, the nearest located 40 km north of the Survey Area near Mt Lesueur.	Kwongan Heath Shield-backed Trapdoor Spider (Mygalomorphae). Eight specimens collected between 1980-90 from three locations. This species is also by the DBCA as Priority 1.
Idiosoma `MYG221`	Specimens collected from Cooljarloo, 18 km southeast of the Survey Area.	Shield-backed Trapdoor Spider. Specimens collected in 2010. The *Idiosoma* genus is known to host range restricted and threatened species.

Family and Species	Previous Records	Additional Information
Idiosoma `MYG222`	Specimens collected from Cooljarloo, 18 km southeast of the Survey Area.	Shield-backed Trapdoor Spider. Specimens collected in 2010. The *Idiosoma* genus is known to host range restricted and threatened species.
Scorpiones		
Urodacidae		
Urodacus 'sp. nov. Gairdner Range'	Two specimens collected 21 km north of the Survey Area in the Gairdner Range.	Scorpion. Specimens collected in 1990.
CHILOPODA		
Geophilomorpha		
Mecistocephalidae		
Mecistocephalus sp. B07	One specimen collected at Cooljarloo, approximately 18 km southeast of the Survey Area.	Record from previous regional survey report (Bennelongia Environmental Consultants, 2013).
DIPLOPODA		
Polydesmida		
Paradoxosomatidae		
Antichiropus sulcatus	Multiple records north and southeast of the Survey Area. The nearest record is from 13 km southeast.	Millipede. The most recent records of this species are from 2018 at Cooljarloo.
Antichiropus whistleri	Multiple records east and southeast of the Survey Area, the nearest located 11 km east at Cooljarloo.	Millipede. The most recent records of this species are from 2018 at Cooljarloo.
Antichiropus `cooljarloo`	Collected from two sites at Cooljarloo, 15 km east of the Survey Area.	Millipede. Specimens collected in both 2014 and 2017. The genus *Antichiropus* is known to contain range restricted and threatened species.
Antichiropus `DIP057`	Collected from two locations, 18 km southeast of the Survey Area at Cooljarloo and 67 km north at Eneabba.	Millipede. The most recent specimens were collected at Cooljarloo in 2012. The genus *Antichiropus* is known to contain range restricted and threatened species.
Antichiropus `DIP076`	Collected from two locations, 17 km southeast of the Survey Area at Cooljarloo and 67 km north at Eneabba.	Millipede. The most recent specimens were collected at Cooljarloo in 2010. The genus *Antichiropus* is known to contain range restricted and threatened species.
Antichiropus `DIP160, cataby`	Collected from two locations near Cataby, 32 km southeast of the Survey Area.	Millipede. The most recent specimens were collected in 2017. The genus *Antichiropus* is known to contain range restricted and threatened species.
Antichiropus `GI/UBS1`	Collected at Beekeepers Nature Reserve, 30 km northwest of the Survey Area.	Millipede. Four specimens were collected in 2008. The genus *Antichiropus* is known to contain range restricted and threatened species.
Antichiropus `GI`	Two specimens collected at Ranger Cave (Nambung National Park), 16 km west of the Survey Area.	Millipede. Two specimens were collected in 1995. The genus *Antichiropus* is known to contain range restricted and threatened species.

Family and Species	Previous Records	Additional Information
Antichiropus `ML1`	Recorded from multiple sites near Mt Lesueur, 38 km north of the Survey Area. Also recorded from a second location further east at Coomallo Hill.	Millipede. The Mt Lesueur and Coomallo Hill specimens were collected in 1989 and 2006 respectively. The genus *Antichiropus* is known to contain range restricted and threatened species.
Antichiropus `Mt Lesueur 2`	Recorded from two locations near Mt Lesueur, approx. 40 km north of the Survey Area. Also known from Alexander Morrison National Park, 61 km northeast of the Survey Area.	Millipede. The Mt Lesueur and Alexander Morrison National Park specimens were collected in 1989 and 1999 respectively. The genus *Antichiropus* is known to contain range restricted and threatened species.
Antichiropus `UBS2?`	Recorded from one location at Cooljarloo, 18 km southeast of the Survey Area.	Millipede. Eight specimens were collected in 2010. The genus *Antichiropus* is known to contain range restricted and threatened species.
Antichiropus `whistleri?`	Collected from two locations, 127 km apart. At Lesueur National Park and Boonanarring Nature Reserve, 37 km north and 87 km southeast.	Millipede. Specimens were collected at Boonanarring in 2017 and Mt Lesueur in 2018. The genus *Antichiropus* is known to contain range restricted and threatened species.
Polyzoniida		
Siphonotidae		
`Vombatotus lesueuri`	Two specimens collected from the Mt Lesueur area, 40 km north of the Survey Area.	Millipede. Two specimens were collected in 1989.
CRUSTACEA		
Isopoda		
Armadillidae		
Acanthodillo sp. B09	Two specimens collected at Cooljarloo, approx. 18 km southeast of the Survey Area.	Record from previous regional survey report (Bennelongia Environmental Consultants, 2013).
Platyarthridae		
Trichorhina sp. B14	Four specimens collected at Cooljarloo, approx. 18 km southeast of the Survey Area.	Record from previous regional survey report (Bennelongia Environmental Consultants, 2013).
MOLLUSCA		
Gastropoda		
Bothriembryontidae		
Bothriembryon perobesus (Moore River)	Known from many locations surrounding the Survey Area. The nearest record is from near Cervantes, 18 km west of the Survey Area.	Land Snail. Records exist from between 1955 and 2017. The Moore River population is listed as Priority 1 by the DBCA. Also recorded at Cooljarloo (Bennelongia Environmental Consultants, 2013).
OLIGOCHAETA		
Oligochaeta sp.	One specimen collected at Cooljarloo, approx. 18 km southeast of the Survey Area.	Record from previous regional survey report (Bennelongia Environmental Consultants, 2013).

300000

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Legend

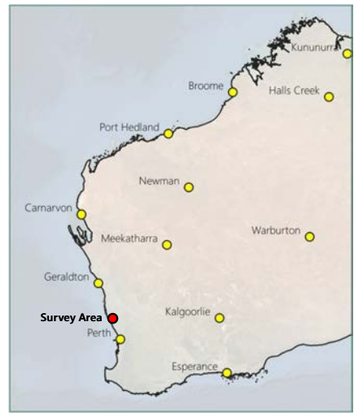
Survey Area

WAM Myriapods and Arachnids Database

- Aname `MYG632`
- Antichiropus `cooljarloo`
- Antichiropus `DIP057`
- Antichiropus `DIP076`
- Antichiropus `DIP160, cataby`
- Antichiropus `GI/UBS1`
- Antichiropus `GI`
- Antichiropus `ML1`
- Antichiropus `Mt Lesueur 2`
- Antichiropus `UBS2?`
- Antichiropus `whistleri?`
- Antichiropus sulcatus
- Antichiropus whistleri
- Bungulla banksia
- Bungulla riparia
- Euoplos mcmillani
- Idiosoma `MYG221`
- Idiosoma `MYG222`
- Idiosoma gardneri
- Idiosoma kwongan
- Leptus minno
- Urodacus `sp. nov. Gairdner Range`
- `Vombatotus` `lesueuri`

WAM Mollusc Database

- Bothriembryon perobesus



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0 5 10 km

Scale 1:340,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum

Author: JV Approved: DC Date: 12-09-2022

WAM SRE Database Results

Atlas Project

Prepared for
Preston Consultancy | Image Resources

MAP 4.2

4.2. Fauna Habitats

Seven fauna habitat types were identified during the first phase survey (360 Environmental, 2012a), however the extent of each habitat type was revised during the current study due to several inconsistencies with the vegetation mapping (360 Environmental, 2012c), and recent observations in the field. A small area of Eucalypt Woodland habitat was defined, and the Degraded Banksia Woodland habitat was incorporated into Banksia Woodland or Pasture based on the habitat characteristics of each area and how fauna may respond to the specific level of degradation. Two ecotone areas of mixed Banksia Woodland / Heath (Banksia) and Melaleuca / Samphire have been mapped separately as they would be expected to support both fauna assemblages. An ecotone is a transitional zone between habitats or ecological communities, often hosting species from each.

The current assessment encompassed the areas surveyed during the previous Level 2 survey and (360 Environmental, 2012a) with the addition of a linear corridor running east to west on the western side of the Survey Area. The extents of the seven revised fauna habitat types and two ecotones within the Survey Area are listed in Table 4.3 and shown on Map 4.3.

Table 4.3: Fauna Habitat Types

Habitat Type	Associated Vegetation Type *	Extent in Survey Area (ha)	% Survey Area
Banksia Woodland	Bp, BaBm	695.3	54.3
Pasture / Cleared	n/a	231.4	18.1
Heath (Banksia)	BtRc, MbTi/BtRc, MbTi/MbGcVp/BtRc	189.1	14.8
Samphire	MrMv, TEC, Ti	69.2	5.4
Melaleuca	MbGcVp, MaMcu, MsVdCaf, MrMtAl, MrHtBt, MrMco, MrMt, Mb, MvMb, MrMvMb, MvMcoMb, BtRc/MvMb, MrMvMco, Ms.	55.0	4.3
Banksia Woodland / Heath (Banksia)	Cr18, CpBt, MNB4, BtRc/Bp, MsGc,	21.6	1.7
Ephemeral Wetland	n/a	13.7	1.1
Melaleuca / Samphire	MbTi, TEC/MvMb, MbTi/MbGcVp	3.9	0.3
Eucalypt Woodland	Er	1.3	0.1
Total		1,280.5	100

*Vegetation codes from Morgan (2021).

4.2.1. Banksia Woodland

Banksia Woodland habitat is the most common habitat type and covers 695.3ha (54.3%) of the Survey Area. This habitat type is mainly located on low rises consisting of deep aeolian white/grey sands located in the southern half of the Survey Area (Plate 4-1). Wood and leaf litter is prevalent, leaf litter particularly so beneath mature *Banksia* and *Adenanthos* sp.

Vegetation associated with Banksia Woodland habitat consists of *Banksia attenuata* with *Banksia menziesii* low woodland (Veg Unit: BaBm) over *Adenanthos cygnorum* subsp. *cygnorum* scattered tall shrubs to high open shrubland (in parts) over a mixed low shrubland (Morgan, 2021). Also associated with this habitat type are small discrete areas of *Banksia prionotes* low woodland (Veg Unit: Bp) which is typically associated with the edges of damp heath.

Plate 4-1: Banksia Woodland Habitat

4.2.2. Pasture / Cleared

Pasture habitat covers 231.4 ha (18.1%) of the Survey Area. The Pasture habitat type is located along the northern edge of the Survey Area and mainly consists of cleared tracks and open farmland typically used to graze livestock (Plate 4-2). Areas of highly degraded Banksia Woodland also form part of this habitat type due to the loss of important habitat characteristics such as a vegetated understorey and the presence of leaf litter beds.

Plate 4-2: Pasture Habitat

4.2.3. Heath (Banksia)

Heath (Banksia) habitat covers 189.1 ha (14.8%) of the Survey Area. This habitat type is mainly located in the northern half of the Survey Area and is associated with damp, low, gentle slopes with white/grey sands (Plate 4-3). Significant wood litter is scarce though leaf litter beds present beneath *Banksia* and dense sedges also provide sheltered microhabitats for fauna.

Vegetation associated with Heath (Banksia) habitat consists of *Banksia telmatiaea*, *Regelia ciliata* dominated heathlands (Veg Unit: BtRc) with a *Melaleuca brevifolia* open shrub layer. This habitat is common in the damper, lower lying areas (Morgan, 2021). This habitat type also forms a transition between dryer areas where *Banksia telmatiaea* is more common to lower damper areas where *Regelia ciliata* and *Melaleuca brevifolia* are more common.

Plate 4-3: Heath (Banksia)

4.2.4. Samphire

Samphire habitat covers 69.2 ha (5.4%) of the Survey Area. An additional 3.9 ha (0.3%) of habitat is formed by a mosaic of Melaleuca and Samphire habitats. This habitat type is associated with low lying areas, often bordering Ephemeral Wetland habitat (Plate 4-4). These areas are partially submerged when sufficient rainfall occurs, altering the salinity levels and by extension the fauna species that occupy the area. Both wood and leaf litter are scarce and what is present does not create significant shelter for fauna.

Vegetation associated with Samphire habitat consists of three vegetation types; tall open shrubland dominated by *Melaleuca rhaphiophylla* (Veg Unit: MrMy), *Tecticornia moniliformis*, *Tecticornia halocnemoides*, *Tecticornia syncarpa* low open samphire shrubland (Veg Unit: TEC), and *Tecticornia indica* subsp. *bidens* low open samphire shrubland (Veg Unit: Ti) (Morgan, 2021).

Plate 4-4: Samphire Habitat

4.2.5. Melaleuca

Melaleuca habitat covers 55 ha (4.3%) of the Survey Area (Plate 4-5). This habitat type is associated with the dense clay and clay sand soils that are located along the flow lines and depressions associated with the large drainage system located in the northern half of the Survey Area. The drainage system flows seasonally after rain though scattered deeper pools persist after this time providing a water source and moist

microhabitats for fauna. Wood and leaf litter is present beneath shrubs and a dense layer of grasses and shrubs also provides shelter for fauna.

Although relatively small in areas the vegetation associated with Melaleuca habitat is diverse and consists of 14 vegetation units (MbGcVp, MaMcu, MsVdCaf, MrMtAl, MrHtBt, MrMco, MrMt, Mb, MvMb, MrMvMb, MvMcoMb, BtRc/MvMb, MrMvMco, Ms.) that are all dominated by either *Melaleuca acutifolia*, *Melaleuca cuticularis*, *Melaleuca brevifolia*, *Melaleuca viminea* subsp. *viminea*, *Melaleuca rhaphiophylla*, *Melaleuca concreta*, and *Melaleuca teretifolia* (Morgan, 2021).

Plate 4-5: Melaleuca Habitat

4.2.6. Banksia Woodland / Heath (Banksia)

Banksia Woodland / Heath (Banksia) habitat covers 21.6 ha (1.7%) of the Survey Area. This habitat type is mainly located in the northern half of the Survey Area and is an ecotone of the Banksia Woodland and Heath (Banksia) habitat types. The habitat is also associated with the damper lower gentle slopes adjacent to Samphire (Plate 4-6). Significant wood litter is scarce though leaf litter beds present beneath *Banksia* and dense sedges also provide sheltered microhabitats for fauna.

Vegetation associated with Banksia Woodland / Heath (Banksia) habitat consists of a mosaic of *Banksia prionotes* low woodland over *Banksia telmatiaea*, *Regelia ciliata*, *Hakea obliqua* subsp. *parviflora* dominated scrubs and heaths (Veg Unit: BtRc/Bp) with a *Melaleuca seriata* low shrub layer (Veg Unit: MsGc) common in the damper, lower lying areas (Morgan, 2021) and *Callitris pyramidalis* tall shrubland over *Banksia telmatiaea*, *Regelia ciliata* open heathland (Veg Unit: CpBt).

Plate 4-6: Banksia Woodland / Heath (Banksia)

4.2.7. Ephemeral Wetland

The Ephemeral Wetland habitat type covers 13.7 ha (1.1%) of the Survey Area and consists of dry open depressions that fill with water when sufficient rainfall occurs. This habitat type is typically devoid of vegetation due to the high salinity present however some samphire species can occur along the edges of these lakes (Plate 4-7).

Plate 4-7: Ephemeral Wetland Habitat

4.2.8. Melaleuca / Samphire

Melaleuca / Samphire habitat covers 3.9 ha (0.3%) of the Survey Area. This habitat is an ecotone, hosting flora and fauna species from both the Melaleuca and Samphire habitat types (Plate 4-8). Wood and leaf litter is sparse though does accumulate in some areas beneath shrubs.

Vegetation associated with Melaleuca / Samphire habitat consists of *Melaleuca brevifolia* open shrubland over *Tecticornia indica* subsp. *bidens* low open samphire shrubland (Veg Unit: MbTi), *Tecticornia moniliformis*, *Tecticornia halocnemoides*, *Tecticornia syncarpa* low open samphire shrubland (Veg Unit: TEC), *Melaleuca brevifolia* mid open shrubland over *Grevillea* sp. Cooljarloo (B.J. Keighery 28 B), *Verticordia plumosa* var. *brachyphylla* low open shrubland (Veg Unit: MbGcVp), *Melaleuca viminea* subsp. *viminea* tall shrubland over *Melaleuca brevifolia* mid sparse shrubland (Veg Unit: MvMb) (Morgan, 2021).

Plate 4-8: Melaleuca / Samphire Habitat

4.2.9. Eucalypt Woodland

Eucalypt Woodland habitat covers 1.3 ha (0.1%) of the eastern part of the Survey Area. It is a small strip of distinct fauna habitat located between Melaleuca and Banksia Woodland habitat. Leaf litter beds are present beneath trees and shrubs and large logs also provide shelter for fauna.

The vegetation associated with this habitat type consists of *Eucalyptus rudis* open woodland to woodland (Veg Unit: ErMr) over *Melaleuca raphiophylla* open scrub over **Ehrarta longiflora*, **Brassica tournefortii* annual grassland/herbland (Morgan, 2021).

Plate 4-9: Eucalypt Woodland Habitat

330000

340000

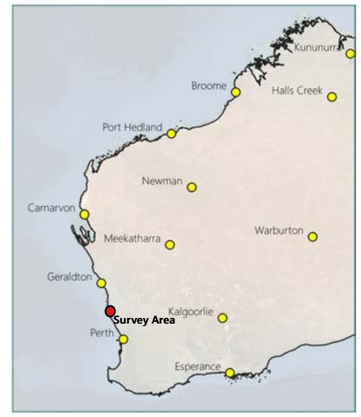
6620000

Legend

Survey Area

Fauna Habitats

- Banksia Woodland
- Pasture / Cleared
- Heath (Banksia)
- Samphire
- Melaleuca
- Banksia Woodland / Heath (Banksia)
- Ephemeral Wetland
- Melaleuca / Samphire
- Eucalypt Woodland



N

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Scale 1:45,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY & SPATIAL

Author: MH Approved: DC Date: 16-09-2022

Fauna Habitats

Atlas Project

Prepared for
PRESTON CONSULTING
IMAGE RESOURCES

MAP
4.3

330000

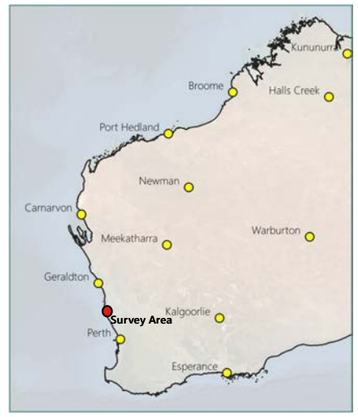
6620000

Legend

Survey Area

Fauna Habitats

- Banksia Woodland
- Pasture / Cleared
- Heath (Banksia)
- Samphire
- Melaleuca
- Banksia Woodland / Heath (Banksia)
- Ephemeral Wetland
- Melaleuca / Samphire
- Eucalypt Woodland



N

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Scale 1:20,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY & SPATIAL

Author: MH Approved: DC Date: 15-09-2022

Fauna Habitats (North)

Atlas Project

Prepared for
PRESTON CONSULTING
IMAGE RESOURCES

MAP 4.4

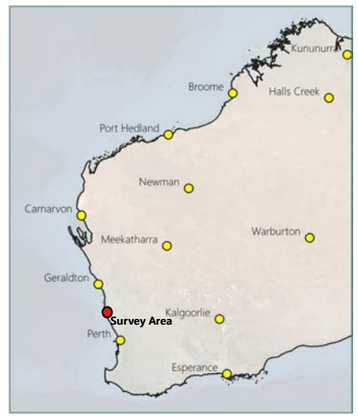
330000

Legend

Survey Area

Fauna Habitats

- Banksia Woodland
- Pasture / Cleared
- Heath (Banksia)
- Samphire
- Melaleuca
- Banksia Woodland / Heath (Banksia)
- Ephemeral Wetland
- Melaleuca / Samphire
- Eucalypt Woodland



N

0 0.2 0.4 0.6 0.8 km

Scale 1:20,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY & SPATIAL

Author: MH Approved: DC Date: 15-09-2022

Fauna Habitats (South)

Atlas Project

Prepared for
PRESTON CONSULTING
IMAGE RESOURCES

MAP
4.5

4.2.10. Fauna Habitat Analysis

Fauna habitats were analysed in terms of both non-metric MDS scatter plots and cluster analysis, separately for vertebrate fauna species caught in trapping grids and for systematically sampled bird species. To simplify interpretation, for all four analyses the data recorded at each site was summed into a single variable. In Figure 4.1 - Figure 4.4 below, Sites 1 and Sites 3-5 fall within the Banksia Woodland habitat type, Site 2 within Eucalypt Woodland, Site 6 within Melaleuca, Site 7 within Samphire and Site 8 within Banksia Woodland (Heath).

In the non-metric MDS scatter plots, the shaded areas (convex envelopes) are a visual representation of sites that fall within the same habitat type. Each site is made up of convex combinations of theoretical points in a bounded subset of each plane (coordinate 1 or 2). Larger envelopes generally indicate that the data is more variable or less consistent between different sites of the same habitat for the given coordinates. Interpretation of the non-metric MDS scatter plots (Figure 4.1, Figure 4.2), and the cluster analyses (Figure 4.3, Figure 4.4) generally substantiates the fauna habitat mapping, which have the most closely related points on the scatter plots and the highest degrees of similarity on the cluster analyses.

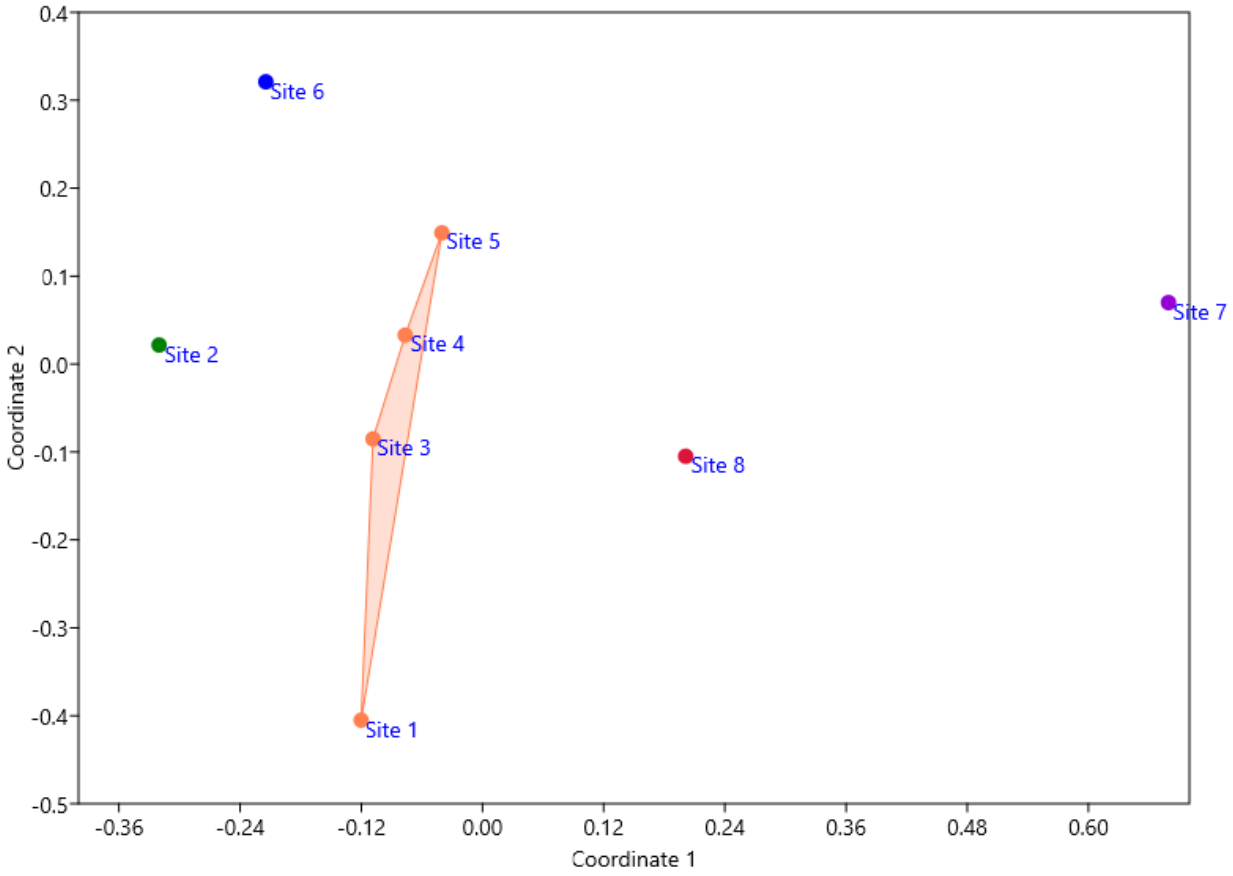


Figure 4.1: Non-metric MDS Scatter Plot of Trapping Grid Vertebrate Fauna Data

Sites 1, 3-5: Banksia Woodland. Site 2: Eucalypt Woodland. Site 6: Melaleuca. Site 7: Samphire. Site 8: Banksia Woodland (Heath).

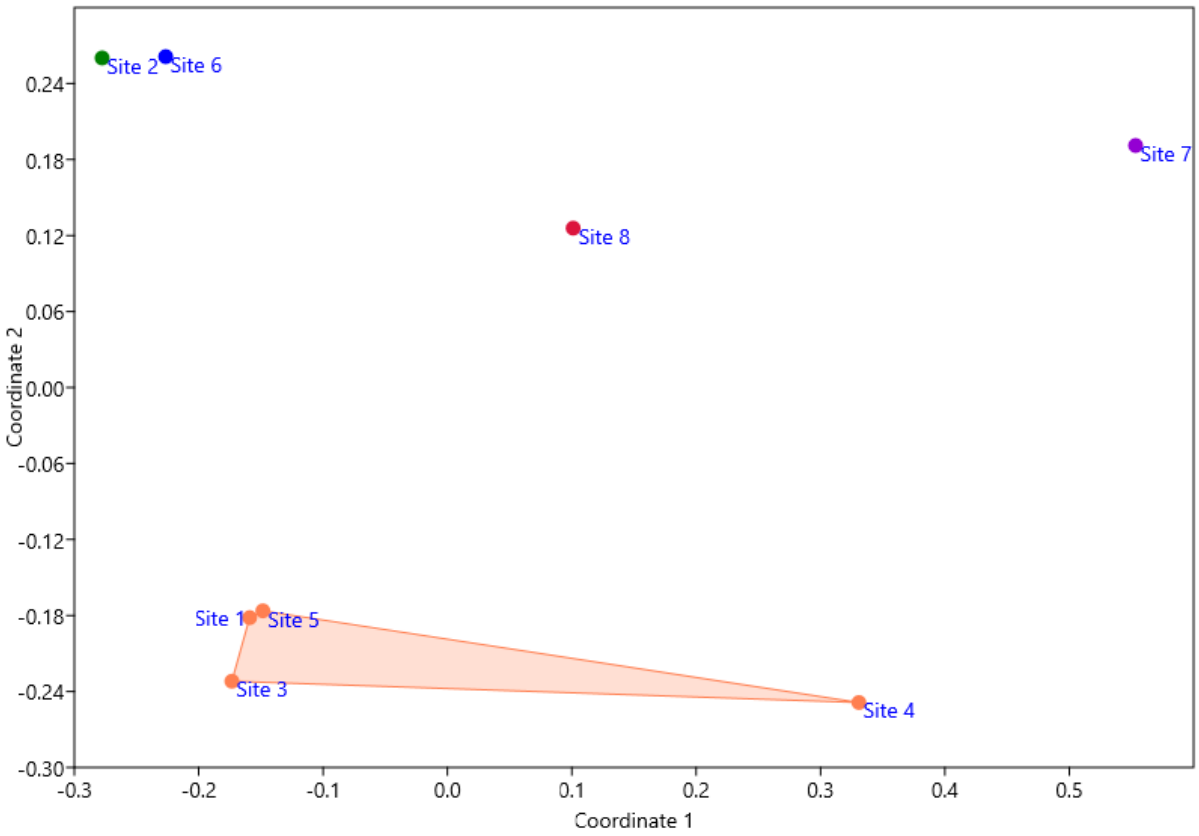


Figure 4.2: Non-metric MDS Scatter Plot of Systematic Bird Survey Data

Sites 1, 3-5: Banksia Woodland. Site 2: Eucalypt Woodland. Site 6: Melaleuca. Site 7: Samphire. Site 8: Banksia Woodland (Heath).

The convex envelopes in the scatter plots above give an approximation of the degree of similarity to each other of the fauna assemblage in each habitat type. The Eucalypt Woodland habitat type is most similar to the Melaleuca habitat. The fact that the convex envelope for the Banksia Woodland habitat type does not overlap with any other point demonstrates that each habitat is somewhat unique with regard to the fauna assemblage included within the analysis.

Within the Banksia Woodland habitat type Site 4 shows little distinction in the trapping grid data, though it is distinct for the bird data, suggesting that the birds present in this habitat are generally more restricted than the reptiles and mammals are. This is unusual in that habitat use by birds is typically more flexible than for herpetofauna and mammals, as they are much more mobile and may use different habitats throughout the day. Similarly, Site 3, 4 and 5 are similar in terms of vertebrate fauna but Site 1 demonstrates greater distinction in terms of herpetofauna and mammal activity.

It is expected that Sites 7 (Samphire) and 8 (Banksia Woodland (Heath)) are distinct from one another as these habitats are unique in species diversity and stratification and therefore will attract specialist species.

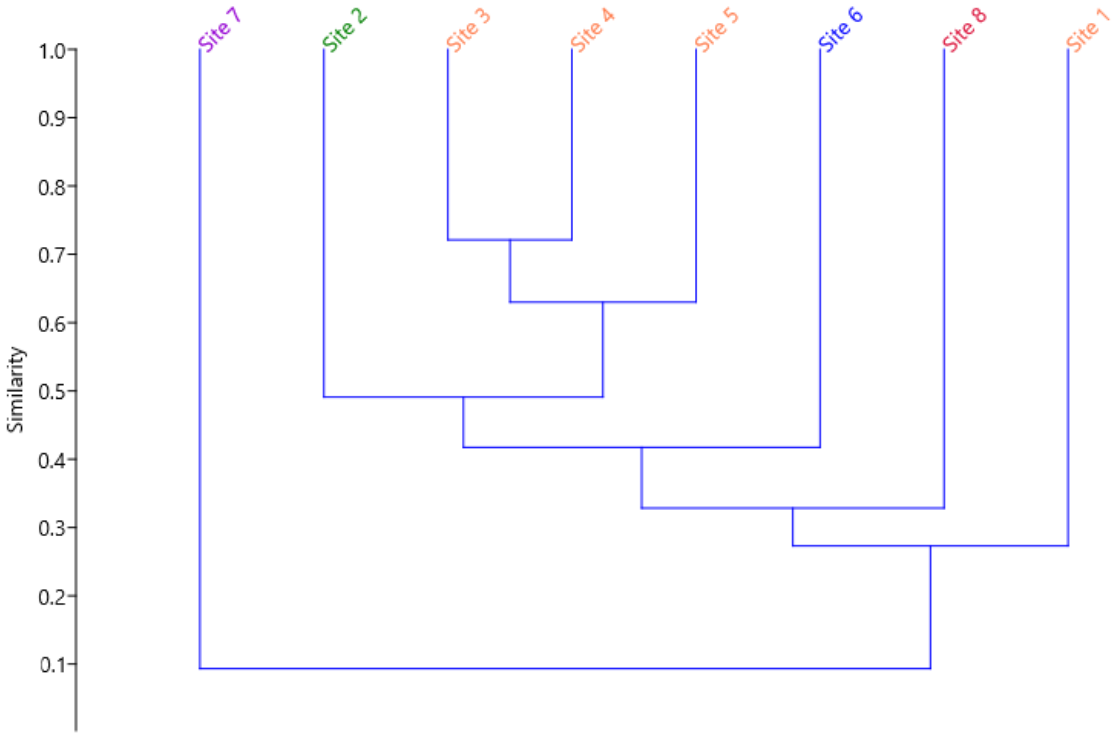


Figure 4.3: Cluster Analysis Results of the Trapping Grid Vertebrate Fauna Data

Sites 1, 3-5: Banksia Woodland. Site 2: Eucalypt Woodland. Site 6: Melaleuca. Site 7: Samphire. Site 8: Banksia Woodland (Heath).

Cluster analysis of the trapping grid vertebrate fauna supports the results of the non-metric MDS scatter plots. For example, Sites 3, 4 and 5 demonstrate 60-70% similarity between them. Site 1 within the same type of habitat, Banksia Woodland, demonstrates only a 25% similarity which is likely due to the small number of common species recorded between these sites (three common species). Sites 2 (Eucalypt Woodland) and 6 (Melaleuca) demonstrate the next greatest similarity to the Banksia Woodland habitat as well as to one another. Site 8 shows only a 30% similarity to all other sites and is clustered most closely with sites 1 and 6.

Site 7 appears to be unique in terms of vertebrate fauna data with very little similarity to any of the other sites. There were very few animals (three species) recorded there, which could both skew and minimise the comparability of the site, but it is likely due to the nature of this habitat type.

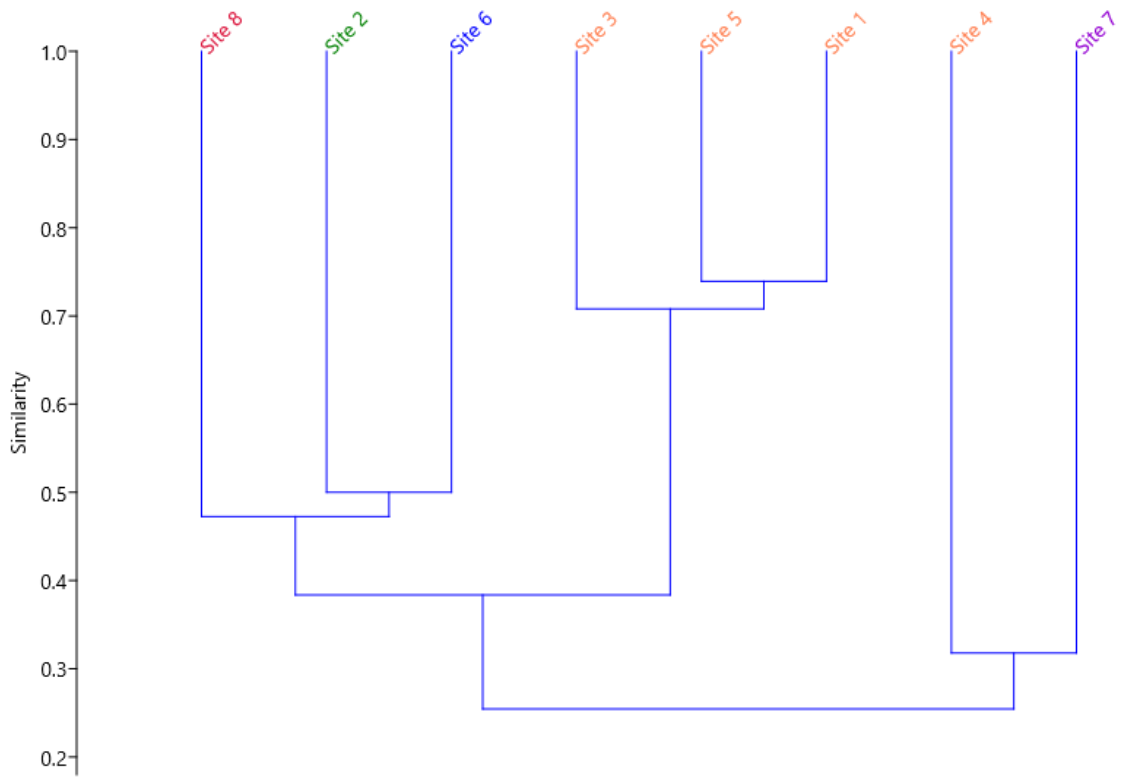


Figure 4.4: Cluster Analysis Results of the Systematic Bird Survey Data

Sites 1, 3-5: Banksia Woodland. Site 2: Eucalypt Woodland. Site 6: Melaleuca. Site 7: Samphire. Site 8: Banksia Woodland (Heath).

Cluster analysis of the bird survey data again backs up the results of the non-metric MDS scatter plots. Sites 1 and 5 are the most similar and are clustered with Site 3 which is within the same habitat type (Banksia Woodland) and there is <5% difference in similarity between these sites. As with the vertebrate fauna data Sites 2 and 6 show a 50% similarity and are clustered with Site 8. Site 2 (Eucalypt Woodland) and 6 (Melaleuca) are most similar in composition to Site 8 (Banksia Woodland (Heath)).

However, unlike the trapping grid data, where Site 1 is the outlier within the Banksia Woodland habitat, Site 4 is the outlier for the bird survey data though is most similar to Site 7.

4.3. Vertebrate Fauna

A total of 121 vertebrate fauna species were recorded during the Basic and Detailed terrestrial fauna surveys:

- 14 mammals (including four introduced mammals);
- 83 bird species;
- 19 reptiles, and.
- Five amphibians.

In comparison, the single-phase Level 2 (Detailed) vertebrate fauna survey completed by 360 Environmental recorded a total of 97 species (118 species indicated as being recorded in report, however there were several instances of the same species being listed more than once). The overall number of vertebrate fauna species were similar between this survey and the current assessment, however 29 species (3 mammals, 16 birds, 7

reptiles, and 3 amphibians) were unique to the phase 1 survey and 31 species (3 mammals, 24 birds, and 4 reptiles) were unique to the phase 2 survey (Table 4.1). A total of 132 vertebrate fauna species (17 mammals, 95 birds, 25 reptiles, and 8 amphibians) were recorded from the Survey Area or close by during both assessment phases. The full species list is detailed in Appendix C.

4.4. Conservation Significant Fauna

Four conservation significant species were recorded within the Survey Area during the Detailed survey:

- Western Brush Wallaby (*Notamacropus irma)* – DBCA Priority 4;
- Common Greenshank (*Tringa nebularia*) – EPBC / BC Act Migratory;
- Black-striped Snake (*Neelaps calonotos*) – DBCA Priority 3; and
- Carnaby's Cockatoo (*Calyptorhynchus latirostris*) – EPBC/ BC Act Endangered.

One Black-striped Snake (*Neelaps calonotos)* was opportunistically recorded in the southwest of the Survey Area, multiple individuals of the Common Greenshank (*Tringa nebularia*) were opportunistically recorded on several occasions during the survey, and two Carnaby's Cockatoos (*Calyptorhynchus latirostris)* were observed in Banksia Woodland habitat at the south of the Survey Area. Further evidence of the species foraging (chewed Banksia flowers) was recorded along the eastern edge of the Survey Area and at a site at the south of the Survey Area. A further three individuals were observed in Banksia Woodland habitats located 6 km north of the Survey Area at the intersection of Munbinea Rd and Bibby Rd, during the initial Basic fauna survey. Carnaby's Cockatoo were also recorded at three locations during the Basic fauna assessment of the infrastructure corridors (September 2021). A large flock of up to 100 individuals was observed (Plate 4-10) flying over Banksia woodland to the west of the project, however a location could not be determined due to the distance from the observers.

The Western Brush Wallaby (*Notomacropus irma*) was recorded inside Survey Area during the Basic fauna survey and was also recorded by 360 Environmental in 2012 within the Survey Area. The details for each record are listed in Table 4.4. The location of each record is shown in Map 4.6.

Table 4.4: Conservation Significant Fauna Recorded

Species	Conservation Status			360 Environmental	Current Survey	Site	Abundance	Easting	Northing	Details
	EPBC Act	BC Act	DBCA							
Common Greenshank (*Tringa nebularia*)	MI	MI			•	APOPP41 APOPP10 APOPP09	12 1 5	331458 331612 331506	6620383 6622160 6622236	Opportunistic and Systematic Survey
Black-striped Snake *(Neelaps calonotos)*			P3		•	APOPP27		331425	6616957	Opportunistic
Western Brush Wallaby *(Notamacropus irma)*			P4	•	•	CERB	1	331422	6617016	2012 survey – Opportunistic
						Opp	1	329921	6619020	Observed crossing road

Species	Conservation Status			360 Environmental	Current Survey	Site	Abundance	Easting	Northing	Details
	EPBC Act	BC Act	DBCA							
Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*)	EN	EN			•	Opp	-	332712	6616981	Secondary Evidence
						Regional Opp	3	331737	6629549	3 individuals recorded 6 km north of the Survey Area
						AP HA11 DC	3	326813	6622982	Observed flying past approx. 150m from Survey Area
						AP HA12 DC	9	326875	6622788	Observed feeding on Banksia approx. 100m from Survey Area
						Regional Opp	3	329883	6619338	Observed flying past
						Regional Opp	~100	n/a	n/a	Observed flying in the distance
						AAA01	2	332112	6612834	Observed flying past
						AAA05	1	332138	6612147	Secondary evidence
						AAA16	1	329710	6620777	Secondary evidence

Plate 4-10: Large Carnaby's Cockatoo flock observed near Survey Area

4.4.1. Carnaby's Cockatoo Habitat

Potential Carnaby's Cockatoo habitat was defined and assessed during the field survey. Suitable foraging habitat in the form of Banksia Woodland, Heath (Banksia), Banksia Woodland/ Heath (Banksia) and Eucalypt Woodland was calculated to account for 873.1 ha (70.4%) of the Survey Area. The Eucalypt Woodland may also be considered potential roosting habitat although no Carnaby's Cockatoos have been observed utilising the area for this purpose.

Using the scoring tool outlined in the draft referral guidelines and listed in Table 3.10, the identified habitat for the Carnaby's Cockatoo was assessed as follows:

Starting score:

- 7 (High Quality): proteaceous woodland and heathland dominated by *Banksia* species with some native *Eucalyptus rudis* woodland present.

Additions:

- +3 Is within the Swan Coastal Plain (important foraging area).

Subtractions:

- -1 Is >12 km from a known breeding location.

The overall scoring of the habitat for the Carnaby's Cockatoo has been rated as 9 (very high quality) based on the above criteria. Evidence of Carnaby's Cockatoo foraging has been recorded in the Survey Area and the species has been well documented using similar habitats across the surrounding region. The Survey Area is located outside of the breeding range of Carnaby's Cockatoo, however the region is considered as important foraging habitat as juvenile cockatoos move into the area after fledging from breeding sites located to the east. Two roost sites were identified within 12 km of the Survey Area and an additional seven roost sites are located in the surrounding region (Map 4.7).

321000 324000 327000 330000 333000 336000 339000 342000

6630000 6627000 6624000 6621000 6618000 6615000 6612000

Legend

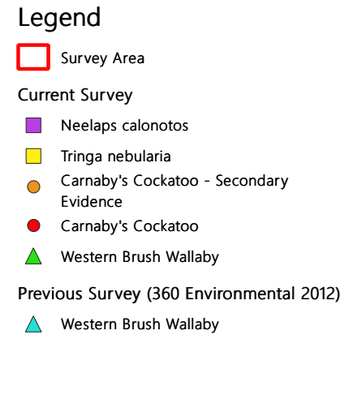
Survey Area

Current Survey

- Neelaps calonotos
- Tringa nebularia
- Carnaby's Cockatoo - Secondary Evidence
- Carnaby's Cockatoo
- Western Brush Wallaby

Previous Survey (360 Environmental 2012)

- Western Brush Wallaby



N

0 0.5 1 km

Scale 1:70,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY & SPATIAL

Author: JV Approved: DC Date: 15-09-2022

Conservation Significant Fauna Species Recorded

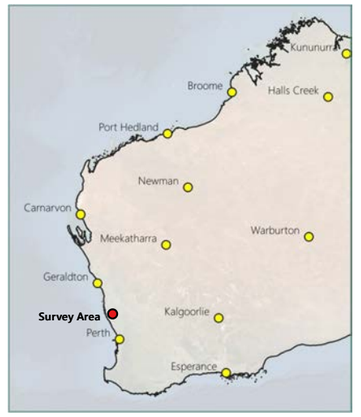
Atlas Project

Prepared for
Preston Consulting | Image Resources

MAP 4.6

Legend

- Survey Area
- 12 km Buffer
- Confirmed Roost with Count (Birdlife 2019)
- Unpublished Roost (Spectrum Ecology 2020)



N

0 2 4 6 8 km

Scale 1:180,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY • SPATIAL

Author: NP

Date: 12-09-2022

Regional Carnaby's Cockatoo Roost Locations

Atlas Project

Prepared for
Preston Consulting | Image Resources

MAP 4.7

4.5. Survey Adequacy

Analyses of both the vertebrate trapping grid and bird data produced flattening species accumulation curves approaching the horizontal asymptote. The graphs below display two data sets; species observed during the survey (S(est)) and the Michaelis-Menten curve (MM Means) that serves as an estimator of total species richness (Figure 4.5, Figure 4.6). Comparison of these two curves shows that approximately 92.5% of the estimated total number of combined mammal, reptile and amphibian species (Figure 4.5), and 92.6% of the potential bird species (Figure 4.6) were sampled. These results indicate that with further trapping effort an additional 2 mammal, reptile or amphibian species may be detected, and another 4 bird species.

The trapping grid data includes records from 56 trapping events. The analysed bird survey data includes records from a total of 55 surveys. Each birding site was surveyed between six and eight times for the duration of the survey. Opportunistic records are not included in the analysis.

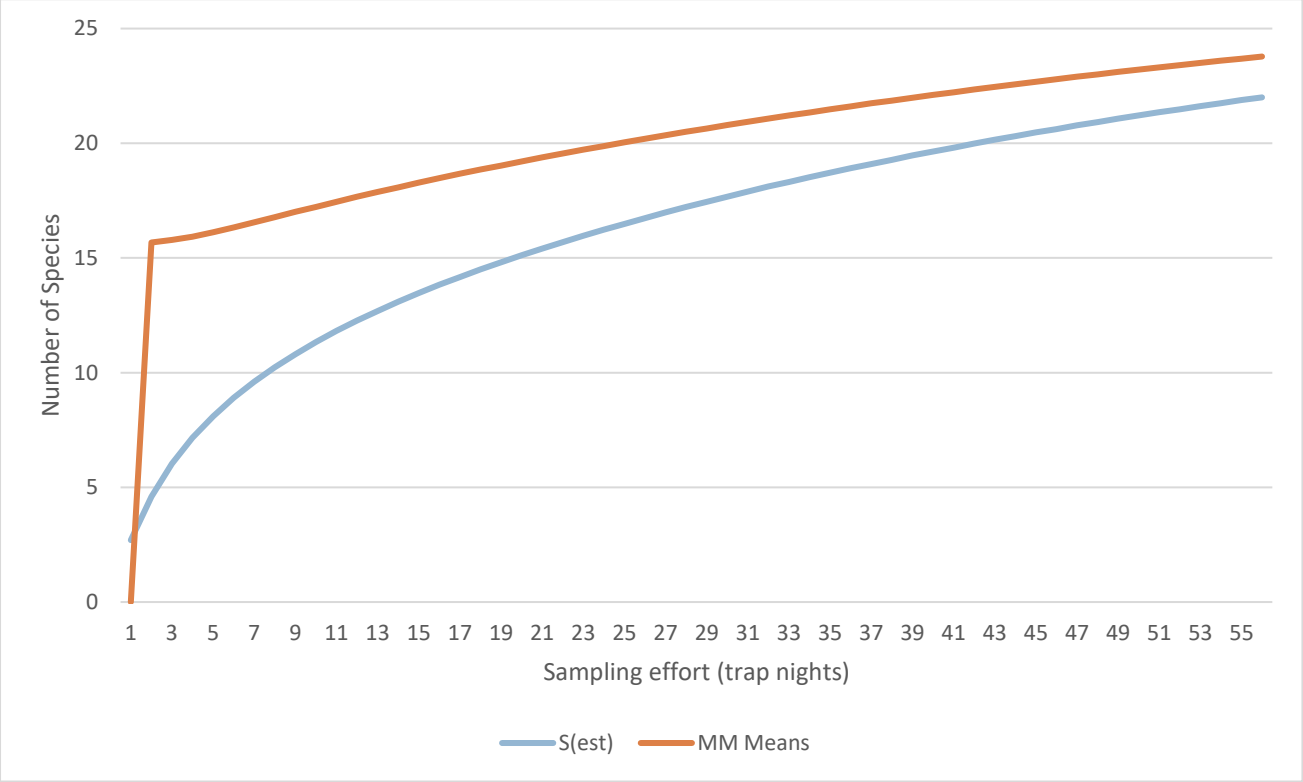


Figure 4.5: SAC for trapping grid data, illustrating species observed and predicted species richness

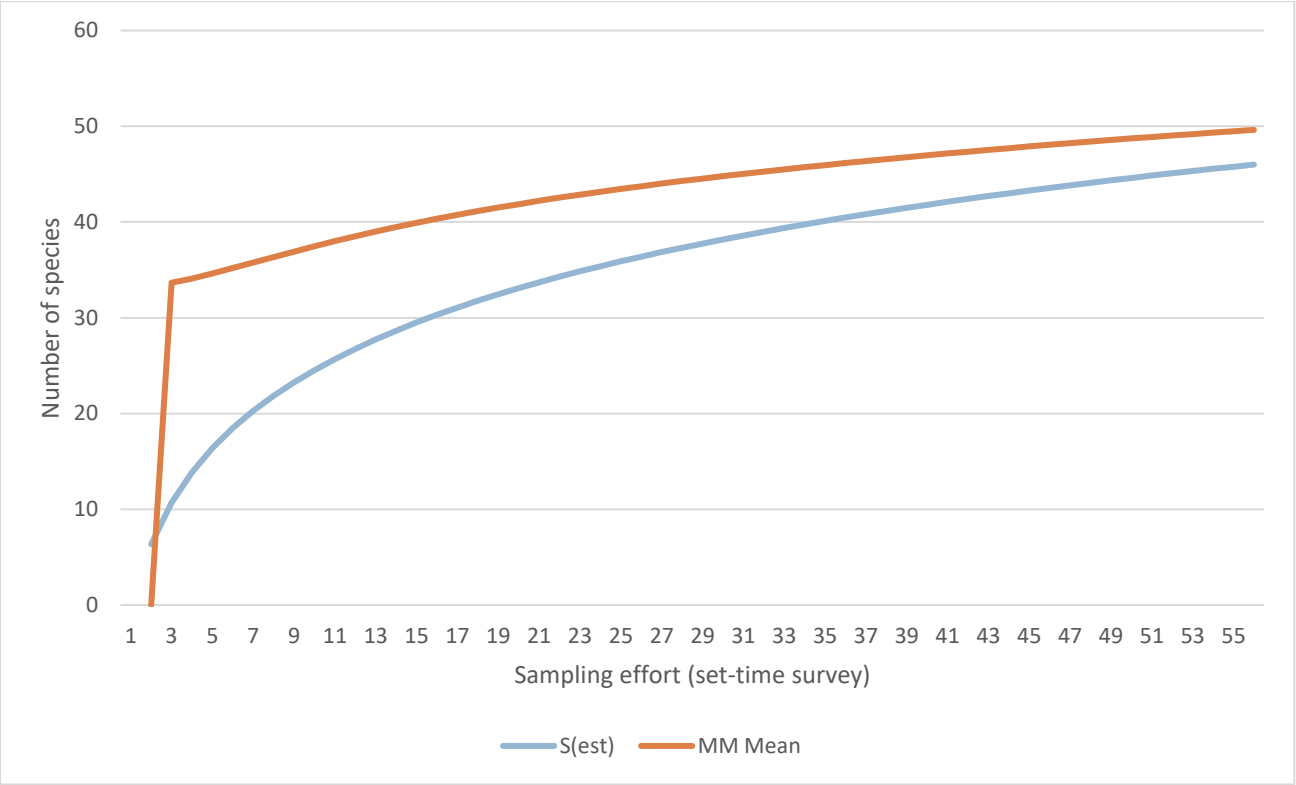


Figure 4.6: SAC for bird data, illustrating species observed and predicted species richness

4.6. Short Range Endemic Invertebrate Fauna

A total of 22 potential SRE species were collected during the Basic and Detailed surveys: one araneomorph spider (Detailed survey), 13 pseudoscorpions (six from the Basic, seven from the Detailed survey), one snail (recorded during both surveys), three isopods (Detailed survey), and four millipedes (Detailed survey). Of these, two morphospecies were recorded only during regional survey outside the Survey Area. Twelve morphospecies have not been recorded elsewhere and are currently only known from the Survey Area. An additional 34 specimens (four species) from SRE target groups were also recorded though are known to be widespread and as such not potential short range endemics.

Each species and its associated details are shown in Table 4.6 and capture locations are shown on Map 4.8.

4.6.1. DNA Analysis

Five morphospecies recorded only within the proposed impact area (a smaller area within the Survey Area) were sequenced in an effort to assign them to previously recorded species found outside the impact area; two pseudoscorpions, one isopod and two millipedes. A further five morphospecies (three from within the Survey Area and two from outside) were also sequenced for comparison purposes. The sequences were then compared to each other, to sequences publicly available through GenBank and to Bennelongia's internal sequence database. The results of the genetic sequencing are summarised in Table 4.5 and the complete report by Bennelongia taxonomists is attached as Appendix D.

Table 4.5: DNA Analysis Results

Class/ Order & Family	Species	Site	Results	Restricted to Impact Area
ARACHNIDA				
Pseudoscoriones				
Olpiidae	*Beierolpium* 8/4 `BPS323`	APSRE4	Recorded only within the impact area. Sequencing failed, likely due to the small size of the specimen.	Yes
Olpiidae	*Beierolpium* 8/2 `BPS325`	APLL2	Did not align with any previously sequenced species. New species, only recorded from the Atlas Survey Area.	Yes
ISOPODA				
Philosciidae	*Laevophiloscia* sp. B23	APSRE1 APSRE6 APSRE7	Aligned with *Laevophiloscia* sp. B23 recorded at Cooljarloo, outside the Survey Area. Recorded outside impact area, sequenced to compare to *Laevophiloscia* sp. B24. recorded inside.	No
Philosciidae	*Laevophiloscia* sp. B23	Cooljarloo	Specimen from Cooljarloo, sequenced for comparison to *Laevophiloscia* sp. B24 recorded from the impact area.	N/A
Philosciidae	*Laevophiloscia* sp. B24	APSRE3	Sequencing was successful though due to the failure of the Cooljarloo specimens, no sequence was available for comparison. Morphologically very similar to specimens collected 10 km south east.	Unlikely
Philosciidae	*Laevophiloscia* sp. B24	Cooljarloo	Sequencing failed, likely due to preservation methods employed in 2012.	N/A

Class/ Order & Family	Species	Site	Results	Restricted to Impact Area
MYRIAPODA				
Polydesmida				
Paradoxosomatidae	*Antichiropus* sp. 712504	APSRE4	Sequence aligns with that of *Antichiropus sulcatus*, a species previously recorded outside the Atlas Survey Area at Eneabba and Cooljarloo.	No
Paradoxosomatidae	*Antichiropus* sp. 712514	APSRE4	Sequence aligns with that of *Antichiropus sulcatus*, a species previously recorded outside the Atlas Survey Area at Eneabba and Cooljarloo.	No
Paradoxosomatidae	*Antichiropus* sp. 713613	APSRE8	Genetically aligned with *Antichiropus whistleri*, a relatively widespread species. Recorded outside impact area, sequenced to compare to *Antichiropus* sp. recorded inside.	No
Paradoxosomatidae	*Antichiropus* sp. 713614	APSRE5	Genetically aligned with *Antichiropus whistleri*, a relatively widespread species. Recorded outside impact area, sequenced to compare to *Antichiropus* sp. recorded inside.	No

Table 4.6: Species from SRE Target Groups Recorded During the Basic and Detailed Survey

Class/ Order & Family	Species	Abundance	Site	Trap Type	Details	Recorded Inside and/or Outside Survey Area	Survey		SRE Status
							Basic	Detailed	
ARACHNIDA									
Araneae									
Salticidae	*Maratus* `BAR130`	1	APSRE5	Wet Pitfall	DNA recommended as is an unusual animal and suspected to be a new species.	Inside		X	Potential SRE
Pseudoscorpiones									
Atemnidae	Atemnidae sp. 712345*	1	APSRE7	Wet Pitfall	Juvenile animal, can't identify further. DNA recommended to compare to *Oratemnus* `BPS326`.	Inside		X	Potential SRE
Atemnidae	*Oratemnus* `BPS326`	3	APSRE7	Wet Pitfall	Adult female & 1 very juvenile animal. DNA recommended to compare to the juvenile Atemnid collected from APSRE7.	Inside		X	Potential SRE
Chthoniidae	*Austrochthonius* sp. 712610*	1	APLL8	Leaf Litter/ Tullgren Funnel	Multicerate epistome. Small pale animal, very juvenile. Cannot ID further. DNA recommended to investigate if juvenile is the same as individuals collected 10km SE.	Inside		X	Potential SRE
Olpiidae	*Beierolpium 8/4 `BPS253`*	1	APS17	Leaf Litter/ Tullgren Funnel	Male and juv compared to sp B08 from Cooljarloo West appox 8km south and not same cheala size and tricobothria pattern different.	Inside	X		Potential SRE
Olpiidae	*Beierolpium* 8/4 `BPS322`	1	APLL8	Leaf Litter/ Tullgren Funnel	Very dark and small pincers. Comparisons to other specimens collected in the area confirmed a distinct new species.	Inside		X	Potential SRE

Class/ Order & Family	Species	Abundance	Site	Trap Type	Details	Recorded Inside and/or Outside Survey Area	Survey		SRE Status
							Basic	Detailed	
Olpiidae	*Beierolpium* 8/4 `BPS323`	1	APSRE4	Wet Pitfall	Small dark pincers, palm significantly darker than pincer. Comparisons to other specimens collected in the area confirmed a distinct new species. Genetic sequencing failed.	Inside		X	Potential SRE
Olpiidae	*Beierolpium* 8/4 `BPS324`	1	APLL8	Leaf Litter/ Tullgren Funnel	Small female animal compared to *Beierolpium* 8/4 `BPS322` and `BPS323` with light claws. Comparisons to other specimens collected in the area confirmed a distinct new species. Did not align genetically with any previously recorded species.	Inside		X	Potential SRE
Olpiidae	*Beierolpium* 8/2 `BPS325`	1	APLL2	Leaf Litter/ Tullgren Funnel	Two trichobothria on moveable chela. Comparisons to other specimens collected in the area confirmed a distinct new species.	Inside		X	Potential SRE
Olpiidae	*Beierolpium* sp.	1	APS02	Leaf Litter/ Tullgren Funnel	-	Inside	X		Potential SRE
Olpiidae	*Euryolpium* `BPS251`		APS04	Leaf Litter/ Tullgren Funnel	Compared to sp. B05 from Cooljarloo West and BPS252 has fatter bigger chela.	Inside	X		Potential SRE
Olpiidae	*Euryolpium* `BPS252`		APS18	Leaf Litter/ Tullgren Funnel	Compared to BPS251 and B05 from Cooljarloo West, not the same size of cheala different	Outside	X		Potential SRE

Class/ Order & Family	Species	Abundance	Site	Trap Type	Details	Recorded Inside and/or Outside Survey Area	Survey		SRE Status
							Basic	Detailed	
Olpiidae	*Euryolpium* sp.		APS18	Leaf Litter/ Tullgren Funnel	-	Outside	X		Potential SRE
Olpiidae	*Olpiidae* sp.		APS02	Leaf Litter/ Tullgren Funnel	Just moulted soft and white, juvenile cannot ID further.	Inside	X		Potential SRE
GASTROPODA									
Stylommatophora									
Punctidae	*Westralaoma* cf. *aprica*	3	APLL6 APS18	Leaf Litter/ Tullgren Funnel	Shell only. Compared to shells collected 10km SE and believe they are the same. Would need DNA to confirm but cannot do so with shells.	Inside/ Outside	X	X	Potential SRE
ISOPODA									
Armadillidae	*Buddelundia* sp. B38	4	APSRE4 APSRE7 APSRE8	Wet Pitfall	DNA recommended to confirm animal is the same species as collected elsewhere.	Inside		X	Potential SRE
Philosciidae	*Laevophiloscia* sp. B23	46	APSRE1 APSRE6 APSRE7	Wet Pitfall	Genetic sequencing confirmed the species is conspecific with *Laevophiloscia* sp. B23 recorded at Cooljarloo.	Inside/ Outside		X	Potential SRE

Class/ Order & Family	Species	Abundance	Site	Trap Type	Details	Recorded Inside and/or Outside Survey Area	Survey		SRE Status
							Basic	Detailed	
Philosciidae	*Laevophiloscia* sp. B24	4	APSRE3	Wet Pitfall	Looks like a trichorhina but has a three segmented flagellum, therefore a new species of *Laevophiloscia*. Distinctly different from *Laevophiloscia* sp. B23. Sequencing was successful though due to the failure of the Cooljarloo specimens, no sequence was available for comparison.	Inside		X	Potential SRE
Porcellionidae	*Porcellionides pruinosus*	3	APSRE7	Wet Pitfall	Introduced species.	Inside		X	Not SRE.
MYRIAPODA									
Lithobiomorpha									
Henicopidae	*Lamyctes* nr *africanus*	9	APSRE5 APSRE7	Wet Pitfall	Keys to *Lamyctes africanus* from Centipedes of Australia however the range distance is challenging. DNA not recommended as rock centipedes are not usually potential SREs.	Inside		X	Not SRE
Polydesmida									
Paradoxosomatidae	*Antichiropus sulcatus* (formerly *Antichiropus* sp. 712504*)	2	APSRE4	Wet Pitfall	Female specimen, cannot be identified further using morphology. Genetically aligns with *Antichiropus sulcatus*.	Inside/ Outside		X	Potential SRE
Paradoxosomatidae	*Antichiropus sulcatus* (formerly *Antichiropus* sp. 712514*)	1	APSRE4	Wet Pitfall	Very juvenile, cannot identify using morphology only. Genetically aligns with *Antichiropus sulcatus*.	Inside/ Outside		X	Potential SRE
Paradoxosomatidae	*Antichiropus whistleri* (formerly *Antichiropus* sp. 713613*)	1	APSRE8	Wet Pitfall	Very juvenile, cannot identify using morphology only. Genetically aligns with *Antichiropus whistleri*.	Inside/ Outside		X	Potential SRE

Class/ Order & Family	Species	Abundance	Site	Trap Type	Details	Recorded Inside and/or Outside Survey Area	Survey		SRE Status
							Basic	Detailed	
Paradoxosomatidae	*Antichiropus whistleri* (formerly *Antichiropus* sp. 713614*)	1	APSRE5	Wet Pitfall	Very juvenile, cannot identify using morphology only. Genetically aligns with *Antichiropus whistleri*.	Inside/ Outside		X	Potential SRE
Scolopendrida									
Scolopendridae	Scolopendrinae `BSCOL071`	1	APSRE3	Wet Pitfall	Does not key to *Cormocephalus* or Scolopendrinae, unusual animal. Spines on all tarsus. Broad large process. 19 segment antennae, large porous area extending over processes. DNA recommended to investigate genus and species.	Inside		X	Not SRE
Polyxenida									
Polyxenidae	*Unixenus* sp.	5	APLL5 APLL8	Leaf Litter/ Tullgren Funnel		Inside		X	Not SRE
Synxenidae	*Phryssonotus novaehollandiae*	17	APLL4 APLL5 APLL6 APLL7 APLL8	Leaf Litter/ Tullgren Funnel		Inside		X	Not SRE

*Bennelongia internal specimen identification number. Details associated with each taxon supplied by Bennelongia.

327000
330000
333000
336000
6621000
6618000

Legend

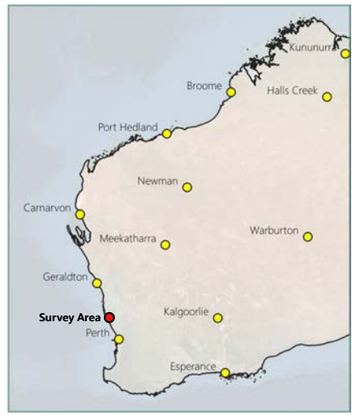
- Survey Area

Basic Fauna Survey

- Beierolpium 8/4 `BPS253`
- Beierolpium sp.
- Euryolpium `BPS251`
- Euryolpium `BPS252`
- Euryolpium sp.
- Olpiidae sp.
- Westralaoma cf. aprica

Detailed Fauna Survey

- Antichiropus sulcatus
- Antichiropus whistleri
- Atemnidae sp. 712345
- Austrochthonius sp. 712610
- Beierolpium 8/2 `BPS325`
- Beierolpium 8/4 `BPS322`
- Beierolpium 8/4 `BPS323`
- Beierolpium 8/4 `BPS324`
- Buddelundia sp. B38
- Laevophiloscia sp. B23
- Laevophiloscia sp. B24
- Maratus `BAR130`
- Oratemnus `BPS326`
- Westralaoma cf. aprica



N

0 0.5 1 km

Scale 1:30,000 @ A3

Coordinate System: GDA 1994 MGA Zone 50
Projection: Transverse Mercator
Units: Meter

Spectrum ECOLOGY & SPATIAL

Author: JV Approved: DC Date: 12-09-2022

Potential SRE Invertebrate Fauna Species Recorded

Atlas Project

Prepared for
Preston Consulting | Image Resources

MAP
4.8

5. DISCUSSION

5.1. Desktop Assessment

5.1.1. Vertebrate Fauna

The regional desktop assessment identified a total of 296 vertebrate fauna species: 11 amphibians, 190 birds, 19 non-volant native mammals, nine bats, five introduced mammals and 64 reptiles. This is significantly higher than the results of any single vertebrate fauna survey completed in the region, including the current survey. This is to be expected, as the desktop draws data from a wide range of sources that were collected over different time periods and seasons, as well as more types of fauna habitats than those present within a single survey area. A suitable example of this is the large number of shorebird and other water bird species reported only by NatureMap. These records may also come via museum collection trips, public specimen collections/ observations, DBCA surveys as well as from the DBCA Fauna Survey Returns Database which includes data from private sources.

The data reported by NatureMap, the DBCA Threatened Fauna Database, Protected Matters Search Tool as well as previous survey reports provide a useful indication of regional vertebrate fauna assemblages. Whilst many species recorded during the desktop assessment have the potential to occur in the Survey Area, the fauna assemblage that typically utilises the habitats found within the Survey Area form a much smaller subset of species. Variations in population distributions and the availability of microhabitats within each area also limit the species that may occur. However, the accumulated data provided by the desktop assessment is invaluable during survey planning to ensure all major fauna assemblages are sampled and any significant species that may occur are targeted appropriately.

5.1.2. SRE Invertebrate Fauna

A total of 28 potential SRE species were identified by the database searches and literature review. Regarding the WAM Invertebrate Database search results, some refinement of the results was required. The initial search area consisted of an approximately 200 km by 200 km square, centered on the Survey Area Table 3.1. The search results were then refined by applying a 40 km buffer to the Survey Area and intersecting this with the results. The refined species list better reflects that which may occur within the Survey Area as it removes species that require habitats that do not occur within, or close to, the Survey Area (e.g., the Darling Scarp and associated Jarrah forests). Four invertebrate species were also identified by the DBCA Threatened Fauna Database search as they are listed under the priority fauna system maintained by the DBCA. Though they may also represent SRE species, for this report they have been included in the conservation significant fauna discussion (Section 5.5).

The SRE status allocated to the millipede species *Antichiropus whistleri* is inconsistent within the available literature. Bennelongia (Bennelongia Environmental Consultants, 2013) states that the species is widespread and not an SRE while Invertebrate Solutions (Invertebrate Solutions, 2018) list it as a confirmed SRE. Based on WAM records, the species approximate distribution appears to be less than 10,000^{2}km and as such it has been included as a potential short range endemic in this report.

5.2. Fauna Habitat Types

A total of seven habitat types (plus two ecotones) occur within the Survey Area including areas allocated as Pasture/Cleared. This habitat type is not typically considered suitable for native fauna however several common bird species and Western Grey Kangaroo will forage on seeds and vegetation when conditions are suitable.

5.2.1. Banksia Woodland

The Banksia Woodland habitat type was the most extensive within the Survey Area, accounting for approximately 55% of the total area. An estimated 60% of native Banksia Woodland has been cleared within the Swan Coastal Plain. As a result, this vegetation community has been listed as a nationally Threatened Ecological Community (Commonwealth of Australia, 2016) and a Priority Ecological Community under the BC Act. Patches of Banksia Woodland are listed when they are greater than 0.5 ha and of Excellent or Pristine condition, greater than 1 ha and of Very Good condition, or greater than 2 ha and of Good condition (Commonwealth of Australia, 2016). Listing of the Banksia Woodland ecological community as nationally threatened indicates that "*impacts should be avoided and if they are unavoidable, must be mitigated, reduced or, as a last resort, offset*" (Commonwealth of Australia, 2016).

Avifauna species associated with Banksia Woodland habitat included generalist species such as the Rufous Whistler, Australian Magpie, Willie Wagtail and Magpie-lark. Nectarivorous species such as White-cheeked and Brown Honeyeaters were also abundant, likely due to the nectar provided by flowering *Banksia menziesii* and *B. attenuata*. Birds of prey were scarce, with only one Australian Kestrel recorded.

The most encountered reptile species within Banksia Woodland were the Western Heath Dragon, restricted to sandy habitats, and the West-coast Laterite Ctenotus which is a habitat generalist. The Crawling Toadlet and Moaning Frog were recorded on multiple occasions, both during systematic trapping and opportunistic nocturnal surveys.

Mammal capture and observation rates were low during the survey though the Dusky Dunnart and Honey Possum were both captured within Banksia Woodland habitat. The Dusky Dunnart is a small carnivorous marsupial that preys on any fauna species it can overpower. The Honey Possum is endemic to Western Australia and feeds exclusively on nectar within proteaceous woodlands and heath.

Three conservation significant vertebrate fauna species were recorded from Banksia Woodland habitat within the Survey Area during the previous and current surveys, Carnaby's Cockatoo (EPBC/ BC Act Endangered), the Western Brush Wallaby (DBCA Priority 4; (360 Environmental, 2012a), and Black-striped Snake (DBCA Priority 3). Two species were assessed to have a high likelihood of occurrence within this habitat;, Fork-tailed Swift (EPBC/ BC Act Migratory) and the Bothriembryontid Land Snail (DBCA Priority 1; Moore River sub-population). Banksia Woodland is known to provide important foraging habitat for Carnaby's Cockatoo though it does not represent breeding habitat.

Banksia Woodland may provide limited microhabitats (e.g., deep leaf litter beds) suitable for use by species within SRE target groups. However, the habitat was regionally extensive prior to European settlement with a high level of connectivity and as such is unlikely to have provided conditions known to produce short range endemic species. The following potential SRE were captured within Banksia Woodland habitat: *Antichiropus* sp. 713613 (millipede), *Antichiropus* sp. 713614 (millipede), *Austrochthonius* sp. 712610 (pseudoscorpion), *Beierolpium* 8/4 `BPS322` (pseudoscorpion), *Beierolpium* 8/4 `BPS324` (pseudoscorpion), *Beierolpium* sp. (pseudoscorpion), Buddelundia sp. B38 (isopod) and *Maratus* `BAR130` (spider), Olpiidae sp. (pseudoscorpion).

5.2.2. Pasture / Cleared

Approximately 18% of the Survey Area was pasture, cleared land or severely degraded native vegetation. This habitat type is not typically considered suitable for native fauna however several bird species such as Australasian Pipit, Australian Magpie, Magpie-lark, Galah, and Crested Pigeon were recorded foraging on vegetation and seeds within areas of pasture and degraded native vegetation. Western Grey Kangaroos (and secondary evidence of their presence) were also recorded grazing on pasture.

No conservation significant vertebrate fauna species are expected to utilise this habitat. The Fork-tailed Swift (EPBC/ BC Act Migratory) may pass over these areas infrequently though are unlikely to be affected by any on ground development or infrastructure due to their almost entirely aerial habits while in Australia.

Pasture/ Cleared habitat does not provide microhabitats suitable for use by SRE taxa.

5.2.3. Heath (Banksia)

Heath (Banksia) habitat accounted for approximately 15% of the Survey Area. Structurally it was lower and denser than Banksia Woodland, the dominant shrub species *Banksia telmatiaea* providing both shelter for heath species and abundant nectar when in flower.

Generalist bird species such as the Australian Magpie, Black-faced Woodswallow, Brown Honeyeater and Singing Honeyeater were regularly recorded as well as heath specialist species like the Tawny-crowned Honeyeater and White-browed Scrubwren. A single Australian Kestrel was also recorded which prefer habitats with low vegetation over which to hunt.

Reptile captures were low within the Heath (Banksia) though the fossorial Western Slender Blue-tongue and Burton's Legless Lizard were recorded both during systematic trapping and opportunistically. Three species of frog were captured systematically including a single Turtle Frog, an unusual burrowing species not recorded anywhere else in the Survey Area.

No native mammals were captured within Heath (Banksia) habitat though Western Grey Kangaroos were conspicuous and regularly observed. A single introduced House Mouse was also recorded during systematic trapping.

No conservation significant vertebrate fauna species were recorded from Heath (Banksia) habitat. Five species were assessed to have a high likelihood of occurrence within this habitat; Carnaby's Cockatoo (EPBC/ BC Act Endangered), Fork-tailed Swift (EPBC/ BC Act Migratory), a Bothriembryontid Land Snail (DBCA Priority 1; Moore River sub-population), Black-striped Burrowing Snake (DBCA Priority 3) and the Western Brush Wallaby (DBCA Priority 4). Heath (Banksia) is a proteaceous woodland and is known to provide important foraging habitat for Carnaby's Cockatoo though it does not represent breeding habitat.

As for the Banksia Woodland, Heath (Banksia) habitat may provide limited microhabitats (e.g., deep leaf litter beds) suitable for use by species within SRE target groups. However, the habitat is well drained and does not provide the habitat isolates and mesic refugia typically associated with SRE fauna. The following potential SRE were captured within Heath (Banksia) habitat: *Laevophiloscia* sp. B24 (isopod) and Scolopendrinae `BSCOL071` (centipede).

5.2.4. Samphire

Samphire habitat covered 5.4% of the Survey Area. These were low lying, saline areas that often occurred adjacent to Ephemeral Wetland habitat. Vegetation was typically low and dense, offering little protection from the wind.

Generalist bird species may pass through Samphire habitat though the species most frequently encountered are known to prefer the open, seasonally inundated habitat that Samphire provides. The Australian Pipit and White-fronted Chat are two such species that were recorded during the survey.

A total of three reptiles were captured within Samphire habitat, two Shrubland Morethia Skinks and a Common Dwarf Skink. This result was expected as no Samphire specialists occur in the region (as they do further east e.g, Claypan Dragons), the substrate was saturated limiting options for burrowing species, and the vegetation offered little by way of shelter and food resources. A single Crawling Toadlet was also recorded.

No mammals were captured during systematic trapping within Samphire habitat. Western Grey Kangaroos were observed frequently passing through this habitat though they did not appear to be foraging or sheltering within it.

No conservation significant vertebrate fauna species were recorded from Samphire habitat. However, the Common Greenshank (EPBC/ BC Act Migratory) was recorded from an Ephemeral Wetland immediately adjacent to systematic trapping site APS7TRAP located in Samphire habitat. During significant rainfall events these low-lying Samphire areas are likely to become inundated and provide temporary habitat for a range of shorebird and wader species, many of which are listed as migratory under state and federal legislation. Due to the temporary nature of the flooding, it is not likely to represent critical habitat as more permanent and substantial habitat is available within the immediate region (e.g, Lake Thetis 16 km east of the Survey Area). Fork-tailed Swifts (EPBC/ BC Act Migratory) may also pass over this habitat though are unlikely to be impacted by any on ground development or infrastructure.

Samphire habitat within the Survey Area did not possess relictual habitat characteristics typically associated with terrestrial SRE species (Section 3.3.1). However, five species belonging to SRE target groups were collected via wet pitfall trap from this habitat: *Antichiropus* sp. 712504 (millipede), *Antichiropus* sp. 712514 (millipede), *Beierolpium* 8/4 `BPS323` (pseudoscorpion), *Beierolpium* 8/2 `BPS325` (pseudoscorpion) and *Buddelundia* sp. B38 (isopod). The genus *Antichiropus* is known to show a high level of endemism (EPA 2016b) and these two specimens may represent habitat specialists; species restricted to specific, often restricted habitat types

5.2.5. Melaleuca

Melaleuca habitat, found in low lying depressions and associated with ephemeral wetlands and drainage lines, accounted for 4.3% of the Survey Area. These areas are intermittently inundated following significant rainfall, creating damplands that support mesic microhabitats.

The dense shrub cover and flowering plant species found within Melaleuca habitat supported a variety of bird species. Large numbers of nectarivorous Grey-breasted White-eyes, Singing Honeyeaters and White-cheeked Honeyeaters were recorded as well as insectivorous species such as Splendid Fairy-wrens, Willie Wagtails and Rainbow Bee-eaters. Small pools associated with the minor drainage line that bisected the Survey Area also provided habitat for an Australian Spotted Crake and Pacific Black Ducks.

Reptile captures and observations were limited within this habitat type, the West-coast Laterite Ctenotus (a skink) and Common Dwarf Skink were the most frequently encountered. Bobtails were also regularly seen

basking at the bases of shrubs in the mornings during trap clearance. The thick vegetation, damp conditions and areas of surface water provided optimal conditions for certain frog species. Moaning Frogs and Crawling Toadlets were captured in large numbers and the only records of the Squelching Froglet were also made in this habitat.

No mammals were directly observed in Melaleuca habitat though secondary evidence suggests that Western Grey Kangaroos regularly use these areas for foraging and shelter.

Two conservation significant vertebrate fauna species were assessed to have a high likelihood of occurrence within Melaleuca habitat. Western Brush Wallaby (DBCA Priority 4) is known to utilise areas of dense vegetation for shelter and the Fork-tailed Swift (EPBC/ BC Act Migratory) is likely to pass over this habitat on occasion though is unlikely to be affected by on ground development.

The freshwater damplands associated with Melaleuca habitat provide microhabitats suitable for SRE invertebrate species. Complex, mesic, and often isolated microhabitats in an otherwise dry and well drained environment may support relictual species isolated by aridification or habitat specialists that have adapted to utilise these areas. The following five potential SRE species were recorded from Melaleuca habitat: Atemnidae sp. 712345 (pseudoscorpion), *Buddelundia* sp. B38 (isopod), *Laevophiloscia* sp. B23 (isopod), *Oratemnus* `BPS326` (pseudoscorpion) and *Westralaoma* cf. *aprica* (snail).

5.2.6. Banksia Woodland / Heath (Banksia)

Banksia Woodland/ Heath (Banksia) was an ecotone between the two broad fauna habitat types and accounted for approximately 2% of the Survey Area. This ecotone area hosted flora and fauna species from both the Banksia Woodland and Heath (Banksia) fauna habitat types though does not appear to have its own unique fauna groups. The combination of habitat types has resulted in a dense *Banksia telmatiaea* heath with a loose canopy of *Banksia prionotes* and/or *Callitris pyramidalis*.

No conservation significant vertebrate or potential SRE invertebrate fauna species were recorded from this ecotone area. For significant species that may occur, see Banksia Woodland (5.2.1) and Heath (Banksia) (5.2.3).

5.2.7. Ephemeral Wetland

The Ephemeral Wetland habitat covered 1.1% of the Survey Area. This habitat consists of intermittently inundated, shallow and often saline clay pans with little vegetation. Fauna associated with these habitats include specialised invertebrate species that can colonise the lakes when water is present or have reproductive strategies that include resistant eggs that form "egg banks" and hatch when suitable water conditions are present. This habitat type is also suitable for a range wetland and shore bird species that utilise inland water bodies when available. The proximity of the Survey Area to the coast would typically indicate that the Ephemeral Wetland habitats are potential habitats, however the small size of these habitats would limit its effective suitability.

While holding water, Ephemeral Wetlands within the Survey Area are used by wetland birds, in particular shorebirds and waders. White-faced Heron and Common Greenshank were observed utilising this habitat during the field survey. Reptiles and mammals are not expected to occupy this habitat as it offers no resources for these groups.

The Common Greenshank (a shorebird; EPBC/ BC Act Migratory) was observed using this habitat on multiple occasions during the survey. Over the course of the survey the surface water evaporated and the birds moved on. This drying clearly illustrated the temporary nature of these wetlands and the short period that they may be of use to conservation significant shorebird species. Similar, more extensive habitat (e.g.,

Lake Thetis) is also available in the region where many of these species have been previously recorded. The presence of these Common Greenshank resulted in the 'medium' likelihood of occurrence allocated to a group of conservation significant shorebirds and waders previously recorded in the region surrounding the Survey Area (Table 5.1).

No terrestrial SRE invertebrate species were recorded (or expected) to occupy Ephemeral Wetland habitat.

5.2.8. Melaleuca / Samphire

Melaleuca/ Samphire habitat accounted for 0.3% of the Survey Area. As for the Banksia Woodland/ Heath (Banksia) ecotone, this area is a combination of both habitat types. It does not appear to host a unique fauna group though species from both the Melaleuca and Samphire habitats are expected to utilise it.

No conservation significant vertebrate or potential SRE invertebrate fauna species were recorded from this ecotone area. For significant species that may occur, see Melaleuca (5.2.5) and Samphire (5.2.4).

5.2.9. Eucalypt Woodland

Eucalypt Woodland accounted for only 0.1% of the Survey Area though was a distinct fauna habitat type that must be defined. It was the only habitat type dominated by *Eucalyptus rudis* and the only one likely to provide breeding habitat for large hollow nesting birds.

Avifauna species included Australian Ravens, Australia Magpies, Striated Pardalote and Western Gerygone that utilised the canopy and species such as the Splendid Fairy-wren, Yellow-rumped Thornbill and Broad-tailed Thornbill occupied the dense shrubs beneath it. A single observation of Cockatiels was made in this habitat and nestling Galahs were heard calling from within a hollow.

Herpetofauna diversity was low within the Eucalypt Woodland. The West-coast Laterite Ctenotus was the most common reptile capture, followed by the Elegant Slider. The Soft Spiny-tailed Gecko and Marbled Velvet Gecko were also recorded. The Moaning Frog was the only amphibian species recorded and was captured and opportunistically observed multiple times.

Two conservation significant vertebrate fauna species may be found within Eucalypt Woodland habitat, though none were recorded. The *Eucalyptus rudis* that make up the canopy of this habitat is potential roosting habitat for Carnaby's Cockatoo (EPBC/ BC Act Endangered), particularly due to its proximity to proteaceous woodland foraging habitat. *Eucalyptus rudis* rarely attains a large enough diameter, at an appropriate height, to develop hollows suitable for nesting. However, nestling Galahs were heard during a systematic bird survey suggesting that at least one hollow was present large enough for a mid to large sized cockatoo to occupy. Quenda (DBCA Priority 4) may also utilise this habitat type.

No potential SRE species were recorded from the Eucalypt Woodland habitat. As for the Banksia Woodland and Heath (Banksia), limited microhabitats (e.g., deep leaf litter beds) were present that may be suitable for use by species within SRE target groups. However, the habitat is well drained and does not provide the mesic refugia typically associated with SRE fauna.

5.3. Fauna Habitat Analysis

Interpretation of both the non-metric MDS scatter plots (Figure 4.1, Figure 4.2 and cluster analyses (Figure 4.3, Figure 4.4). substantiates the fauna habitat mapping. The cluster analysis suggests that the fauna assemblage of Sites 1 and 3-5 are most similar to one another as each of these sites fall within the same habitat type, Banksia Woodland. Site 7 is the most unique when compared to all other sites falling within the Samphire habitat type. This is the expected result given the differences in landform, vegetation, and substrate across these two habitats and it is easy to delineate between the two. Although the fauna assemblages are typically separate, this does not preclude a variety of species from being found in both habitats.

The remaining three systematically sampled fauna habitat types theoretically hold more similar fauna assemblages due to their greater commonalities in vegetation type and structure. This includes; Banksia Woodland (Heath) and Melaleuca. However, cluster analysis of the bird data identified Sites 4 and 7 as having the most similar assemblage to one another. Site 7 is geographically close to Banksia Woodland (Heath) and Banksia Woodland. Birds are highly mobile species with a greater ability than mammals and reptiles to move between habitat types in search of resources. This could account for species similarities with birds moving across Samphire habitat to more favorable habitat within Banksia Woodland.

5.4. Vertebrate Fauna Assemblage

The previous single-phase Level 2 vertebrate fauna survey completed by 360 Environmental within the Survey Area recorded a total of 109 vertebrate fauna species. This includes three species of native non-volant mammals, six species of bats, five introduced mammals, 63 bird species, 22 reptiles and seven amphibians. Comparatively the current Detailed survey recorded a total of 98 vertebrate fauna species: three species of native non-volant mammal, six species of bat, four introduced mammals, 62 bird species, 19 reptiles and four amphibians (Table 4.1).

These surveys were both completed in spring (October- November) within the recommended period for terrestrial fauna surveys in the region. Prior to the single-phase Level 2 survey in 2011, rainfall was significantly higher than that recorded prior to the current survey. A further 150mm of annual rainfall occurred in 2011 when compared to annual rainfall in 2020, much of which occurred in July. This may have contributed to the increased vertebrate fauna abundance and activity recorded by 360 Environmental. Higher rainfall often results in an increase in food resources such as insects, nectar, and seeds etc. Higher rainfall pre-survey likely also accounts for the increased number of amphibians recorded during the 2011 survey. Monthly mean maximum temperature averages were comparable between the two surveys.

Mammal captures were generally low with just three native non-volant mammal species recorded during both surveys of a potential 17 species identified by the desktop review. In addition to the species recorded by 360 Environmental, the current survey recorded a Dusky Dunnart increasing the number of native non-volant mammals recorded within the survey area overall to four. The SAC results indicate that with further trapping effort only an additional two mammal, reptile or amphibian species may be detected.

5.5. Conservation Significant Fauna

The literature review, database searches and survey results indicate that four species of conservation significant vertebrate fauna have been recorded from the Survey Area. One non-volant mammal, two birds, and one reptile species were recorded from within the Survey Area during previous and/ or current surveys. A further two species (one bird and one invertebrate) were assessed to have a high likelihood of occurrence based on previous records and the habitat types present within the Survey Area. The recorded species and those with a high likelihood of occurrence are discussed in the following section.

Due to the occurrence of Common Greenshank within the Survey Area, migratory shorebird and seabirds could not be excluded from the assessment. Nineteen migratory shorebird, seabird and wader species identified by the literature review and database searches were assessed as having medium likelihood of occurrence within the Survey Area. The likelihood ranking assigned to each species is detailed below in Table 5.1. Suitable habitat for these species within the Survey Area is dependent on rainfall and season, with suitable conditions generally lasting for very short periods, if at all. In addition to these species, a further one mammal, three birds, one reptile and two invertebrates were also assessed as having a medium likelihood of occurrence.

Twenty additional species of conservation significance were assessed to have a low or very low likelihood of occurrence, based on the criteria listed in Table 3.3. The PMST and DBCA database records returned marine listed species which were excluded from the assessment as no suitable habitat occurs within the Survey Area.

Table 5.1: Summary of the Likelihood of Occurrence of Conservation Significant Fauna Species

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Mammals						
Woylie *Bettongia penicillata ogilbyi*	EN	CR		Woodland and heath with an understorey of dense shrubs (Threatened Species Scientific Committee, 2018).	Records exist from Nambung National Park, 10 km west of the Survey Area (DBCA 2004-2005).	**Very Low** The species has not been recorded in the region since a failed translocation attempt in 2004-2005 (Threatened Species Scientific Committee, 2018). Locally extinct.
Dibbler *Parantechinus apicalis*	EN	EN		Mainland habitat is characterised by long unburnt heaths on sandy substrates (Australian Government & Department of the Environment and Energy, 2019a).	All local records are restricted to islands off the coast of Jurien Bay, approx. 31 km northwest of the Survey Area.	**Very Low** Suitable sandy heath habitat occurs within the Survey Area though no mainland populations are known in the region. Locally extinct.
Ghost Bat *Macroderma gigas*	VU	VU		Occupies a wide range of habitats, from the arid ranges of the Pilbara region to the rainforests of Northern Queensland (van Dyck and Strahan, 2008).	Historical records only, fossilised remains were found at Drover's Cave National Park.	**Very Low** Contemporary Western Australian distribution restricted to the Pilbara and Kimberley regions. Locally extinct.
South-western Brush-tailed Phascogale *Phascogale tapoatafa subsp. wambenger*	VU	VU		Dry sclerophyll forests and open woodlands that contain hollow-bearing trees with sparse ground cover (Soderquist and Ealey, 1994).	Historical record only, approx. 35km from the Survey Area.	**Very Low** Contemporary Western Australian distribution restricted to suitable habitat south of Perth to Albany.
Chuditch *Dasyurus geoffroii*	VU	VU		Inhabits sclerophyll forest, drier woodlands, heath and mallee shrubland (van Dyck and Strahan, 2008).	PMST record only.	**Low** Contemporary Western Australian distribution restricted to the south west of Western Australia.

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Quenda *Isoodon fusciventer*			P4	Woodland, heath and areas with dense vegetation in the lower stratum (van Dyck and Strahan, 2008).	Multiple records exist in proximity to the Survey Area, the nearest from 8 km west (2005).	**Medium** Suitable woodland and heath habitat recorded from the Survey Area though no individuals or secondary evidence was observed. **Suitable Habitats Within the Survey Area:** Banksia Woodland Heath (Banksia) Melaleuca Banksia Woodland/ Heath (Banksia) Melaleuca/ Samphire Eucalypt Woodland
Western Brush Wallaby *Notamacropus irma*			P4	Open forest or woodland. Open, seasonally wet flats with low grasses and scrubby thickets. Mallee and heathland occasionally utilised (van Dyck and Strahan, 2008).	Recorded by 360 Env. (2012) within the Survey Area and Spectrum Ecology (2020) in banksia woodland adjacent to the Survey Area.	**Recorded** One individual was recorded within the Survey Area in Banksia Woodland habitat. Extensive habitat exists within the southern part of the Survey Area and the local region. **Suitable Habitats Within the Survey Area:** Banksia Woodland Heath (Banksia) Melaleuca Banksia Woodland/ Heath (Banksia) Melaleuca/ Samphire Eucalypt Woodland

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Tammar Wallaby *Notamacropus eugenii derbianus*			P4	Coastal scrub, heath, dry sclerophyll forest and thickets in woodland habitat (van Dyck and Strahan, 2008).	Records from 9 km west of the Survey Area in Nambung National Park (DBCA 2004-2006).	**Low** Suitable woodland and heath habitat occurs within the Survey Area. However, the 2004-2006 records from Nambung National Park are the result of a translocation attempt. No records have been made since this time and the result of the translocation attempt in unknown.
Birds						
Western Ground Parrot *Pezoporus flaviventris*	CR	CR		Long unburnt, near coastal heath (DAWE, 2021).	Historical written record only from 19 km north of the Survey Area. No date or location information is associated with the record.	**Very Low** Currently only known from two locations on the south coast of Western Australia, Fitzgerald River National Park and Cape Arid National Park. Locally extinct.
Curlew Sandpiper *Calidris ferruginea*	CR, MI	CR		Mostly recorded from intertidal mudflats and coastal wetlands. Also recorded from ephemeral and permanent lakes further inland (DAWE, 2021).	Multiple coastal and salt lake (Lake Thetis) records west of the Survey Area.	**Medium** Seasonally inundated salt lakes within the Survey Area may represent temporary migratory shorebird habitat. **Suitable Habitats Within the Survey Area:** Samphire Ephemeral Wetland
Great Knot *Calidris tenuirostris*	CR, MI	CR		Mainly coastal, habitat includes intertidal mudflats, sandy beaches, estuaries and shallow saline and freshwater wetlands (DAWE, 2021).	Two records from Lake Thetis, west of the Survey Area.	**Medium** Seasonally inundated salt lakes within the Survey Area may represent temporary migratory shorebird habitat. **Suitable Habitats Within the Survey Area:** Samphire Ephemeral Wetland

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Carnaby's Cockatoo *Calyptorhynchus latirostris*	EN	EN	-	Breeding in tree hollows of Wandoo, Tuart, Jarrah, York Gum, Karri and Marri. Foraging in proteaceous woodland, forests, riparian vegetation, heath and introduced species (DSEWPaC 2012).	Many historical and contemporary records from the region, the closest record located less than 2 km from the Survey Area (2001).	**Recorded** Two individuals recorded in Banksia Woodland. Proteaceous woodland and heath within the Survey Area represents foraging habitat. No breeding habitat was recorded. **Suitable Habitats Within the Survey Area:** Foraging Banksia Woodland Heath (Banksia) Banksia Woodland/ Heath (Banksia) Roosting Eucalypt Woodland
Lesser Sand Plover *Charadrius mongolus*	EN, MI	EN		Prefers coastal habitats including sheltered sand flats, mudflats, bays and estuaries though may infrequently utilise coastal salt lakes (DAWE, 2021).	Two records from west of the Survey Area, Lake Thetis and Kangaroo Point.	**Medium** Seasonally inundated salt lakes within the Survey Area may represent temporary migratory shorebird habitat. **Suitable Habitats Within the Survey Area:** Samphire Ephemeral Wetland
Red Knot *Calidris canutus*	EN, MI	EN		Prefers coastal habitats including sheltered sand flats, mudflats, bays, sandy beaches and estuaries though may infrequently utilise coastal salt lakes (DAWE, 2021).	Two records from west of the Survey Area, Lake Thetis and Kangaroo Point.	**Medium** Seasonally inundated salt lakes within the Survey Area may represent temporary migratory shorebird habitat. **Suitable Habitats Within the Survey Area:** Samphire Ephemeral Wetland

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Malleefowl *Leipoa ocellata*	VU	VU		Semi-arid and arid mallee, shrubland, mulga and other habitats with dense litter forming vegetation (Benshemesh, 2007).	Two records from Nambung National Park, 8 km west southwest of the Survey Area (2012).	**Medium** Suitable shrubland and heath habitat exists in the Survey Area though no individuals or secondary evidence in the form of nesting mounds (contemporary or historical) or tracks were observed. **Suitable Habitats Within the Survey Area:** Heath (Banksia) Banksia Woodland/ Heath (Banksia)
Greater Sand Plover *Charadrius leschenaultii*	VU, MI	VU		Sandy or shelly beaches, sand spits and intertidal mudflats (DAWE, 2021).	Three coastal records from Nambung and Wedge Island. A single record was also returned from Badgingarra though the coordinate does not correspond with suitable habitat.	**Low** No suitable habitat recorded within the Survey Area.
Fairy Tern *Sternula nereis*	VU	VU		Islands, beaches and estuarine systems (DAWE, 2021).	Coastal and island records only.	**Low** No suitable habitat recorded within the Survey Area.
Bar-tailed Godwit *Limosa lapponica*	MI (VU or CR at ssp.)	MI (VU or CR at ssp.)		Prefers coastal habitats including sand flats, mudflats, bays and estuaries though may infrequently utilise coastal salt lakes and marshes (DAWE, 2021).	Multiple coastal and salt lake (Lake Thetis) records west of the Survey Area.	**Medium** Seasonally inundated salt lakes within the Survey Area may represent temporary migratory shorebird habitat. **Suitable Habitats Within the Survey Area:** Samphire Ephemeral Wetland

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Fork-tailed Swift *Apus pacificus*	MI	MI		Displays almost entirely aerial behaviour while in Australia. Utilises air space over a wide variety of habitat types including open plains, woodlands, salt marsh, rainforest, pasture and urban areas (Australian Government & Department of Agriculture Water and the Environment, 2020).	Recorded approx. 12 km west southwest of the Survey Area (2013).	High May occur infrequently over any part of the Survey Area (all habitat types).
Common Greenshank *Tringa nebularia*	MI	MI		Habitat including sheltered sand flats, mudflats, bays, sandy beaches, estuaries and salt lakes (DAWE, 2021).	Numerous coastal records exist. One record occurs inland to the east along Koonah road. Five records exist to the southwest around Lake Guraga.	Recorded Multiple individuals recorded during the current survey. Seasonally inundated salt lakes within the Survey Area provides temporary habitat for the species. Suitable Habitats Within the Survey Area: Samphire Ephemeral Wetland

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Black-tailed Godwit *Limosa limosa* Caspian Tern *Sterna caspia* Common Sandpiper *Tringa hypoleucos* Grey Plover *Pluvialis squatarola* Gull-billed Tern *Sterna nilotica* Long-toed Stint *Calidris subminuta* Pacific Golden Plover *Pluvialis fulva* Pectoral Sandpiper *Calidris melanotos* Red-necked Stint *Calidris ruficollis* Ruddy Turnstone *Arenaria interpres* Sanderling *Calidris alba* Sharp-tailed Sandpiper *Calidris acuminata*	MI	MI		Habitat including sheltered sand flats, mudflats, bays, sandy beaches, estuaries and salt lakes (DAWE, 2021).	Predominantly coastal records from islands, beaches and coastal salt lakes (Lake Thetis in particular).	**Medium** Migratory shorebird and seabird species that may utilise seasonally inundated salt lake habitat for foraging and/ or roosting purposes. With the exception of the Caspian Tern, these birds are non-breeding visitors to Australia. No breeding habitat for Caspian Tern was recorded. **Suitable Habitats Within the Survey Area:** Samphire Ephemeral Wetland

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Glossy Ibis *Plegadis falcinellus*	MI	MI		Foraging habitat consists of shallow saline and freshwater lakes, flooded pasture and samphire as well as man-made water bodies such as sewerage ponds (DAWE, 2021).	Sporadic visitor to southern parts of Western Australia. A single record was returned during the database searches from approx. 22 km southeast of the Survey Area.	**Medium** Freshwater wetland, salt lake and samphire habitat occurs within the Survey Area. **Suitable Habitats Within the Survey Area:** Samphire Ephemeral Wetland
Wood Sandpiper *Tringa glareola*	MI	MI		Mainly freshwater river and pool habitat though rarely associated with brackish, salt lake and estuary environments (DAWE, 2021).	A single record from disturbed freshwater wetland habitat north northwest of the Survey Area.	**Medium** Freshwater wetland habitat occurs within the Survey Area. **Suitable Habitats Within the Survey Area:** Samphire Ephemeral Wetland
Bridled Tern *Sterna anaethetus*	MI	MI		Species occupies islands for breeding and forages offshore (DAWE, 2021).	Island, coastal and offshore Naturemap records only.	**Low** No suitable habitat recorded within the Survey Area.
Crested Tern *Sterna bergii*	MI	MI		Sandy beaches, shallow lagoons, coral reefs, estuaries, mudflats and open ocean (Birdlife International, 2018).	Many coastal records from the region.	**Low** No suitable habitat recorded within the Survey Area.
Eastern Osprey *Pandion haliaetus cristatus*	MI	MI		Littoral and coastal environments as well as terrestrial wetlands. Requires large areas of fresh, brackish or saline water for foraging (DAWE, 2021).	Naturemap records only.	**Low** No suitable habitat recorded within the Survey Area.
Roseate Tern *Sterna dougallii*	MI	MI		Rocky and sandy beaches, coral reefs and islands (DAWE, 2021).	Coastal and island records only.	**Low** No suitable habitat recorded within the Survey Area.

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Grey-tailed Tattler *Tringa brevipes*	MI	MI	P4	Prefers sheltered coastal areas with rock platforms, reef or intertidal mudflats (DAWE, 2021).	Naturemap records only.	**Low** No suitable habitat recorded within the Survey Area.
Peregrine Falcon *Falco peregrinus*		OS		Widespread but uncommon; variety of habitats ranging from urban areas, coastal cliffs, riverine gorges, wooded watercourses or margins of cleared lands (Australian Government & Department of the Environment and Energy, 2019b).	Multiple records from the greater region.	**Medium** May utilise all habitat types for foraging purposes on an irregular basis. No nesting habitat present. **Suitable Habitats Within the Survey Area:** Foraging All habitats
Hooded Plover *Thinornis rubricollis*			P4	Sandy ocean beaches and inland salt lakes for foraging purposes. Breeding habitat consists sandy beaches above the high tide mark and coastal dunes. (Birdlife Australia, 2020).	A single record from sandy beach habitat near Jurien Bay.	**Medium** Ephemeral salt lake habitat within the Survey Area may be used for foraging purposes. No nesting habitat present. **Suitable Habitats Within the Survey Area:** Samphire Ephemeral Wetland
Blue-billed Duck *Oxyura australis*			P4	Prefers deep and permanent freshwater wetlands that allow diving behaviour while foraging (NSW Government & Office of Environment and Heritage, 2020).	Aerial imagery does not show any wetland or watercourse habitat that coincides with the single record for this species in the region.	**Low** Ephemeral freshwater habitat is present though unlikely to be deep enough to be suitable for the Blue-billed Duck.

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Reptiles						
Black-striped Burrowing Snake *Neelaps calonotos*			P3	Dunes and sandplains vegetated with heaths and woodland (Wilson and Swan, 2017).	Recorded from Banksia Woodland habitat within the Survey Area during the current survey in the southern part of the Survey Area.	**Recorded** Suitable sandy heath and woodland habitat is present within the Survey Area. **Suitable Habitats Within the Survey Area:** Banksia Woodland Heath (Banksia) Banksia Woodland/ Heath (Banksia)
Jewelled Southwest Ctenotus *Ctenotus gemmula*			P3	Pale sandplains in association with heaths and woodland (Wilson and Swan, 2017).	Multiple records from approx. 15 km east southeast of the Survey Area (2013).	**Medium** Suitable pale sandplain with heath and woodland is present within the Survey Area though no individuals were recorded during two phases of Level 2/ Detailed survey. **Suitable Habitats Within the Survey Area:** Banksia Woodland Heath (Banksia) Banksia Woodland/ Heath (Banksia)
Western Spiny-tailed Skink *Egernia stokesii badia*	EN	VU		Typically found in York Gum (*Eucalyptus loxophleba*) woodland, also Gimlet (*E. salubris*) and Salmon Gum (*E. salmonophloia*). Hollows of fallen timber are used as shelter (Australian Government & Department of the Environment and Energy, 2020)	A single record from 34 km north of the Survey Area (2011).	**Low** No suitable hollow habitat present within the Survey Area. The Survey Area is also outside of the species predicted range.

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Woma Python (south west population) *Aspidites ramsayi*			P1	Wheatbelt and Goldfields sandplains (Maryan *et al.*, 2007). Specific habitat preferences in the region are unknown.	Historical records (Naturemap only) from Badgingarra, east of the Survey Area.	Low No recent records in the region. Previous records all occur inland of the Survey Area.
Jurien Bay Skink *Liopholis pulchra longicauda*	VU	VU		Woodlands and heaths on islands off Jurien Bay (Wilson and Swan, 2017).	This subspecies is known only from islands off Jurien Bay.	Very Low Does not occur on the mainland, island populations only.
Lancelin Island Skink *Ctenotus lancelini*	VU	VU		Limestone outcrops on Lancelin and Favorite Islands (Wilson and Swan, 2017).	No known mainland population. Restricted to Lancelin and Favorite Islands.	Very Low Does not occur on the mainland, island populations only.
Invertebrates						
Bothriembryontid Land Snail (Moore River) *Bothriembryon perobesus*			P1	Stabilised sand dunes supporting *Banksia* and/ or *Eucalyptus* woodland over heath (Bennelongia Environmental Consultants, 2013).	A single record from 19 km southeast of the Survey Area (2012).	High Suitable sand dune with woodland over heath habitat exists within the Survey Area. Suitable Habitats Within the Survey Area: Banksia Woodland Heath (Banksia) Banksia Woodland/ Heath (Banksia)
Spiny Katydid *Austrosaga spinifer*			P2	No habitat information available.	Two records from less than 5 km west of the Survey Area (1984). Aerial imagery suggests the habitat is similar to that found within the Survey Area (sandplain with heath and proteaceous woodland).	Medium No specific habitat information is available for this species. Suitable Habitats Within the Survey Area: Banksia Woodland Heath (Banksia) Banksia Woodland/ Heath (Banksia)

Species	Conservation Status			Preferred Habitats	Previous Records	Likelihood of Occurrence
	EPBC Act	BC Act	DBCA			
Woollybush Bee *Hylaeus globuliferus*			P3	Associated with *Adenanthos cygnorum* and *Banksia attenuata* from north of Eneabba, the Swan Coastal Plain and south coast (Invertebrate Solutions, 2019)	Two records from the Hill River region approx. 18 km north of the Survey Area (1996).	**Medium** Suitable Woollybush and *Banksia* habitat may occur within the Survey Area. **Suitable Habitats Within the Survey Area:** Banksia Woodland Banksia Woodland/ Heath (Banksia)
Graceful Sun Moth *Synemon gratiosa*			P4	Coastal heath on secondary Quindalup Dunes hosting *Lomandra maritima*. Also present in *Banksia* woodland on Spearwood and Bassendean Dunes hosting *Lomandra hermaphrodita* (DoE 2019)	Multiple coastal records located west of the Survey Area.	**Low** Previous targeted survey (360 Environmental, 2012b) completed according to DEC guidelines did not detect Graceful Sun-moth within the Survey Area. Known host species, *Lomandra hermaphrodita*, was recorded in low density only.

5.5.1. Mammals

5.5.1.1. Western Brush Wallaby (*Notamacropus irma*)

- DBCA Priority 4.

Ecology, Habitat and Distribution: The Western Brush Wallaby was once very common, prior to extensive land clearing for agriculture within its range. The species is now restricted to the south west of Western Australia from Kalbarri to Cape Arid (Van Dyck and Strahan, 2008). Western Brush Wallaby are thought to occur in open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and scrubby thickets. It is also found in some areas of mallee and heathland (DEC 2012). Recent research indicates that a dense understorey may form critical habitat with individuals preferentially utilising dense understorey in *Banksia* woodlands (Povh *et al.*, 2019).

Western Brush Wallaby feed sparingly on a wide range of plant rather than extensively on a few species, indicating they require floristically diverse habitat for foraging (Wann and Bell, 1997). Their home range has been calculated to be approximately 10-12 ha (Povh *et al.*, 2019). Foxes are thought to have also been a major factor in the species decline through predation on juveniles, though population increases have been observed in areas where fox control programs have been implemented.

Likelihood of Occurrence – Recorded: Western Brush Wallaby was recorded within the Survey Area on one occasion during the first phase of Detailed (then Level 2) survey (360 Environmental, 2012a) in Banksia Woodland habitat. A second record of the species inside the Survey Area was made during the second phase of the Detailed survey. All habitat types with the exception of the Ephemeral Wetland and Samphire habitats are expected to host Western Brush Wallaby.

5.5.2. Birds

5.5.2.1. Common Greenshank (*Tringa nebularia*)

- EPBC/ BC Act Migratory

Ecology, Habitat and Distribution: The Common Greenshank is a migratory, non-breeding visitor to Australia between August and March though some individuals overwinter in Australia, particularly juveniles. The species inhabits a variety of freshwater habitats including open mudflats and ephemeral sat lakes and wetlands of still shallow water (DAWE 2021). This excitable and vocal species is solitary when feeding. It is often observed wading in shallow water, lunging at fish or running to catch prey. They will roost in small flocks or on the margin of larger flocks of other species (Menkhorst *et al.*, 2019).

Likelihood of Occurrence – Recorded: Common Greenshank were recorded on six occasions at three locations during the survey. Initially the species was recorded utilising a shallow pool within the Ephemeral Wetland habitat type. This dried up during the survey period and the species was then observed at an artificial dam within pasture in the northern part of the Survey Area. A further record was made to the west of the Survey Area associated with another artificial dam. It is likely that the original six birds first recorded at APOPP41/ APS7BIRD and then at the dams were the same individuals, moving between areas of suitable habitat. Natural habitat for Common Greenshank and other conservation significant shorebird and wader species is limited and temporary, available only immediately after significant rainfall.

5.5.2.2. Carnaby's Cockatoo (*Calyptorhynchus latirostris*)

- EPBC/ BC Act Endangered

Ecology, Habitat and Distribution: The Carnaby's Cockatoo is endemic to the southwest of Western Australia. It occurs between the Murchison River to Esperance, and inland to Coorow, Kellerberrin and Lake Cronin (Cale, 2003). There has been a shift in its breeding range to the west and the south since the middle of the 1900s. It is now located in the Jarrah-Marri forest of the Darling Scarp, and the Tuart forests of the Swan Coastal Plain. Breeding takes place from July to mid-December (Johnstone and Johnstone, 2006). Carnaby's Cockatoos pair for life and only one chick per year will be raised , remaining with the parents for up to 18 months (Shah, 2006).

The Carnaby's Cockatoo utilises a variety of forests, shrublands and banksia woodlands. The species uses native shrubland, kwongan heathland and proteaceous woodland, including banksia woodland for foraging. Roost sites are often associated with riparian vegetation, large trees such as pine trees or eucalypt trees with a closed canopy. Breeding habitat consists of woodland or forests that provide hollows in live or dead trees (any eucalypt species). Wandoo, Tuart, Jarrah, York gum, Karri and Marri are typical breeding trees (Commonwealth of Australia, 2017). Carnaby's Cockatoos often move up to 13 km a day with the greatest distances covered in the early morning and late evening (Shah, 2006). The birds then travel between roost sites, foraging sites and wetlands for drinking.

Likelihood of Occurrence – Recorded: Two individuals were observed in Banksia Woodland at the south of the Survey Area. Further observations of both small and large flocks were recorded outside the Survey Area by Spectrum Ecology, either moving through the local region or foraging in Banksia Woodland. A Black Cockatoo assessment of the Survey Area identified suitable foraging habitat across the Banksia Woodland and Heath (Banksia) habitats, and evidence of foraging (chewed Banksia flowers) was recorded. Two roost sites were identified within 12 km of the Survey Area and an additional seven roost sites are located in the surrounding region. The Survey Area is located on the outer edge of the breeding range of Carnaby's Cockatoo, however the region is considered important foraging habitat.

Three Important Bird Areas (IBA) for Carnaby's Cockatoo occur in the region surrounding the Survey Area (Dutson, Garnett and Gole, 2009; DPaW 2013). These are summarized below:

- Coomallo: Located approximately 40 km to the northeast of the Survey Area, this area supports at least 1% of the Carnaby's Cockatoo breeding population (minimum of 40 breeding pairs) which nest in woodland remnants and isolated paddock trees and feed in native shrublands.
- Koobabbie: Located near Coorow and approximately 110 km northeast of the Survey Area, supporting at least 1% of the Carnaby's Cockatoo breeding population (up to 32 breeding pairs), this large pastoral property has 254 ha of remnant Wandoo and Salmon Gum woodland vegetation. Fledglings have been recorded at Coomallo Creek and Beekeepers Nature Reserve.
- Northern Swan Coastal Plain: Located between the Swan River and Moore River, this area supports 4,600-15,000 birds in the non-breeding season and a small number of pairs of breeding birds; this is the largest population of birds that gather in the non-breeding season.

Approximately 44,000 hectares of Carnaby's Cockatoo habitat occurs within the regional conservation reserves listed below, although additional areas of habitat located outside of the conservation estate are also utilised for foraging and nesting:

- Badgingarra National Park: 13,108 ha;
- Coomallo Nature Reserve: 8,807 ha;
- Southern Beekeepers Nature Reserve: 10,808 ha;

- Nambung National Park: 8,362 ha;
- Hill River Nature Reserve: 882 ha; and
- Un-named Conservation Park: 2,369 ha.

Breeding sites in the region surrounding the Survey Area include Three Springs, Coomallo, Carnamah, Coorow, Badgingarra and Moora regions which are vacated by the end of February each year. Adult Carnaby's Cockatoo and their fledglings fly west to coastal feeding habitat where they aggregate in flocks in Kwongan heath and pine plantations (Saunders, 1980). Occasionally a flock of 60 – 100 birds remain in the Badgingarra National Park area into March – April (Ron Johnstone pers. comm. 2008), and from July through to September the Carnaby's Cockatoo population moves back to breeding sites (Williams *et al.*, 2017).

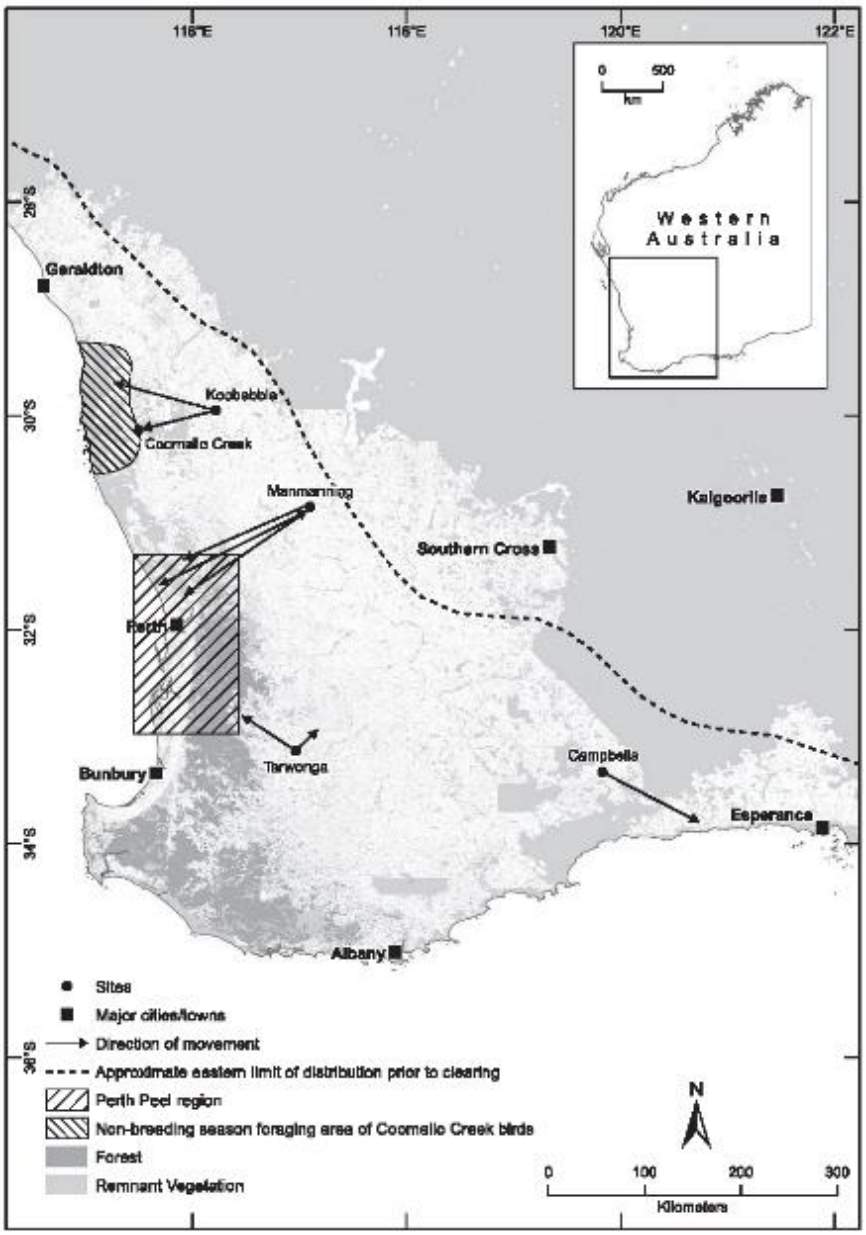


Figure 5.1: Known movement patterns of Carnaby's Cockatoo (Williams *et. al.* 2017)

5.5.2.3. Fork-tailed Swift (*Apus pacificus*)

- EPBC/ BC Act Migratory

Ecology, Habitat and Distribution: The Fork-tailed swift is a migratory, non-breeding visitor to Australia. Within Western Australia, records are most abundant in coastal areas of the, southwest, Pilbara, and Kimberly regions. This medium sized swift is characterised by its forked tail and white rump, with back swept wings that taper to a fine point (Menkhorst *et al.*, 2019). The species is known to be highly nomadic, rarely landing, spending much of their time foraging in large flocks high above the canopy. The species is known to be insectivorous but its food source is relatively unknown within Australia (Menkhorst *et al.*, 2019).

Likelihood of Occurrence – High: Three regional records exist from Nature Map and the DBCA, the most recent recorded in 2012. Two of these records occur along the coat and one further inland to the northeast. Due to the aerial lifestyle of the Fork-tailed Swift the species is unlikely to directly utilise any terrestrial habitats within the Survey Area or to be negatively affected by on ground development.

5.5.3. Reptiles

5.5.3.1. Black-striped Snake (*Neelaps calonotos*)

- DBCA Priority 3

Ecology, Habitat and Distribution: This fossorial elapid is rarely seen on the surface and is restricted to the coastal sand plain region between Cataby and Mandurah with what appears to be isolated population occurring further north near Eneabba and Dongara. The species inhabits dunes and sandplains vegetated with heaths and eucalypt/banksia woodlands. Black-striped Snakes are specialist feeders, preying largely on the small fossorial slider skink, *Lerista praepedita* (Wilson and Swan, 2017).

Likelihood of Occurrence – Recorded: Black-striped Snake was recorded opportunistically while foraging in Banksia Woodland habitat. One individual was raked from a track side spoil heap (mounded sand and vegetation left from track construction). Banksia Woodland, Heath (Banksia) and Banksia Woodland/ Heath (Banksia) habitat is expected to host the Black-striped Snake though detection can be difficult due to their mostly sub-terranean habits.

5.5.4. Invertebrates

5.5.4.1. Bothriembryontid Land Snail (Moore River) (*Bothriembryon perobesus)*

- DBCA Priority 1

Ecology, Habitat and Distribution: The Bothriembryontid Land Snail (Moore River) is known to occupy stabilised sand dunes supporting Banksia and/or Eucalyptus woodland over heath (Bennelongia Environmental Consultants, 2013).

Likelihood of Occurrence – High: The Bothriembryontid Land Snail (Moore River) was collected by Bennelongia Environmental from stabilised dunes within the Cooljarloo West Development Envelope, 20km south east of the Survey Area in 2013 (Bennelongia Environmental Consultants, 2013). The closest record is from 18 km west of the Survey Area near Cervantes and records also exist from many other locations within the immediate region from between 1955 and 2017 (WAM). The species has been allocated a high likelihood of occurrence due to the proximity of previous records and suitable habitat existing within the Survey Area in the form of Banksia Woodland, Heath (Banksia) and Banksia Woodland/ Heath (Banksia).

5.6. SRE Invertebrate Fauna

The Basic and Detailed surveys recorded 22 potential SRE species, 20 within the Survey Area and two in the immediate region. Twelve of these appear to have only been recorded from the Survey Area; one araneomorph spider and 11 pseudoscorpions.

The majority of species/ morphospecies from SRE target groups are considered data deficient due to lack of sampling, lack of taxonomic resolution and a lack of data consolidation between the Western Australian Museum (WAM) and private consultancies. It is possible that if the collection of specimens at Bennelongia was compared to the WAM collection (or the collections of other private consultants), some individual morphospecies may be found to have multiple phrase names, as comparison between collections and consolidation of data is not often undertaken. Many records also lack unique phrase names and this further limits a consultant's ability to consolidate data without further inspection and comparison of the original specimens. Partly due to the lack of a centralised specimen collection and limited data sharing between all interested parties, knowledge gain regarding species distributions and by extension their status as potential SRE species is slow. Following the Precautionary Principle, all data deficient species from SRE target groups are considered potential SREs.

Of the 20 potential SRE species recorded within the Survey Area, preliminary morphological identification determined that four were recorded only within the proposed impact area and one species required DNA analysis to confirm its conspecificity with a species found 10 km southeast. Genetic sequencing revealed that two of these morphospecies (*Antichiropus* sp. 712504 and *Antichiropus* sp. 712514) align with the described millipede species *Antichiropus sulcatus*. Though still assigned potential SRE status, the species has been recorded from locations outside the Survey Area. The isopod *Laevophiloscia* sp. B24 aligns morphologically with specimens collect 10 km southeast of the Survey Area though sequencing of these regional specimens failed and as such no genetic comparison was possible. This leaves the two pseudoscorpions *Beierolpium* 8/4 `BPS323` and *Beierolpium* 8/2 `BPS325` as the only morphospecies known only from the proposed impact area.

Each SRE target group recorded during the Detailed survey is discussed separately and in detail below.

5.6.1. Araneae (Spiders)

The order Araneae is divided into two infraorders, the Araneomorphae or modern spiders and the Mygalomorphae or primitive spiders. Typically, short range endemism is associated with the Mygalomorphae and in particular the trapdoor spiders, due to their limited dispersal capabilities and sedentary nature. However, certain genera within the Araneomorphae have been recognised as containing potential short range endemics. The specimen *Maratus* 'BAR130' collected at wet pitfall site APSRE5 in Banksia Woodland habitat during the Detailed survey belongs to one such genus and after preliminary analysis appears to be an undescribed species. The genus *Maratus* (Karsch 1878) is comprised of 86 species, 47 of which could be considered short range endemics based on the current understanding of their distributions (Schubert, 2020). One species, *Maratus sarahae*, is listed as critically endangered under the Western Australian Biodiversity Conservation Act. As for many potential SRE taxa, further targeted survey effort and taxonomic resolution may show these species to have larger distributions than once thought. At this time *Maratus* 'BAR130' has been included as a potential SRE in accordance with the Precautionary Principle. Bennelongia Environmental Consultants (Bennelongia) taxonomists have recommended genetic sequencing for comparison with known species to determine the species identity.

No Mygalomorph spiders or other potential SRE Araneomorph spiders were collected during the field surveys.

5.6.2. Pseudoscorpiones

Pseudoscorpions are small arachnids that resemble small scorpions; however, they do not have an elongated tail. Pseudoscorpions are often associated with vegetated habitats where they are recorded from under bark and from within leaf litter. A total of fifteen pseudoscorpion specimens from three families, representing 13 potential SRE species, were collected during the Basic and Detailed fauna survey. Of these, two species (*Euryolpium* `BPS252` and *Euryolpium* sp.) were only recorded from outside the Survey Area.

Morphospecies Atemnidae sp. 712345, *Austrochthonius* sp. 712610, *Beierolpium* 8/2 `BPS325`, *Beierolpium* 8/4 `BPS322`, *Beierolpium* 8/4 `BPS323`, *Beierolpium* 8/4 `BPS324` and *Oratemnus* `BPS326` were collected only from within the Survey Area during the current survey and are not known from any other locations.

Two morphospecies were recorded only from the proposed impact area and as such, genetic sequencing was completed in an effort to align them with species recorded outside of the impact and Survey Area. Sequencing failed for the single *Beierolpium* 8/4 `BPS323` specimen available, likely due to its small size. *Beierolpium* 8/2 `BPS325` was sequenced successfully though did not align with any previously recorded species.

Pseudoscorpions are included as an SRE target group though Harvey (Harvey, 2002) states that few SRE species are known from this order and those species that fit the criteria are troglobitic. Since that time, epigean short range endemic pseudoscorpion species have been described(Harvey *et al.*, 2016)ion of WA (Harvey *et al.*, 2016) though it is unknown if similarly range restricted species occur on the Swan Coastal Plain.

5.6.3. Gastropoda (Snails)

One potential SRE Punctid land snail species was recorded from both inside and outside the Survey Area. *Westralaoma* cf. *aprica* was recorded from leaf litter in Samphire habitat approx. 1.3 km west of the Survey Area during the Basic fauna survey. The species was also collected within a leaf litter sample during the Detailed survey in Melaleuca habitat. Both locations are low lying and prone to seasonal inundation though they are separated by a significant area of typically dry Banksia Woodland habitat. The Basic fauna survey record is associated with a dampland drainage system that flows east-west through the centre of the Survey Area. The Detailed survey record location is from a small depression, isolated by dry Heath (Banksia) and Banksia Woodland habitat. Unfortunately, only shells were collected so no further analysis is possible.

Short range endemism is well documented within the Australian land snails (Harvey, 2002; EPA 2016b). Within the northern Swan Coastal Plain region, the snail *Bothryembryon perobesus* (DBCA Priority 1) is recognised as a short range endemic species though it is unknown if any further land snail species from the region are range restricted.

5.6.4. Isopoda (Wood Lice)

Isopods are crustaceans found in marine, freshwater, and terrestrial environments. Terrestrial isopods (superfamily Oniscoidea) have segmented exoskeletons, seven pairs of legs and are often associated with decaying wood leading to the common name wood louse. Four possible species of isopod (57 specimens), representing three potential SREs, were recorded within the Survey Area during the Detailed survey.

Morphological analysis suggests that the three potential SRE species *Buddelundia* sp. B38, *Laevophiloscia* sp. B23 and *Laevophiloscia* sp. B24 have been previously recorded from approximately 10 km southeast of the Survey Area. Due to difficulty of identifying many species using morphological characters alone, the two *Laevophiloscia* sp. were genetically sequenced to confirm their conspecificity with specimens recorded

outside of the Survey Area. *Laevophiloscia* sp. B23 was found to align with those specimens collected at Cooljarloo. Unfortunately, the sequencing of *Laevophiloscia* sp. B24 specimens from Cooljarloo failed and could not be compared to specimens collected within the proposed Atlas Project impact area. The failure can likely be attributed to poor preservation technique used in 2012 when the specimens were collected. The remaining species, *Porcellionides pruinosus*, is an introduced cosmopolitan species native to Europe.

Short range endemism in terrestrial isopods appears to be directly related to the availability of microhabitats with high levels of moisture and accrued surface organic material. Species with limited distributions are known from the Darling Scarp and it has been suggested that range restricted species may also occur on the Swan Coastal Plain (Judd, 2004). The Survey Area is predominantly comprised of habitat types that do not maintain moist microhabitats and organic material is typically limited to thin layers that are unlikely to act as an effective buffer against seasonal aridity. The exception to this is the Melaleauca habitat that may retain enough moisture to be suitable for moisture dependent isopod species.

5.6.5. Chilopoda (Centipedes)

Two centipede species were collected during the Detailed survey, *Lamyctes* nr *africanus* and Scolopendrinae `BSCOL071`. The former species belongs to the order Lithobiomorpha (rock centipedes), a group not associated with short range endemism. The latter is an unusual animal that does not fit within any of the currently recognised genera of the family Scolopendridae. Due to the unusual nature of the specimen, Bennelongia have recommended the specimen be genetically sequenced in an effort to resolve its identification. However, it must be made clear that the order Scolopendrida (that the specimen belongs to) is not known to host SRE species (Harvey, 2002).

5.6.6. Diplopoda (Millipedes)

Five potential SRE specimens of the millipede genus *Antichiropus* were collected from three locations during the Detailed survey: *Antichiropus* sp. 712504, *Antichiropus* sp. 712514, *Antichiropus* sp. 713613 and *Antichiropus* sp. 713614. The genus is known to contain many undescribed taxa and a high proportion of SRE species, likely due to poor mobility and an extremely seasonal life cycle that's strictly associated with rainfall (Harvey, 2002). Male only characters (e.g. gonopod morphology) are the primary diagnostic features used when identifying species which makes species level identification difficult when only juvenile or female specimens are available (Wojcieszek, Harvey and Rix, 2010). All five specimens collected during the survey were female or juvenile and as such, genetic sequencing was required to determine which species they represent.

DNA analysis successfully identified *Antichiropus* sp. 712504 and *Antichiropus* sp. 712514 as *Antichiropus sulcatus*, a species previously recorded outside the Survey Area at Eneabba and Cooljarloo. The remaining millipede specimens *Antichiropus* sp. 713613 and *Antichiropus* sp. 713614 aligned with *Antichiropus whistleri*, a relatively widespread species. Though confirmed to occur outside the Survey Area, both species are still regarded as potential short range endemics.

5.7. Survey Adequacy

Interpretation of the species accumulation curves indicates that the majority of both trappable vertebrates and bird species were recorded by systematic survey efforts over both phases. However, the corresponding estimates of total species richness (Michaelis-Menten curves) give a combined theoretical maximum of approximately 74 species considerably lower than the 98 species recorded during the current survey (Figure 4.5, Figure 4.6). This demonstrates the significance and efficacy of non-systematic survey methods in better representing the vertebrate fauna present. When considering the determination of survey adequacy, the likelihood of certain species being recorded by systematic survey methods must also be considered. Many species are unlikely to be recorded this way, which is why non-systematic survey methods such as opportunistic searches, motion cameras and bat recording devices were used to supplement this. These methods mostly target such habitats which are typically unable to be surveyed systematically. This explains the discrepancy between the total number of species recorded versus those only recorded systematically, whereby extra reptiles, mammals and birds were recorded. When these species are taken into account, the overall species richness actually exceeds that predicted by the Michaelis-Menten curves. The results of the current survey are therefore considered to be a more than adequate representation of the fauna present.

6. CONCLUSION

The Detailed survey recorded a total of 98 vertebrate fauna species: three species of native non-volant mammal, six species of bat, four introduced mammals, 62 bird species, 19 reptiles and four amphibians. This result is comparable to those achieved during other Level 2/ Detailed surveys completed within the region. The survey timing (October) was suitable for each species group.

Seven fauna habitat types and two ecotone/ mixed habitats were identified within the Atlas Survey Area. Banksia Woodland habitat is the most common habitat type within the Survey Area and is considered important for several conservation significant fauna species including Carnaby's Cockatoo, Western Brush Wallaby and Black-striped Snake. Habitat formed by a mosaic of Banksia Woodland and Banksia Woodland (Heath) is also considered likely to be utilised by these conservation significant species. Ephemeral Wetland habitat was occupied by Common Greenshank and Samphire habitat may also be utilised following significant rainfall on a temporary basis.

The following species of conservation significance were recorded from the survey area during the assessment: Western Brush Wallaby (*Notamacropus Irma*; DBCA Priority 4), Common Greenshank (*Tringa nebularia*; EPBC/ BC Act Migratory), Black-striped Snake (*Neelaps calonotos*; DBCA Priority 3), and Carnaby's Cockatoo (*Calyptorhynchus latirostris*; EPBC/ BC Act Endangered). A further two conservation significant fauna species are considered to have a high likelihood of occurring within the Survey Area: Fork-tailed Swift (*Apus pacificus*; EPBC/ BC Act Migratory) and Bothriembryontid Land Snail (Moore River) (*Bothriembryon perobesus*; DBCA Priority 1).

Seventeen potential SRE species were recorded during the survey, 14 of which appear to have only been recorded from the Survey Area: one araneomorph spider, seven pseudoscorpions, one snail, three isopods, four millipedes and one centipede. The remaining three species, all isopods, have been recorded previously from approx. 10 km southeast of the Survey Area. The Melaleuca fauna habitat type was assessed to be the most likely habitat to host SRE species due to the mesic microhabitats it supports and its limited coverage within the Survey Area.

The desired objectives and outcomes were successfully reached during the current assessment. There were no significant limitations to the survey work, and the level of survey effort and number of species recorded is considered adequate for the Survey Area. All field work was completed in accordance with relevant government legislation, guidance, and standard operating procedures.

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Appendix A: Conservation Codes

EPBC Act 1999 Categories for Flora and Fauna

Code	Definition (EPBC Act)
Extinct	A native species is eligible to be included in the extinct category at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.
Extinct in the wild	A native species is eligible to be included in the extinct in the wild category at a particular time if, at that time: (a) it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
Critically Endangered (CE)	A native species is eligible to be included in the critically endangered category at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
Endangered (EN)	A native species is eligible to be included in the endangered category at a particular time if, at that time: (a) it is not critically endangered; and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
Vulnerable (VU)	A native species is eligible to be included in the vulnerable category at a particular time if, at that time: (a) it is not critically endangered or endangered; and (b) it is facing a high risk of extinction in the wild in the medium term future, as determined in accordance with the prescribed criteria.
Conservation Dependent (CD)	A native species is eligible to be included in the conservation dependent category at a particular time if, at that time: (a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or (b) the following subparagraphs are satisfied: (i) the species is a species of fish; (ii) the species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long-term survival in nature are maximised; (iii) the plan of management is in force under a law of the Commonwealth or of a State or Territory; (iv) cessation of the plan of management would adversely affect the conservation status of the species.

Conservation Codes for Western Australian Flora and Fauna (DBCA 2019)

Code	Definition (BC Act)
Threatened Species (T) Listed by order of the Minister as Threatened in the category of critically endangered, endangered or vulnerable under section 19(1), or is a rediscovered species to be regarded as threatened species under section 26(2) of the Biodiversity Conservation Act 2016 (BC Act). **Threatened fauna** is that subset of 'Specially Protected Fauna' listed under schedules 1 to 3 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for Threatened Fauna. **Threatened flora** is that subset of 'Rare Flora' listed under schedules 1 to 3 of the Wildlife Conservation (Rare Flora) Notice 2018 for Threatened Flora. The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.	
Critically Endangered (CR)	Threatened species considered to be "facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as critically endangered under section 19(1)(a) of the BC Act in accordance with the criteria set out in section 20 and the ministerial guidelines. Published under **schedule 1** of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for critically endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for critically endangered flora.
Endangered (EN)	Threatened species considered to be "facing a very high risk of extinction in the wild in the near future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as endangered under section 19(1)(b) of the BC Act in accordance with the criteria set out in section 21 and the ministerial guidelines. Published under **schedule 2** of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for endangered fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for endangered flora.
Vulnerable (VU)	Threatened species considered to be "facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with criteria set out in the ministerial guidelines". Listed as vulnerable under section 19(1)(c) of the BC Act in accordance with the criteria set out in section 22 and the ministerial guidelines. Published under **schedule 3** of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for vulnerable fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for vulnerable flora.
Extinct species Listed by order of the Minister as extinct under section 23(1) of the BC Act as extinct or extinct in the wild.	
Extinct species (EX)	Species where "there is no reasonable doubt that the last member of the species has died", and listing is otherwise in accordance with the ministerial guidelines (section 24 of the BC Act). Published as presumed extinct under **schedule 4** of the Wildlife Conservation (Specially Protected Fauna) Notice 2018 for extinct fauna or the Wildlife Conservation (Rare Flora) Notice 2018 for extinct flora.

Code	Definition (BC Act)
Extinct in the wild species (EW)	Species that "is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; and it has not been recorded in its known habitat or expected habitat, at appropriate seasons, anywhere in its past range, despite surveys over a time frame appropriate to its life cycle and form", and listing is otherwise in accordance with the ministerial guidelines (section 25 of the BC Act). Currently there are no threatened fauna or threatened flora species listed as extinct in the wild. If listing of a species as extinct in the wild occurs, then a schedule will be added to the applicable notice.
Specially protected species Listed by order of the Minister as specially protected under section 13(1) of the BC Act. Meeting one or more of the following categories: species of special conservation interest; migratory species; cetaceans; species subject to international agreement; or species otherwise in need of special protection. Species that are listed as threatened species (critically endangered, endangered or vulnerable) or extinct species under the BC Act cannot also be listed as Specially Protected species.	
Migratory species (MI)	Fauna that periodically or occasionally visit Australia or an external Territory or the exclusive economic zone; or the species is subject of an international agreement that relates to the protection of migratory species and that binds the Commonwealth; and listing is otherwise in accordance with the ministerial guidelines (section 15 of the BC Act). Includes birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and fauna subject to the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), an environmental treaty under the United Nations Environment Program. Migratory species listed under the BC Act are a subset of the migratory animals, that are known to visit Western Australia, protected under the international agreements or treaties, excluding species that are listed as Threatened species. Published as migratory birds protected under an international agreement under schedule 5 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018.
Conservation Dependent (CD)	Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened, and listing is otherwise in accordance with the ministerial guidelines (section 14 of the BC Act). Published as conservation dependent fauna under schedule 6 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018
Other specially protected fauna (OS)	Fauna otherwise in need of special protection to ensure their conservation, and listing is otherwise in accordance with the ministerial guidelines (section 18 of the BC Act). Published as other specially protected fauna under schedule 7 of the Wildlife Conservation (Specially Protected Fauna) Notice 2018

Code	Definition (BC Act)
Priority species (P) Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened fauna or flora. Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring. Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.	
Priority 1: Poorly-known species (P1)	Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.
Priority 2: Poorly-known species (P2)	Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.
Priority 3: Poorly-known species (P3)	Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.
Priority 4: Rare, Near Threatened and other species in need of monitoring (P4)	(a) Rare. Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection but could be if present circumstances change. These species are usually represented on conservation lands. (b) Near Threatened. Species that are considered to have been adequately surveyed and that are close to qualifying for vulnerable but are not listed as Conservation Dependent. (c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

[1] The definition of flora includes algae, fungi and lichens; [2] Species includes all taxa (plural of taxon - a classificatory group of any taxonomic rank, e.g. a family, genus, species or any infraspecific category i.e. subspecies or variety, or a distinct population).

Definitions of Threatened Ecological Communities (DEC 2013)

Code	Definition
Presumed Totally Destroyed (PD	An ecological community that has been adequately searched for but for which no representative occurrences have been located. The community has been found to be totally destroyed or so extensively modified throughout its range that no occurrence of it is likely to recover its species composition and/or structure in the foreseeable future. An ecological community will be listed as presumed totally destroyed if there are no recent records of the community being extant and either of the following applies (A or B): A) Records within the last 50 years have not been confirmed despite thorough searches of known or likely habitats or B) All occurrences recorded within the last 50 years have since been destroyed
Critically Endangered (CR)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or that was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated. An ecological community will be listed as Critically Endangered when it has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future. This will be determined on the basis of the best available information, by it meeting any one or more of the following criteria (A, B or C): A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have been reduced by at least 90% and either or both of the following apply (i or ii): i) geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is imminent (within approximately 10 years); ii) modification throughout its range is continuing such that in the immediate future (within approximately 10 years) the community is unlikely to be capable of being substantially rehabilitated. B) Current distribution is limited, and one or more of the following apply (i, ii or iii): i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the immediate future (within approximately 10 years); ii) there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes; iii) there may be many occurrences but total area is very small and each occurrence is small and/or isolated and extremely vulnerable to known threatening processes. C) The ecological community exists only as highly modified occurrences that may be capable of being rehabilitated if such work begins in the immediate future (within approximately 10 years).

Code	Definition
Endangered (EN)	An ecological community that has been adequately surveyed and found to have been subject to a major contraction in area and/or was originally of limited distribution and is in danger of significant modification throughout its range or severe modification or destruction over most of its range in the near future. An ecological community will be listed as Endangered when it has been adequately surveyed and is not Critically Endangered but is facing a very high risk of total destruction in the near future. This will be determined on the basis of the best available information by it meeting any one or more of the following criteria (A, B, or C): A) The geographic range, and/or total area occupied, and/or number of discrete occurrences have been reduced by at least 70% since European settlement and either or both of the following apply (i or ii): i) the estimated geographic range, and/or total area occupied and/or number of discrete occurrences are continuing to decline such that total destruction of the community is likely in the short term future (within approximately 20 years); ii) modification throughout its range is continuing such that in the short term future (within approximately 20 years) the community is unlikely to be capable of being substantially restored or rehabilitated. B) Current distribution is limited, and one or more of the following apply (i, ii or iii): i) geographic range and/or number of discrete occurrences, and/or area occupied is highly restricted and the community is currently subject to known threatening processes which are likely to result in total destruction throughout its range in the short term future (within approximately 20 years); ii) there are few occurrences, each of which is small and/or isolated and all or most occurrences are very vulnerable to known threatening processes; iii) there may be many occurrences but total area is small and all or most occurrences are small and/or isolated and very vulnerable to known threatening processes.
Vulnerable (VU)	An ecological community that has been adequately surveyed and is found to be declining and/or has declined in distribution and/or condition and whose ultimate security has not yet been assured and/or a community that is still widespread but is believed likely to move into a category of higher threat in the near future if threatening processes continue or begin operating throughout its range. An ecological community will be listed as Vulnerable when it has been adequately surveyed and is not Critically Endangered or Endangered but is facing a high risk of total destruction or significant modification in the medium (within approximately 50 years) to long-term future. This will be determined on the basis of the best available information by it meeting any one or more of the following criteria (A, B or C): A) The ecological community exists largely as modified occurrences that are likely to be capable of being substantially restored or rehabilitated. B) The ecological community may already be modified and would be vulnerable to threatening processes, is restricted in area and/or range and/or is only found at a few locations. C) The ecological community may be still widespread but is believed likely to move into a category of higher threat in the medium to long-term future because of existing or impending threatening processes.

Definitions of Priority Ecological Communities (DEC 2013)

Code	Definition
Priority One	Poorly-known ecological communities. Ecological communities that are known from very few occurrences with a very restricted distribution (generally ≤5 occurrences or a total area of ≤ 100ha). Occurrences are believed to be under threat either due to limited extent, or being on lands under immediate threat (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) or for which current threats exist. May include communities with occurrences on protected lands. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
Priority Two	Poorly-known ecological communities. Communities that are known from few occurrences with a restricted distribution (generally ≤10 occurrences or a total area of ≤200ha). At least some occurrences are not believed to be under immediate threat (within approximately 10 years) of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
Priority Three	Poorly known ecological communities. (i) Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (ii) communities known from a few widespread occurrences, which are either large or with significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat (within approximately 10 years), or; (iii) communities made up of large, and/or widespread occurrences, that may or may not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, inappropriate fire regimes, clearing, hydrological change etc. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.
Priority Four	Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened, or that have been recently removed from the threatened list. These communities require regular monitoring. (i) Rare. Ecological communities known from few occurrences that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These communities are usually represented on conservation lands. (ii) Near Threatened. Ecological communities that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for a higher threat category. (iii) Ecological communities that have been removed from the list of threatened communities during the past five years.
Priority Five	Conservation Dependent ecological communities Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Appendix B: Survey Site Locations

All Survey Site Locations

Site Name	Survey Site Type	Survey Site Type Coordinates (GDA94 Z50)	
		Easting	Northing
APS1 BAT	Bat Recorder	331438.616	6616953.405
APS2 BAT	Bat Recorder	332626.901	6617669.252
APS3 BAT	Bat Recorder	331682.551	6618075.335
APS4 BAT	Bat Recorder	332368.429	6618996.442
APS5 BAT	Bat Recorder	331433.524	6619003.735
APS6 BAT	Bat Recorder	332664.112	6620182.293
APS7 BAT	Bat Recorder	331573.475	6620590.182
APS8 BAT	Bat Recorder	332227.057	6620773.873
APOPP01	Birding Sites	332481.267	6620190.948
APOPP02	Birding Sites	331369.189	6619211.388
APOPP03	Birding Sites	331041.388	6618215.472
APOPP04	Birding Sites	332698.061	6619097.379
APOPP05	Birding Sites	331369.189	6619211.388
APOPP06	Birding Sites	331041.388	6618215.472
APS1BIRD	Birding Sites	314717.553	6624123.366
APS2BIRD	Birding Sites	331423.379	6620412.667
APS3BIRD	Birding Sites	314742.111	6624162.827
APS4BIRD	Birding Sites	314717.194	6624128.682
APS5BIRD	Birding Sites	314735.350	6624135.967
APS6BIRD	Birding Sites	314702.443	6624156.882
APS7BIRD	Birding Sites	314723.293	6624130.783
APS8BIRD	Birding Sites	332067.966	6620835.527
APS1TRAP	Fauna Trapping Site	331435.088	6617008.561
APS2TRAP	Fauna Trapping Site	332612.330	6617631.928
APS3TRAP	Fauna Trapping Site	331671.216	6618078.647
APS4TRAP	Fauna Trapping Site	332369.244	6618971.165
APS5TRAP	Fauna Trapping Site	331442.035	6618971.153
APS6TRAP	Fauna Trapping Site	332528.836	6620184.267
APS7TRAP	Fauna Trapping Site	331564.425	6620578.451
APS8TRAP	Fauna Trapping Site	332200.095	6620792.643
APLLS1	Leaf litter	332433.002	6620081.000
APLLS2	Leaf litter	332012.002	6620759.000
APLLS3	Leaf litter	331895.002	6619069.000
APLLS4	Leaf litter	332012.002	6620759.000
APLLS5	Leaf litter	331703.002	6616956.000
APLLS6	Leaf litter	332004.002	6618121.000
APLLS7	Leaf litter	332667.002	6617758.000
APLLS8	Leaf litter	332193.002	6616050.000
MC21	Motion Camera	332527.816	6620969.564
MC23	Motion Camera	331093.905	6616730.219
MC24	Motion Camera	332482.199	6620983.940
MC25	Motion Camera	331216.461	6616714.952
MC26	Motion Camera	332517.635	6616555.157
MC27	Motion Camera	332499.750	6616477.488
MC28	Motion Camera	332625.942	6620942.034
MC29	Motion Camera	332586.582	6620961.720
MC30	Motion Camera	332471.352	6620940.533
MC33	Motion Camera	332539.029	6616635.752
MC34	Motion Camera	331321.981	6618227.534
MC35	Motion Camera	331306.249	6618122.519

Site Name	Survey Site Type	Survey Site Type Coordinates (GDA94 Z50)	
		Easting	Northing
MC38	Motion Camera	331317.421	6618156.948
MC39	Motion Camera	331319.508	6618256.657
MC40	Motion Camera	331573.443	6616961.223
MC61	Motion Camera	331308.333	6618198.160
MC63	Motion Camera	331565.151	6617012.865
MC64	Motion Camera	331592.604	6617141.351
MC65	Motion Camera	331619.469	6617221.486
MC66	Motion Camera	331592.230	6617073.051
MC72	Motion Camera	332510.086	6616324.314
MC77	Motion Camera	332394.598	6619886.529
MC78	Motion Camera	332405.988	6620043.255
MC79	Motion Camera	331285.499	6616711.152
MC80	Motion Camera	332394.407	6619991.741
MC102	Motion Camera	331147.521	6616718.642
MC104	Motion Camera	332501.363	6616398.355
MC105	Motion Camera	331332.201	6616700.460
MC106	Motion Camera	332427.295	6619875.615
MC107	Motion Camera	332435.358	6619931.507
APNOC1	Nocturnal Opp	332623.079	6617816.237
APNOC2	Nocturnal Opp	332106.387	6616156.836
APNOC3	Nocturnal Opp	330645.920	6618051.295
APNOC4	Nocturnal Opp	332565.514	6618587.640
APOPP07	Opportunistic Site	331954.940	6622353.719
APOPP08	Opportunistic Site	331249.856	6621868.937
APOPP09	Opportunistic Site	331514.838	6622244.788
APOPP10	Opportunistic Site	331945.213	6621955.316
APOPP11	Opportunistic Site	332428.332	6621849.989
APOPP12	Opportunistic Site	331717.287	6616707.257
APOPP13	Opportunistic Site	332085.596	6616340.235
APOPP14	Opportunistic Site	331548.127	6619987.763
APOPP15	Opportunistic Site	331885.172	6621024.713
APOPP16	Opportunistic Site	332711.431	6618211.897
APOPP17	Opportunistic Site	330487.417	6618054.604
APOPP18	Opportunistic Site	330343.396	6622291.179
APOPP19	Opportunistic Site	331286.796	6620405.869
APOPP20	Opportunistic Site	332707.609	6618708.631
APOPP20	Opportunistic Site	330231.204	6621533.942
APOPP21	Opportunistic Site	329735.974	6619881.133
APOPP22	Opportunistic Site	329895.730	6619336.395
APOPP23	Opportunistic Site	329933.709	6618018.759
APOPP24	Opportunistic Site	331889.372	6620353.182
APOPP25	Opportunistic Site	331315.971	6616251.154
APOPP26	Opportunistic Site	330919.116	6616258.486
APOPP27	Opportunistic Site	331433.516	6616946.380
APOPP28	Opportunistic Site	330494.440	6618052.793
APOPP29	Opportunistic Site	331307.920	6620359.015
APOPP30	Opportunistic Site	332704.413	6618178.750
APOPP31	Opportunistic Site	331066.185	6617890.594
APOPP32	Opportunistic Site	332474.693	6615889.313
APOPP33	Opportunistic Site	332684.054	6620271.605
APOPP34	Opportunistic Site	330159.890	6618033.423
APOPP35	Opportunistic Site	331068.309	6616890.937

Site Name	Survey Site Type	Survey Site Type Coordinates (GDA94 Z50)	
		Easting	Northing
APOPP36	Opportunistic Site	331888.016	6619966.351
APOPP37	Opportunistic Site	331427.154	6620985.110
APOPP38	Opportunistic Site	332217.711	6620630.260
APOPP39	Opportunistic Site	331696.693	6619088.319
APOPP40	Opportunistic Site	331412.966	6620444.712
APOPP41	Opportunistic Site	331396.935	6620460.383
APOPP42	Opportunistic Site	331566.217	6620394.370
APOPP43	Opportunistic Site	332079.823	6620808.693
AAA01	Habitat Assessment, Active search	332113.307	6612839.666
AAA02	Habitat Assessment, Active search	332116.227	6612613.281
AAA03	Habitat Assessment, Active search	332108.908	6612408.889
AAA04	Habitat Assessment, Active search	332112.188	6612225.904
AAA05	Habitat Assessment, Active search	332123.213	6612059.825
AAA06	Habitat Assessment, Active search	332111.179	6612944.905
AAA07	Habitat Assessment, Active search	331971.433	6615318.999
AAA08	Habitat Assessment, Active search	331766.859	6615323.740
AAA09	Habitat Assessment, Active search	331537.667	6615345.876
AAA10	Habitat Assessment, Active search	331262.426	6615354.061
AAA11	Habitat Assessment, Active search	331099.063	6615362.205
AAA12	Habitat Assessment, Active search	330890.894	6615364.822
AAA13	Habitat Assessment, Active search	330646.889	6616757.469
AAA14	Habitat Assessment, Active search	330522.859	6616753.916
AAA15	Habitat Assessment, Active search	329801.226	6620690.600
AAA16	Habitat Assessment, Active search	329728.119	6620773.179
AAA17	Habitat Assessment, Active search	329659.709	6620848.126
AAA18	Habitat Assessment, Active search	330325.716	6616747.805
APSRES1	Wet pitfall	332433.002	6620081.000
APSRES2	Wet pitfall	332012.002	6620759.000
APSRES3	Wet pitfall	331895.002	6619069.000
APSRES4	Wet pitfall	332012.002	6620759.000
APSRES5	Wet pitfall	331703.002	6616956.000
APSRES6	Wet pitfall	332004.002	6618121.000
APSRES7	Wet pitfall	332667.002	6617758.000

Appendix C: Vertebrate Fauna Species Recorded During Current and Previous Surveys

Regional Fauna Records

Family and Species	Common Name	Conservation status			DBCA Database	NatureMap	PMST	360 Environmental (2012a)	Bamford, Bancroft and Turpin (2015)	Ecologia Environment (2017)	Spectrum Ecology (2020)	Current survey
		EPBC Act	BC Act	DBCA								
MAMMALS												
Tachyglossidae												
Tachyglossus aculeatus	Short-beaked Echidna					●			●			
Dasyuridae												
Dasyurus geoffroii	Chuditch	VU	VU				●					
Parantechinus apicalis	Dibbler	EN	EN		●	●	●					
Phascogale tapoatafa subsp. wambenger	South-western Brush-tailed Phascogale	VU	VU			●						
Sminthopsis crassicaudata	Fat-tailed Dunnart					●						
Sminthopsis dolichura	Little Long-tailed Dunnart					●			●			
Sminthopsis fuliginosis	Dusky Dunnart					●						●
Sminthopsis gilberti	Gilbert's Dunnart					●						
Sminthopsis granulipes	White-tailed Dunnart					●			●			
Sminthopsis griseoventer	Grey-bellied Dunnart					●			●			
Peramelidae												
Isoodon fusciventer	Quenda			P4	●	●						
Potoroidae												
Bettongia penicillata ogilbyi	Woylie	EN	CR		●	●	●					
Potorous platyops	Broad-faced Potoroo	X	X			●						
Macropodidae												
Macropus fuliginosus	Western Grey Kangaroo					●		●			●	●
Notamacropus eugenii derbianus	Tammar Wallaby			P4	●	●						
Notamacropus irma	Western Brush Wallaby			P4	●	●		●			●	
Osphranter robustus	Euro					●						
Tarsipedidae												
Tarsipes rostratus	Honey Possum					●		●	●			●
Megadermatidae												
Macroderma gigas	Ghost Bat	VU	VU		●							
Molossidae												
Austronomus australis	White-striped Freetail-bat							●			●	●

Family and Species	Common Name	Conservation status			DBCA Database	NatureMap	PMST	360 Environmental (2012a)	Bamford, Bancroft and Turpin (2015)	Ecologia Environment (2017)	Spectrum Ecology (2020)	Current survey
		EPBC Act	BC Act	DBCA								
Ozimops kitcheneri	Western Free-tailed Bat							●				●
Vespertilionidae												
Chalinolobus gouldii	Gould's Wattled Bat					●		●				●
Chalinolobus morio	Chocolate Wattled Bat					●		●				
Nyctophilus geoffroyi	Lesser Long-eared Bat					●		●				
Nyctophilus sp.	Long-eared Bat										●	●
Vespadelus baverstocki	Inland Forest Bat											●
Vespadelus regulus	Southern Forest Bat					●		●			●	●
Muridae												
Rattus fuscipes	Western Bush Rat					●			●			
Pseudomys albocinereus	Ash-grey Mouse					●			●			
Mus musculus	House Mouse *					●		●	●			●
Leporidae												
Oryctolagus cuniculus	Rabbit *					●		●			●	●
Bovidae												
Bos taurus	Cattle *							●				●
Canidae												
Vulpes vulpes	Red Fox *					●		●			●	●
Felidae												
**Felis catus*	Feral Cat					●		●				
BIRDS												
Casuariidae												
Dromaius novaehollandiae	Emu					●		●	●	●	●	●
Anatidae												
Stictonetta naevosa	Freckled Duck					●						
Tadorna tadornoides	Australian Shelduck					●						●
Malacorhynchus membranaceus	Pink-eared Duck					●						●
Chenonetta jubata	Australian Wood Duck					●						●
Anas platyrhynchos	Mallard					●						
Anas superciliosus	Pacific Black Duck					●						●
Anas rhynchotis	Australasian Shoveler					●						
Anas gracilis	Grey Teal					●						●

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		EPBC Act	BC Act	DBCA								
Anas castanea	Chestnut Teal					●						
Aythya australis	Hardhead					●						●
Oxyura australis	Blue-billed Duck			P4	●	●						
Biziura lobata	Musk Duck					●						●
Megapodiidae												
Leipoa ocellata	Malleefowl	VU	VU		●	●	●					
Phasianidae												
Coturnix pectoralis	Stubble Quail					●		●		●		
Coturnix ypsilophora	Brown Quail					●		●				
Podicipedidae												
Tachybaptus novaehollandiae	Australasian Grebe					●						
Poliocephalus poliocephalus	Hoary-headed Grebe					●						●
Podiceps cristatus	Great Crested Grebe					●						
Threskiornithidae												
Threskiornis molucca	Australian White Ibis							●				
Threskiornis spinicollis	Straw-necked Ibis					●		●		●		●
Plegadis falcinellus	Glossy Ibis	MI	MI		●	●						
Platalea flavipes	Yellow-billed Spoonbill					●		●				
Ardeidae												
Nycticorax caledonicus	Nankeen Night Heron					●						
Ardea ibis	Cattle Egret							●				
Ardea pacifica	White-necked Heron					●						
Ardea modesta	Eastern Great Egret					●						
Egretta novaehollandiae	White-faced Heron							●		●		●
Pelecanidae												
Pelecanus conspicillatus	Australian Pelican					●						
Phalacrocoracidae												
Phalacrocorax sulcirostris	Little Black Cormorant					●						
Phalacrocorax varius	Pied Cormorant					●						●
Phalacrocorax carbo	Great Cormorant					●						
Anhingidae												
Anhinga novaehollandiae	Australasian Darter					●						

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		EPBC Act	BC Act	DBCA								
Pandionidae												
Pandion haliaetus cristatus	Osprey	MI	MI			●	●					
Accipitridae												
Elanus caeruleus	Black-shouldered Kite					●				●		
Lophoictinia isura	Square-tailed Kite									●		
Haliastur sphenurus	Whistling Kite					●						
Accipiter fasciatus	Brown Goshawk					●						●
Accipiter cirrocephalus	Collared Sparrowhawk					●						●
Circus approximans	Swamp Harrier					●						
Circus assimilis	Spotted Harrier					●		●				●
Milvus migrans	Black Kite					●						
Aquila audax	Wedge-tailed Eagle					●					●	
Hieraeetus morphnoides	Little Eagle					●						
Haliaeetus leucogaster	White-bellied Sea Eagle					●						
Otididae												
Ardeotis australis	Australian Bustard					●		●				
Rallidae												
Gallirallus philippensis	Buff-banded Rail					●						
Porzana tabuensis	Spotless Crake					●						
Porzana fluminea	Australian Spotted Crake											●
Porphyrio porphyrio	Purple Swamphen					●						
Tribonyx ventralis	Black-tailed Native-hen					●						●
Fulica atra	Eurasian Coot					●						●
Turnicidae												
Turnix varius	Painted Button-quail					●						●
Turnix velox	Little Button-quail					●						
Turnix sp.	Button-quail								●			
Haematopodidae												
Haematopus longirostris	Pied Oystercatcher					●						
Recurvirostridae												
Himantopus himantopus	Black-winged Stilt					●						
Recurvirostra novaehollandiae	Red-necked Avocet					●						

Family and Species	Common Name	Conservation status			DBCA Database	NatureMap	PMST	360 Environmental (2012a)	Bamford, Bancroft and Turpin (2015)	Ecologia Environment (2017)	Spectrum Ecology (2020)	Current survey
		EPBC Act	BC Act	DBCA								
Cladorhynchus leucocephalus	Banded Stilt					●						
Charadriidae												
Vanellus tricolor	Banded Lapwing					●						
Pluvialis fulva	Pacific Golden Plover	MI	MI		●	●						
Pluvialis squatarola	Grey Plover	MI	MI		●	●						
Charadrius ruficapillus	Red-capped Plover					●						
Charadrius mongolus	Lesser Sand Plover	EN & MI	EN		●	●						
Charadrius leschenaltii	Greater Sand Plover	VU & MI	MI		●	●						
Thinornis rubricollis	Hooded Plover			P4	●	●						
Elseyornis melanops	Black-fronted Dotterel					●						●
Scolopacidae												
Limosa limosa	Black-tailed Godwit	MI	MI		●	●						
Limosa lapponica	Bar-tailed Godwit	MI (& VU or CR at ssp. level)	MI (& VU or CR at ssp. level)		●	●	●					
Numenius madagascariensis	Eastern Curlew	CR & MI	CR				●					
Tringa nebularia	Common Greenshank	MI	MI		●	●	●					●
Tringa glareola	Wood Sandpiper	MI	MI		●	●						
Tringa brevipes	Grey-tailed Tattler	MI	MI	P4		●						
Tringa hypoleucos (*Actitis*)	Common Sandpiper	MI	MI			●	●					
Arenaria interpres	Ruddy Turnstone	MI	MI		●	●						
Calidris tenuirostris	Great Knot	CR & MI	CR		●	●						
Calidris canutus	Red Knot	EN & MI	EN		●	●	●					
Calidris alba	Sanderling	MI	MI		●	●						
Calidris ruficollis	Red-necked Stint	MI	MI		●	●						
Calidris subminuta	Long-toed Stint	MI	MI		●	●						

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		EPBC Act	BC Act	DBCA								
Calidris melanotos	Pectoral Sandpiper	MI	MI		●	●	●					
Calidris acuminata	Sharp-tailed Sandpiper	MI	MI		●	●	●					
Calidris ferruginea	Curlew Sandpiper	CR & MI	CR		●	●	●					
Rostratula benghalensis australis	Australian Painted Snipe	EN	EN				●					
Glareolidae												
Stiltia isabella	Australian Pratincole					●						
Laridae												
Larus pacificus	Pacific Gull					●						
Larus dominicanus	Kelp Gull					●						
Sterna nilotica	Gull-billed Tern	MI	MI			●						
Sternula nereis	Fairy Tern	VU	VU		●	●	●					
Sterna dougallii	Roseate Tern	MI	MI		●	●	●					
Sterna caspia	Caspian Tern				●	●	●					
Sterna bergii	Crested Tern	MI	MI		●	●	●					
Sterna anaethetus	Bridled Tern	MI	MI			●	●					
Columbidae												
Geopelia cuneata	Diamond Dove											●
Spilopelia chinensis	Spotted Turtle Dove					●						
Spilopelia senegalensis	Laughing Turtle Dove					●						●
Phaps chalcoptera	Common Bronzewing					●				●	●	●
Phaps elegans	Brush Bronzewing					●						
Ocyphaps lophotes	Crested Pigeon					●		●	●		●	●
Geophaps plumifera	Spinifex Pigeon					●						
Cuculidae												
Chrysococcyx basalis	Horsfield's Bronze-Cuckoo					●		●	●			●
Cacomantis pallidus	Pallid Cuckoo					●		●				
Cacomantis flabelliformis	Fan-tailed Cuckoo					●				●		●
Strigidae												
Ninox novaeseelandiae	Southern Boobook							●				●
Podargidae												
Podargus strigoides	Tawny Frogmouth					●						
Aegothelidae												

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		EPBC Act	BC Act	DBCA								
Aegotheles cristatus	Australian Owlet Nightjar					●						
Apodidae												
Apus pacificus	Pacific Swift (Fork-tailed Swift)	MI	MI		●	●	●					
Alcedinidae												
Dacelo novaeguineae	Laughing Kookaburra									●		
Todiramphus sanctus	Sacred Kingfisher					●						
Meropidae												
Merops ornatus	Rainbow Bee-eater					●		●			●	●
Falconidae												
Falco cenchroides	Australian Kestrel					●		●		●	●	●
Falco berigora	Brown Falcon					●		●			●	●
Falco longipennis	Australian Hobby					●				●		
Falco subniger	Black Falcon							●				
Falco peregrinus	Peregrine Falcon		OS		●	●						
Cacatuidae												
Calyptorhynchus latirostris	Carnaby's Cockatoo	EN	EN		●	●	●			●	●	●
Eolophus roseicapillus	Galah					●		●	●	●	●	●
Cacatua tenuirostris	Eastern Long-billed Corella *					●						
Cacatua pastinator butleri	Western Corella					●				●		
Cacatua sanguinea	Little Corella					●						●
Nymphicus hollandicus	Cockatiel											●
Psittacidae												
Polytelis anthopeplus	Regent Parrot					●						
Platycercus zonarius	Australian Ringneck					●		●	●	●	●	●
Neophema elegans	Elegant Parrot								●			
Neophema petrophila	Rock Parrot					●						
Melopsittacus undulatus	Budgerigar					●						
Pezoporus flaviventris	Western Ground Parrot	CR	CR		●	●						
Maluridae												
Malurus splendens	Splendid Fairy-wren					●		●	●	●		●
Malurus leucopterus	White-winged Fairy-wren					●		●	●			●
Malurus lamberti	Variegated Fairy-wren					●			●	●		●
Malurus pulcherrimus	Blue-breasted Fairy-wren					●		●			●	●

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		EPBC Act	BC Act	DBCA								
Stipiturus malachurus	Southern Emu-wren					●			●			
Meliphagidae												
Gliciphila melanops	Tawny-crowned Honeyeater					●			●			●
Acanthorhynchus superciliosus	Western Spinebill					●						●
Lichmera indistincta	Brown Honeyeater					●		●	●	●		●
Phylidonyris novaehollandiae	New Holland Honeyeater					●				●		
Phylidonyris niger	White-cheeked Honeyeater					●		●	●	●	●	●
Melithreptus brevirostris	Brown-headed Honeyeater					●		●				
Epthianura tricolor	Crimson Chat					●						
Epthianura aurifrons	Orange Chat					●						
Epthianura albifrons	White-fronted Chat					●		●				
Acanthagenys rufogularis	Spiny-cheeked Honeyeater					●						●
Anthochaera lunulata	Western Wattlebird					●			●	●		●
Anthochaera carunculata	Red Wattlebird					●		●	●	●	●	●
Purnella albifrons	White-fronted Honeyeater								●			
Lichenostomus leucotis	White-eared Honeyeater										●	
Manorina flavigula	Yellow-throated Miner					●				●		
Gavicalis virescens	Singing Honeyeater							●		●		●
Pardalotidae												
Pardalotus punctatus	Spotted Pardalote					●						
Pardalotus striatus	Striated Pardalote					●		●	●	●		●
Acanthizidae												
Calamanthus campestris	Rufous Fieldwren					●		●	●			●
Calamanthus cautus	Shy Groundwren (Shy Heathwren)											●
Sericornis frontalis	White-browed Scrubwren					●		●	●	●		●
Pyrrholaemus brunneus	Redthroat					●						
Smicrornis brevirostris	Weebill					●				●		●
Gerygone fusca	Western Gerygone					●		●	●	●		●
Acanthiza chrysorrhoa	Yellow-rumped Thornbill					●		●	●	●		●
Acanthiza uropygialis	Chestnut-rumped Thornbill					●						●
Acanthiza inornata	Western Thornbill					●		●	●	●		●

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		EPBC Act	BC Act	DBCA								
Acanthiza apicalis	Broad-tailed Thornbill					•		•		•		•
Pomatostomidae												
Pomatostomus superciliosus	White Browed Babbler											•
Artamidae												
Artamus personatus	Masked Woodswallow					•					•	
Artamus cinereus	Black-faced Woodswallow					•		•	•	•	•	•
Artamus cyanopterus	Dusky Woodswallow					•			•			
Cracticidae												
Cracticus torquatus	Grey Butcherbird					•		•		•		•
Cracticus nigrogularis	Pied Butcherbird					•					•	•
Cracticus tibicen	Australian Magpie					•		•		•		•
Strepera versicolor	Grey Currawong					•						
Campephagidae												
Coracina novaehollandiae	Black-faced Cuckoo-shrike					•		•	•	•	•	•
Lalage tricolor	White-winged Triller					•			•			•
Neosittidae												
Daphoenositta chruysoptera	Varied Sittella					•			•			
Oreoicidae												
Oreoica gutturalis	Crested Bellbird					•			•		•	•
Pachycephalidae												
Pachycephala rufiventris	Rufous Whistler					•		•	•	•		•
Colluricincla harmonica	Grey Shrike-thrush					•				•		•
Rhipiduridae												
Rhipidura leucophrys	Willie Wagtail					•		•	•	•		•
Rhipidura albiscapa	Grey Fantail					•		•		•	•	•
Monarchidae												
Grallina cyanoleuca	Magpie-Lark					•		•		•	•	•
Corvidae												
Corvus coronoides	Australian Raven					•		•		•	•	•
Corvus bennetti	Little Crow					•						
Petroicidae												
Microeca fascinans	Jacky Winter							•				

Family and Species	Common Name	Conservation status			DBCA Database	NatureMap	PMST	360 Environmental (2012a)	Bamford, Bancroft and Turpin (2015)	Ecologia Environment (2017)	Spectrum Ecology (2020)	Current survey
		EPBC Act	BC Act	DBCA								
Petroica boodang	Scarlet Robin					●						
Petroica goodenovii	Red-capped Robin					●		●				
Melanodryas cucullata	Hooded Robin					●						●
Eopsaltria georgiana	White-breasted Robin					●						●
Hirundinidae												
Cheramoeca leucosterna	White-backed Swallow					●		●			●	
Hirundo neoxena	Welcome Swallow					●		●				●
Petrochelidon nigricans	Tree Martin					●		●	●	●		
Acrocephalidae												
Acrocephalus australis	Australian Reed warbler					●						
Locustellidae												
Poodytes gramineus	Little Grassbird					●						
Cincloramphus mathewsi	Rufous Songlark							●	●			●
Zosteropidae												
Zosterops lateralis	Silvereye					●		●	●	●		●
Dicaeidae												
Dicaeum hirundinaceum	Mistletoebird					●						
Estrildidae												
Taeniopygia guttata	Zebra Finch							●				
Motacillidae												
Motacilla cinerea	Grey Wagtail	MI	MI				●					
Anthus australis	Australian Pipit					●		●		●	●	●
REPTILES												
Cheluidae												
Chelodina colliei	South-western Long-necked Turtle					●						
Carphodactylidae												
Underwoodisaurus milii	Barking Gecko					●						
Diplodactylidae												
Crenadactylus ocellatus	Clawless Gecko					●						
Diplodactylus granariensis	Western Stone Gecko					●						
Diplodactylus ornatus	Ornate Stone Gecko					●						
Diplodactylus polyophthalmus	Spotted Sandplain Gecko					●			●			

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		EPBC Act	BC Act	DBCA								
Lucasium alboguttatum	White-spotted Ground Gecko					●			●			
Strophurus spinigerus	Soft Spiny-tailed Gecko					●		●	●			●
Gekkonidae												
Christinus marmoratus	Marbled Gecko					●						●
Gehyra variegata	Common Dtella					●						
Pygopodidae												
Aprasia repens	Sandplain Worm Lizard					●						
Delma australis	Southern (Marble-faced) Delma					●						
Delma concinna	Javelin Legless Lizard					●						●
Delma fraseri	Fraser's Legless Lizard					●						
Delma grayii	Gray's Legless Lizard					●						
Lialis burtonis	Burton's Legless lizard					●		●				●
Pletholax gracilis	Keeled Legless Lizard					●		●	●			
Pygopus lepidopodus	Common Scaley Foot					●		●	●			
Agamidae												
Ctenophorus adelaidensis	Western Heath Dragon					●		●	●			●
Ctenophorus maculatus	Spotted Military Dragon					●						
Pogona minor	Western Bearded Dragon					●		●	●			●
Scincidae												
Acritoscincus trilineatus	Western Three-lined Skink					●						
Cryptoblepharus buchananii	Buchanan's Snake-eyed Skink					●		●	●			●
Cryptoblepharus plagiocephalus	Péron's Snake-eyed Skink					●		●				
Ctenotus australis	Western Limestone Ctenotus					●						
Ctenotus catenifer	Chain-striped South-west Ctenotus					●						
Ctenotus fallens	West-coast Laterite Ctenotus					●		●	●			●
Ctenotus gemmula	Jewelled South-west Ctenotus			P3	●	●			●			

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		EPBC Act	BC Act	DBCA								
Ctenotus impar	South-western Odd-striped Ctenotus					•			•			
Ctenotus lancelini	Lancelin Island Skink	VU	VU		•							
Ctenotus pantherinus	Leopard Ctenotus					•						
Cyclodomorphus celatus	Western Slender Bluetongue					•		•				•
Egernia kingii	King's Skink					•						
Egernia napoleonis	South-western Crevice-skink					•		•	•			
Egernia stokesii badia	Western Spiny-tail Skink	EN	VU		•		•					
Hemiergis quadrilineata	Two-toed Earless Skink					•						
Lerista christinae	Bold-striped Slider					•						
Lerista distinguenda	South-western Orange-tailed Slider					•						
Lerista elegans	Elegant Slider					•		•	•			•
Lerista lineopunctulata	Southern Dotted-line Robust Slider					•						
Lerista planiventralis decora	Keeled Slider					•						
Lerista praepedita	Blunt-tailed West-coast Slider					•		•	•			•
Liopholis multiscutata	Bull Skink					•						
Liopholis pulchra longicauda	Jurien Bay Skink	VU	VU		•	•	•					
Menetia greyii	Common Dwarf Skink					•		•	•			•
Morethia lineoocellata	West Coast Morethia Skink					•		•				
Morethia obscura	Shrubland Morethia Skink					•		•	•			•
Tiliqua occipitalis	Western Bluetongue					•						
Tiliqua rugosa	Bobtail					•		•				•
Varanidae												
Varanus gouldii	Gould's Sand Monitor					•		•	•		•	•
Typhlopidae												
Anilios australis	Southern Blind Snake					•		•	•			
Pythonidae												
Aspidites ramsayi	Woma Python			P1		•						

Family and Species	Common Name	Conservation status			DBCA Database	NatureMap	PMST	360 Environmental (2012a)	Bamford, Bancroft and Turpin (2015)	Ecologia Environment (2017)	Spectrum Ecology (2020)	Current survey
		EPBC Act	BC Act	DBCA								
Morelia spilota imbricata	Carpet Python					●						
Elapidae												
Brachyurophis fasciolatus	Narrow-banded Shovel-nosed Snake					●						
Brachyurophis semifasciatus	Southern Shovel-nosed Snake					●						
Demansia psammophis reticulata	Yellow-faced Whipsnake					●		●				
Echiopsis curta	Bardick					●						
Neelaps bimaculatus	Black-naped Snake					●						●
Neelaps calonotos	Black-striped Snake			P3	●	●						●
Parasuta gouldii	Gould's Hooded Snake					●		●	●			●
Pseudechis australis	Mulga Snake, King Brown					●						
Pseudonaja affinis	Dugite					●						
Pseudonaja mengdeni	Gwardar					●						
Simoselaps littoralis	West Coast Banded Snake					●						
AMPHIBIANS												
Pelodryadidae												
Litora moorei	Motorbike Frog					●						●
Limnodynastidae												
Heleioporus albopunctatus	Western Spotted Frog					●						
Heleioporus eyrei	Moaning Frog					●		●	●			●
Heleioporus psammophilus	Sand Frog					●		●	●			
Limnodynastes dorsalis	Western Banjo Frog					●		●	●			
Neobatrachus pelabatoides	Humming Frog					●			●			
Myobatrachidae												
Crinia glauerti	Clicking Frog					●		●				
Crinia insignifera	Squelching Froglet					●		●	●			●
Crinia pseudinsignifera	Bleating Froglet					●						
Myobatrachus gouldii	Turtle Frog					●		●	●			●
Pseudophryne guentheri	Crawling Toadlet					●		●				●

Fauna recorded during the Spectrum Ecology Detailed Survey

Scientific Name	Common Name	Conservation Status			Fauna Trapping/Bird Survey Site								Opportunistic Site		Motion Camera	SRE By-catch
		EPBC Act	BC Act	DBCA	APS1TRAP	APS2TRAP	APS3TRAP	APS4TRAP	APS5TRAP	APS6TRAP	APS7TRAP	APS8TRAP	Nocturnal	Opportunist		
Mammals																
Dasyuridae																
Sminthopsis fuliginosus	Dusky Dunnart				●		●								●	
Tarsipedidae																
Tarsipes rostratus	Honey Possum, Noolbenger						●									
Macropodidae																
Macropus fuliginosus	Western Grey Kangaroo													●	●	
Molossidae																
Austronomus australis	White-striped Freetail-bat				●	●	●	●	●	●	●	●				
Ozimops kitcheneri	Western Free-tailed Bat					●	●	●		●		●				
Vespertilionidae																
Chalinolobus gouldii	Gould's Wattled Bat				●		●			●	●					
Nyctophilus geoffroyi	Lesser Long-eared Bat				#	#	#	#	#	#	#					
Vespadelus baverstocki	Inland Forest Bat				#		#	#		#	#					
Vespadelus regulus	Southern Forest Bat				●	●	●	●	●	●	●	●				
Introduced Mammals																
Muridae																
Mus musculus	House Mouse					●	●	●				●		●		
Leporidae																
Oryctolagus cuniculus	Rabbit												●	●	●	

Scientific Name	Common Name	Conservation Status			Fauna Trapping/Bird Survey Site								Opportunistic Site		Motion Camera	SRE By-catch
		EPBC Act	BC Act	DBCA	APS1TRAP	APS2TRAP	APS3TRAP	APS4TRAP	APS5TRAP	APS6TRAP	APS7TRAP	APS8TRAP	Nocturnal	Opportunist		
Canidae																
Vulpes vulpes	Red Fox														•	
Bovidae																
Bos taurus	European Cattle													•		
Birds																
Dromaiidae																
Dromaius novaehollandiae	Emu											•		•	•	
Anatidae																
Tadorna tadornoides	Australian Shelduck (Mountain Duck)													•		
Anas superciliosa	Pacific Black Duck									•						
Anas gracilis	Grey Teal													•		
Ardeidae																
Ardea novaehollandiae	White-faced Heron									•	•			•		
Accipitridae																
Accipiter cirrocephalus	Collared Sparrowhawk									•						
Rallidae																
Porzana fluminea	Australian Spotted Crake									•						
Turnicidae																
Turnix varius	Painted Button-quail													•		
Scolopacidae																
Tringa nebularia	Common Greenshank										•			•		

Scientific Name	Common Name	Conservation Status			Fauna Trapping/Bird Survey Site								Opportunistic Site		Motion Camera	SRE By-catch
		EPBC Act	BC Act	DBCA	APS1TRAP	APS2TRAP	APS3TRAP	APS4TRAP	APS5TRAP	APS6TRAP	APS7TRAP	APS8TRAP	Nocturnal	Opportunist		
Columbidae																
Spilopelia senegalensis	Laughing Turtle-Dove					●										
Phaps chalcoptera	Common Bronzewing														●	
Ocyphaps lophotes	Crested Pigeon				●			●		●		●		●		
Geopelia cuneata	Diamond Dove				●	●										
Cuculidae																
Chrysococcyx basalis	Horsfield's Bronze Cuckoo					●				●		●		●		
Cacomantis flabelliformis	Fan-tailed Cuckoo									●		●				
Tytonidae																
Ninox boobook	Boobook Owl													●		
Meropidae																
Merops ornatus	Rainbow Bee-eater					●				●	●			●		
Falconidae																
Falco cenchroides	Australian Kestrel (Nankeen Kestrel)								●			●		●		
Falco berigora	Brown Falcon													●		
Cacatuidae																
Cacatua roseicapilla	Galah					●				●	●	●		●		
Nymphicus hollandicus	Cockatiel													●		
Psittacidae																
Platycercus zonarius	Australian Ringneck										●					
Maluridae																
Malurus lamberti	Variegated Fairy-wren											●				

Scientific Name	Common Name	Conservation Status			Fauna Trapping/Bird Survey Site								Opportunistic Site		Motion Camera	SRE By-catch
		EPBC Act	BC Act	DBCA	APS1TRAP	APS2TRAP	APS3TRAP	APS4TRAP	APS5TRAP	APS6TRAP	APS7TRAP	APS8TRAP	Nocturnal	Opportunist		
Malurus pulcherrimus	Blue-breasted Fairy-wren											●				
Malurus splendens	Splendid Fairy-wren					●				●		●		●		
Malurus leucopterus	White-winged Fairy-wren										●			●		
Meliphagidae																
Glyciphila melanops	Tawny-crowned Honeyeater						●	●	●	●	●	●		●		
Lichmera indistincta	Brown Honeyeater				●	●	●		●	●	●	●		●		
Phylidonyris niger	White-cheeked Honeyeater				●		●	●	●	●		●		●		
Epthianura albifrons	White-fronted Chat									●	●			●		
Acanthagenys rufogularis	Spiny-cheeked Honeyeater						●							●		
Anthochaera lunulata	Western Little Wattlebird (Western Wattlebird)					●		●		●		●		●		
Anthochaera carunculata	Red Wattlebird					●			●	●		●				
Gavicalis virescens	Singing Honeyeater				●	●	●		●	●	●	●				
Pardalotus striatus	Striated Pardalote					●										
Acanthizidae																
Calamanthus cautus	Shy Groundwren (Shy Heathwren)													●		
Calamanthus campestris	Rufous Fieldwren													●		
Sericornis frontalis	White-browed Scrubwren						●		●	●		●		●		
Smicrornis brevirostris	Weebill					●	●									
Gerygone fusca	Western Gerygone					●				●						
Acanthiza apicalis	Broad-tailed Thornbill (Inland Thornbill)															
Acanthiza uropygialis	Chestnut-rumped Thornbill					●										

Scientific Name	Common Name	Conservation Status			Fauna Trapping/Bird Survey Site								Opportunistic Site		Motion Camera	SRE By-catch
		EPBC Act	BC Act	DBCA	APS1TRAP	APS2TRAP	APS3TRAP	APS4TRAP	APS5TRAP	APS6TRAP	APS7TRAP	APS8TRAP	Nocturnal	Opportunist		
Acanthiza inornata	Western Thornbill													●		
Acanthiza chrysorrhoa	Yellow-rumped Thornbill				●	●				●						
Pomatostomidae																
Pomatostomus superciliosus	White Browed Babbler														●	
Artamidae																
Artamus cinereus	Black-faced Woodswallow															
Cracticidae																
Cracticus torquatus	Grey Butcherbird													●	●	
Cracticus nigrogularis	Pied Butcherbird													●		
Cracticus tibicen	Australian Magpie				●	●		●		●	●	●		●		
Campephagidae																
Coracina novaehollandiae	Black-faced Cuckoo-shrike													●		
Lalage tricolor	White-winged Triller				●											
Oreoicidae																
Oreoica gutturalis	Crested Bellbird														●	
Pachycephalidae																
Pachycephala rufiventris	Rufous Whistler				●	●	●	●	●	●		●		●		
Colluricincla harmonica	Grey Shrike-thrush					●										
Rhipiduridae																
Rhipidura leucophrys	Willie Wagtail					●		●		●				●	●	

Scientific Name	Common Name	Conservation Status			Fauna Trapping/Bird Survey Site								Opportunistic Site		Motion Camera	SRE By-catch
		EPBC Act	BC Act	DBCA	APS1TRAP	APS2TRAP	APS3TRAP	APS4TRAP	APS5TRAP	APS6TRAP	APS7TRAP	APS8TRAP	Nocturnal	Opportunist		
Rhipidura albiscapa	Grey Fantail															
Monarchidae																
Grallina cyanoleuca	Magpie-lark					●		●		●		●				
Corvidae																
Corvus coronoides	Australian Raven				●	●	●	●	●	●	●	●		●		
Hirundinidae																
Hirundo neoxena	Welcome Swallow											●		●		
Locustellidae																
Megalurus mathewsi	Rufous Songlark										●					
Zosteropidae																
Zosterops lateralis	Grey-breasted White-eye (Silvereye)				●	●	●	●	●	●	●	●		●		
Motacillidae																
Anthus australis	Australian Pipit									●	●			●		
Reptiles																
Diplodactylidae																
Strophurus spinigerus	Soft Spiny-tailed Gecko					●							●			
Gekkonidae																
Christinus marmoratus	Marbled Gecko				●								●			
Pygopodidae																
Delma concinna	Javelin Legless Lizard						●							●		
Lialis burtonis	Burton's Legless Lizard				●							●				
Agamidae																

Scientific Name	Common Name	Conservation Status			Fauna Trapping/Bird Survey Site								Opportunistic Site		Motion Camera	SRE By-catch
		EPBC Act	BC Act	DBCA	APS1TRAP	APS2TRAP	APS3TRAP	APS4TRAP	APS5TRAP	APS6TRAP	APS7TRAP	APS8TRAP	Nocturnal	Opportunist		
Ctenophorus adelaidensis	Western Heath Dragon						●	●	●					●		
Pogona minor	Western Bearded Dragon				●				●					●		
Scincidae																
Cryptoblepharus buchananii	Buchanan's Snake-eyed Skink							●	●					●		●
Ctenotus australis	Western Limestone Ctenotus								●							
Ctenotus fallens	West-coast Laterite Ctenotus				●	●	●	●	●	●		●		●		
Cyclodomorphus celatus	Western Slender Blue-tongue							●	●			●				
Lerista elegans	Elegant Slider					●	●	●	●	●						●
Lerista praepedita	Blunt-tailed West-coast Slider						●							●		
Menetia greyii	Common Dwarf Skink					●		●	●	●	●	●		●		●
Morethia obscura	Shrubland Morethia Skink							●			●			●		
Tiliqua rugosa	Bobtail				●		●	●		●				●	●	
Varanidae																
Varanus gouldii	Bungarra or Sand Goanna													●		
Elapidae																
Neelaps bimaculatus	Black-naped Snake													●		
Neelaps calonotos	Black-striped Snake			P3										●		
Parasuta gouldii	Gould's Hooded Snake													●		
Amphibians																
Limnodynastidae																
Heleioporus eyrei	Moaning Frog				●	●	●	●	●	●			●			●

Scientific Name	Common Name	Conservation Status			Fauna Trapping/Bird Survey Site								Opportunistic Site		Motion Camera	SRE By-catch
		EPBC Act	BC Act	DBCA	APS1TRAP	APS2TRAP	APS3TRAP	APS4TRAP	APS5TRAP	APS6TRAP	APS7TRAP	APS8TRAP	Nocturnal	Opportunist		
Myobatrachidae																
Crinia insignifera	Squelching Froglet									●						●
Myobatrachus gouldii	Turtle Frog											●				
Pseudophryne guentheri	Crawling Toadlet						●	●	●	●	●	●				●

Species calls are too similar to distinguish reliably.

Appendix D: SRE Invertebrate DNA Analysis Report

Damien Cancilla
Spectrum Ecology
660C Newcastle St, Leederville
WA 6007

Author: Bruno Buzatto
8th June 2021

Atlas Short Range Endemics (SRE) Genetics Results

This memo presents data from genetic work carried out on SRE species collected from the Atlas Project, near Cervantes, WA. Bennelongia Environmental Consultants (BEC) were commissioned to identify the SRE specimens collected during the surveys. Morphological identifications were conducted, and molecular barcoding analyses were performed to support and confirm the morphological identifications in 11 target specimens (along with four reference animals from BEC's collection) belonging to SRE groups.

Depending on the size of the specimens, legs or whole animals were used for DNA extractions using a Qiagen DNeasy Blood & Tissue kit (Qiagen 2006). Elute volumes varied from 40 µL to 200 µL depending on the quantity and quality of material.

Primers combinations used for PCR amplifications were: (1) LCO1490:HCO2198 and C1J1718:HCO2198 for the MT-CO1 gene (Folmer *et al.* 1994; Schwendinger and Giribet 2005); and (2) SRJ14197:SRN14745 for the 12S gene (Kambhampati and Smith 1995; Simon *et al.* 1994). Next, dual-direction, sanger sequencing was undertaken for PCR products by the Australian Genome Research Facility (AGRF). Sequences returned were aligned in Geneious (Kearse *et al.* 2012) and neighbour-joining phylogenetic trees were estimated using 1,000 bootstraps. Genetic distances (using the Tamura-Nei method) between sequences were measured as uncorrected p-distances (total percentage of nucleotide differences between sequences). Sequences on GenBank and in the grey literature were included in phylogenetic analyses to provide a framework for assessing intra- and interspecific variation, as well as to document the levels of intra-specific differentiation in described species across their geographic ranges.

The results of the genetical analysis are presented below.

Pseudoscorpions

Beierolpium 'BPS325' (family Olpiidae)

The Bennelongia Database contains four sequences of the genus *Beierolpium*, and a manual search on GenBank returned five more sequences. A BLAST only returned the same five sequences, so the analysis was run with nine reference sequences, plus the target sequence from the new specimen collected in the Atlas project. The new specimen did not align with any of the reference sequences, and the most similar sequence (from the described species *Beierolpium bornemisszai*; GenBank accession EU559545.1) was still 11% distant in Mt-COI, which is more consistent with interspecific divergence. In conclusion, *Beierolpium* 'BPS325' is a new species only known from its collection site in the Atlas project.

Millipedes

Genus *Antichiropus* (Family Paradoxosomatidae)

Five specimens (one female and four juveniles) of the millipede genus *Antichiropus* were sequenced. The female and juveniles lack gonopods, and therefore could not be initially morphologically identified to species level. The genetics aligned all specimens sequenced with two different species of *Antichiropus*.

The female and two of the juveniles (individuals coded as 52_B1, 52_B2 and 52_B3 in Figure 1) from sites AP SRE 4.4 and AP SRE 4.2 were genetically aligned with the species *Antichiropus sulcatus*. This species has been previously recorded in Cooljarloo and Eneabba (Car *et al.* 2013), and has a known linear range of approximately 100 km. The new specimens were identical in their Mt-COI sequences to two reference sequences of individuals previously collected in Cooljarloo.

The other two juveniles (individuals coded as 52_B4 and 52_B5 in Figure 1) from sites AP SRE 8.4 and AP SRE 5.2 were genetically aligned with the species *Antichiropus whistleri*. This is a relatively widespread species, having been previously collected around Perth (only north of the Swan River), Cooljarloo and Cervantes (Car *et al.* 2013). The minimum linear range of the species is approximately 170 km. The two new specimens of *A. whistleri* from the Atlas project were only 2% divergent in their Mt-COI sequences, and their maximum divergence with other previously sequenced specimens of that species was only 3.3% for that gene.

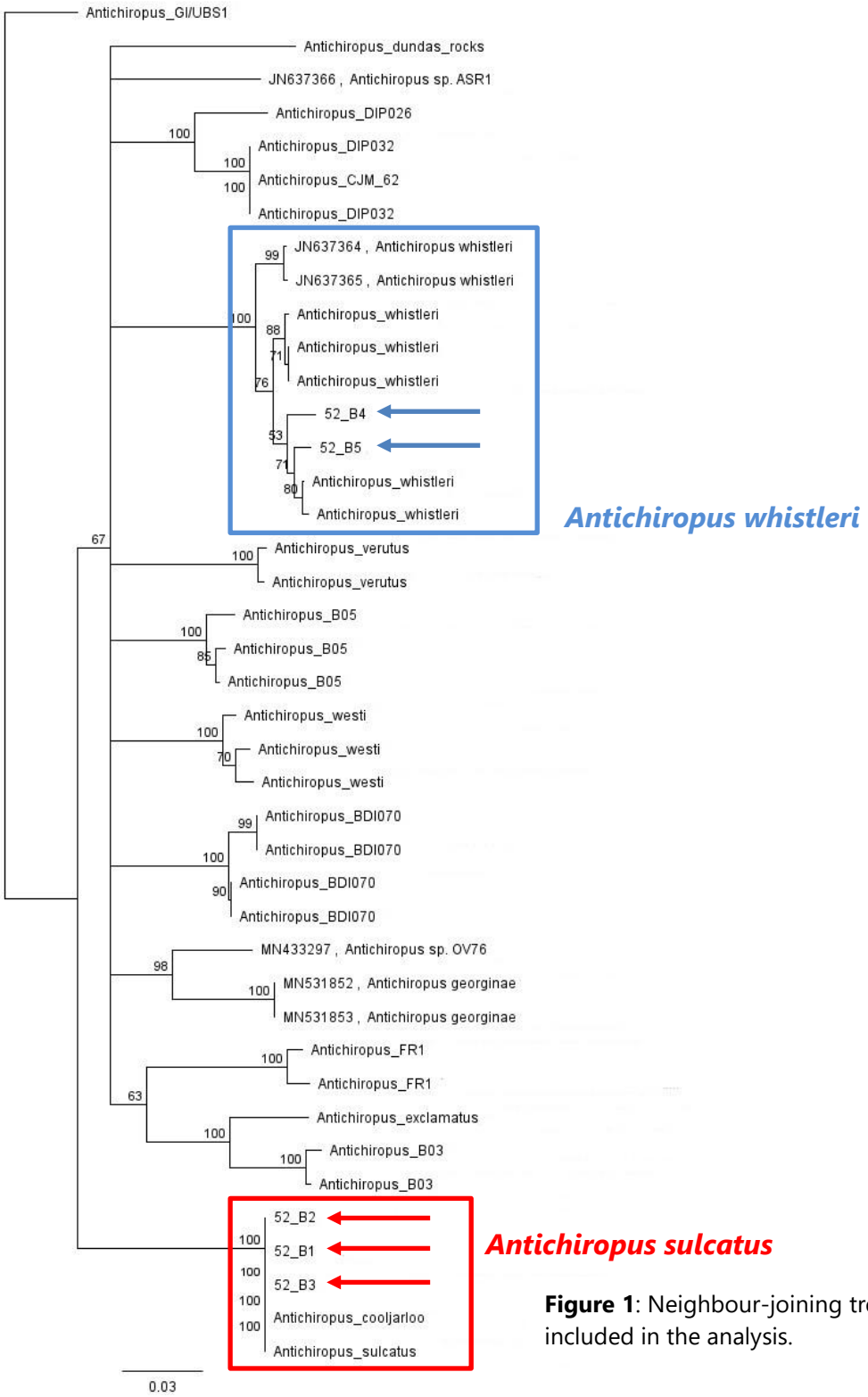

Figure 1: Neighbour-joining tree of species of *Antichiropus* included in the analysis.

Isopods

Genus *Laevophiloscia* (Family Philosciidae)
Two species of the genus *Laevophiloscia* were sequenced. The first species, *Laevophiloscia* B23, was represented in the analysis by two new specimens collected in the Atlas project, from sites AP SRE 7.2 and AP SRE 6.1, as well as two specimens collected in 2012 in Cooljarloo. All these specimens were compared for their 12S sequences. The new specimens were confirmed as conspecifics with 0% divergence in the 12S gene between themselves. Their conspecificity with the previously collected specimens from Cooljarloo (and previously identified as *Laevophiloscia* B23) was also confirmed, as the new specimens were only a maximum of 7.6% divergent in the gene 12S with the previously sequenced specimens.

The second species sequenced, *Laevophiloscia* B24, was represented in the analysis by two new specimens collected in the Atlas project, from sites AP SRE 3.4 and AP SRE 3.2, as well as two specimens collected in 2012 in Cooljarloo. Unfortunately, the 2012 specimens from Cooljarloo failed to return sequences for all primers used, and their conspecificity with the new specimens could not be tested genetically. The two new specimens, however, were confirmed to be conspecifics, with 0% divergence in the 12S gene between themselves. BLAST searches in GenBank returned no other sequences of the genus *Laevophiloscia* for comparison, and a manual search only returned a Mt-COI sequence of *Laevophiloscia yalgooensis*, a species from South Australia. Unsurprisingly, that sequence was at least 17.5% divergent to any Mt-COI sequences of *Laevophiloscia* B23 and *Laevophiloscia* B24 used in this analysis.

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Appendix E: Bat Call Analysis

Acoustic analysis and bat call identification from Cervantes, Western Australia

Prepared for **Spectrum Ecology Pty Ltd**

Version **3 December 2020**

SZ project reference **SZ551**

Prepared by **Dr Kyle Armstrong and Yuki Konishi**

Specialised Zoological ABN 92 265 437 422
Tel +61 (0)404 423 264
kyle.n.armstrong@gmail.com
http://szool.com.au

This report should be included as an appendix in any larger submission to Government, and cited as:

Specialised Zoological (2020). Acoustic analysis and bat call identification from Cervantes, Western Australia. Unpublished report by Specialised Zoological for Spectrum Ecology Pty Ltd, 3 December 2020, project reference SZ551.

Summary

Bat identifications from acoustic recordings are provided from near Cervantes, Western Australia. The identification of bat species from full spectrum WAV-format recordings of their echolocation calls was based on measurements of characteristic frequency, observation of pulse shape, and the pattern of harmonics. At least six species of bat were identified as being present (**Tables 1** and **2**). Representative echolocation calls for each species identified are illustrated (**Figure 1**), as recommended by the Australasian Bat Society (ABS 2006). Further details are available should verification be required.

Methods

The data provided were recorded in full spectrum WAV format with Wildlife Acoustics Song Meter SM4BAT bat detectors (sampling rate 384 kHz, set to turn on automatically at sunset and off at sunrise).

A multi-step acoustic analysis procedure developed to process large full spectrum echolocation recording datasets from insectivorous bats (Armstrong and Aplin 2014; Armstrong et al. 2016) was applied to the recordings made on the survey. Firstly, the WAV files were scanned for bat echolocation calls using several parameter sets in the software SCAN'R version 1.8.3 (Binary Acoustic Technology), which also provides measurements (SCAN'R parameters) from each putative bat pulse. The outputs were then used to determine if putative bat pulses measured in SCAN'R could be identified to species. This was done using a custom [R] language script that performed three tasks: 1. undertook a Discriminant Function Analysis on training data from representative calls from southern Australia; 2. from the measurements of each putative bat pulse from SCAN'R, calculated values for the first two Discriminant Functions that could separate the echolocation call types derived from the analysis of training data, and plotted these resulting coordinates over confidence regions for the defined call types; and 3. facilitated an inspection in a spectrogram of multiple examples of each call type for each recording night by opening the original WAV files containing pulses of interest in Adobe Audition CS6 version 5.0.2.

Species were identified based on information in Churchill (2008) and the author's own unpublished material; and nomenclature follows Jackson and Groves (2015).

Comments on ambiguous identifications

Most species were identified unambiguously, but two call types have more than one possibility for their source. Most call sequences with a characteristic frequency of just over 40 kHz were assigned to the Southern Forest Bat *Vespadelus regulus*, but examples with a slightly higher characteristic frequency might have derived instead from the Inland Forest Bat *V. baverstocki*.

It is often difficult to make an unambiguous identification of long-eared bats *Nyctophilus* spp. In this dataset, call sequences with minimum frequencies close to 40 kHz are most likely to have come from the Lesser Long-eared Bat *Nyctophilus geoffroyi*, but there is a possibility some may have derived instead from Gould's Long-eared Bat *Nyctophilus gouldi*.

Limitations

The identifications presented in this report have been made within the following context:

1. The identifications made herein were based on the ultrasonic acoustic data recorded and provided by a 'third party' (the client named on the front of this report).
2. The scope of this report extended to providing information on the identification of bat species in bulk ultrasonic recordings. Further comment on these species and the possible impacts of a planned project on bat species were not part of the scope.
3. In the case of the present report, the recording equipment was not set up and supplied by Specialised Zoological. The equipment was operated by the third party during the survey.
4. Other than the general location of the study area, Specialised Zoological has not been provided with detailed information of the survey area, has not made a visit to observe the habitats available for bats, nor have we visited the specific project areas on a previous occasion.
5. Specialised Zoological has had no input into the overall design and timing of this bat survey, recording site placement, nor the degree of recording site replication.
6. While Specialised Zoological has made identifications to the best of our ability given the available materials, and reserves the right to re-examine the data and revise any identification following a query, it is the client's and / or proponent's responsibility to provide supporting evidence for any identification, which might require follow-up trapping effort or non-invasive methods such as video recordings. Specialised Zoological bears no liability for any follow-up work that may be required to support an identification based initially on the analysis of acoustic recordings undertaken and reported on here.
7. There are a variety of factors that affect the 'detectability' of each bat species, given the frequency, power and shape characteristics of their calls. Further information on the analysis and the various factors that can impinge on the reliability of identifications can be provided upon request.
8. The analysis of ultrasonic recordings is one of several methods that can be used to survey for bats, and comprehensive surveys typically employ more than one method. If an identification in the present report is ambiguous or in question, a trapping programme would help to resolve the presence of the possibilities in the project area.

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Table 1. Species identified in the present survey from all sites combined.

VESPERTILIONIDAE	
Gould's Wattled Bat	*Chalinolobus gouldii*
Inland Forest Bat	*Vespadelus baverstocki*
Southern Forest Bat	*Vespadelus regulus*
Ambiguous identifications	
Unidentified long-eared bat	*Nyctophilus* sp.
MOLOSSIDAE	
White-striped Free-tailed Bat	*Austronomus australis*
Western Free-tailed Bat	*Ozimops kitcheneri*

Table 2. Species identifications, with the degree of confidence indicated by a code. Date and recording unit number correlates with site; see *Table 1* for full species names.

	A. australis	*C. gouldii*	*Nyctophilus sp.*	*O. kitcheneri*	*V. baverstocki*	*V. regulus*
SM2BAT 6174						
18/10/2020	—	—	NC	—	—	◆
19/10/2020	◆	—	NC	—	—	◆
20/10/2020	◆	—	NC	◆	NC	◆
21/10/2020	—	—	—	◆	—	◆
SM2BAT 6256						
18/10/2020	◆	—	—	◆	—	◆
19/10/2020	◆	—	—	—	—	◆
20/10/2020	◆	◆	NC	—	NC	◆
21/10/2020	◆	◆	NC	◆	—	◆
SM2BAT 6269						
18/10/2020	—	◆	—	—	NC	◆
19/10/2020	◆	—	NC	—	—	◆
20/10/2020	◆	—	NC	◆	—	◆
21/10/2020	◆	—	NC	◆	—	◆
SM2BAT 6272						
18/10/2020	—	◆	NC	◆	NC	◆
19/10/2020	◆	◆	—	—	NC	◆
20/10/2020	◆	◆	NC	—	NC	◆
21/10/2020	◆	—	NC	—	NC	◆

Definition of confidence level codes

— Not detected.

◆ Unambiguous identification of the species at the site based on measured call characteristics and comparison with available reference material. Greater confidence in this ID would come only after capture and supported by morphological measurements or a DNA sequence.

NC Needs Confirmation. Either call quality was poor, or the species cannot be distinguished reliably from another that makes similar calls. Alternative identifications are indicated in the *Comments on identifications* section of this report. If this is a species of conservation significance, further survey work might be required to confirm the record.

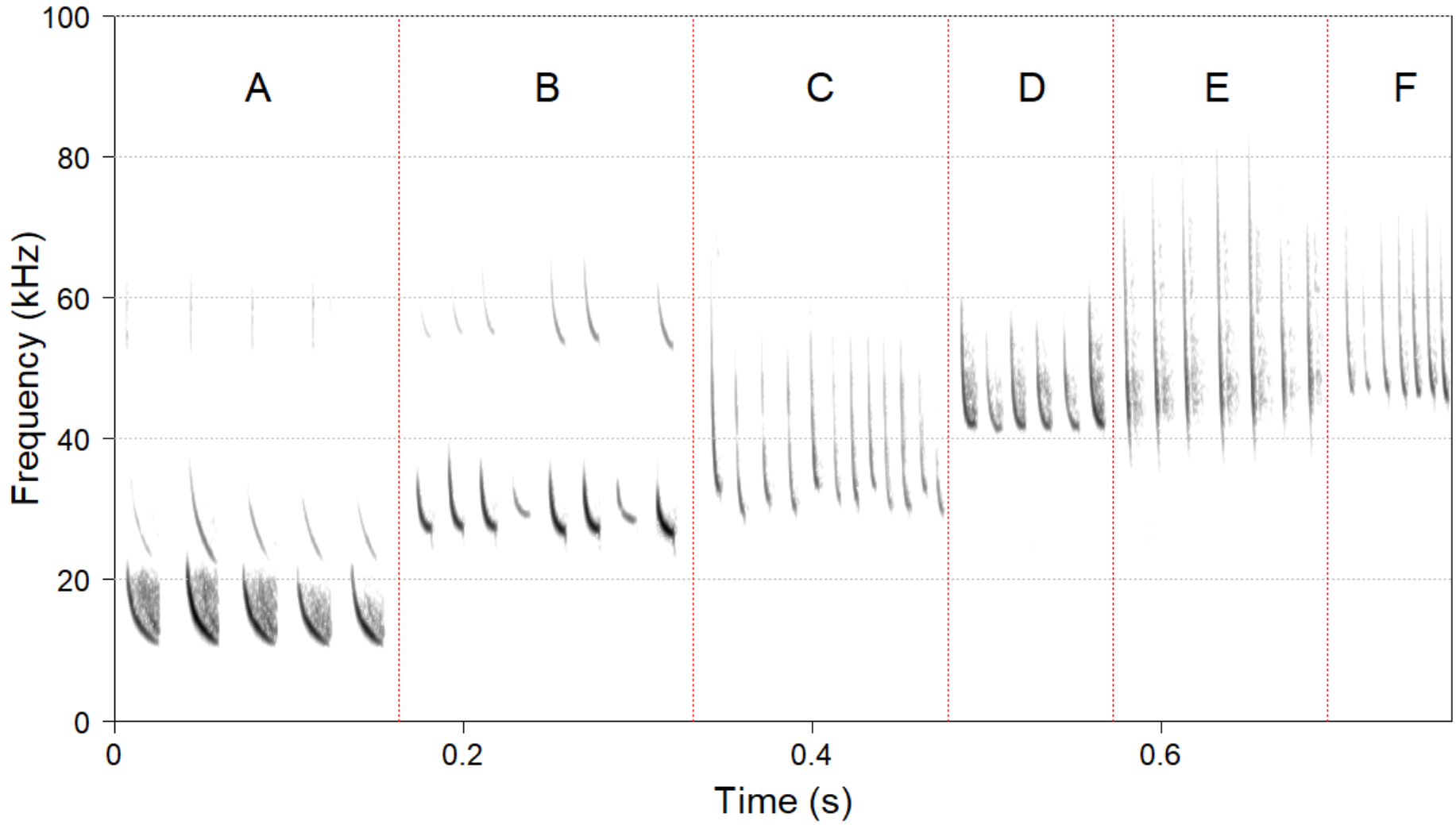

Figure 1. Representative echolocation call sequence portions of the species identified (**A**: *Austronomus australis*; **B**: *Ozimops kitcheneri*; **C**: *Chalinolobus gouldii*; **D**: *Vespadelus regulus*; **E**: *Nyctophilus* sp.; **F**: *Vespadelus baverstocki*; time between pulses has been compressed).