

BORR Northern and Central Section Targeted Fauna Assessment (Biota 2019a) – Part 1 (part 1 of 7)



Bunbury Outer Ring Road Northern and Central Section Targeted Fauna Assessment



Prepared for GHD

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Biota
Environmental
Sciences



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BORR Northern and Central Section Fauna

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1.0 Executive Summary

1.1 Introduction

The Commissioner of Main Roads Western Australia (Main Roads) is proposing to construct and operate the Northern and Central sections of the Bunbury Outer Ring Road (BORR) project. The BORR is a planned Controlled Access Highway linking the Forrest Highway and Bussell Highway, and will provide a high standard route for access to the Bunbury Port. The completed BORR will also provide an effective bypass of Bunbury for inter-regional traffic and freight, reducing traffic on the local road network, and facilitate proposed development to the east of the city of Bunbury.

BORR forms a major component of the planned regional road network for the Greater Bunbury area. The proposed BORR comprises three sections:

- 'BORR Northern Section' – Forrest Highway to Boyanup-Picton Road
- 'BORR Central Section' – Boyanup-Picton Road to South Western Highway (south), an existing 4 km section which was completed in May 2013, along with a 3 km extension of Willinge Drive southwards to South Western Highway
- 'BORR Southern Section' – South Western Highway (near Bunbury Airport) to Bussell Highway.

This document refers to a study area in relation to the BORR Northern and Central Sections only.

To inform the environmental impact assessment of the proposal, Biota Environmental Sciences was commissioned to undertake a desktop review and targeted field survey in relation to the following conservation significant species:

- Carnaby's Black-Cockatoo (Schedule 2, Endangered);
- Baudin's Black-Cockatoo (Schedule 2, Endangered);
- Forest Red-tailed Black-Cockatoo (Schedule 3, Vulnerable);
- Western Ringtail Possum (Schedule 1, Critically Endangered); and,
- Carter's Freshwater Mussel (Schedule 3, Vulnerable).

Furthermore, the likelihood of occurrence was to be assessed for the following conservation significant species:

- Wambenger Brush-tailed Phascogale (hereafter the Brush-tailed Phascogale) (Schedule 6); and,
- Chuditch (Schedule 3, Vulnerable).

1.2 Methods

Habitat for black-cockatoos was assessed by foot-traversing as much of the woodland habitat of the study area as practicable. In larger vegetation fragments, a systematic approach was applied, whereby transects of 25 m spacing were overlain on the study area in GIS. A zoologist then walked down the middle of two 25 m transects, effectively using them as the boundary of a strip-search, and recorded the location of all trees within the strip. This was continued until the entire fragment had been searched. In small fragments or where there were singular trees, foot traverses were also undertaken and recorded via a track file. Foraging habitat descriptions were recorded while conducting foot traverses. For any tree supporting hollow/s, details of the hollows were taken, and a differential GPS was used to record an accurate location of the tree. These trees were also subject to a dedicated breeding hollow assessment, which included the use of a remotely piloted aircraft (RPA) to obtain images of the hollows.

During the black-cockatoo habitat assessment, any areas representing habitat for Carter's Freshwater Mussels were described and searched for evidence of the mussel.

Western Ringtail Possums were surveyed at night using two approaches:

- strip-searches (similar to those used for black-cockatoo habitat description), where the aim was to record all individuals. This method was only practicable in small fragments; and
- line-transect Distance sampling, in which accurate perpendicular distances of possums from the transect were used to model the probability of detection, and thereby an overall estimate of total possum density and abundance.

In addition to surveying for Western Ringtail Possums within the study area, density estimation was also conducted at four contextual sites within 18 km of the study area.

Night-spotting for the Western Ringtail Possum was also used as the search method for the Brush-tailed Phascogale and Chuditch.

1.3 Results

1.3.1 Fauna Habitats

The large majority of the study area has been cleared for agriculture and road infrastructure; approximately 200 ha of native vegetation remains within the 1,128 ha study area.

Much of the vegetation occurs as singular trees or small stands within paddocks or road reserves. Areas of more significant vegetation comprised the riparian vegetation, particularly where the Preston River intersected the study area, and the larger woodland fragments within Lots 104, 5 and 131 south of Clifton Road and Victoria Road.

As far as practicable, all of the vegetation in the study area was ground-truthed. Based on the field observations, together with reference to the vegetation mapping of the study area (GHD 2019), the following broad habitats were described (from most common to least):

- *Mari/Eucalyptus* woodland (47.92 ha);
- Dampland with *Melaleuca* shrubland and/or woodland (47.89 ha);
- *Mari/Eucalyptus* in paddocks and road reserves (39.65 ha);
- Riparian woodland (30.14 ha);
- Peppermint woodland (28.98 ha); and,
- Artificial wetland (5.3 ha).

Low value habitats comprised:

- Highly modified/cleared (786.18 ha); and,
- Non-native vegetation (included large blue gum plantation) (123.34 ha).

1.3.2 Target Species

Much of the study area was devoid of black-cockatoo foraging habitat being cleared, highly disturbed, consisting of non-native vegetation (e.g. blue gum plantation) or native vegetation that did not contain foraging plants, together this represented 967.1 ha or 86% of the study area. Applying the Foraging Habitat Scoring Tool (DoEE 2017) to the remainder of the native vegetation within the study area resulted in a total 58.2 ha of habitat being classified as Very High Quality, 19.2 ha as High Quality, 14.2 ha as Quality and 69.8 ha as Low Quality. Evidence of foraging by all three black-cockatoo species was recorded within the study area.

A total of 2,804 trees of hollow-forming species with diameter at breast height >50 cm were recorded within the study area. The follow-up dedicated breeding hollow assessment took in 145 trees; 30 could be assessed from the ground as containing no suitable hollows, seven trees were inaccessible with the RPA but for one it was possible to give an assessment from the ground as potentially suitable. A total of 156 hollows, from 139 trees, were described as follows: 20 hollows from 19 trees were found suitable for black-cockatoo breeding, 50 hollows from 49 trees were found to have marginal suitability (some but not all criteria for suitability met), 84 hollows from 74 trees were assessed as unsuitable for black-cockatoo nesting and one hollow from one tree was assessed as potentially suitable from the ground. No hollows were conclusively identified as supporting black-cockatoo breeding activity although four appeared to be both suitable for black-cockatoo nesting and showing evidence of use consistent with black-cockatoos. This evidence ranged from chew marks around the hollow entrance to in one case, what appeared to be a black-cockatoo nest from the previous breeding season (two broken eggs of a size and colour consistent with black-cockatoos).

A total of 46 Western Ringtail Possums were recorded via strip-transects. Using line-transect Distance Sampling an additional 21 ± 9 individuals were estimated to occur within a large vegetation remnant at the northern end of the study area. Together, 58 – 76 individuals were estimated to occur within the 133.8 ha of vegetation surveyed, yielding a density estimate of between 0.43 and 0.57 individuals per ha. This study area density estimate was within the range of density estimates calculated for four contextual sites: the lowest being 0.39 ± 0.11 per ha at the Southern Lots site to 1.37 ± 0.19 per ha at the Lot 2 Boyanup–Picton Rd site.

Two Brush-tailed Phascogales were recorded within the study area, while an additional nine individuals were recorded from contextual sites within 5 km of the study area.

Live individuals and shells of Carter's Freshwater Mussel were observed within and on the banks of the Preston River within the study area and immediately adjacent.

No Chuditch were recorded within the study area. Based on recent regional records and availability of habitat, the species was assessed as a possible transient occurrence in the study area, it is unlikely to be resident.

1.3.3 Non-target Conservation Significant Species

In addition to the target species, it was determined that the following five conservation significant species have some potential to occur within the study area:

- Southern Brown Bandicoot, Quenda (Priority 4) – Likely to occur;
- Water Rat (Priority 4) – Likely to occur;
- Blue-billed Duck (Priority 4) – Likely to occur;
- Western False Pipistrelle (Priority 4) – Possible; and
- Western Brush Wallaby (Priority 4) – Possible.

None of these species were recorded during the field survey.

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2.0 Glossary and Acronyms

BC Act	Western Australian <i>Biodiversity Conservation Act 2016</i> .
Biota	Biota Environmental Sciences.
BORR	Bunbury Outer Ring Road.
Black-cockatoos	Refers to all three species of black-cockatoo endemic to the south-west of Western Australia: Carnaby's Black-Cockatoo, Baudin's Black-Cockatoo and Forest Red-tailed Black-Cockatoo.
Breeding habitat (black-cockatoo)	Defined in the DoEE (2017) referral guidelines as species of trees known to support breeding within the range of the species which either have a suitable nest hollow OR are of a suitable diameter at breast height (DBH) to develop a nest hollow. For most species of trees, suitable DBH is 500 mm; for Salmon Gum and Wandoo, suitable DBH is 300 mm.
Conservation significant	Defined as those species listed under the Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i> , the WA <i>Biodiversity Conservation Act 2016</i> or Department of Biodiversity, Conservation and Attractions Priority species list.
DBCA	Western Australian Department of Biodiversity, Conservation and Attractions (formerly the Department of Environment and Conservation).
DBH	Diameter at breast height (approximately 1.3 m from base).
DoEE	Federal Department of Environment and Energy.
EPA	Environmental Protection Authority, Western Australia.
EPBC Act	Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i> .
Foraging habitat (black-cockatoo)	Defined in the DoEE draft referral guidelines as plants of species known to support foraging within the range of each of the species.
Known nesting trees (black-cockatoo)	Any existing tree in which breeding has been recorded or suspected (i.e. showing evidence of use through scratches or feathers).
PDF	Probability density function.
Roosting habitat (black-cockatoo)	Defined as a suitable tree (generally the tallest) or group of tall trees, native or introduced, usually close to an important water source, and within an area of quality foraging habitat within the range of the species.
RPA	Remotely-piloted aircraft.
Suitable nest hollow (black-cockatoo)	Any hollow that appears to be deep enough and with an opening large enough to be used by black-cockatoos.
SCP	Swan Coastal Plain.
Study area	The area of interest to which the study was constrained; in this study, an area encompassing the North/Central Alignment of the Bunbury Outer Ring Road.
Brush-tailed Phascogale	Wambenger Brush-tailed Phascogale, <i>Phascogale tapoatafa wambenger</i> .
WC Act	Western Australian <i>Wildlife Conservation Act 1950</i> (now repealed).

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3.0 Introduction

3.1 The Proposal

The Commissioner of Main Roads Western Australia (Main Roads) is proposing to construct and operate the Northern and Central sections of the Bunbury Outer Ring Road (BORR). The BORR is a planned Controlled Access Highway linking the Forrest Highway and Bussell Highway, and will provide a high standard route for access to the Bunbury Port. The completed BORR will also provide an effective bypass of Bunbury for inter-regional traffic and freight, reducing traffic on the local road network, and facilitate proposed development to the east of the city of Bunbury. BORR forms a major component of the planned regional road network for the Greater Bunbury area. The proposed BORR comprises three sections:

- 'BORR Northern Section' – Forrest Highway to Boyanup-Picton Road
- 'BORR Central Section' – Boyanup-Picton Road to South Western Highway (south), an existing 4 km section which was completed in May 2013, along with a 3 km extension of Willinge Drive southwards to South Western Highway
- 'BORR Southern Section' – South Western Highway (near Bunbury Airport) to Bussell Highway.

This report details the methods and results of a desktop assessment and targeted field fauna assessment over a 1128.01 ha study area in relation to the Northern and Central Sections (Figure 3.1).

3.2 Study Objectives and Scope

In order to inform the environmental impact assessment of the BORR project, Biota Environmental Sciences (Biota) was commissioned to undertake the following:

- conduct a desktop review of relevant previous fauna survey work;
- assess black-cockatoo foraging habitat, roosting, potential breeding and actual breeding trees as per Commonwealth guidelines;
- estimate abundance of the Western Ringtail Possum;
- assess the likelihood of occurrence of Carter's Freshwater Mussel;
- assess the likelihood of occurrence of the Brush-tailed Phascogale and Chuditch; and
- identify and map fauna habitats.

Results from within the study area are considered within a framework of recent contextual work, including a dedicated programme surveying Western Ringtail Possum in the wider Bunbury area, as well as the survey of other alignment options (reported separately).

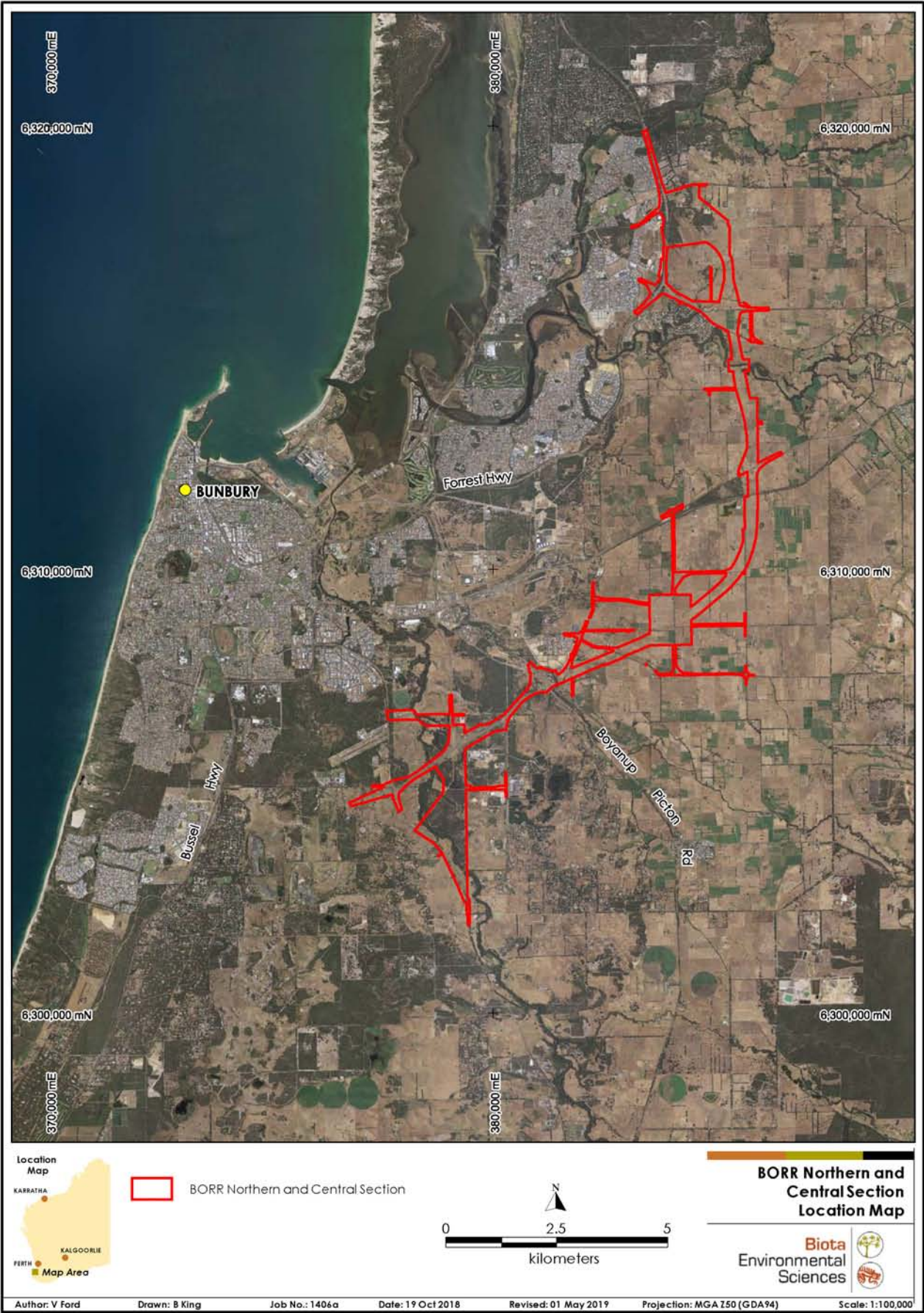


Figure 3.1: Location of the study area.

4.0 Methods

4.1 Desktop Review

A literature review was carried out to ascertain previous sampling effort in the local area (within 10 km); in particular, records of the target species (Western Ringtail Possum, black-cockatoos, Chuditch, Brush-tailed Phascogale and Carter's Freshwater Mussel), but also other conservation significant fauna.

The following sources of information were reviewed to compile a species inventory for the study area:

1. NatureMap database (<http://NatureMap.dec.wa.gov.au>): a joint project of the Department of Biodiversity Conservation and Attractions (DBCA) and the Western Australian Museum (WAM). This database represents the most comprehensive source of information on the distribution of Western Australia's fauna, comprising records from the Fauna Survey Returns database and WA Threatened Fauna Database (both managed by the DBCA), the WAM Specimen database and the Birdlife Australia Birddata database. The database search was completed on 25 October 2018 using a 10 km buffer on a central line described by the coordinates:
 - 33°15'7.57"S 115°44'56.34"E;
 - 33°20'31.1"S 115°46'14.11"E;
 - 33°24'8.66"S 115°40'42.65"E.

The raw data returned are included as Appendix 4.

2. The Commonwealth EPBC Act Protected Matters Search Tool database. The database was searched using the same coordinates as the NatureMap search above, on the 25 October 2018. The raw data returned are included as Appendix 5.
3. Biota's internal database. Biota has conducted a number of recent studies associated with the BORR proposal; our database of records was utilised particularly in the context of Western Ringtail Possums and black-cockatoos. These studies are detailed in Table 4.2; and,
4. Studies by other authors, as detailed in Table 4.2.

4.2 Conservation Significant Species Likelihood Assessment

The conservation significant species returned from the desktop review were assigned to one of four categories, ranging from 'Occurs' to 'Unlikely to Occur' as defined in Table 4.1. The number of historical records, and their timing and distance from the study area were considered in the likelihood assessment. Some species returned during the desktop review were confidently assessed as 'Unlikely to Occur' due to an absence of specific habitat requirements within the study area, or a well-defined distribution that does not include the study area.

Table 4.1: Categories of likelihood assigned to conservation significant species in desktop search.

Status	Description
Occurs	Recorded in current survey through direct sighting or secondary evidence such as nut chews or diggings.
Likely to Occur	Recent records (past 5 years) within study area and nearest record <1 km from study area boundary.
Possible	Nearest record <5 km from study area boundary, and suitable habitat present. Lack of records may be due to low survey effort/cryptic behaviour of species or rarity.
Unlikely to Occur	Few records overall in past 10 years, or no records at all. Nearest record >5 km from study area boundary. Habitat unsuitable or degraded/fragmented.

Table 4.2: Previous studies reviewed in relation to the study area.

Report / Survey	Survey Dates (effort)	Survey Description	Key Findings	Proximity to Study Area
Lot 1 Wallrodt Road, Picton Environmental Values Assessment (GHD 2010a)	October 2010 (1 day)	Site inspection searching for evidence of Western Ringtail Possum and cockatoos (scats, dreys, nut chews, sightings).	Western Ringtail Possum and black-cockatoo species confirmed.	0.5 km.
Lot 15 Bunbury Outer Ring Road (Stage 2) Environmental Values Assessment (GHD 2010b)	October 2010 (1 day)	Site inspection searching for evidence of Western Ringtail Possum and cockatoos (scats, dreys, nut chews, sightings).	Western Ringtail Possum and black-cockatoo species confirmed.	Adjacent to middle eastern portion of study area.
Western Ringtail Possum Survey & Black Cockatoo Habitat Assessment of Sabina Vale Loc 3819 (Harewood 2013)	(i) 26 March 2013 (ii) 2 April 2013 (1 day, 1 night)	Targeted daytime searches for cockatoo habitat trees and evidence of Western Ringtail Possum (scats, dreys, sightings). Nocturnal survey for Western Ringtail Possum.	1 Western Ringtail Possum, 195 cockatoo habitat trees (13 with hollows).	40 km.
Bunbury Outer Ring Road Southern Section, South Western to Bussell Highway (GHD 2012)	21 – 23 September 2011 (3 days)	Targeted daytime searches for cockatoo habitat trees and evidence of Western Ringtail Possum (scats, dreys, sightings).	565 black-cockatoo habitat trees, secondary evidence Western Ringtail Possum (<3 Western Ringtail Possum sightings).	Adjacent to southern end.
Main Roads Lot 1 Ducane Road Environmental Values Assessment (GHD 2014)	12 – 13 June 2013 (2 days, 1 night)	Level 1 and targeted daytime searches for cockatoo habitat trees and evidence of Western Ringtail Possum (scats, dreys, sightings). Nocturnal survey for Western Ringtail Possum.	38 black-cockatoo habitat trees, 1 Western Ringtail Possum recorded during night survey.	3 km.
Shire of Dardanup Waterloo Urban and Industrial Expansion Flora and Fauna Survey (GHD 2015)	(i) 13 – 14 August 2014 (ii) 29 – 31 October 2014 (5 days)	Black-cockatoo and Western Ringtail Possum habitat assessment. Evidence of Western Ringtail Possum and cockatoos (scats, dreys, nut chews, sightings).	Western Ringtail Possum and black-cockatoo species confirmed.	Partially overlapping.
Bunbury Port Access Road Project Stage 2 Rare Fauna Survey (GHD 2010c)	(i) 17 Feb. – 5 March 2009 (ii) 4 – 7 August 2009 (8 days, 5 nights)	Level 1 fauna survey.	3 Western Ringtail Possum, black-cockatoo confirmed.	Overlapping.
Bunbury Outer Ring Road (Southern Section) Black Cockatoo Tree Survey (Biota 2017)	13 – 15 November 2017 (3 days)	Black-cockatoo habitat tree assessment.	649 black-cockatoo breeding habitat trees (139 with hollows).	Adjacent to southern end.
Bunbury Outer Ring Road, Southern Section Western Ringtail Possum Assessment (Biota 2018a)	25 February – 5 March 2018 (8 nights)	Targeted survey for Western Ringtail Possum within the BORR alignment and contextual sites (Reserve 23,000, Lot 1 and Lot 2).	136 Western Ringtail Possum.	Adjacent to southern end, plus contextual sites within 18 km.
Phase 1 Survey for the Western Ringtail Possum in the BORR, Lot 1, Bussell Highway, Maidment Parade Road Reserve, Gelorup and Davenport Localities (Biota 2018b)	10 – 13 July 2018 (3 nights)	Targeted survey for Western Ringtail Possum within the BORR alignment and contextual sites (Lot 1, Bussell Highway, Maidment Parade Road Reserve, Gelorup and Davenport Localities).	73 Western Ringtail Possum.	Adjacent to southern end, plus contextual sites within 18 km.

4.3 Legislation and Policy Conformance

All surveys were completed as far as practicable in accordance with relevant State and Commonwealth policy, and to a standard that would provide adequate information to assess the proposal against principles and environmental aims relating to the environmental factor 'Terrestrial Fauna' (EPA 2016a). Table 4.3 provides a summary of the most important and relevant legislation, policy and guidelines relating to this study.

Table 4.3: State and Commonwealth legislation, policy and guidelines of most relevance to this study.

Legislation, Guideline or Policy	Application to this Study	Regulating Authority
Commonwealth		
<i>Environment Protection and Biodiversity Conservation Act 1999</i> (the EPBC Act).	The Australian Government's central piece of environmental legislation.	The Department of Environment and Energy
Significant Impact Guidelines 1.1 - Matters of National Environmental Significance (DotE 2013).	Details the species falling within the MNES category and what constitutes a significant impact.	The Department of Environment and Energy
Significant impact guidelines for the vulnerable western ringtail possum (<i>Pseudocheirus occidentalis</i>) in the southern Swan Coastal Plain, Western Australia (DEWHA 2009)	Details habitat classification.	The Department of Environment and Energy
Revised draft referral guideline for three threatened black cockatoo species: Carnaby's Cockatoo (<i>Calyptorhynchus latirostris</i>), Baudin's Cockatoo (<i>Calyptorhynchus baudinii</i>) and the Forest Red-tailed Black Cockatoo (<i>Calyptorhynchus banksii naso</i>) (DoEE 2017)	Details distribution, ecology and recommended survey methodology. Although this document is a draft, it does represent the expected standard.	The Department of Environment and Energy
Western Australia		
<i>Biodiversity Conservation Act 2016</i> (BC Act) and <i>Biodiversity Conservation Regulations 2018</i>	Western Australia's central environmental legislation. Came into effect 1 January 2019 and replaces the <i>Wildlife Conservation Act 1950</i> .	Department of Biodiversity, Conservation and Attractions
<i>Wildlife Conservation Act 1950</i> (WC Act)	Now defunct and replaced by the BC Act, however the most recently published Wildlife Conservation (Specially Protected Fauna) Notice 2018 under this act is current at time of writing.	Environmental Protection Authority
Environmental Factor Guideline: Terrestrial Fauna (EPA 2016a).	Overall aim of the study is to provide adequate information to assess the proposal against the objective of the environmental factor Terrestrial Fauna; stated to be "To protect terrestrial fauna so that biological diversity and ecological integrity are maintained".	Environmental Protection Authority
Western Ringtail Possum (<i>Pseudocheirus occidentalis</i>) Recovery Plan. Wildlife Management Program No. 58 (Department of Parks and Wildlife 2017)	Details ecology of the species and priority survey objectives.	Department of Biodiversity, Conservation and Attractions

4.4 Timing, Team and Permits

The field survey was conducted in four phases over the course of late winter and spring 2018, as detailed in Table 4.4. Multiple phases were conducted as access to private land became available.

In relation to the timing of typical black-cockatoo presence on the Swan Coastal Plain, the surveys in September, October and November should have been well placed to record both Forest Red-tailed Black-Cockatoo and Baudin's Black-Cockatoo foraging within the study area. Carnaby's Black-Cockatoo individuals would be expected to have returned to their breeding grounds within the Wheatbelt at this time of year. All three species typically breed over the summer months and so the survey work generally preceded any likely breeding activity.

Conditions during the survey were generally warm and dry. Heavy rainfall on one night reduced visibility and surveying was ceased.

With the exception of RPA pilot Shane Priddle (SW Environmental), all team members were Biota biologists. GIS mapping and calculations were undertaken by Paul Sawers and Brandon King of Biota.

The fauna survey was conducted under Regulation 17 "Licence to Take Fauna for Scientific Purposes" Permit No. 08-002773-2 issued by the DBCA to Dr Victoria Ford (Appendix 2).

Table 4.4: Summary of survey timing and weather conditions.¹

	Date	Methods	Personnel	Minimum Temperature (°C)	Maximum Temperature (°C)	Rainfall (mm)
Phase 1	10/9/18	Black-cockatoo habitat assessment, Nocturnal searches	Roy Teale, Victoria Ford	11.9	19.4	1.4
	11/9/18			3.4	16.3	1.4
	12/9/18			6.5	17.1	0.2
	13/9/18			12.0	18.2	1.0
	14/9/18			11.1	15.6	0.4
	15/9/18			1.8	15.5	0
	Avg./Total			7.8	17.0	4.4
Phase 2	1/10/18	Black-cockatoo habitat assessment, Nocturnal searches	Victoria Ford, Michael Greenham, Joshua Keen, Brandon King	11.3	20.9	0
	2/10/18			9.6	21.8	0
	3/10/18			10.2	21.0	0
	4/10/18			12.4	22.7	4.4
	5/10/18			15.1	20.9	0.2
	6/10/18			12.7	21.2	0.6
	Avg./Total			11.9	21.4	5.2
Phase 3	22/10/18	RPA survey of hollow-bearing trees	Joshua Keen, Shane Priddle	12.7	18.9	0.2
	23/10/18			8.5	19.5	0
	24/10/18			7.9	19.7	0
	25/10/18			12.0	26.9	0
	26/10/18			11.3	26.1	0
	Avg./Total			10.5	22.2	0.2
Phase 4	30/10/18	Black-cockatoo habitat assessment, Nocturnal searches	Victoria Ford, Joshua Keen, Brandon King	10.7	23.1	0
	31/10/18			9.8	22.6	0
	1/11/18			7.7	19.4	0
	2/11/18			12.1	19.8	0
	3/11/18			11.5	22.4	0.2
	4/11/18			7.9	20.0	0
	5/11/18			10.6	18.2	0.6
	Avg./Total			10.0	20.8	0.8

1. Data from Bureau of Meteorology recording station at Carey Park (no. 9965), near Bunbury.

Conditions in the year preceding the survey were largely typical of long-term averages, although the winter immediately preceding the survey work was slightly wetter than average (Figure 4.1). This would be expected to have had a positive effect on foliage productivity and food resources for the Western Ringtail Possum and black-cockatoo species.

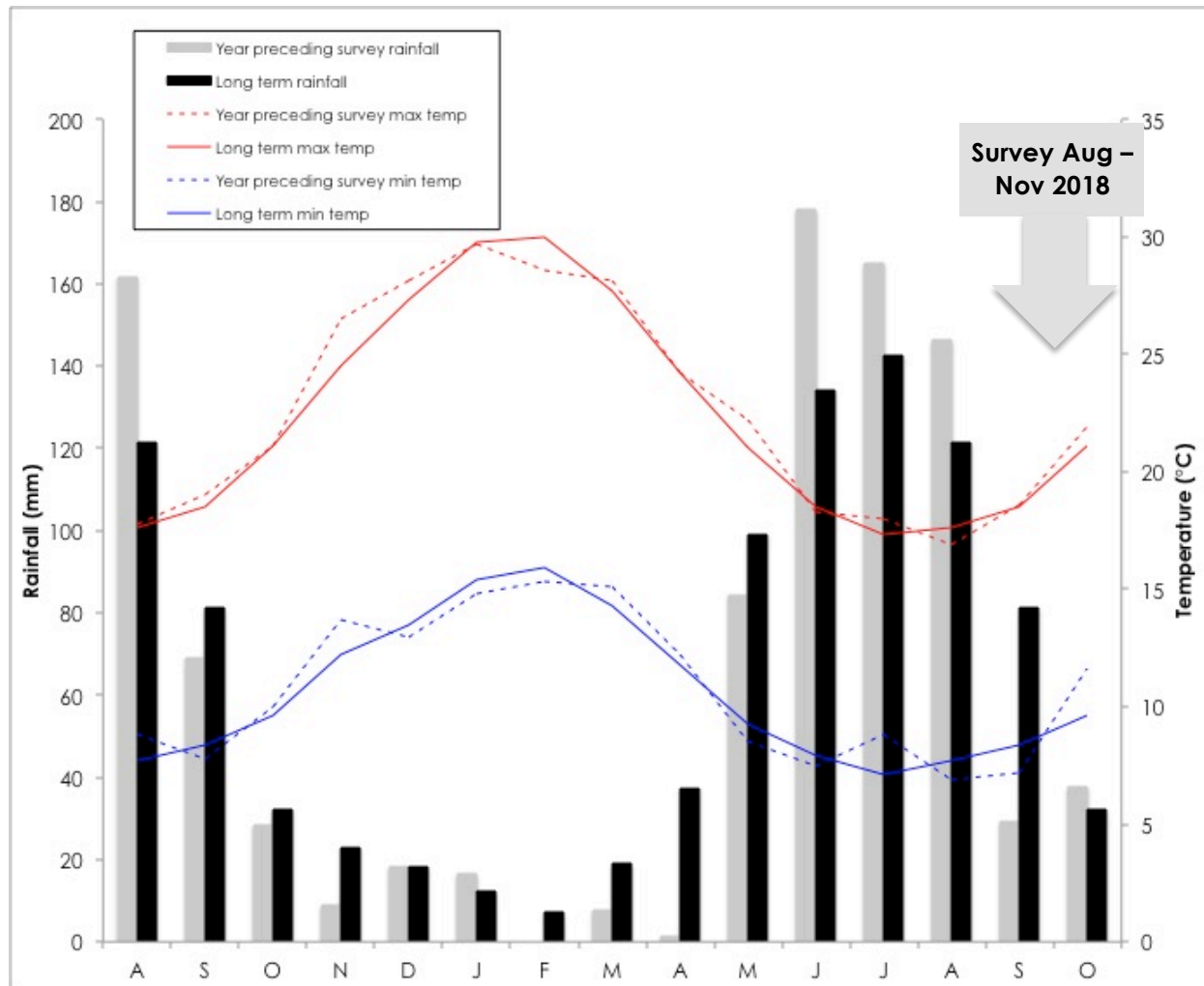


Figure 4.1: Average monthly weather conditions in the year preceding the survey (August 2017 through October 2018) compared with long-term climatological averages (data from the Bureau of Meteorology station at Carey Park, 1995–2018).

4.5 Western Ringtail Possum

Surveys for Western Ringtail Possums spanned 2018 and comprised several different studies, some of which have been reported on separately (Table 4.5). These have been included in our assessment where they include portions of the study area or provide local context. This document therefore provides a synthesis of these studies as they relate to the assessment of the current study area.

Table 4.5. Studies on Western Ringtail Possums conducted for the Bunbury Outer Ring Road.

Study Title	Scope in Relation to Western Ringtail Possums	Timing
Bunbury Outer Ring Road, Southern Section Western Ringtail Possum Assessment (Biota 2018a)	Undertake a seasonal (late summer and winter) distance sampling program for Western Ringtail Possums at four localities.	Phase 1 February – March 2018 Phase 2 August 2018
BORR Western Ringtail Possum Spotlighting Surveys (Biota in prep., 2018b, 2018c)	Undertake repeat spotlight surveys for Western Ringtail Possums at multiple localities.	Phase 1 July 2018 Phase 2 June 2018 Phase 3 October – November 2018
North and Central Alignment Fauna Assessment (this study)	Undertake Western Ringtail Possum surveys in suitable habitat within the North and Central Alignment project area.	June – November 2018

Two approaches were adopted to survey for the Western Ringtail Possum:

1. Strip transects (Section 4.5.1); and
2. Line-transect Distance sampling (Section 4.5.2).

Both methods were applied with a view to obtaining density estimates, thereby permitting direct comparisons across the various study sites. Study sites comprised areas of suitable habitat within the study area, as well as several contextual sites in the local area (detailed in Section 4.5.3).

4.5.1 Strip Transects

Narrow and relatively small vegetation remnants within the study area, together with contextual sites, were surveyed using strip transects (Figure 4.2). Each transect was at most 25 m in width and varied in length between 30 m and 1,471 m. Nocturnal spotlight searches were undertaken within each strip transect for Western Ringtail Possums. The 25 m width was selected to yield greater than 90% probability of detection, as derived from modelled detection functions fitted to perpendicular distances of Western Ringtail Possum sightings data from other studies (Biota 2018b, 2018c).

Each 25 m wide strip transect was systematically searched for Western Ringtail Possums by one zoologist, with survey work commencing when conditions became effectively dark (30 minutes after sunset) and ending prior to 2:00 am. In the case of road reserves and where roadside vegetation was continuous, one person walked through the middle of the vegetation searching for possums using a high-powered head torch (LED Lenser XEO 19R model). In areas where the road reserve contained only scattered single trees, spotlighting was conducted from a vehicle. In all cases, the location of an observed possum was recorded using a GPS with accuracy to within 3 m while standing directly below the animal.

Strip transect locations have been defined as follows for the purposes of analysis: Brunswick River to Raymond Road, Picton East, Golf Drive, Davenport Localities, Maidment Parade and Gelorup (Figure 4.2 and Figure 4.3). Some localities and transects were sampled on two occasions separated by about one month (Table 4.6) whilst all others were sampled on a single occasion.

Table 4.6: Strip transects: summary of locations and timing for each of the study sites within the study area and for the contextual sites.

Study Site	Jul 2018	Aug/Sep 2018	Oct 2018
Study area			
Brunswick River to Raymond Road			✓
Part Davenport Localities (part surveyed in July, entirety surveyed in August)	✓	✓	
Picton East (surveyed in July and again in August)	✓	✓	
Contextual sites			
Part Davenport Localities	✓		
Gelorup	✓	✓	
Maidment Parade Road Reserve	✓	✓	

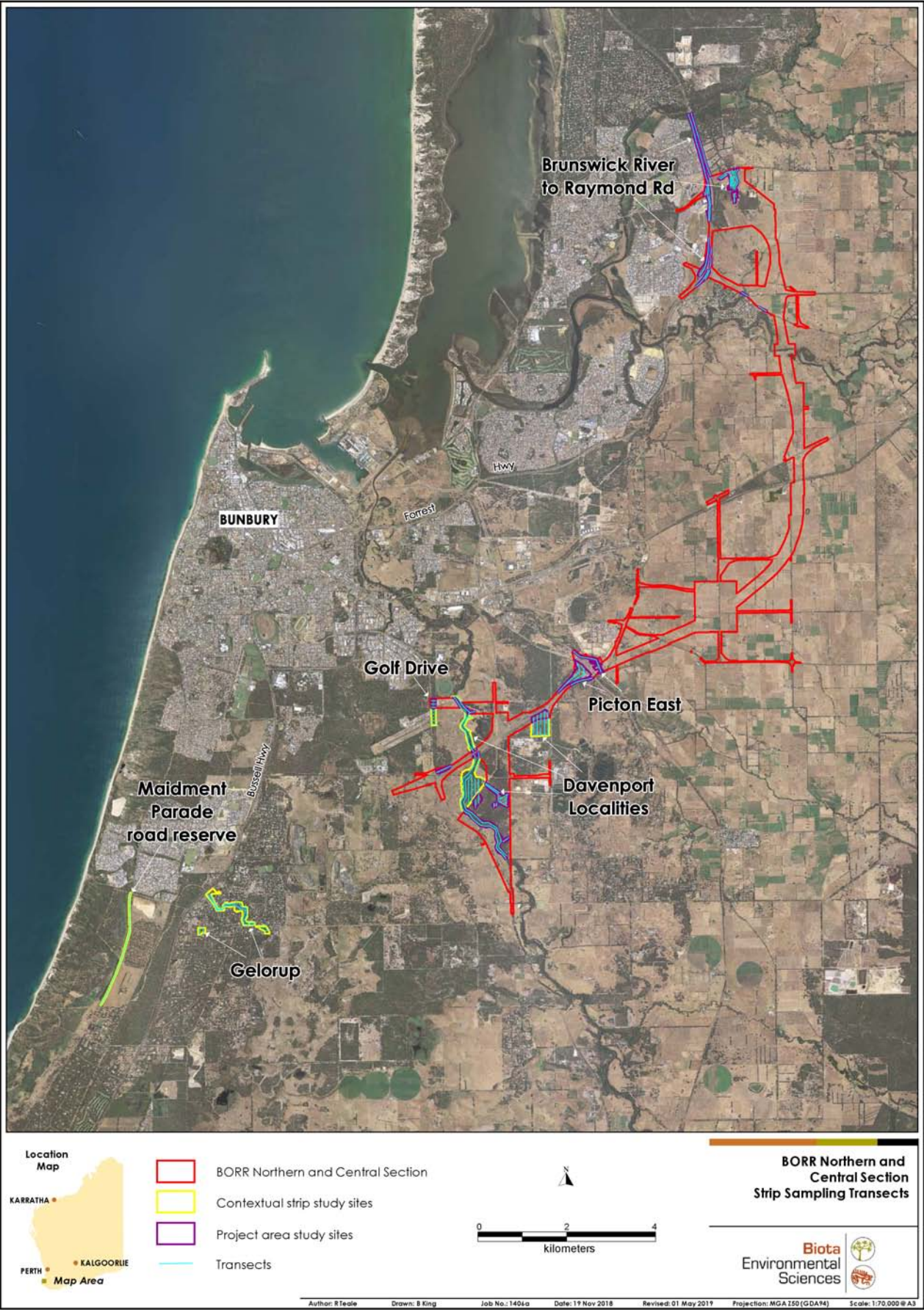


Figure 4.2: Location of strip transects within the study area and contextual sites.

4.5.2 Line-transect Distance Sampling

Line-transect Distance sampling was undertaken at five locations considered relevant to the assessment of the study area: the Northern Lots study site within the study area, and four contextual sites (see Table 4.5 and Figure 4.3).

Table 4.7: Summary of sites and survey timing at which line-transect Distance sampling was conducted and data incorporated into the Distance analyses.

Study Site	February	August	October	November
Study area				
Northern Lots		✓		
Contextual sites				
Lot 2 Boyanup–Picton Rd	✓	✓		
Reserve 23,000 (entire) Shire of Capel	✓	✓		
Manea Park			✓	
Southern Lots				✓

Line transects were spaced at 75 m intervals. Each line-transect was walked by one observer using a high-powered head torch (Led Lenser XEO 19R model) to detect animals. The location of each observation was recorded using a Hemisphere R330 Differential GPS, typically providing accuracy to within 1.5 m.

The following information was recorded with every Western Ringtail Possum observation, whether via strip-searches or line-transect Distance sampling:

- Species;
- Observer;
- On-transect point of observation using GPS;
- Animal location using GPS, taken while standing directly underneath;
- Time;
- Number of individuals;
- Age class: Subadult independent, Adult, Adult with young at heel, or Female with young on back;
- Cue: Seen (eyeshine), Seen (no eyeshine), Heard, or Silhouette;
- Vertical distance using rangefinder;
- Drey or hollow at observation point; and,
- Dominant habitat.

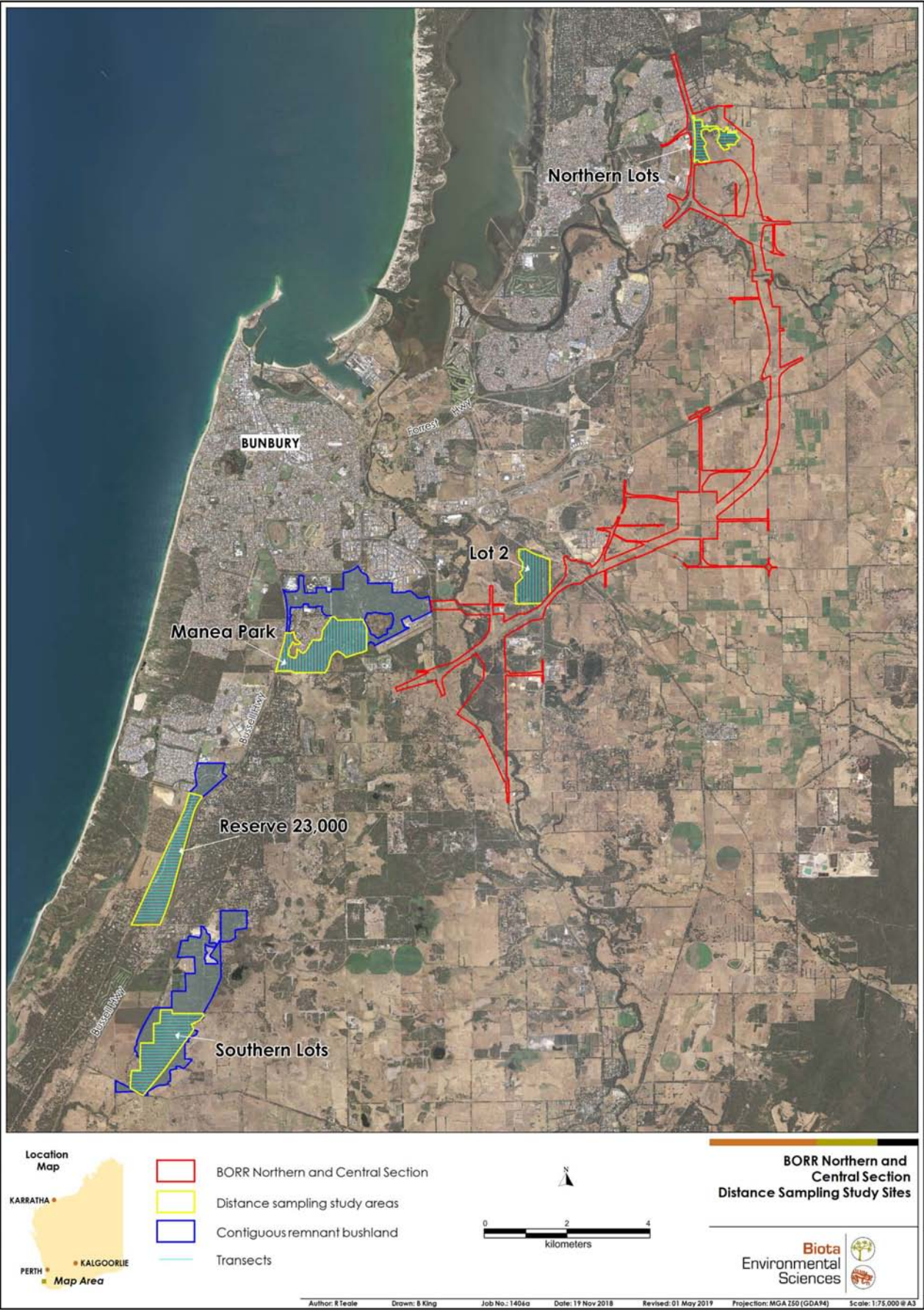


Figure 4.3: Locations where distance sampling was undertaken within the study area and at contextual sites.

4.5.2.1 Analyses

Parameter estimates were derived for each combination of study site and season, however, whilst seasonal data were incorporated into the modeling for the two contextual sites sampled twice (Lot 2 Boyanup–Picton Rd and Reserve 23,000), the parameter estimates from the most recent phase of sampling (August) are have been discussed in the context of comparison with other sites as this timing was more similar to other sites (September – November).

Perpendicular distance data were analysed using the *mrds* (Laake et al. 2013) and *Distance* (Miller 2013) packages in R statistical software (R Core Team 2013). Probability detection functions (PDFs) were modelled based on the histogram of perpendicular distance measurements to individuals and clusters.

Histograms were right truncated as necessary to achieve better model fit, optimally at the distance at which detection probability was 0.15 as recommended by Buckland et al. (2001), but other truncation distances were tested as part of the model selection phase. Akaike's Informative Criterion (AIC) is a quantitative method of model selection and was used to select between potential models (Buckland et al. 2001). In addition to AIC, candidate models were also compared using visual inspection of their fit to histograms of the perpendicular distance, goodness of fit quantile-quantile (Q-Q) plots, Kolmogorov-Smirnov (K-S) and Cramér-von Mises (CvM) test statistics (Buckland et al. 2004). The half-normal and hazard rate keys were used for modelling the PDF, with or without adjustment terms (Buckland et al. 2001).

The selected model was used to estimate the following parameters:

1. the encounter rate (n/L), where n was the number of observed clusters and L was the total length of the transect;
2. the average probability of detection (p);
3. a density estimate (D); and
4. an estimate of the number of animals in the specified area (N).

Variation in the shape of the PDF caused by observers (factor covariate: observer) and study area (factor covariate: study area) were modelled. Only the results from the preferred model are discussed here.

4.5.3 Sampling Effort within the Study Area and Contextual Sites

4.5.3.1 Study Area

Within the study area, the following discrete localities were defined for the purpose of analysis: Northern Lots (at which distance sampling was undertaken), Brunswick River to Raymond Road, Picton East, Davenport Localities, Maidment Parade and Gelorup (Figure 4.2 and Figure 4.3). Some localities and transects were sampled on two occasions separated by about one month, whilst all others were sampled on a single occasion (Table 4.6).

Effort (combined transect length) and the area (hectares) of each of the study sites located within the study area is given in Table 4.8, with their location and transect orientation shown in Figure 4.2 and Figure 4.3.

The Northern Lots study site encompassed approximately 33.3 ha and was sampled by 16 line transects spaced at 75 m intervals, yielding a total effort (combined transect length) of 4.29 km (Table 4.8). The Brunswick River to Raymond Road study site overlaps part of the Northern Lots study site but only includes habitat surveyed by strip transects (whereas the Northern Lots study site only includes habitat surveyed using distance sampling). Together with the Picton East, Golf Drive and Davenport localities, a total of 20.4 km of strip transect was sampled equating to an area of 51 ha of potential habitat (Table 4.8).

Table 4.8: Number of transects and total effort for each site used to sample for the Western Ringtail Possum within the study area.

Study Area	Number of Transects	Effort (km)	Area (ha)
Distance Sampling			
Northern Lots	16	4.3	33.3
Subtotal	16	4.3	33.3
Strip transects			
Brunswick River to Raymond Road	27	10.0	34.5
Picton East (surveyed in July and again in August)	4	2.7	20.3
Part Golf Drive	3	0.3	2.1
Part Davenport Localities (part surveyed in July and entirety surveyed in August / September)	29	7.4	43.6
Subtotal	63	20.4	100.5
Total	79	24.7	133.8

4.5.3.2 Contextual Sites

Four contextual study sites (Reserve 23,000 (Shire of Capel), Lot 2 Boyanup–Picton Rd, Manea Park (and surrounds) and Southern Lots; all within an 18 km radius of Bunbury town centre) were surveyed using a line-transect Distance sampling approach (see Biota 2018d for additional details on Reserve 23000 and Lot 2 Boyanup–Picton Rd). A further four study sites (or parts of those study sites) were sampled using strip transects.

Effort (combined transect length) and the area searched at each site is given in Table 4.9, with their location and transect orientation shown in Figure 4.2 and Figure 4.3.

Table 4.9: Number of transects and total effort for each site used to sample for the Western Ringtail Possum at contextual sites

Study Area	Number of Transects	Effort (km)	Area (ha)
Distance Sampling			
Reserve 23,000 (Shire of Capel)	41	18.6	146.1
Lot 2 Boyanup–Picton Rd	9	5.1	87.62
Southern Lots	27	22.1	188.0
Manea Park	28	20.4	155.0
Subtotal	105	66.2	576.7
Strip transects			
Part Davenport Localities	18	8.5	57.6
Gelorup	6	3.9	20.2
Maidment Parade road reserve	1	2.7	5.4
Subtotal	25	15.1	83.2

4.6 Black-cockatoos

4.6.1 Breeding Habitat Assessment

The field assessment aimed to determine whether suitable breeding habitat for black-cockatoos was present within the study area. The Commonwealth *Revised draft referral guideline for three black cockatoo species* (DoEE 2017) defines breeding habitat as those species of trees known to support breeding within the range of the species, which either have a suitable nest hollow or are of a suitable diameter at breast height to develop a nest hollow (being greater than 50 cm DBH for most Eucalypts or 30 cm in the case of Wandoo and Salmon Gum).

The aim was to assess, as far as practicable, all potential breeding trees within the study area. Two approaches were taken:

1. Larger areas of continuous vegetation were identified from aerial imagery and overlain with 25 m spaced transects in GIS. Using a GPS, a biologist walked up the middle of each 25 m wide transect, assessing all trees within it;
2. In smaller treed areas (e.g. roadside verges and paddocks containing singular trees), a biologist would maintain a GPS track file while using aerial imagery to visit as many trees as possible.

All individual trees of species with the potential to form hollows (primarily Jarrah, Marri and Tuart) and with sufficient diameter to be considered breeding habitat trees (DBH >50 cm) were recorded using a GPS (accurate to within 3 m). Furthermore, the positions of trees observed to contain hollows that were potentially suitable for black-cockatoo nesting were recorded using differential GPS (accurate to less than 1 m) and the following parameters were scored:

- DBH (diameter at breast height; approximately 1.3 m above the ground);
- tree height using a laser rangefinder;
- tree species;
- the number and height above the ground of observed hollows;
- the diameter of each hollow;
- signs of cockatoo use (including wear around hollows, nut chews, scarring, scratch marks on trunks and branches, secondary evidence of feeding sites and moulted feathers); and
- photographs were also taken as a visual reference and to aid future identification of the tree.

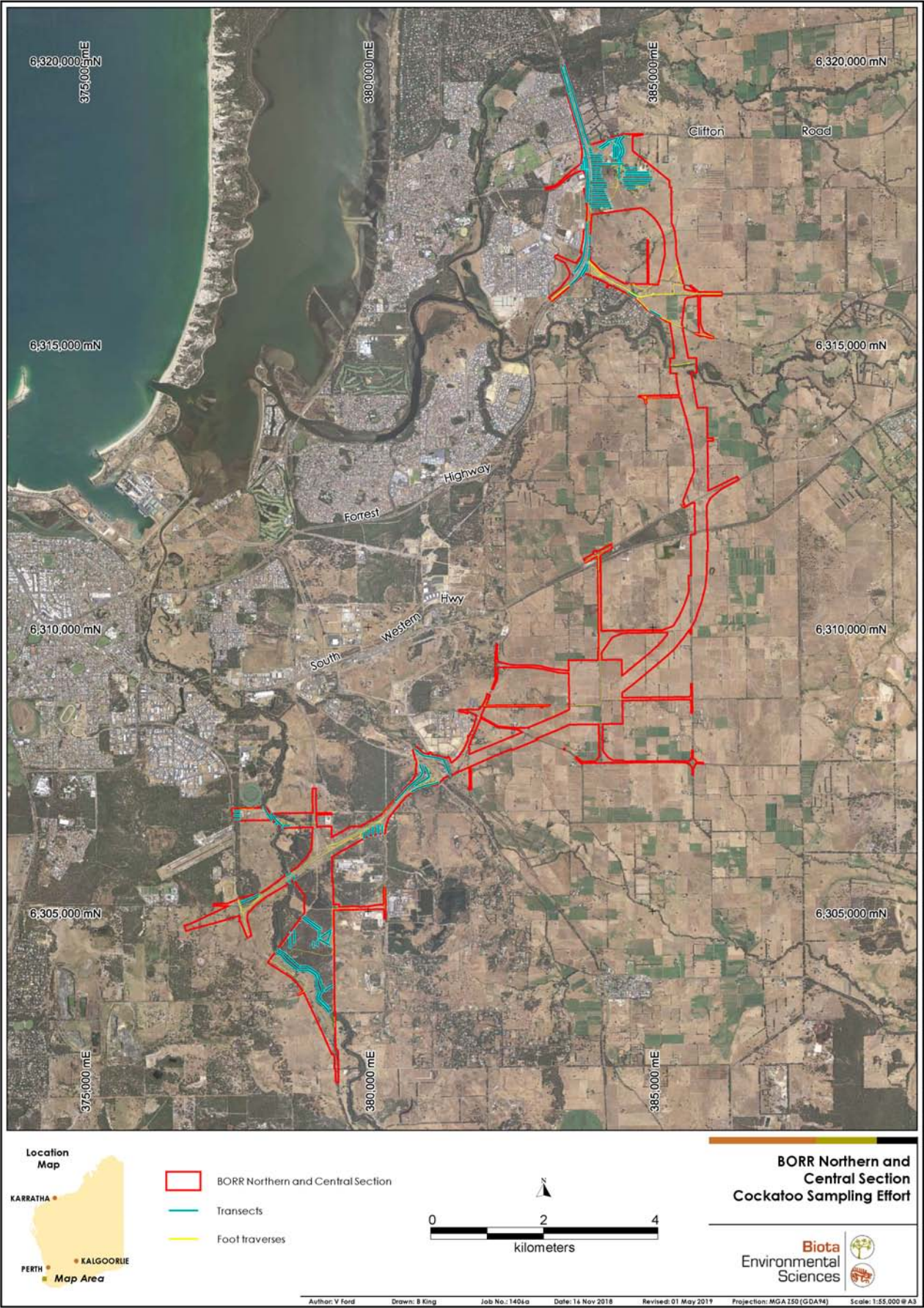


Figure 4.4: Survey effort applied to describing black-cockatoo breeding habitat within the study area.

4.6.1.1 Black-cockatoo Breeding Hollow Assessment Field Methodology

Black-cockatoos on the Swan Coastal Plain breed in large hollow-bearing trees, generally within woodlands and forests (Johnstone and Kirkby 2011). Hollow formation results from a number of processes including fungal infection, termite activity and fire, and propensity for hollow formation varies between eucalyptus species (Whitford and Williams 2002). Studies on hollow formation in Jarrah/Marri forests identified a minimum tree age of 130 years before a tree would be suitable for hollow-dependent fauna (Whitford and Williams 2002). Habitat destruction, and the subsequent loss of suitable breeding hollows, has been identified as a process leading to population decline of black-cockatoos (Johnstone and Kirkby 2008). Furthermore, increased competition with both native and introduced species (e.g. Galahs, ducks and European honey bees) continues to reduce the availability of such trees for breeding sites (Johnstone et al. 2013).

Studies of the breeding behaviours of the three threatened black-cockatoo species have identified variation between the tree species and characteristics of hollows chosen for nesting (Table 4.10). For example, hollows formed in Jarrah are typically smaller than those in Marri, and Forest Red-tailed Black-Cockatoos breed predominantly in Marri in the Jarrah-Marri forest of the south-west (Johnstone et al. 2013). Breeding records of Carnaby's Black-Cockatoo on the Swan Coastal Plain indicate that the majority of their nests are in Tuart (Johnstone and Kirkby 2011).

Table 4.10: Breeding habitat for the three Threatened black-cockatoo species.

	Baudin's	Carnaby's	Forest Red-Tailed
Specific breeding habitat for the three black-cockatoo species	Nest in hollows in live or dead trees of Karri, Marri, Wandoo and Tuart.	Nest in hollows in live or dead trees of Salmon Gum, Wandoo, Tuart, Jarrah, Flooded Gum, York Gum, Powderbark, Karri and Marri.	Nest in hollows in live or dead trees of Karri, Marri, Bullich, Swan River Blackbutt, Tuart and Jarrah.
Hollow Characteristics			
Aspect	No preference. Does not affect nesting success (Saunders 1979).	No preference. Does not affect nesting success (Saunders 1979).	–
Depth	Ranges from 0.1 to 2.5+ m (Johnstone and Kirkby 2011).	Majority between 0.5 and over 2.0 m, average just over 1 m (Saunders 1979).	1.0 - 5.0 m (Johnstone and Kirkby 2011).
Height above ground	No preference (Serventy and Whittell 1976).	No evidence that higher hollows are preferred (Saunders 1979).	No preference (Johnstone and Kirkby 2011).
Living or dead	No preference (Saunders 1979).	No preference (Saunders 1979).	No preference (Saunders 1979).
Entrance Diameter	–	–	>12 cm (Johnstone and Kirkby 2011).

For all hollow-bearing trees >50 cm DBH, which also contained hollows greater than approximately 12 cm dimension that were recorded during the black-cockatoo habitat mapping exercise (see Section 4.6.1), a follow-up survey was conducted using a remotely-piloted aircraft (RPA; DJI Mavic Pro) to assess the likelihood or evidence of black-cockatoo breeding within these hollows. The hollow assessment was conducted in two phases.

The RPA exercise was carried out by two biologists: one of whom is also an experienced RPA pilot assisted by a zoologist. A pre-flight assessment of the tree was completed to ensure proper flight conditions and confirm the order in which hollows would be assessed. Prior to flight, the side of the tree was raked with a branch, which will generally cause any black-cockatoo or other bird species within a hollow to emerge. This provides an indication of hollow use and also reduces the likelihood of RPA-fauna collision.

During the flight stage of the RPA survey, the two participants were each tasked with a specific duty: (i) the pilot was responsible for flying the RPA and (ii) the spotter monitored the surroundings to ensure the aircraft was not in close proximity to branches and informed the pilot if any birds fled the hollows.

All accessible hollows with an entrance of 12 cm were examined with the RPA. During the first phase of drone survey, only the best (most suitable) hollow from each tree was described in detail and was used to provide a suitability ranking for the tree as a whole. During the second phase of survey, all hollows on each tree were described in detail. Table 4.11 provides a summary of the number of trees and hollows assessed and described.

Photographs of the hollows were then assessed in detail to determine if they actually represented suitable hollows and/or if they showed any signs of current or previous use by black-cockatoos (e.g. chew marks around hollow entrance).

Table 4.11: Summary of Breeding Hollow Assessment

	Phase 1	Phase 2	Total
Trees visited	113	32	145
Ground assessed as not suitable (not flown)	25	5	30
Inaccessible (not flown)	5	2	7
Trees flown (hollows examined, hollows described)	83 (198,108)	25 (53,48)	108 (251,156)

Breeding suitability of the hollows examined was categorised as per Table 4.12.

Table 4.12: Categories of hollow suitability for black-cockatoo nesting.

Category	Characteristics
Suitable	<ul style="list-style-type: none"> Entrance greater than 12 cm. Branch width and depth large enough to support a nesting chamber. Angle of entrance/egress suitable for black-cockatoo. Entrance is clear of large branches and excessive foliage that would block access for black-cockatoo.
Suitable with Evidence of Use	<p>As for "Suitable" above, but also showing evidence of use that may be from black-cockatoos. The following represent the types of use that were observed:</p> <ul style="list-style-type: none"> Fresh chews around the rim and inside of the hollow. Freshly cleared vegetation around the entrance. Eggs that were similar in appearance to those of black-cockatoos. <p>Neither black-cockatoos at/in hollows or fledglings were observed during the survey, however this may reflect timing of the survey, which preceded the peak breeding period.</p>
Limited Suitability	Hollows with an entrance greater than 12 cm, and which included some, but not all of the characteristics of a Suitable hollow.
Not Suitable	Not a hollow, or hollow not suitable for black-cockatoo nesting.
Ground Assessment Only	The hollow could only be assessed from the ground due to limitations with RPA access (e.g. proximity to road traffic, within a prescribed no-fly zone, foliage covering hollow).

4.6.2 Foraging Habitat Assessment

Foraging habitat is defined as areas including plants of species known to support foraging within the range of each cockatoo species. While a broader range of species is utilised for foraging (including introduced species such as pines, **Pinus* spp.), Marri and Jarrah woodlands are particularly important to Baudin's Black-Cockatoo and the Forest Red-tailed Black-Cockatoo, while proteaceous heaths (i.e. shrublands dominated by *Banksia*, *Hakea* and *Grevillea* species) are also utilised by Carnaby's Black-Cockatoo (DSEWPac 2012). The quality of the foraging habitat was scored using the elements of the habitat scoring tool described in the referral guideline (DoEE 2017) (Appendix 6).

The detailed vegetation mapping of the study area (GHD 2019) was used in conjunction with the on-site breeding assessment in order to apply the Foraging Habitat Scoring Tool (DoEE 2017) to the vegetation of the study area.

While conducting assessments of breeding habitat in the areas shown in Figure 4.4, foraging habitat and foraging evidence were also opportunistically recorded. Not all locations of foraging evidence were recorded, as these were too numerous for this to be practicable. However, generally any first encounter with foraging evidence within a vegetation fragment was recorded and subsequent encounters were also recorded if they were indicative of an additional species utilising the area.

4.7 Brush-tailed Phascogale and Chuditch

The spotlighting methods applied to the sampling of Western Ringtail Possum were considered equally applicable to the Brush-tailed Phascogale and Chuditch.

4.8 Carter's Freshwater Mussel

Surveying for Carter's Freshwater Mussel was undertaken in drainage areas. This comprised walking along the bank and searching for individuals, which are readily detectable in this habitat given their considerable adult size. A separate study targeting aquatic species has been completed (WRM 2019) so the results of the current study are supplemental to a more intensive study.

4.9 Limitations of the Study

A number of potential limitations, including those identified in EPA (2016b) have been considered in relation to the study (Table 4.13).

Table 4.13: Assessment against potential survey limitations.

Potential Limitation	Assessment
Availability of contextual information at a regional and local scale	<ul style="list-style-type: none"> To provide context for estimates of Western Ringtail Possum numbers in the study area, additional sites outside the study area were sampled using consistent methodology. Seven surveys targeting Western Ringtail Possum and/or black-cockatoos have been conducted within 20 km of the study area; these were reviewed to provide local context. Contextual information was not considered a limitation.
Competency / experience of the team carrying out the survey, including experience in the bioregion surveyed	<ul style="list-style-type: none"> The field personnel conducting the work were all suitably qualified. A core group of personnel completed all survey phases to standardise recording as far as practicable. Competency was not considered to be a limitation.
Proportion of fauna recorded and/or collected, any identification issues	<ul style="list-style-type: none"> In some cases, identifying white-tailed black-cockatoos to species level was not possible when they were at a distance or heard only In some areas, discerning Flooded Gum (<i>Eucalyptus rudis</i>) from Tuart (<i>E. gomphocephala</i>) was difficult due to lack of visible fruit. In this situation, species was ascribed based on habitat and other elements of tree morphology (for example, the Flooded Gum tended to be more stunted and have lower branches). There is potential for suitable breeding hollows to be missed, as recorders were limited in detecting hollows from ground level and their view may have been blocked by foliage or the aspect of the hollow entrance. Within the study area, nine hollows could not be assessed using the RPA; five had foliage covering the hollow and two were located too close to roads. This study targeted specific fauna species of conservation significance and did not represent an inventory style survey. The target species (particularly Western Ringtail Possum and black-cockatoos) were intensively surveyed and proportion of fauna and identification issues were not considered a limitation.
Appropriate area fully surveyed (effort and extent)	<ul style="list-style-type: none"> This study targeted specific fauna species of conservation significance. The study comprehensively sampled the occurrence of habitat for these species within the study area. Sufficient time was allocated to the field survey component to allow for all potential habitat for the target conservation significant species to be surveyed. The extent of survey was not considered to be a limitation.
Access restrictions within the survey area	<ul style="list-style-type: none"> Access within the survey area was not considered a limitation for the current study.
Survey timing, rainfall, season of survey (timing / weather / season / cycle)	<ul style="list-style-type: none"> Survey timing was not considered to be a limitation to the assessment of breeding habitat for black-cockatoos and the survey of Western Ringtail Possum.
Disturbances (e.g. fire, flood, accidental human intervention etc.) which affected results of survey	<ul style="list-style-type: none"> Disturbances were not considered a limitation to the survey.

BORR Northern and Central Section Targeted Fauna Assessment (Biota 2019a) – Part 2a (part 2 of 7)

5.0 Results

5.1 Desktop Review

Tables detailing all species returned from the desktop review are presented in Appendix 3. Database search results, together with four studies within 10 km of the study area, yielded a combined species inventory of 230 vertebrate fauna species, comprising 28 mammals (14 native non-volant mammals, 5 bats and 9 non-native species), 159 birds (72 of which are largely reliant on freshwater or marine habitats), 33 reptiles and 10 amphibians.

Nineteen of these species are of conservation significance; these are considered in more detail in Section 6.0.

5.2 Fauna Habitats

Much of the study area has been cleared for agriculture and road infrastructure while approximately 200 ha of vegetation remains within the 1,128 ha study area. The large majority of this vegetation was ground-truthed over the course of field survey (see Figure 4.2, Figure 4.3, Figure 4.4). Following the survey, fauna habitats were refined based on on-site descriptions and vegetation mapping of the study area (GHD 2019). Some refinement of fauna habitat within vegetation units was necessary; for example, Eucalypts within a road reserve were considered to represent a different fauna habitat to a large fragment, even if the two had similar vegetation composition. Conversely, much of the narrow strips of roadside vegetation were considered to represent a single habitat type, although in some instances there was variation in flora species composition.

A limitation of any habitat classification system is that it is not specific to any one species. Rather, the classification provides a convenient framework to summarise species occurrence. When considering habitat for individual species of elevated conservation significance, the habitat availability within the study area has been considered in relation to particular species requirements and this is detailed in Section 6.0.

Six broad fauna habitats were described for the study area, they are detailed in Table 5.1 and mapped in Figure 5.1 to Figure 5.3

- *Marri/Eucalyptus* woodland (47.92 ha)
Refers to the larger remnants of *Marri/Eucalyptus* woodland within the study area, primarily those found within the Northern Lots.
- *Marri/Eucalyptus* in paddocks and road reserves (39.65 ha)
In lower lying paddock areas trees were scattered *Eucalyptus rudis*. In road reserves, trees were typically *Marri*. Understorey typically introduced weedy grasses.
- Dampland with *Melaleuca* woodland and shrubland in paddocks and road reserves (47.89 ha)
Common in paddocks and occasionally road reserves throughout the study area. In one area, this habitat comprised *Astartea* shrubland
- Riparian woodland (significant drainage) (30.14 ha)
Woodlands of the upper banks and floodplains of the significant drainages (Preston River, Collie River and Brunswick River) within the study area.
- Peppermint woodland (28.98 ha)
While Peppermint occurred as a mid-storey species in mixed woodland habitats, some homogenous stands of Peppermint were considered as a distinct fauna habitat due to their distinct three dimensional structure.
- Artificial wetland (5.28 ha)
Occurs at two locations in the northern lots where man made drains have been used to create areas of semi-permanent water.

The following are/vegetation were considered largely devoid of fauna habitat:

- Highly modified / cleared (906.28 ha)
Land cleared for agriculture, housing, roads and other infrastructure.
- Early revegetation (14.07 ha)
Includes the blue gum plantation and some areas of early growth of planted vegetation in roadside reserves.
- Non-native vegetation (7.8 ha)
Mature planted vegetation including *Eucalyptus* species along internal fence lines, driveways and landscaping.





Areas of riparian vegetation, particularly along the Preston River, and the woodland within Lots 104, 5 and 131 south of Clifton Road (the 'Northern Lots') and Victoria Road represented the largest areas of native vegetation occurring within the study area.





A considerable proportion of the vegetation within the study occurred as single trees or small stands within paddocks and road reserves. Both of these habitat types have the potential to represent linkages that allow fauna to disperse throughout the landscape, although their usefulness is likely to vary considerably between species depending on their mobility (e.g. black-cockatoos greater than Western Ringtail Possum). For paddock remnants, their usefulness as stepping stones may be reduced in instances where they are heavily fenced or where there is little or no understorey due to grazing.



The vegetation within the road reserves varied broadly in species composition and connectivity. As fauna habitat, it was separated into two types; areas dominated by *Melaleuca* shrubland and areas supporting scattered trees or woodland. Road reserve woodland comprised native species (including *Corymbia calophylla*, *Eucalyptus marginata*, *E. rudis*, occasionally *E. gomphocephala* and some distinct areas of *Casuarina obesa*), but also non-native *Eucalyptus* species. The section of Forrest Highway road reserve adjacent to the Northern Lots (104, 5 and 131) and extending north to the end of the study area was considered to represent a potentially important habitat linkage for the Western Ringtail Possum. This section of the road reserve was found to support a high abundance of possums (21 individuals from 17 observations made on one night) and connects the Northern Lots to the riparian habitat of the Collie River.

The riparian woodland of the Preston River is also likely to represent a habitat linkage for the Western Ringtail Possum; high abundances were recorded and this long strip of woodland habitat connects a number of widely separated reserve areas occurring outside the study area (e.g. Manea Park and Franklandia Nature Reserve).

Table 5.1: Broad fauna habitats of the study area.

Broad Fauna Habitat	Area (ha)	Example Photograph/s	
<p>Marri/<i>Eucalyptus</i> woodland</p> <p>Jarrah (<i>Eucalyptus marginata</i>) +/- Marri (<i>Corymbia calophylla</i>) dominated overstorey, varying understorey of Banksia (<i>Banksia attenuata</i> and <i>B. grandis</i>) or Peppermint (<i>Agonis flexuosa</i>).</p>	47.92		
<p>Dampland with <i>Melaleuca</i> woodland and shrubland in paddocks and road reserves</p> <p>Very open woodland of Swamp Paperbark (<i>Melaleuca raphiophylla</i>) over herbs and weeds in road reserves and over introduced grasses in paddocks and very occasionally road reserves.</p> <p>When occurring in paddocks, the understorey was heavily grazed.</p>	47.89		

Broad Fauna Habitat	Area (ha)	Example Photograph/s	
<p>Marri/<i>Eucalyptus</i> in paddocks and road reserves</p> <p>Typically occurring as widely spaced trees or occasionally as small stands in paddocks; comprising a mosaic of scattered trees of <i>Melaleuca</i>, Marri and/or Flooded Gum (<i>Eucalyptus rudis</i>). The understorey was usually heavily grazed.</p> <p>Roadside species composition was variable including native tree species as above, areas of <i>Casuarina</i> (see photograph), as well as planted introduced <i>Eucalyptus</i>.</p>	39.65		
<p>Riparian woodland (significant drainage)</p> <p>The study area intersected the Preston, Collie and Brunswick Rivers. This habitat comprised:</p> <ul style="list-style-type: none"> • Woodland of Flooded Gum and Marri over Swamp Paperbark on Preston River; • Woodland of Swamp Paperbark, Flooded Gum and Swamp Sheoak (<i>Casuarina obesa</i>) fringing Collie River. • Open forest of Flooded Gum on the banks/floodplain of the Brunswick River. 	30.14		

Broad Fauna Habitat	Area (ha)	Example Photograph/s
<p>Peppermint woodland</p> <p>While Peppermint was more commonly found as a midstorey species within Marri/Eucalypt woodland, it did occur in uniform stands in some areas, often over introduced pasture grasses.</p>	28.98	
<p>Artificial wetland</p> <p>Man-made drainage channels used to create small artificial wetlands in two locations within the study area, the most notable being south of Clifton Road.</p> <p>Very open woodland of Swamp Paperbark over introduced grasses and herbs in paddocks and road reserves.</p>	5.28	

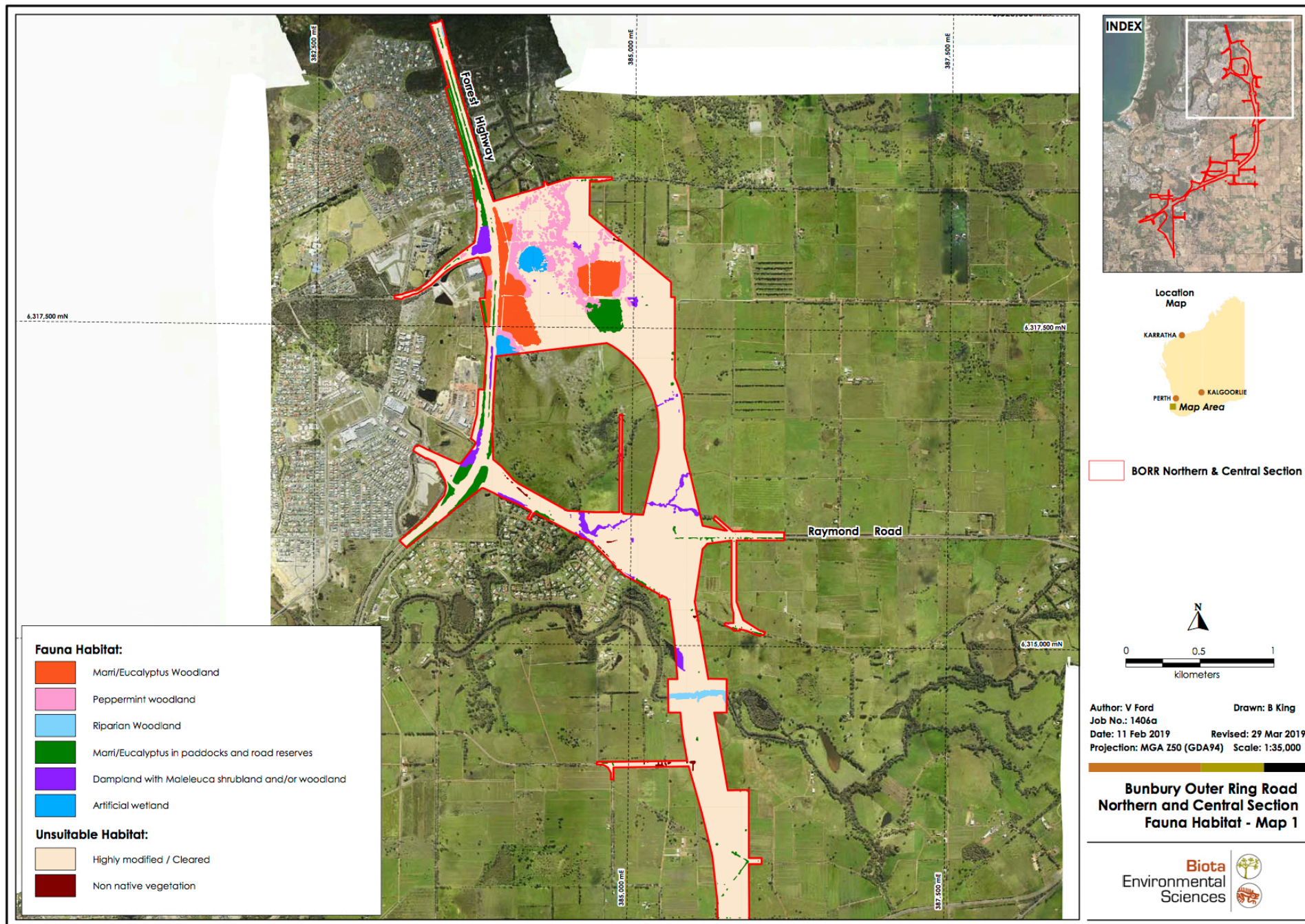


Figure 5.1: Broad fauna habitats of the study area (northern section, map 1/3).

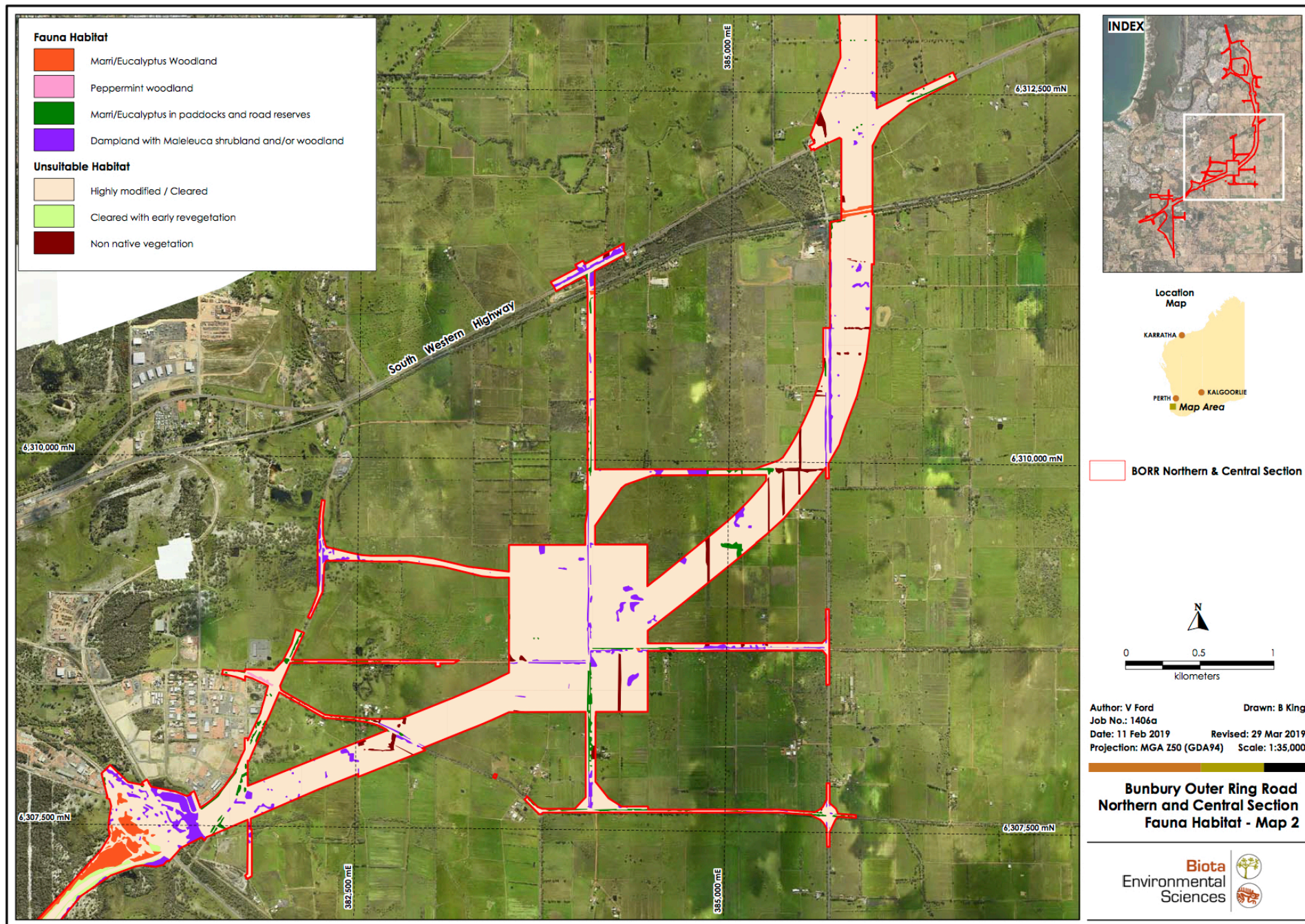


Figure 5.2: Broad fauna habitats of the study area (middle section, map 2/3).

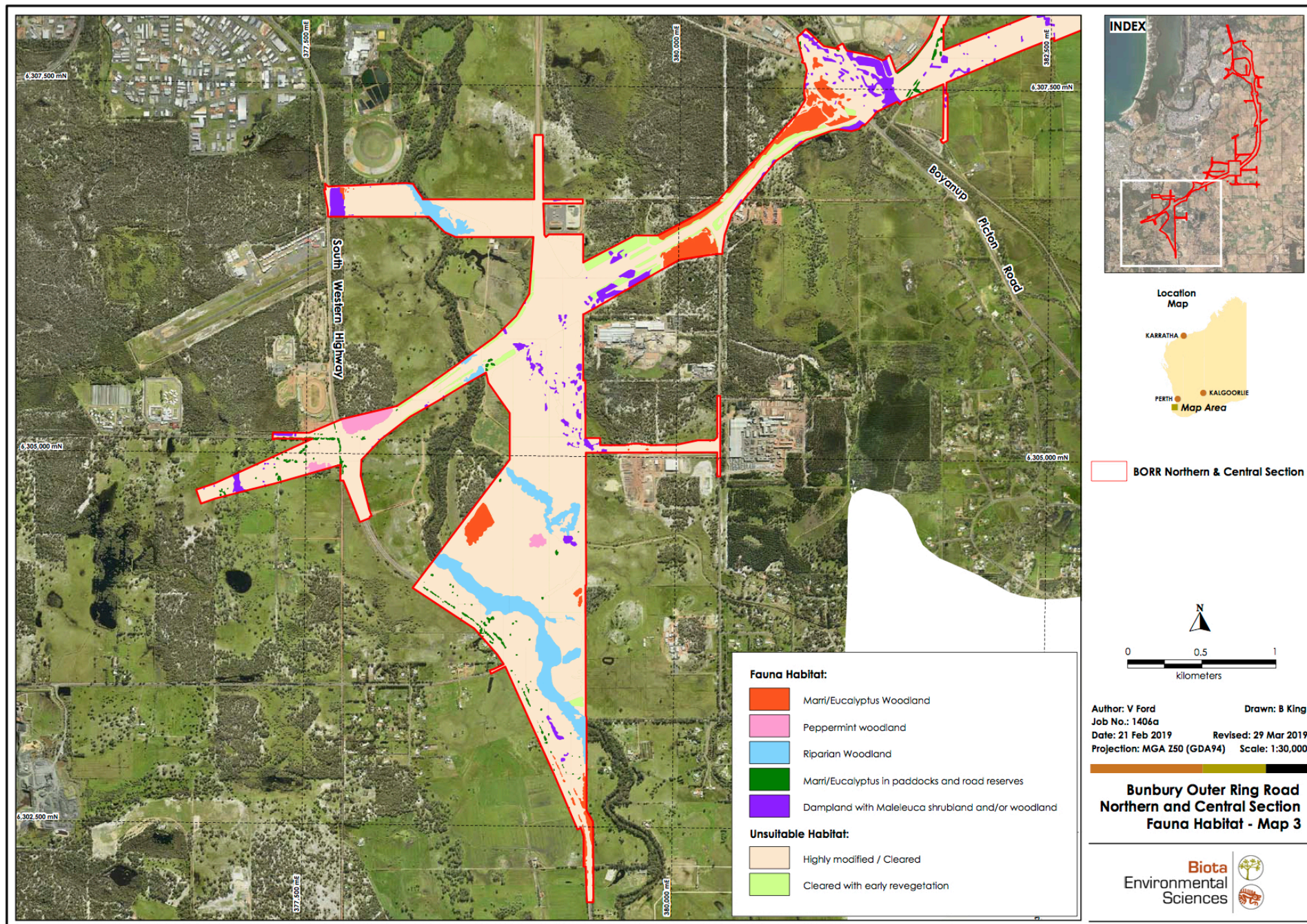


Figure 5.3: Broad fauna habitats of the study area (southern section, map 3/3).

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5.3 Western Ringtail Possum

Across all study sites (including those used for context) and all transects, 339¹ Western Ringtail Possums were sighted (including joeys at heel or on the back). Sixty-four of these sightings were made within the study area and 275 were from contextual sites (see Figure 5.4 and Figure 5.7).

A calculation of the density as determined from strip transects (both within the study area and contextual sites) is provided in Section 5.3.1. Density estimation from the line-transect Distance sampling program in both the study area and contextual sites is discussed in Section 5.3.2.

5.3.1 Strip Transects: Density Estimates of Western Ringtail Possum

Of the 64 Western Ringtail Possums sighted within the study area, 46 were recorded from strip transects (Table 5.2); the remaining 18 were recorded from the Distance sampling program at the Northern Lots site and are discussed in Section 5.3.2). These strip transects sampled an area of 100.5 ha, yielding a density estimate of 0.46 per hectare.

Within the contextual sites, a total of 27 individuals were recorded from 86.94 ha, yielding a density of 0.31 per hectare.

Table 5.2: Number of observations and total number of individuals (in parentheses) of Western Ringtail Possums recorded from strip transects within the study area and at contextual sites.
Bold numbers indicate those counts used to obtain the sub-totals and grand total (assumed to represent a count of unique individuals).

Study Site	Number of Observations (Sightings)		
	July	August/September	October
Within Study Area			
Brunswick River to Raymond Road	-	-	17 (21) ¹
Davenport Localities (part Moore Road)	1 (1)	2 (2)	3 (4)
Davenport Localities (part Picton River)	2 (3)	6 (6)	-
Davenport Localities (Timber Mill Place)	-	-	4 (4)
Golf Drive – part	-	2(2)	-
Picton East	-	6 (6)	8 (9)
Sub-total	40 (46)		
Contextual Sites			
Davenport Localities (part Moore Road)	3 (3)	4 (5)	-
Davenport Localities (part Picton River)	-	2 (2)	-
Golf Drive – part	-	2 (4)	-
Gelorup	11 (12)	11 (14)	-
Maidment Parade road reserve	1 (2)	2 (2)	-
Sub-total	21 (27)		
Grand Total	61 (73)		

¹ N.B. Where repeat sampling was undertaken, only the sightings from the most recent phase are included in the tally.

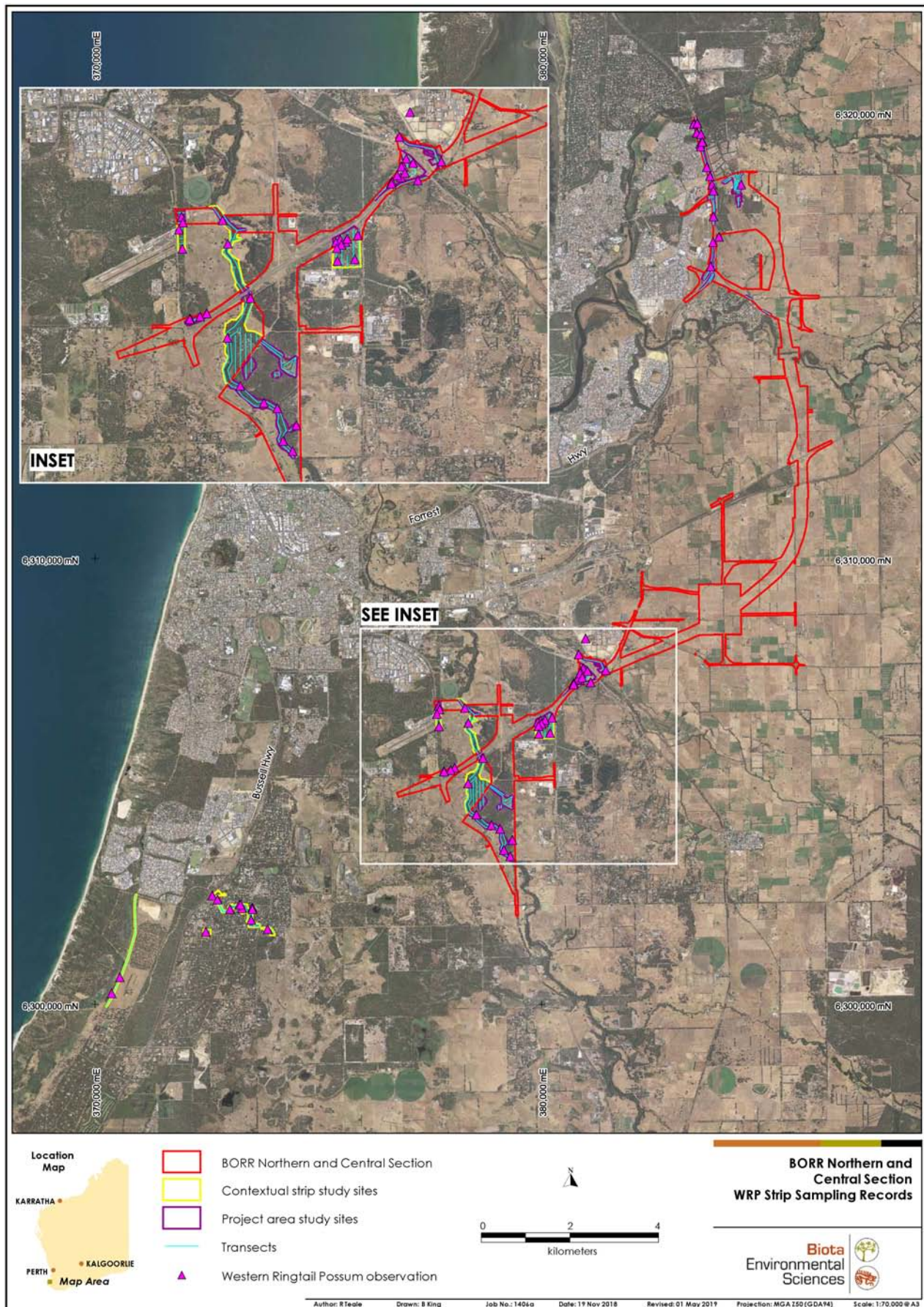


Figure 5.4: Records of Western Ringtail Possums from strip transects within the study area and contextual sites.

5.3.2 Line-transect Distance Sampling: Density Estimates of Western Ringtail Possum

The combined surveys (including the seasonal repeats) yielded 413 observations and 522 individual Western Ringtail Possums (prior to truncation). Considering just the results of the most

recent phase of sampling, 18 individuals were recorded within the Northern Lots (inside the study area); for the contextual sites, 60 individuals were recorded in Lot 2 Boyanup–Picton Rd (August survey), 52 in Reserve 23,000 Shire of Capel (August survey), 103 in Manea Park and 33 in the Southern Lots (Table 5.3)

Table 5.3. Number of observations and individuals (in parentheses) of Western Ringtail Possums (prior to truncation) in each study site made during Distance sampling surveys.

Bold numbers indicate those counts used to obtain the grand total.

Study Site	February	August	September	October	November
Study Area					
Northern Lots	-	-	11 (18)	-	-
Contextual Sites					
Lot 2 Boyanup–Picton Rd	51 (59)	54 (60)	-	-	-
Reserve 23,000 (entire) Shire of Capel	56 (75)	46 (52)	-	-	-
Manea Park	-	-	-	74 (103)	-
Southern Lots	-	-	-	-	25 (33)
Grand Total					210 (266)

N.B.: Truncation of observation data occurs during analysis and results in fewer observations being tabulated in the subsequent tables.

When examining the data from the line-transect Distance sampling, stepped lower initial intervals that increase away from the centreline can indicate movement of individuals away from the observers, while initially high then decreasing intervals indicate relatively little movement away from the observers (Buckland et al. 2001). Both can lead to bias in density estimation. The histogram of detection distances generated in the present study did not indicate Western Ringtail Possum movement either toward or away from the observer (Figure 5.5).

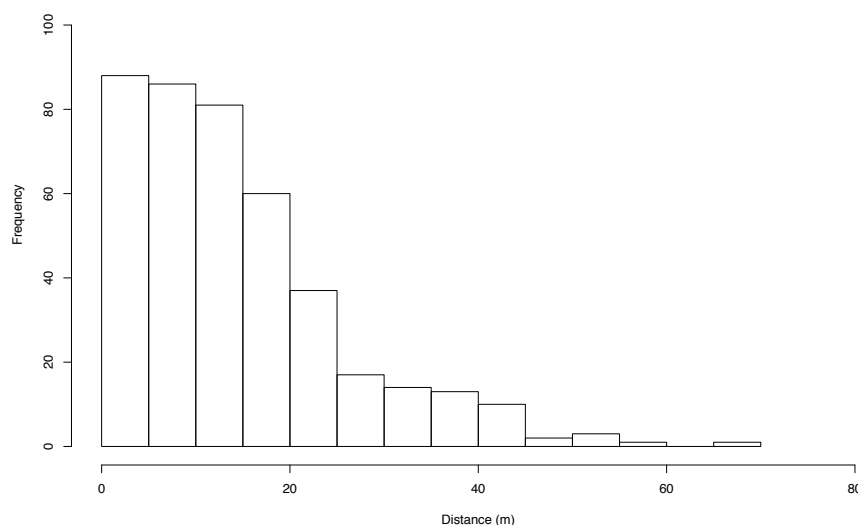


Figure 5.5: Histogram of all Western Ringtail Possum observations (n=413) from all surveys included in the distance sampling analyses.

The best overall model fit of the combined data was a half-normal key with no adjustment terms and no covariates (truncation = 18 m, n = 298, K-S p = 0.999, CvM p = 0.999) (Figure 5.6).

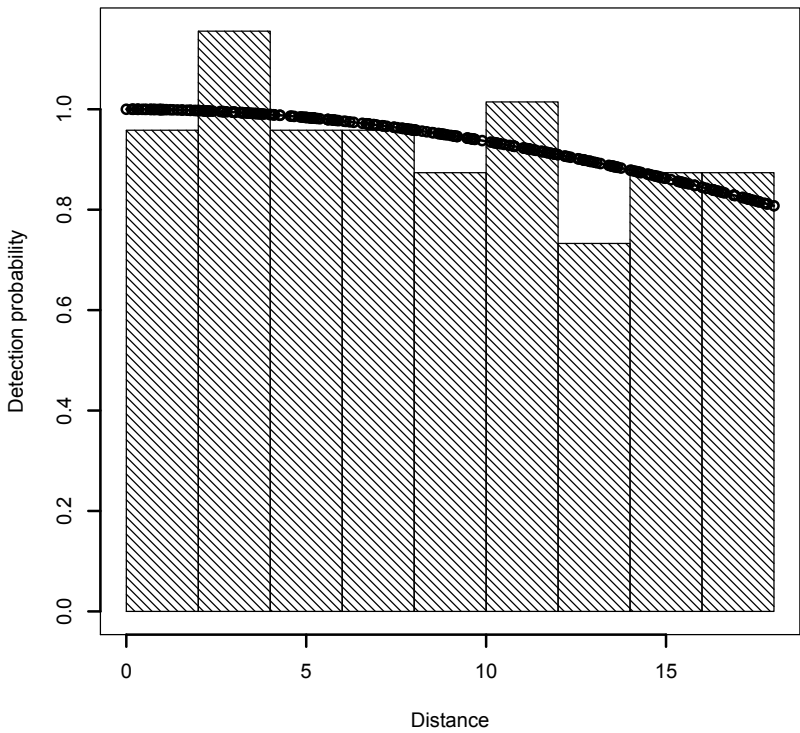


Figure 5.6: Histogram of Western Ringtail Possum observations from the combined surveys with half-normal probability detection function and truncation at 18 m.

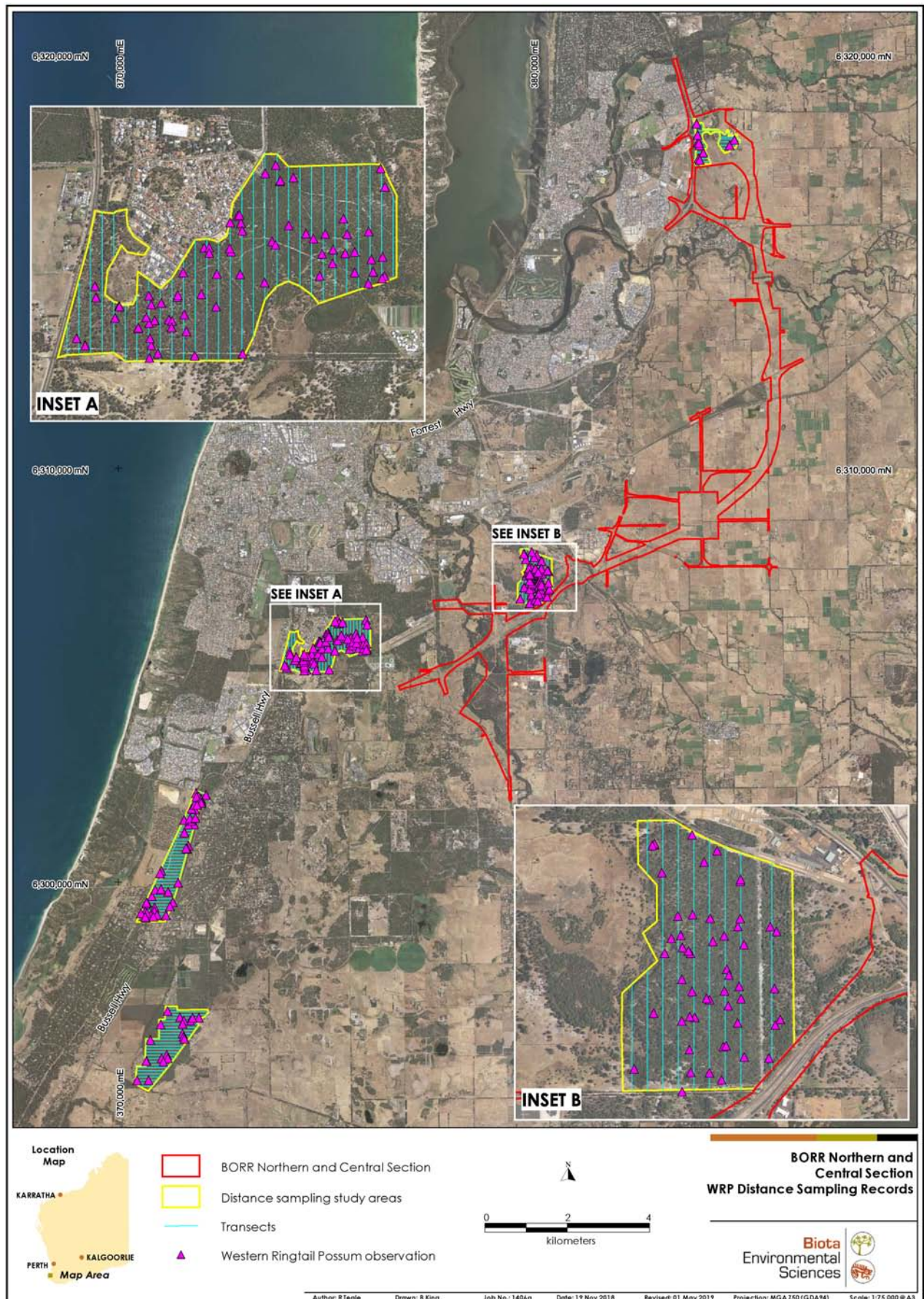


Figure 5.7: Records of Western Ringtail Possums obtained from distance sampling surveys within the study area and contextual sites.

The data were post-stratified by study site to provide parameter estimates for each area separately (Table 5.4 to Table 5.6).

Table 5.4: Key summary statistics from the Distance sampling program for Western Ringtail Possums in the study sites relevant to the study area.

(n = number of observations (equals clusters), k = number of transects, ER = Encounter Rate, se = standard error, cv = coefficient of variation.)

Study Site	Area (ha)	Covered Area (ha)	Effort (km)	n	k	ER per km	se.ER	cv.ER
Lot 2 Boyanup–Picton Rd								
February	87.62	34.98	9.72	42	9	4.32	0.71	0.16
August	87.62	34.98	9.72	40	9	4.12	0.59	0.14
Reserve 23,000 Shire of Capel								
February	146.1	67.20	18.60	38	41	2.03	0.49	0.24
August	146.1	67.20	18.60	30	41	1.60	0.30	0.19
Northern Lots survey								
September	33.3	15.50	4.29	6	16	1.40	0.56	0.40
Manea Park survey								
October	155.0	73.28	20.40	51	28	2.51	0.41	0.16
Southern Lots survey								
November	188.0	79.58	22.10	22	27	1.00	0.17	0.07

Table 5.5: Density estimates for Western Ringtail Possums (individuals) in the study sites relevant to the study area.

(se = standard error, cv = coefficient of variation, lcl = lower confidence limit, ucl = upper confidence limit, df = degrees of freedom.)

Study Site	Density per ha	se	cv	lcl	ucl	df
Northern Lots survey						
September	0.62	0.26	0.42	0.26	1.48	15.66
Lot 2 Boyanup–Picton Rd 2018 surveys						
February	1.50	0.25	0.17	1.04	2.16	10.78
August	1.37	0.19	0.16	0.94	1.93	10.90
Reserve 23,000 Shire of Capel 2018 surveys						
February	0.78	0.20	0.25	0.47	1.29	45.24
August	0.56	0.11	0.20	0.35	0.79	48.66
Manea Park survey						
October	1.201	0.267	0.20	0.73	1.64	33.05
Southern Lots survey						
November	0.39	0.11	0.27	0.26	0.68	28.90

Table 5.6: Abundance estimates for Western Ringtail Possums (individuals) in the study sites relevant to the study area.

(se = standard error, cv = coefficient of variation, lcl = lower confidence limit, ucl = upper confidence limit, df = degrees of freedom.)

Study Site	Abundance Estimate	se	cv	lcl	ucl	df
Northern Lots survey						
September	20.78	8.82	0.42	8.75	49.36	15.66
Lot 2 Boyanup–Picton Rd 2018 surveys						
February	131.51	21.92	0.17	91.25	189.51	10.78
August	121	17	0.16	82.49	169.06	10.90
Reserve 23,000 Shire of Capel 2018 surveys						
February	114.07	28.94	0.25	68.98	188.61	45.25
August	82	16	0.20	51.29	114.91	48.66
Manea Park survey						
October	186	41.45	0.20	113.65	254.25	33.06
Southern Lots survey						
November	73.42	20.08	0.27	42.38	127.18	28.90

The highest density estimates were recorded from two contextual sites, Lot 2 Boyanup–Picton Rd and Manea Park; these yielded 1.37 ± 0.19 (August phase) and 1.201 ± 0.267 individuals per ha (October phase) respectively. These density estimates resulted in abundance estimates of 121 ± 17 (August survey) and 186 ± 41.45 individuals based on the surveyed area polygons (i.e. the polygons depicted in Figure 5.7). The survey area polygon of Lot 2 Boyanup–Picton Rd encompasses almost the entirety of the extent of the remnant patch of vegetation, so there is little opportunity to increase the abundance estimate by further interpolation. However, the surveyed area of Manea Park represents only a portion (30%) of the total extent of the contiguous remnant patch, which extends further to the east and north (highlighted in blue in Figure 4.3). The extension encompasses a further 258 ha of apparently similar habitat (based on aerial imagery); if this area supports a comparable density to the surveyed section, it would yield a further 310 Western Ringtail Possums. The total number of Western Ringtail Possums in this single remnant would therefore be estimated at approximately 496.

A much lower density of Western Ringtail Possums (0.39 ± 0.11 per ha) was estimated from the Southern Lots. However, this remnant extends further to the north and west beyond the area sampled, and if this density estimate is likewise extended to the contiguous sections of the remnant (an additional 211 ha), then a further 82 individuals are estimated. This would take the total estimate to approximately 156 ± 40 for the single contiguous remnant (approximately 399 ha in size) of which the Southern Lots forms a part. The last of the contextual sites, Reserve 23,000, yielded a density estimate of 0.56 ± 0.11 individuals per ha (August survey), which translates to an estimate of 82 ± 16 individuals. If this estimate is applied to the 40 ha remnant to the north of Harewood Road, a further 22 ± 4 individuals are estimated to occur in the broader remnant patch.

The combined tally from the four large contextual remnants in which distance sampling was undertaken is estimated to be approximately 462 individuals. This increases to approximately 878 individuals if density estimates are interpolated into contiguous (or nearly so) sections of the surveyed remnants.

The Northern Lots area, situated inside the study area, yielded a density estimate of 0.62 ± 26 individuals per ha; this equates to approximately 21 ± 9 individuals based on the estimated remnant size of 33.3 ha. Very few observations within the Northern Lots ($n=6$) were used in the modelling following truncation at 18 m, resulting in a high coefficient of variation (0.42) and in turn large 95% confidence intervals around the estimate.

5.4 Black-cockatoos

5.4.1 Observations

Two observations of white-tailed black-cockatoos flying over the study area were recorded; a single individual and a group of three. The birds could not be distinguished to species level (i.e. Carnaby's Black-Cockatoo versus Baudin's Black-Cockatoo) at a distance. A small group of calling white-tailed black-cockatoos was heard but not seen. The location of these records is shown in Figure 5.8.

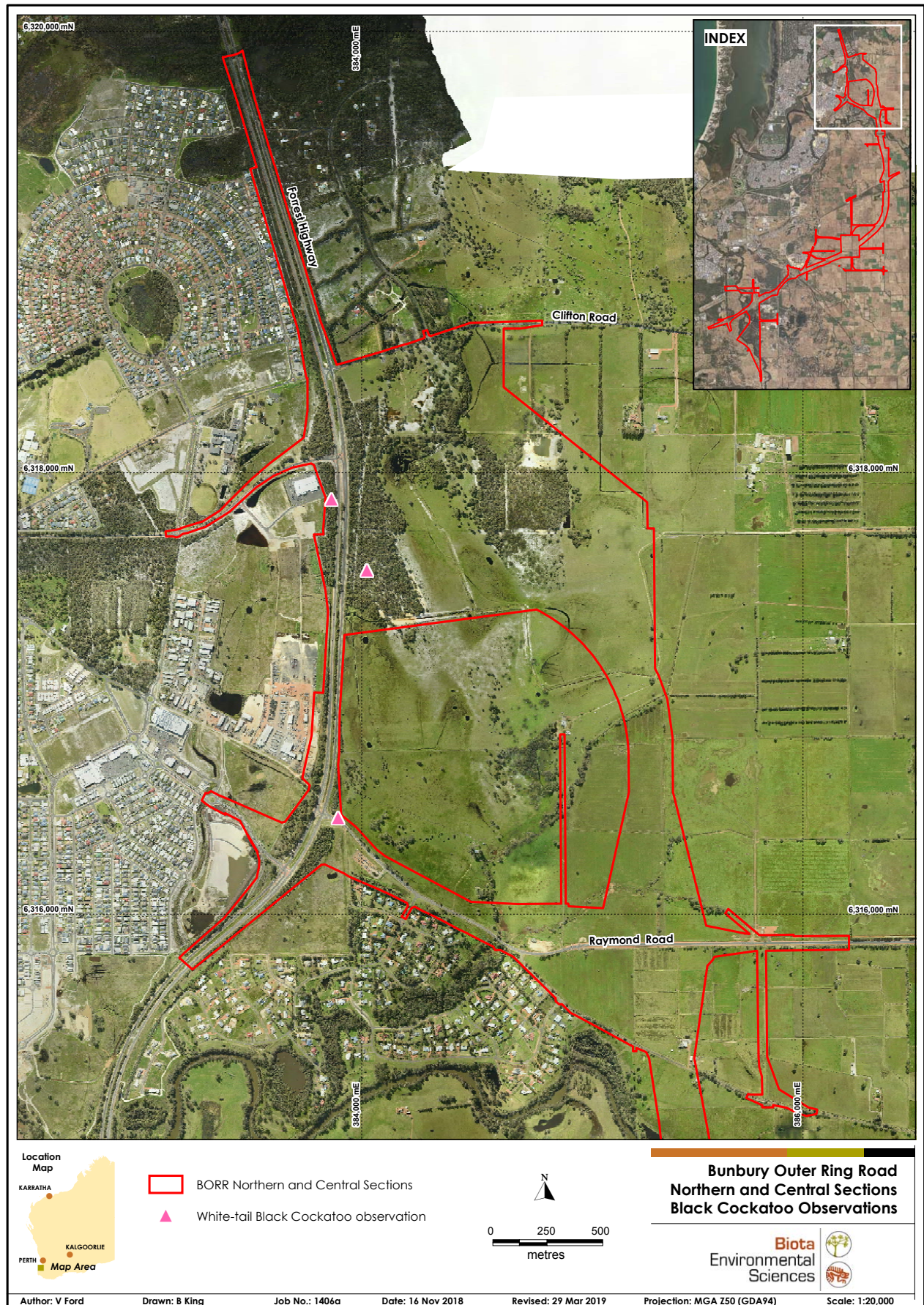


Figure 5.8: Records of white-tailed black-cockatoos.