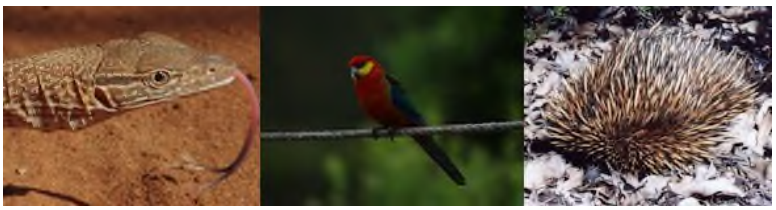
Worsley Alumina Mine Expansion (WME)
Desktop Fauna Assessment

Prepared for: South32 Worsley Alumina Pty Ltd

By BIOSTAT Pty Ltd

May 2019



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REVISION SCHEDULE

Rev. No.	Date	Description	Prepared/Approved By
a	14/12/2018	Pre-release draft. Information not reviewed, edited or confirmed. Data in this document to be used with care.	EGC
b	18/1/2019	First Draft release. Draft notation advanced to avoid confusion with pre-release draft.	EGC
c	4/2/2019	Near final release. Returned to South32 with edits and responses to comments	EGC
1	8/2/2019	Final Release with figures	EGC
1c	12/2/2019	Minor edits relating to changes in acronyms	EGC
1d	9/5/2019	Update to areas of habitat resulting from a review and refinement of spatial data	EGC

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(The 'Project' is defined as the scope of services as set out in the contract and agreed to by BIOSTAT Pty Ltd and the Client.)

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Glossary

Acronym	Description
BBM	Boddington Bauxite Mine
BTC	Boddington Transport Corridor
Bonn	Convention on the Conservation of Migratory Species of Wild Animals
CAMBA	China-Australia Migratory Bird Agreement
CBME	Contingency Bauxite Mining Envelope
DBCA	Department of Biodiversity, Conservation and Attractions
DPaW	Department of Parks and Wildlife
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
JAMBA	Japan-Australia Migratory Bird Agreement
IUCN	International Union for the Conservation of Nature
MMB	Mornington Mills Block
MEA	Mine Expansion Area (historical survey term)
MNES	Matters of National Environmental Significance
MAR	Worsley Marradong Mine Operations
NBGM	Newmont Boddington Gold Mine
OBC	Overland Belt Conveyor
PHT	Potential Habitat Tree
QIN	Quindanning Mine Operations
RLA	Refinery Lease Area
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
SAD	Saddleback Mine Operations
WME	Worsley Mine Expansion
WMDE	Worsley Mining Development Envelope
WMDEC	Combined WMDE and BTC Combined boundary areas

EXECUTIVE SUMMARY

Biostat Pty Ltd (Biostat) was commissioned in 2018 by South32 Worsley Alumina Pty Ltd (South32) to undertake a terrestrial vertebrate fauna survey and review of the proposed Worsley Mine Expansion (WME).

The WME consists of three development envelopes: two in the Boddington area and one in the Collie area of Western Australia:

- the Worsley Mining Development Envelope (WMDEC) covering an area of 27,796 ha from the Saddleback Tree Farm and Newmont Boddington Gold Mine (NBGM) to the North and south to Quindanning;
- the Bauxite Transport Corridor (BTC) covering 4,146 ha of which 3,332 ha overlaps WMDE; and,
- the Contingency Bauxite Mining Envelope (CBME), located at the Refinery Lease Area (RLA) near Collie which covers 747 ha (there is an additional 5 ha "Maintenance Area" within the CBME boundary that will not be considered separately in this report).

In relation to fauna, the area of impact at Boddington is considered the collective area covered by both WMDE and BTC. The combined merged area covered by these two administrative boundaries is 29,362 ha. They will be collectively referred to as the Worsley Mine Development Envelope Combined (WMDEC) for the analysis presented in this document.

This report will detail the adequacy, currency and validity of the data already held by South32 and Newmont Mining (for their NBGM) providing substantiating information for the referral of threatened species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Gaps in knowledge identified during the analysis of data for this report will be highlighted and recommendations made for further assessment, where required.

This report will detail the adequacy, currency and validity of the data already held by South32 and utilise it in providing substantiating information for the referral of threatened species under the EPBC Act. Gaps in knowledge identified during the analysis of data for this report will be highlighted and recommendations made for further assessment, where required.

The data available for the areas under consideration is generally robust and current for its use in impact assessment and of a substantially higher-level than what could be expected if basic guideline methodologies set out for impact assessments are followed.

Data for the WMDEC area, with systematic survey data available for most of the mining operations from 1982 to 2018, provides the necessary spatial-temporal data measure that allow confidence in assessing trends and likelihoods. This is especially relevant for data collected for the Boddington Bauxite Mine (BBM) area within the WMDEC. Certain areas including for the NBGM area, Marradong Timber Reserve (MTR) and for sites along the Overland Belt Conveyor (OBC) could benefit from updated data collection. The most evident gap in data is for the CBME area where systematic biodiversity surveys have not been undertaken since 2001.

The value of systematic survey design and data collection is discussed, and it is recommended that such surveys be preferred over other more typical methods such as passive monitoring or targeted surveys due to their limitations (i.e., short-term, lacking multi-seasonal perspective, speculative, generally poorly designed).

The fauna habitats present in the WME are typical for the bioregion, representing and dominated by, varying form of forest and woodland communities. The majority of the WMDEC consists of a mosaic of agricultural and cleared areas. The remnant native vegetation communities of relatively high quality are present in the northern and western portion of the WMDEC. In some cases, these form contiguous

tracts of native forests and woodlands such as the northern area of NBGM and in the central west area of SAD. There are remnants within agricultural lands as well as rehabilitation of mined areas that form connecting corridors allowing for fauna movements across the landscape.

All native vegetation remnants are of some level of use to much of the fauna dependent on the resources they contain. For example, rehabilitation performs a significant function in supporting fauna species associated with heath habitats. They also provide suitable feeding habitat for black-cockatoos and other nectarivore and granivore species. Stands of tall trees in agricultural lands can provide temporary refuge for volant and to a lesser degree non-volant fauna in their movements in the landscape.

Threatened species listed under the EPBC Act were assessed in relation to:

- Likely habitat utilisation;
- Threatening processes;
- The likelihood of occurrence in the WMDEC and CBME (including known records); and,
- data availability and potential for additional data collection.

Several of the EPBC Act listed Threatened species have been recorded at the WMDEC over time and, recently the kenngoor was added to the list of conservation significant species found in the area. Some of the more cryptic species, quokka and woylie, have been recorded infrequently. Other cryptic species may occur in low densities outside of the focus areas for surveys but still within the boundaries of the WME. By their nature, rare species are difficult to assess due to the lack of data. However, in some cases, the level of data available for assessment is relatively high although focused on areas of mine activity.

Of the threatened species under consideration, all three species of black-cockatoo, woylie, kenngoor, and chuditch have been recorded in the surveys undertaken within the WMDEC boundaries. Black-cockatoo have been recorded breeding at both WMDEC and CBME. The western ringtail possum has been recorded along the OBC in areas close to RLA but not within the CBME. The quokka has been recorded from areas adjoining the RLA (which included the CBME) but not within its boundaries.

From the available information it was possible to determine the likelihood of occurrence of the threatened species within both the WMDEC and CBME. However, it was also evident that there was a need to collect more current information from some areas including CBME and northern NBGM to raise the certainty of likelihood and arrive at a better understanding of fauna distributions and habitat use.

In conclusion, the overriding issues in the fauna assessment of the proposed WME are:

1. There is adequate robust information to allow a greater degree of certainty in assessing risk to threatened fauna at the proposed WMDEC.
2. Biodiversity information from CBME will need to be updated. It is recommended that a trapping survey, similar to the 2000-2001 general biodiversity survey, covering all terrestrial vertebrate fauna groups be undertaken, possibly using the same site locations. Targeted surveys are not designed to determine spatial and seasonal variation in species and would prove inadequate to determine the ecosystem functions of the area. However, targeted searches as part of the biodiversity survey could be incorporated to provide additional information.
3. It is likely the project will be referred on the evidence of information on all three species of black-cockatoo.
4. Certain listed species will need continued monitoring including all three black-cockatoo species, chuditch, woylie, kenngoor, and western ringtail possum. These monitoring programs can be incorporated as part of longer-term management strategies. Targeted populations studies are also recommended as part of the monitoring.

5. Connectivity in a fragmented landscape is critical for the longer-term sustainability of ecosystems. This may require active establishment and maintenance of corridors or protection of existing corridor systems.
6. A broader approach is required to undertake management of landscapes at both sites in the proposed WME. Collaboration with all stakeholders would be required to ensure effective ecological management of the landscape.
7. For highest value outcomes enhancement of habitats should commence early in the planning phase to ensure that they are advanced enough to provide the ecological function of the areas they are to replace.
8. Fauna monitoring is a critical component for collating detailed ecological data that will allow for the avoidance, mitigation and management of impacts on threatened species, ecosystems and other fauna within both areas.
9. General systematic biodiversity surveys are recommended for areas of native forests that have not been surveyed previously to obtain a better understanding of the distribution of fauna in the landscape, e.g., areas in the northern section of NBGM.
10. Climate change is an important consideration in the maintenance and management of ecosystems for the conservation of threatened fauna.

1 INTRODUCTION

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2 STATUTORY AND OTHER REQUIREMENTS

This section summarises the various Australian Government and Western Australian Government Acts that cover rare, threatened and vulnerable vertebrate fauna species and was correct at the time of the preparation of this document. However, as changes are made to both State and Australian Government legislation and new treaties are entered, all current documentation regarding rare, threatened and vulnerable fauna should be periodically reviewed for any changes to the status of fauna in each area.

Additionally, in any discussion of rare, threatened or vulnerable species, several aspects require clarification before the significance of these species can be considered in context of the development and operation of any project.

- Resident, habitat-specific rare fauna are much more susceptible to the influences of disturbance than nomadic or migratory species.
- Not all rare species are equally susceptible to disturbance. Some rare species such as the Peregrine Falcon can accommodate the high levels of disturbance present in urban and rural environments.
- The concept of species rarity is a dynamic process considerably influenced by the level of survey work carried out in a location.

2.1 Protected Species – Australian Government

The EPBC Act (Commonwealth of Australia 1999) is administered by the Department of the Environment and Energy (DEE) (https://www.environment.gov.au/epbc) which also administers the international treaties discussed below.

Several animals are covered by the EPBC Act under six categories of threat (S.179: *EPBC Act 1999*):

- extinct (X);
- extinct in the wild (XW);
- critically endangered (CR);
- endangered (EN);
- vulnerable (VU); and,
- conservation dependent (CD).

A range of birds are listed under the Japan-Australia (JAMBA), China-Australia (CAMBA) and Republic of Korea/Australia (ROKAMBA) Migratory Bird Agreements. The main aim of these international agreements is to protect migratory birds and their breeding and/or feeding habitats. An earlier agreement, Bonn Convention (Bonn), binds signatories to the conservation of species of wild animals and aims to conserve terrestrial, marine and avian migratory species throughout their range. There are several birds listed on these international treaties that could occur within the two areas, WMDEC and CBME, and these are discussed in this report.

2.2 Protected Species - Western Australia

In Western Australia, species of conservation significance have historically been protected under the *Wildlife Conservation Act 1950* (*WC Act 1950*) (Government of Western Australia 1950) however are now transferred to the *Biodiversity Conservation Act 2016* (*BC Act 2016*) (Government of Western Australia 2016). The schedules defined under this Act are:

Schedule 1 (CR): *fauna that is rare or likely to become extinct, as critically endangered fauna, are declared to be fauna that is in need of special protection*;

Schedule 2 (EN): *fauna that is rare or likely to become extinct, as endangered fauna, are declared to be fauna that is in need of special protection*;

Schedule 3 (VU): *fauna that is rare or likely to become extinct, as vulnerable fauna, are declared to be fauna that is in need of special protection*;

Schedule 4 (X[1]): *fauna that is presumed to be extinct, are declared to be fauna that is in need of special protection*;

Schedule 5 (IA): *birds that are subject to international agreements relating to the protection of migratory birds, are declared to be fauna that is in need of special protection*;

Schedule 6 (S1): *fauna that are of special conservation need being species dependent on ongoing conservation intervention, are declared to be fauna that is in need of special protection*;

Schedule 7 (S2): *fauna that is in need of special protection, otherwise than for the reasons mentioned in* [previous schedules).

(Schedule definitions are quoted from Wildlife Conservation Act 1950 for consistency and relevance)

[1] A new category, Extinct in the Wild (XW), will be introduced with the next fauna notice in 2019.

This Act is periodically reviewed. The current list of protected fauna can be viewed on the Department of Biodiversity, Conservation and Attractions (DBCA) website (http://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities).

2.3 Priority Species - Western Australia

There are several species not listed under the *WC Act 1950* that, for various reasons, require attention and these are listed on the DBCA's Priority Fauna List which classifies species as[2]:

- Priority 1 - Poorly-known species with few, poorly known populations on threatened lands.

Taxa which are known from few specimens or sight records from one or a few localities on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, active mineral leases. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

- Priority 2 - Poorly-known species with few, poorly known populations on conservation lands.

Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat of habitat destruction or degradation, e.g. national parks, conservation parks, nature reserves, State forest, vacant Crown land, water reserves, etc. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

- Priority 3 - Poorly-known species with several, poorly known populations, some on conservation lands.

Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

- Priority 4 - Rare, Near Threatened and other species in need of monitoring.

Rare. Taxa which are considered to have been adequately surveyed, or for which sufficient knowledge is available, and which are considered not currently threatened or in need of special protection, but could be if present circumstances change. These taxa are usually represented on conservation lands.

Near Threatened. Taxa that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable.

Taxa that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

- Priority 5 - Conservation Dependent species.

Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

The Priority Fauna List does not confer any additional legal protection to the species listed apart from the normal protection afforded to most native animals. It does, however, indicate the need for vigilance during the construction and commissioning of development projects to manage native vegetation and rehabilitation, so that Priority Species do not meet the criteria for listing as Protected Species resulting from that development.

[2] Definitions can be found (https://www.dpaw.wa.gov.au/images/documents/plants-animals/threatened-species/Listings/conservation_code_definitions.pdf)

2.4 Other Classification

The International Union for Conservation of Nature (IUCN: https://www.iucn.org/) aims to assess the conservation status of species, subspecies, varieties and even selected subpopulations on a global scale to highlight taxa threatened with extinction, and therefore promote their conservation.

There are several animals that are shown on the IUCN Red List that are not listed on any Australian Government or Western Australian Acts. The IUCN Red List does not confer any additional protection over and above that provided to Australia's native animals. However, in the interests of good project management, where possible, conservation of species within a project area will reflect a comprehensive approach to environmental management of that project.

2.5 Significant Fauna Habitats

Australia-wide, a small number of Threatened Ecological Communities (TECs) have been defined in, and are protected by, the EPBC Act. The DBCA has developed a list of TECs specific to Western Australia that include communities in addition to those listed under the EPBC Act. These communities are protected under the BC Act.

Further to these lists and, while not defined under any legislation, some fauna habitats within a project may be defined as locally significant because they (Department of Parks and Wildlife 2013):

- support rare or vulnerable species;
- support specialised or habitat specific fauna;
- are regionally or locally uncommon; or
- are restricted in area.

Such habitats are not protected under any State or Australian Government legislation. In the interests of good project management and, where possible, conservation of such locations within a project will provide the basis for the fauna component of an environmental management plan to be put in place for the duration of a project.

3 NOMENCLATURE, TAXONOMY AND DISTRIBUTION PATTERNS

The literature review conducted prior to the field survey consisted of:

- a search of Australian and State Government vertebrate fauna databases (Protected Matters Search/SPRAT, DEE, and NatureMap, DPaW, respectively);
- a search of other databases including BirdLife Australia, Bird Atlas data and Atlas of Living Australia;
- a review of published literature on the vertebrate fauna of the general area.

The following literature sources have been employed to discuss fauna distribution patterns and ecology in the preparation of this report:

Birds: Barrett et al. 2003; Johnstone & Storr 1998, 2004.

Mammals: Churchill 2008; Jackson & Groves 2015; eds Van Dyck, Gynther & Baker 2013; eds Van Dyck & Strahan 2008.

Amphibians: Tyler & Doughty 2009; Tyler & Knight 2011.

Reptiles: Wilson & Swan 2013.

The nomenclature in this report follows the references listed and more recent taxonomic revisions.

Species listed in this report will adhere to strict taxonomic order as outlined in the references above. The taxonomic order tends to reflect broad guild commonality between species. The more familiar alphabetical listing of species is ecologically irrelevant and hides much of this broader information.

4 METHODS

The focus of this study are matters of national environmental significance (MNES). That is, fauna species that would require referral under Federal legislation as part of the approvals process. It also includes species that may require referral under State legislation.

It should be noted that ecological processes and species distributions do not recognize artificial boundaries (i.e., administrative boundaries such as local government boundaries, development envelopes, etc.) and assessments are undertaken on a local and regional basis. This is an important aspect of determining the applicability of the information in relation to the landscapes being assessed.

4.1 Data Assessment

The WMDEC area consists of four sections in which fauna investigations have been focused since 1982 (Figure 1):

- South32 Marradong Operations (MAR);
- South32 Saddleback Operations (SAD);
- South32 Quindanning Timber Reserve Operations (QIN); and,
- Newmont Mining Ltd Newmont Boddington Gold Mine (NBGM).

These sections do not define ecological boundaries and fauna will move between them. However, the use of these sections as geographical reference points is intended to facilitate discussions in this document. The CBME is contained within the RLA.

4.1.1 Existing Data

South32 and NBGM hold substantial fauna data collected for the SAD, MAR, and QIN areas that has been collected primarily through multi-seasonal systematically designed surveys since 1982. The data base contains over 25,000 observations from a diverse number of sites and collected over 36 years. There is less data available for the CBME, also held by South32, although there have been several assessments in and around RLA since the systematic multi-seasonal surveys of 2000-2001. In addition, studies were undertaken in habitats alongside the 50km conveyor belt (OBC) that carries ore from SAD and MAR to the refinery.

Survey data from NBGM was made available for this survey and contained systematic survey data primarily collected by Ninox Wildlife Consulting contracted to Newmont Mining and previous owners of the mine.

All data sets contained material collated by other consultancies/research groups undertaking investigations on behalf of the mine owners since they began.

This data will be collated and assessed for its currency and relevance to the assessment. This data set will be collectively referred to as the “survey data”.

4.1.2 Database searches

Database search through the DBCA NatureMap, for threatened species records for search areas centred around WMDEC and CBME were undertaken using the following search centroid coordinates:

Area	Central Point (latitude, longitude WGS84)
WMDEC	-32.88669256, 116.4222041
CBME	-33.225464, 116.040507

A search of the Matters of National Environmental Significance was undertaken using the same centroids to identify those fauna species of greatest concern and likely to be considered as triggers for referral (Appendix 1).

Buffers were applied to these points dependent on the data availability:

Database	WMDEC Buffer	CBME Buffer
Threatened species search, including black-cockatoo breeding, roosting and foraging data	50km	15km
Protected matters search	30km	15km
Australian Living Atlas	30km	15km

Data from these searches was combined to provide a list of species for the WME proposal. As with other data used in this assessment, the more recent data (i.e., from the last 20 years) was considered the more relevant in the analysis. However, historical data did provide temporal context for locally extirpated species.

4.1.3 Literature Review

All survey reports relating to the WMDEC and CBME areas were reviewed as background reference for this study. Other material relevant to this study were also included in the desktop assessment.

4.2 Reconnaissance Survey

A field assessment of additional areas not accessed during the earlier assessment in 2015 was to be undertaken between 12-17 November 2018. Standardised habitat descriptions, potential habitat tree assessments and searches for signs or individuals of threatened species were to be carried out in these areas. The survey was undertaken by two experienced field ecologists, Eddy Cannella and Andrew McCreery (Table 1).

Table 1 Team members for the fauna assessment.

Name	Position	Experience	Tasks
Eddy Cannella	Senior Zoologist	>29 years of experience	Field assessment, Data analysis, Report preparation
Andrew McCreery	Assisting Zoologist	>7 years of experience	Field assessment

During the survey, access to some of the land parcels could not be obtained, therefore, the survey was reduced from 5 days to 1 day and only 2 of the 3 areas were assessed.

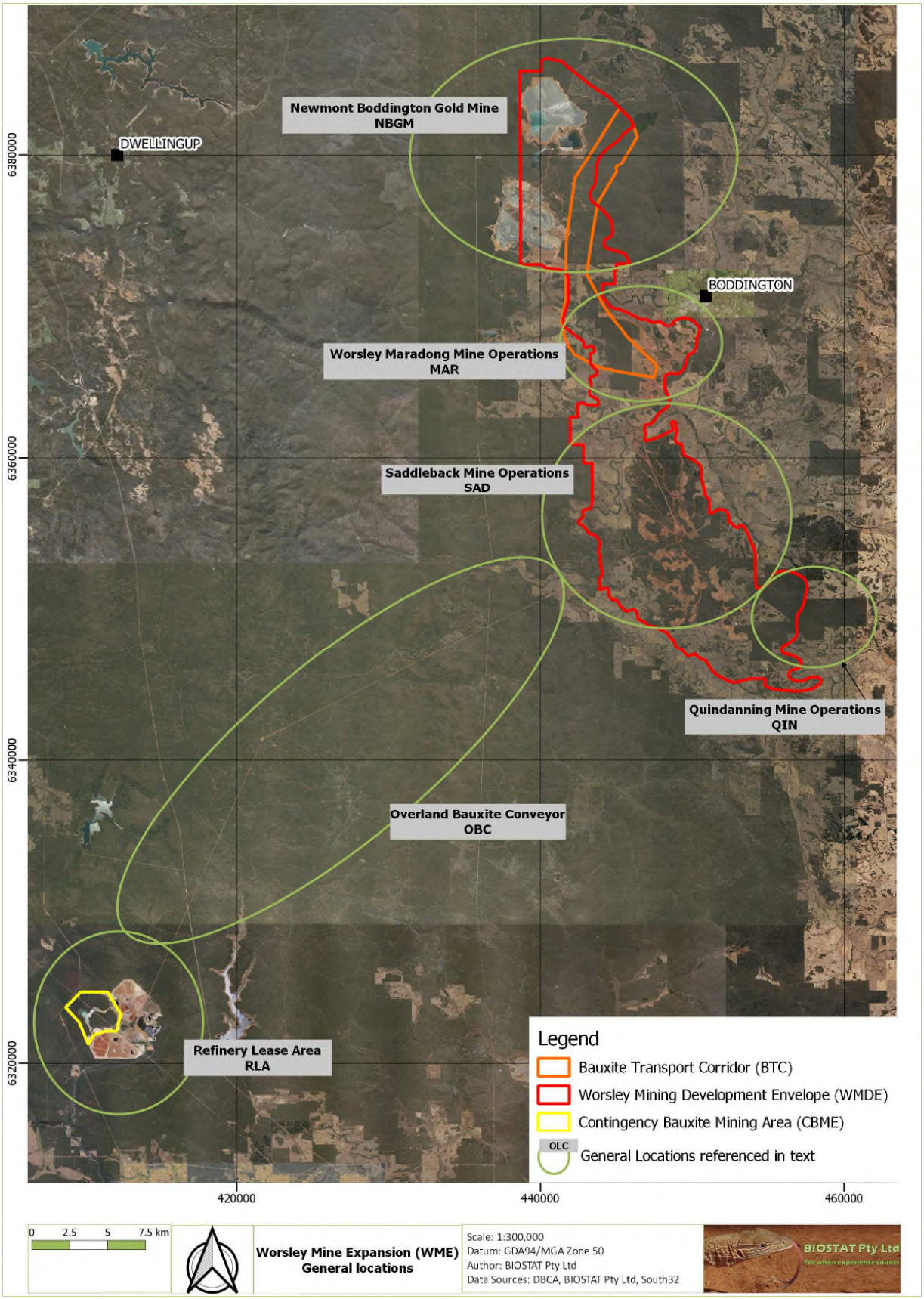

Figure 1 Locations in WME project area referred to in text.

5 RESULTS AND DISCUSSION

5.1 Data Currency and Relevance

5.1.1 Literature Review

Twenty-four reports describing the fauna assemblages of the WMDEC and CBME areas were identified and collated for the review (Table 2). Two additional reports of surveys along the conveyor belt linking the two areas together were also included as they report on fauna assemblages within similar habitats. All but four of the projects were undertaken by Ninox Wildlife Consulting. Biodiversity surveys were undertaken at SAD, NBGM and RLA areas from the earliest point in their developments (circa 1982). BIOSTAT continued the implementation of Worsley's rehabilitation fauna monitoring program since 2014.

Most of these are unpublished internal reports, although the "Phase Two" at BBM (Worsley Alumina Pty Ltd 1985) and the "Gold Mine Project" at NBGM (Worsley Alumina Pty Ltd 1999) studies were made available publicly at the time (both out of print). Two reports are currently in preparation for survey work undertaken in 2017-2018 at SAD and QIN. In addition, a "Phase" report is also in the process of being prepared which will undertake an assessment of fauna at SAD from surveys undertaken over the last 10 years (BIOSTAT Pty Ltd in prep.) .

Eighteen of the documents report on the results of multi-seasonal systematic biodiversity surveys. It is important to note that well designed biodiversity surveys that focus on systematic and repeatable collection of data that investigate both spatial and temporal variability, provide substantially more robust data than is possible using other techniques such as single season trapping surveys, targeted surveys or site assessments. Furthermore, the methodology employed in these studies was relatively consistent with only minor alterations in physical design and the addition of equipment, such as trail cameras, ultrasonic recorder, as these became available and relevant to the focus of the studies. The data resulting from such surveys lend themselves to vigorous statistical analysis and can be used to benchmark and characterise ecosystems with a greater level of certainty. In this capability, these survey designs exceed the robustness and scientific rigour of the requirements usually associated with Level 1 and Level 2 survey requisites.

It was not possible to source all the original reports for fauna surveys at the NBGM prior to 1999 although the data is still held by South32. A "Phase" document published in 1999 (Worsley Alumina Pty Ltd 1999) contained an analysis of all data collected to that point as an investigation into the biological aspects of NBGM. Systematic seasonal studies were undertaken in 2003 and 2012 (Ninox Wildlife Consulting 2003, 2012d) to investigate alternative rock waste areas as part of the NBGM mine expansion. A biodiversity assessment was undertaken in 2011-2012 in an area potentially designated for the expansion of the large northern tailings dam (Ninox Wildlife Consulting 2012a). The most recent study at NBGM consisted of the translocation and salvage of fauna at sites being cleared for the expansion of the waste dump (Ninox Wildlife Consulting 2016).

The first MAR survey (Ninox Wildlife Consulting 2007b) focused on the eastern portion of the Marradong Timber Reserve (MTR). A second survey of the western portion of the MTR was undertaken in 2012 (Ninox Wildlife Consulting 2012c). Most of MTR has been cleared and mined with rehabilitation undertaken on some areas in the eastern portion.

There has been a substantial level of effort concentrated on SAD, the major bauxite mine area. Surveys include pre-mining areas (Ninox Wildlife Consulting 1992, 1997, 1998a; Worsley Alumina Pty Ltd 1985), monitoring programs to evaluate the progress of rehabilitation in relation to fauna assemblages (BIOSTAT Pty Ltd 2015b, 2018; Ninox Wildlife Consulting 2006, 2012b), and comprehensive research investigations using compilations of environmental data (BIOSTAT Pty Ltd in prep.; Ninox Wildlife Consulting 1992; Worsley Alumina Pty Ltd 1985).

Table 2 Reports of fauna surveys undertaken at PBA and EBMA.

Area	Location	Researchers	Year	Report Title	Level of Assessment
WMDEC	**NBGM**		1999	Worsley Alumina Boddington Gold Mine Project. Flora and Fauna Studies.	A compilation and analysis of baseline surveys undertaken to 1998.
			2003	The vertebrate fauna of the Boddington Gold Mine[3]	3 season systematic trapping survey with systematic area search bird surveys.
			2012	Vertebrate fauna survey within Newmont Boddington Gold Mine: An assessment of potential waste rock disposal areas.	
			2012	A vertebrate fauna survey within the Saddleback Treefarms area. Newmont Boddington Gold Mine. An assessment of potential residue disposal areas.	
			2016	Vertebrate fauna translocation program from the waste rock dump extension area to be developed within Newmont Boddington Gold Mine.	An intensive 2 month trapping program to translocate all terrestrial vertebrate fauna caught during the period prior to the clearing of vegetation.
	MAR		2007	Vertebrate fauna survey of Marradong Timber Reserve 2006-2007.	3 season systematic trapping survey with systematic area search bird surveys.
			2012	Vertebrate fauna survey of Marradong Timber Reserve 2012.	
	SAD	Ninox Wildlife Consulting	1985	Worsley Alumina Project. Flora and Fauna Studies, Phase Two.	A compilation and analysis of data collected to 1985.
			1992	Phase Three: Vertebrate Fauna Studies, 1991-1992.	A compilation and analysis of data collected to 1992.
			1997	A vertebrate fauna survey of the proposed Northern Saddleback mining area 1996-1997.	3 season systematic trapping survey with systematic area search bird surveys.
			1998	A vertebrate fauna survey of the proposed Southern Saddleback mining area 1997-1998.	
			2003	Monitoring of vertebrate fauna within forest & rehabilitation at the Boddington Bauxite Mine 2002 – 2003	
			2007	Monitoring of vertebrate fauna within forest & rehabilitation at the Boddington Bauxite Mine 2006 – 2007	
			2012	Monitoring of vertebrate fauna within forest & rehabilitation at the Boddington Bauxite Mine 2009-2011 including comparisons with previous sampling.	
		BIOSTAT Pty Ltd	2015	Vertebrate fauna monitoring, Boddington Bauxite Mine 2014-2015.	
			In prep	Vertebrate fauna monitoring, Boddington Bauxite Mine 2017-2018	
	QTR	Ninox Wildlife Consulting	2002	The vertebrate fauna of the Quindanning Timber Reserve	
		BIOSTAT Pty Ltd	In prep	Biodiversity survey of the Quindanning Timber Reserve 2017-2018 (working title)	

[3] The original focus of this study was on a 3-season survey. Due to the unexpectedly large number of Chuditch caught (47 over the entire survey period) during the initial survey, extra sites and additional survey events were undertaken purely to monitor the population of this species.

Area	Location	Researchers	Year	Report Title	Level of Assessment
RLA	**CBME**	Ninox Wildlife Consulting	2002	The vertebrate fauna of the Refinery Lease Area and Mornington Mills Block	3 season systematic trapping survey with systematic area search bird surveys.
			2007	An Assessment of the Presence of the Western Ringtail Possum at the Worsley Alumina Pty Ltd Refinery, near Collie, Western Australia	Desktop assessment undertaken using field data.
		Bamford Consulting Ecologists	2011	Conservation significant fauna and habitat tree survey. Proposed BRDA cleared areas, Worsley Alumina Refinery	Targeted surveys for species of conservation significance.
		BIOSTAT Pty Ltd	2015	Vegetation Clearing: Fauna Assessment	Habitat and fauna assessment of small areas at the edge of EBMA.
			2016	RDA1 Baseline Vertebrate Fauna Monitoring 2015 South 32 Worsley Alumina Refinery	Baseline 2 season survey of a rehabilitated tailings dam to the east of MMB
Additional Studies[4]		Ninox Wildlife Consulting	1998	Vertebrate Fauna of the Overland Conveyor Corridor 1997-1998	3 season systematic trapping survey with systematic area search bird surveys. Included specific studies to determine fauna movements across the conveyor.
			2004	A Vertebrate Fauna Survey of the Overland Conveyor Corridor between the Boddington Bauxite Mine and Refinery Lease Area near Collie, Western Australia	
			2010	A Vertebrate Fauna Survey of the Overland Conveyor Corridor 2009 - 2010	

[4] These studies included sites located close to both WMDE and CBME and in State Forests between the two areas.

Systematic biodiversity surveys of the Quindanning Timber Reserve (QTR) were undertaken in 2000-2001 (Ninox Wildlife Consulting 2002) and 2017-2018 (BIOSTAT Pty Ltd in prep.). The most recent survey replicated the original study by using the same survey sites. Changes in methodology in addition to the original trapping grid design and included the use of Funnel Traps, Trail Cameras, Ultrasonic Recorders and Bioacoustic Recorders.

Three surveys were completed for the OBC in 1998, 2004, and 2010 (Ninox Wildlife Consulting 1998b, 2004, 2010). The survey area is within the State Forest between the CBME and WMDEC and represent a relatively contiguous area of remnant habitats. The survey focus was on the potential impact of the Overland Belt Conveyor on fauna movements but also compared fauna assemblages between upland (hills) and lowland (valley) habitats. Systematic bird surveys were not undertaken on the second and third studies along the conveyor and the focus was directed to a live trapping design.

The reports outlined the results of surveys but also interpreted the data to define the quality of habitats, the use of surveyed habitats by fauna, and the observed seasonal variations in relative abundance of fauna. Unlike less robust survey methods, systematic repeatable survey results in quantitative data that can be analysed to make it possible to support interpretations of ecosystems processes (Cochran 2007). In the case of the monitoring program undertaken at SAD, the extensive level of data collected over a decade provides a very strong assessment of terrestrial vertebrate fauna ecology.

The quantity and currency of surveys at the RLA are not comparable to the WMDEC area. Only one multi-seasonal survey has been undertaken at the CBME in 2000-2001 (systematic surveys were carried out in the RLA area prior to construction in 1982). Since then several smaller surveys have been carried out in other areas associated with the RLA but not within the CBME (e.g., BIOSTAT Pty Ltd 2014, 2015a). Further investigations of the CBME are recommended to update and improve understanding of the fauna within this area. To update the available data, the preferred level of assessment at this site would ideally be a repeat of the multi-seasonal survey undertaken in 2000-2001, possibly utilising the same survey sites.

The floristics and vegetation structure covering most of the WMDEC and CBME have been surveyed extensively over a similar period (i.e., 1982 to the present). This report will make use of the vegetation community mapping undertaken by Mattiske Consulting Pty Ltd (Mattiske Consulting Pty Ltd 2018).

Several articles have been published in peer reviewed journals have resulted from projects undertaken at NBGM and QIN (Table 3). The focus of research at NBGM was in black-cockatoo ecology and included investigations into foraging and breeding activities in and around the mine. Other articles included research notes on chuditch (*Dasyurus geoffroii*) and *Phascogale* sp. at NBGM and QIN, respectively.

Currently, there is research continuing at NBGM and BBM on black-cockatoo species habitat utilisation through Murdoch University. This research has identified substantial roosting sites across the area in addition to resource usage patterns.

The available information from the reports and published articles is substantial and can provide a robust assessment of the fauna of the WMDEC. Further investigations of the CBME are required. As indicated earlier, to fully understand the fauna and habitat use of the CBME, a repeat of the previous systematic survey methodology is recommended. This would allow for a direct comparison of data that could not occur if, for example, targeted surveys are employed in the investigations.

Table 3 Peer reviewed published articles resulting from research projects at BBM and NBGM.

Authors[5]	Year of Publication	Title
Cannella, Browne-Cooper, Fairbairn, & Turpin	2018	Possible sympatry between kenngoor (*Phascogale calura*) and wambenger (*Phascogale tapoatafa wambenger*)
Cannella & Henry	2017	A case of homing after translocation of chuditch, *Dasyurus geoffroii* (Marsupialia: Dasyuridae)
Doherty, Wingfield, Stokes, Craig, Lee, Finn & Calver	2016	Successional changes in feeding activity by threatened cockatoos in revegetated mine sites
Lee, Finn & Calver	2013	Feeding activity of threatened black cockatoos in mine-site rehabilitation in the jarrah forest of south-western Australia
Lee, Finn & Calver	2013	Ecology of black cockatoos at a mine-site in the eastern jarrah-marri forest, western Australia
Biggs, Finn, Taplin & Calver	2011	Landscape position predicts distribution of eucalypt feed trees for threatened black-cockatoos in the northern jarrah forest, Western Australia
Lee, Finn & Calver	2010	Mine-site revegetation monitoring detects feeding by threatened black-cockatoos within 8 years

5.1.2 Data Currency and Relevance

A substantial set of data has been collated for this analysis. They have come from several sources with varying levels of adequacy and robustness. There are limitations inherent in any data set:

- The database held by South32 is continuously curated by BIOSTAT Pty Ltd. As errors are encountered they are corrected, or the record omitted if information is not available to allow correction. The same level of confidence for other data sets is unknown and are assumed to be adequate.
- Survey data is point location specific. Records from other sources tend to be correlated with accessibility to areas. For example, there are many occasions where records are aligned with tracks or roads. This can result in gaps in the landscape lacking any data. Therefore, the likelihood of occurrence of a species in the wider landscape is a result of extrapolation based primarily on the availability of suitable habitats.

Long-term and biodiversity monitoring are important in understanding the dynamic and stochastic nature of ecosystems (Lindenmayer 2012; Lindenmayer & Likens 2018). It is very important that seasonal (temporal) and landscape (spatial) variability is measured to assist in understanding fauna utilisation of the landscape and changes that may have occurred to influence that landscape use. Additionally, long-term studies are very important in surveying for rare or elusive species whose detection rates, by their very nature, are low (Thompson 2013).

Generally, by their very nature, designs for short-term surveys, such as targeted surveys or site assessments, provide a simplistic overview of ecosystems within landscapes. Short-term surveys tend to inordinately rely on the investigators knowledge of the survey area, especially in the interpretation of the limited data usually obtained from such surveys. The interpretation can be compromised if the investigator is unfamiliar with the ecosystems in the area or lack the understanding of ecological variation they may encounter. Short-term surveys are characterised by:

- lower levels of detection of rare and threatened species;
- inability to assess variability in fauna distributions and relative abundances in the landscape;
- lack the ability to consider environmental processes and interactions between fauna groups in landscapes;
- inability to assess seasonal variations in fauna use of landscapes; and,
- have a limited ability to investigate interactions of environmental factors in ecosystems

[5] Full details can be found in section *8 References*

As indicated previously, most of data for the WME is derived from robust systematic surveys designed specifically to allow repeatable standardised data collection. The use of similar designs and similar methodologies across investigations provide robust data that can be used in direct comparisons. Data collected at WME sites are maintained by both South32 and BIOSTAT Pty Ltd.

Furthermore, the surveys integrate the temporal variation with multi-seasonal events being mandatory components in their design. This level of robustness increases the understanding of ecosystems and the way fauna interacts in those systems. It also raises the level of certainty in interpretation well beyond what is possible with data derived from non-systematic survey design methods, especially single effort surveys (e.g., site assessments, single season trapping or targeted surveys).

The level of survey effort for different survey methods using the available documentation (Table 2), but only for the last 20 years, was calculated for all areas (Table 4). The methods employed include:

- **Live Trapping** – this involves the use of fenced pit traps, cage and box traps, and funnel traps. These are deployed in a standard grid pattern at sites. Monitoring sites in rehabilitation and some forest control areas at BBM are permanent and re-used on cyclic schedule. The number of nights traps are opened changed from 6 nights to 7 nights in 2000. Survey effort shown in the table is calculated as trap nights.
- **Systematic Bird Surveys** – these have developed from distance transect surveys employed until the mid-1990s by Ninox Wildlife Consulting and later replaced with timed area searches. The bird surveys are carried out a minimum of 5 days at each site and the timing of the searches is rotated within the morning period. Systematic bird surveys are likely to identify most bird species within a site as opposed to opportunistic or single survey methods. Survey effort is calculated as minimum total hours.
- **General Searches** – searches of habitats, including sites that are being trapped, is a standard design feature of all systematic surveys. It is calculated as the minimum total number of personnel hours for each area (usually a minimum of 2 hours). These general searches involve hand searches for reptiles and other small mammals, and searches for signs of activity such as nesting, tracks and scats. The use of highly experienced personnel in the field ensured a high level of search efficacy which captured all signs of activity regardless of which terrestrial vertebrate fauna group.
- **BC (black-cockatoo) Targeted Surveys** – due to the increasing vulnerability status of the three black-cockatoo species (*Calyptorhynchus banksii naso*, forest red-tailed black-Cockatoo; *Calyptorhynchus latirostris*, Carnaby's black-cockatoo; *Calyptorhynchus baudinii*, Baudin's black-cockatoo) in Western Australia, standardised Federal survey guidelines were established in an effort to provide a level of certainty in the manner in which surveys could be assessed (Department of Environment and Energy 2017; Department of Sustainability, Environment, Water, Populations and Communities 2012). These guidelines have been used in several of the more recent surveys where it was deemed necessary. Guidelines provide a minimum set of goals and aims to be achieved. Not all survey methodologies suggested in guidelines result in robust data that could increase the level of certainty in determining impacts. Survey effort shown in the table is calculated as minimum total hours.
- **Other Targeted Surveys** – at various times since 1982, searches targeting specific species were undertaken during the projects. These included targeted searches for black-cockatoo species, chuditch, quenda (*Isoodon fusciventris*), western ring-tail possum (*Pseudocheirus occidentalis*), and common brushtail possum (*Trichosurus vulpecula hypoleucus*) searches. The effort in these searches is calculated as for General Searches and were in in addition to those searches.
- **Bat Survey** – until the advent of electronic recording equipment, Bat surveys were undertaken using Mist Nets or Harp Traps and only in situations where suitable locations could be found (i.e., farm dams, small creek line). These methods were replaced with Anabat (Titley Scientific) and, later, SongMeter Systems (Wildlife Acoustics) with much improved identification

capabilities of the microbat species. Survey effort shown in the table is calculated as recording nights.

- **Bioacoustic Recording** – as with the bat surveys, bioacoustic recording (BAR) is utilised to record audible calls made by night birds (owls in particular) and frogs. In addition, they can be used to identify the presence and dial cycle of species such as black-cockatoo. Survey effort is shown in the table calculated as recording days.
- **Passive Survey** – The evolution of trail cameras (Infra-red triggered) has allowed their deployment in fauna surveys. The variation in technical abilities of cameras makes them extremely difficult to use in a systematic manner. There are also issues in using these cameras for certain groups of fauna such as birds and smaller ground-dwelling and fossorial species. To 2018, the use of trail cameras is purely as an adjunct to opportunistic assessment. Survey effort shown in the table is calculated as recording days.
- **Habitat Tree Surveys –** As part of the environmental regulatory process, it is required that Potential Habitat Trees (PHT), as outlined in the referral guideline (Department of Sustainability, Environment, Water, Populations and Communities 2012), are located prior to any vegetation clearing for mine operations. This information is used to avoid or mitigate potential impacts for trees that may hold suitable hollows for black-cockatoos. Both mining companies, South32 and NBGM, collect and maintain this data. The value of this data is limited by its coverage in the landscape with the focus being in areas identified for vegetation clearing. However, the data can provide an indication of the distribution of PHT within specific locations.

The chronosequence of survey effort is displayed in Table 4 for the last 20 years of activity in the WMDEC and RLA areas. The survey effort in all sites within the WMDEC area is substantial and recent, especially at SAD. In most cases close to 50% of the survey effort has been since 2008, i.e., in the last 10 years.

The intensity of the surveys undertaken in each of the areas resulted in 68,185 individuals recorded from 180 species of terrestrial vertebrate fauna (birds, herpetofauna and mammals) during systematic surveys (Table 5). This does not include individuals recorded opportunistically that added another 9 species of bird, 1 species of native mammal, and 4 species of reptile and a total of 3,727 individuals recorded.

Additional data on black-cockatoos and standardised habitat assessments were carried out for the earlier assessment of Mine Expansion Areas (BIOSTAT Pty Ltd 2017). The data collected included transects for PHT, standardised fauna habitat assessments, bioacoustic recording and ultrasonic recordings.

Although the volume of data for the WMDEC is substantial, it was highlighted in the previous section, information for CBME is not as current or extensive. It is recommended that further investigations of this area be undertaken using robust systematic survey designs.

The expansive long-term fauna data presented in this document to support the referral documentation is regarded as substantial, current and relevant to the project.

Table 4 Survey effort at the various sites of the proposed WMDEC and CBME areas since 1998.

Area and Trapping Method	Survey year[6]																				Totals
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
NBGM																						
Live Trapping					11,040										14,602				12,046			**37,688 Trap Nights**
Systematic Bird Survey					150										202.5							**352.5 Minimum Hours**
General Searches					160																	**160 Minimum Hours**
Other Targeted Survey					30																	**30 Minimum Hours**
BC Targeted Survey															48							**48 Minimum Hours**
SAD																						
Live Trapping	7,200					6,480				6,912				6,080				7,450			7,755	**41,877 Trap Nights**
Systematic Bird Survey	100					120				120				120				70			70	**600 Minimum Hours**
General Searches	120					96												66			10	**302 Minimum Hours**
Bat Survey																		24			68	**92 Recording Nights**
Bioacoustic Recording																		6			18	**24 Recording Days**
Passive Survey																		58			349	**407 Recording Days**
MAR																						
Live Trapping										3,528					5,040							**8,568 Trap Nights**
Systematic Bird Survey										70					70							**140 Minimum Hours**
General Searches										42					30							**72 Minimum Hours**
Other Targeted Survey										42					30							**72 Minimum Hours**
QIN																						
Live Trapping				7,200																	6,825	**14,025 Trap Nights**
Systematic Bird Survey				100																	60	**160 Minimum Hours**
General Searches				120																	110	**230 Minimum Hours**
Other Targeted Survey				30																		**30 Minimum Hours**
Bat Survey																					60	**60 Recording Nights**
Bioacoustic Recording																					10	**10 Recording Days**
Passive Survey																					260	**260 Recording Days**

[6] This is the year in which the last of the survey events occurred

Area and Trapping Method	Survey year[6]																					Totals
	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	
RLA																						
Live Trapping				9,600														952				**10,552 Trap Nights**
Systematic Bird Survey				150														31.5				**181.5 Minimum Hours**
General Searches				160										40			30	48				**278 Minimum Hours**
Other Targeted Survey				30																		**30 Minimum Hours**
Bat Survey																		6				**6 Recording Nights**
Bioacoustic Recording																		12				**12 Recording Days**
Passive Survey																		56				**56 Recording Days**
OBC																						
Live Trapping	7,776					7,334							7,776									**22,896 Trap Nights**
Systematic Bird Survey	135																					**135 Minimum Hours**
General Searches	81																					**81 Minimum Hours**
Bat Survey	10																					**10 Recording Nights**

Table 5 ***Species abundance and species richness for each year since 1998.***

		Systematic Records Only						
Year	Area	Total Abundance	Total Species Richness	Bird Species Richness	Native Mammal Species Richness	Introduced Mammals Species Richness	Frog Species Richness	Reptile Species Richness
1998	**OBC**	**719**	73	35	8	3	5	22
	SAD	**1,256**	69	40	10	3	1	15
1999	***No surveys undertaken***							
2000	**QIN**	**1,825**	84	53	9	3	6	13
	RLA	**1,945**	76	46	7	3	3	17
2001	**NBGM**	**2,622**	94	71	6	1	1	15
	QIN	**3,105**	79	50	7	5	3	14
	RLA	**5,271**	84	49	9	5	7	14
2002	**NBGM**	**3,330**	78	50	7	5	7	9
	SAD	**2,482**	69	43	9	4		13
2003	**OBC**	**212**	22		8	3	6	5
	SAD	**3,157**	79	48	10	4	5	12
2004	**OBC**	**234**	26	1	8	3		14
2005	***No surveys undertaken***							
2006	**MAR**	**989**	64	37	7	2	2	16
	SAD	**3,774**	85	57	8	3		17
2007	**MAR**	**990**	63	37	9	3	2	12
	SAD	**1,467**	73	48	8	3		14
2008	***No surveys undertaken***							
2009	**OBC**	**413**	36	2	6	2	7	19
	SAD	**1,696**	70	41	7	4	1	17
2010	**OBC**	**310**	25	1	6			18
	SAD	**342**	50	26	5	4	3	12
2011	**NBGM**	**931**	62	35	8	1	9	9
	SAD	**1,577**	61	44	5	3		9
2012	**NBGM**	**1,471**	81	42	9	1	4	25
	NBGM	**2,328**	89	49	8	1	7	24
	MAR	**1,224**	65	36	8	1		20
2013	***No surveys undertaken***							
2014	**SAD**	**3,348**	86	52	8	3	4	19
2015	**SAD**	**2,345**	77	51	7	5	1	13

Systematic Records Only								
Year	Area	Total Abundance	Total Species Richness	Bird Species Richness	Native Mammal Species Richness	Introduced Mammals Species Richness	Frog Species Richness	Reptile Species Richness
	RLA	**835**	46	29	4	4	3	6
2016	**NBGM**	**1,209**	27		7	1	1	18
2017	**SAD**	**2,646**	90	52	13	3	2	20
	QIN	**2,892**	81	49	7	5	4	16
2018	**SAD**	**5,258**	86	49	16	6	5	10
	QIN	**5,982**	84	52	16	5	1	10
Grand Total		**68,185**	**180**	**98**	**24**	**8**	**13**	**37**

5.2 Landscape Types and Fauna Habitats

Most animals are more influenced by vegetation community physical structure and soil types than plant assemblages *per se*. Faunal assemblage distributions are generally aligned to vegetation community and landscape function at the scale in which the fauna exists. Wider ranging species, whose home ranges may be measured in km^2, are unlikely to discriminate between the sometimes-subtle distinctions that characterise floristic differences between associations. The smaller spatially confined species rely on microhabitat characteristics such as soil types, humic contents, ground cover, patch radiant values which are often not considered as important to wider ranging species. In anthropogenic modified environments, specifically agricultural areas, the amount and quality of habitats and the diversity of habitats are the more important determinants in biodiversity (Gardiner et al. 2018; Redlich et al. 2018; Sawatzky, Martin & Fahrig 2019).

5.2.1 Overview of WMDEC Habitats

The previous assessment of a subset of the WMDEC area identified a total of 16 major landscape type (Table 6) using available vegetation community mapping data and a field assessment of habitats (BIOSTAT Pty Ltd 2017). A table of fauna habitats and their vegetation community equivalents is provided in Appendix 2 and photographic examples of the habitats are provided in Appendix 3. These 16 landscape types have been categorised into 5 major fauna habitat types that reflect landscape position and general habitat function similarities.

The WMDEC covers a large area, approximately 2,8610 ha, containing mostly cleared lands (approximately 12,662 ha) within a primarily wheat and crop farming district (Figure 2). These cleared lands represent highly homogenous landscape types with generally poor values for native fauna.

In the agricultural lands within these cleared landscapes are stands of remnant native trees. For this study, these remnants have been classified under the appropriate vegetation community categorisation shown in Table 6. The remnants represent ubiquitous features of agricultural lands and have been retained generally as shelter belts for stock. They are characterised as:

- Generally consisting of stands of trees, with various combinations of jarrah/marri/blackbutt/flooded gum/wandoo (dependent on their position in the landscape);
- usually in varying levels of condition and of relatively homogenous age cohort (e.g., Plates 1 and 2: Appendix 3);
- lacking a native vegetation understorey;
- if native understorey exists, it is sparse and in very poor condition due to grazing; and,
- ground cover is dominated by introduced pasture grasses and grain species.

These stands, however, provide a resource for native fauna, especially volant fauna (i.e., birds and bats). They can act as supplementary foraging resource or provide breeding/denning/roosting habitat. Remnants can also provide some level of connectivity within the landscape allowing for movements of individuals or flocks between more suitable habitats.

Conversely, introduced predators, such as fox (*Vulpes vulpes*) and cat (*Felis catus*), benefit from the less complex and homogeneity of agricultural landscapes (Carter & Luck 2013; May & Norton 1996; White et al. 2006). This can increase the risk of depredation within these “in-field” remnants and in areas where agricultural areas are adjacent to more complex and higher quality native vegetation communities.

Plantations within agricultural systems are either established for commercial properties or to create shelter belts/feed shrubs for livestock and are predominantly of Tasmanian blue gum (*Eucalyptus globulus*). They can provide additional foraging resource and some limited connectivity, if adjacent to relatively undisturbed habitats. In most cases it would be unlikely that plantation trees would reach a point where hollows would form prior to harvesting. Plantations should only be considered as a last

resort temporary low quality refuge for resource enhancement (e.g., Arnold 2003; Davies Jr. & Recher 2012).

Riparian, wetland and mesic valley systems, including the Hotham River and its tributaries, are located through the WMDEC landscape (Figure 3: Plates 3, 4, 5: Appendix 3). Although the main Hotham River branch has been excluded from the WMDEC by a 100m buffer, it remains part of the extended drainage ecosystems in the areas via direct physical connections or proximity to vegetation communities and associated wetlands. The deeper pools that support water for substantial periods act as refuge for aquatic species as well as frog, waterfowl and the native mammals such as rakali (*Hydromys chrysogaster*). The role of riparian and mesic systems and the landscape connectivity they represent requires both upstream and downstream level impacts to be assessed and managed.

The vegetation communities that exist along the tributaries range from melaleuca woodlands and heaths (MW and MS), jarrah/marri/flooded gum riparian woodlands (FD), and flooded gum woodlands (FG). Additional mesic habitats that are occasionally associated with riparian systems habitats include blackbutt and jarrah-marri communities (BB and JS). These occur in lower slopes and valleys in the landscape and can sometimes be seasonally inundated.

The largest of these communities are the flooded gum woodlands (FG: 699 ha) and the melaleuca shrublands (MW: 135 ha). The former is associated with the Hotham River and its drainage tributaries of while the melaleuca shrublands form distinct habitats throughout the WMDEC however with the largest concentration at QIN.

The jarrah-marri communities (DL, JC, JM) cover a substantial area of the WMDEC (approximately 8,808 ha) (Figure 4). The differentiation between these communities relates to their position in the landscape and the associated soil type and soil structure (Plates 6, 7, 8: Appendix 3). Most these habitats are found within the MAR, QIN and NBGM. In many cases, these Jarrah/Marri woodlands have been logged at some time and tend to support trees of similar age cohorts with minimal variation. A substantial portion of these habitat types has been cleared for mining in the SAD area, as they tend to correspond to the presence of bauxite ore. The largest contiguous remnants of these habitats exist at NBGM and QIN and form forest complexes that include other major habitat types such as wandoo woodlands. A large area remains at MAR although areas of this remnant are proposed to be cleared as part of the expansion of mining operations at Marradong.

Generally, most upper slope and ridge jarrah/marri communities (JC/JM) are found on rockier soils and tend to have a lower tree layer characterised by the presence of bull banksia (*Banksia grandis*). Rocky lateritic outcrops or granite capping is common within these habitats. Understorey consists primarily of low shrubs and native grasses. Where they occur on mid and lower slopes (JM/JC/DL), these communities tend to be located on more humic soils with a relatively denser shrub understorey.

The presence of western sheoak (*Allocasuarina fraseriana*) is an important landscape characteristic for these jarrah/marri communities. These areas have the potential to support populations of wambenger (*Phascogale tapoatafa*) and kenngoor (*Phascogale calura*). Additionally, western sheoak fruit is a component of the food resource types for black-cockatoo.

These habitats represent large but fragmented areas within WMDEC. In this type of landscape their role is to provide refuge for fauna as breeding, denning/roosting and foraging habitats. More importantly, they provide a means for movements across the fragmented landscape. Connectivity is a critical aspect for the sustainability of viable populations within the landscape and should be a prime consideration in impact assessments that may result in greater fragmentation and reduced connectivity.

Table 6 Areas of fauna habitats identified in the WMDEC.

Fauna Habitats		Fauna Habitat Code	General Fauna Type	WMDEC Area (ha)*	WMDE Area (ha)*	BTC Area (ha)*
Blackbutt woodlands on lower slopes		**BB**	**Riparian/Wetland and associated communities**	34	34	27
Mosaic of marri/jarrah on lower slopes and flooded gum riparian communities		**FD**		5	5	5
Flooded gum woodlands riparian community.		**FG**		699	640	253
Jarrah/marri valley floors/swamps		**JS**		<1ha	<1ha	0
Melaleuca shrublands on seasonally wet valley floors		**MS**		135	126	40
Flooded gum/Melaleuca shrublands on seasonally wet valley floors		**MW**		2	2	0
Marri/jarrah on lower slopes		**DL**	**Jarrah/marri communities**	409	399	152
Jarrah/marri/Allocasuarina woodlands on slopes and ridges		**JC**		4,987	4,945	1,138
Jarrah/marri woodlands on slopes		**JM**		3,412	3,151	730
Low *Eucalyptus* woodland over low shrubs		**ML**	**Mallee woodlands**	14	12	2
Wandoo woodlands		**WO**	**Wandoo communities**	2,675	2,426	581
Heaths including perched heaths		**PH**	**Heath communities**	149	149	10
Rehabilitation	**Rehabilitation not in Agricultural Areas**	**RE**	**Others**	2,977	2,977	45
	Rehabilitation in Agricultural Areas	**RE – Ag**		27	3	26
Plantations	**Plantations not in Agricultural Areas**	**PL**		178	178	0
	Plantations in Agricultural Areas	**PL – Ag**		244	243	1
Dam		**Dam**		1	1	0
Cleared Lands	**Cleared Lands not in Agricultural Areas**	**CL**		6,127	6,126	396
	Cleared Lands in Agricultural areas	**CL – Ag**		6,535	6,378	739
			Grand Total	**28,610**	**27,796**	**4,145**

** figures should be used as approximation for relative comparisons.*

The wandoo woodland habitat is a common feature of the region covering approximately 2,675 ha (Figure 5). These areas occur on sandy to clay soils and can be found in all elevations in the landscape. Lower storeys and ground cover can vary widely, including *Xanthorrhoea* sp, *Acacia* sp and *Hakea* sp (Plates 9 and 10: Appendix 3). All the areas visited during the assessment show signs of previous logging, characterised by the relative uniformity in tree age cohorts even in areas that had not been logged for many decades (e.g., eastern portions of QIN).

Wandoo form hollows readily, which makes these habitats an important component in the biodiversity of the landscape. The flowers and fruit also provide a feeding resource for several vertebrate fauna species. Most of the wandoo woodlands, as with other native remnants, have been logged and display relatively homogenous age cohort demographics.

Heaths and perched heaths occur infrequently in the landscape (Figure 5). Areas of heath are found in the NBGM, MAR and in a small area associated with the Conveyor Belt travelling between SAD and the RLA. Heaths tend to occur on shallow soils usually over granite cap-rock. They offer a distinct habitat type within the landscape. The high diversity of flowering plant species in such habitats is favoured by such fauna as honey possum, *Tarsipes rostratus*, as well as other nectarivores and insectivores (e.g., honeyeaters, *Sminthopsis* sp, *Chiropterans*, etc.).

There are several other habitats which are of varying ecological value. Rehabilitated areas (RE) form an important component of the landscape with approximately 2,997 ha (including 27 ha of rehabilitated areas on agricultural landscapes) completed to 2018[7]. Their value to fauna is further enhanced if they form part of the landscape connectivity joining less disturbed habitats. Within the controlled operations in mine sites, rehabilitated areas tend to progress along a relatively predictable path as they mature; from bare ground to heath-like habitat through to shrubland, low closed forest, and finally tall forest. After 5-8 years, these areas are useful foraging resource for black-cockatoo species, nectarivores and granivores (Lee, Finn & Calver 2010a).

Dams are present throughout the WMDEC. They are artificial and, in most cases, non-permanent water sources. They do provide an additional water source for many native species and can act as temporary refugia for waterfowl.

Even with the level of fragmentation and the poor quality of some of the remnants within the WMDEC, the local area supports relatively diverse fauna assemblages. This includes threatened species such as all three black-cockatoo species, chuditch, kenngoor, woylie (*Bettongia penicillata ogilbyi*), and others, which reflects not only the resilience of these species, but also the importance of remnant vegetation.

One component that could not be assessed for WMDEC assessment was the impact of fire. All efforts are made to minimise fire on mine leases and prescribed burning is not part of the management plan for the mine site areas. However, bush-fires have erupted in the WMDEC area at different times especially in the State Forest areas at the western boundaries. The lack of fire over a long period has altered the structure of remnant forest blocks within the WMDEC mine area and are different to areas of similar vegetation communities outside lease boundaries. This difference has not been quantified and is an area of special interest for management and conservation purposes.

A more definitive determination of the quality of all habitats within the WMDEC will have to be undertaken as areas are earmarked for development. On a general basis, all habitats of native and remnant vegetation are likely to be utilised by fauna where resources are available. In the first instance, the *prima facie* case would require that these habitats be considered relatively high value and of importance to all fauna, including threatened fauna. For example, all remnants found in agricultural areas, containing mature trees have the potential to develop hollows and can become important nesting sites, and rehabilitated mine lands can provide suitable foraging resource for numerous volant

[7] This figure is of rehabilitation undertaken by Worsley Alumina on their BBM and MTR leases. It does not include rehabilitation undertaken at NBGM or in other lands not in control of South32.

and non-volant species. In both cases the actual value of these areas could be said to be greater than would be suggested at a superficial level.

The true ecological value of habitats for any species, however, is determined by many other factors including on-going management activities and, importantly, connectivity in the landscape. Although the level of information available for this study is relatively comprehensive, it is focused to very specific areas within WMDEC (i.e., mining and mining infrastructure footprints), making it difficult to generalise over the larger WMDEC area. Therefore, the determination of habitat value must be undertaken at a more detailed level for each species for WMDEC in its entirety and will require further field survey and verification.

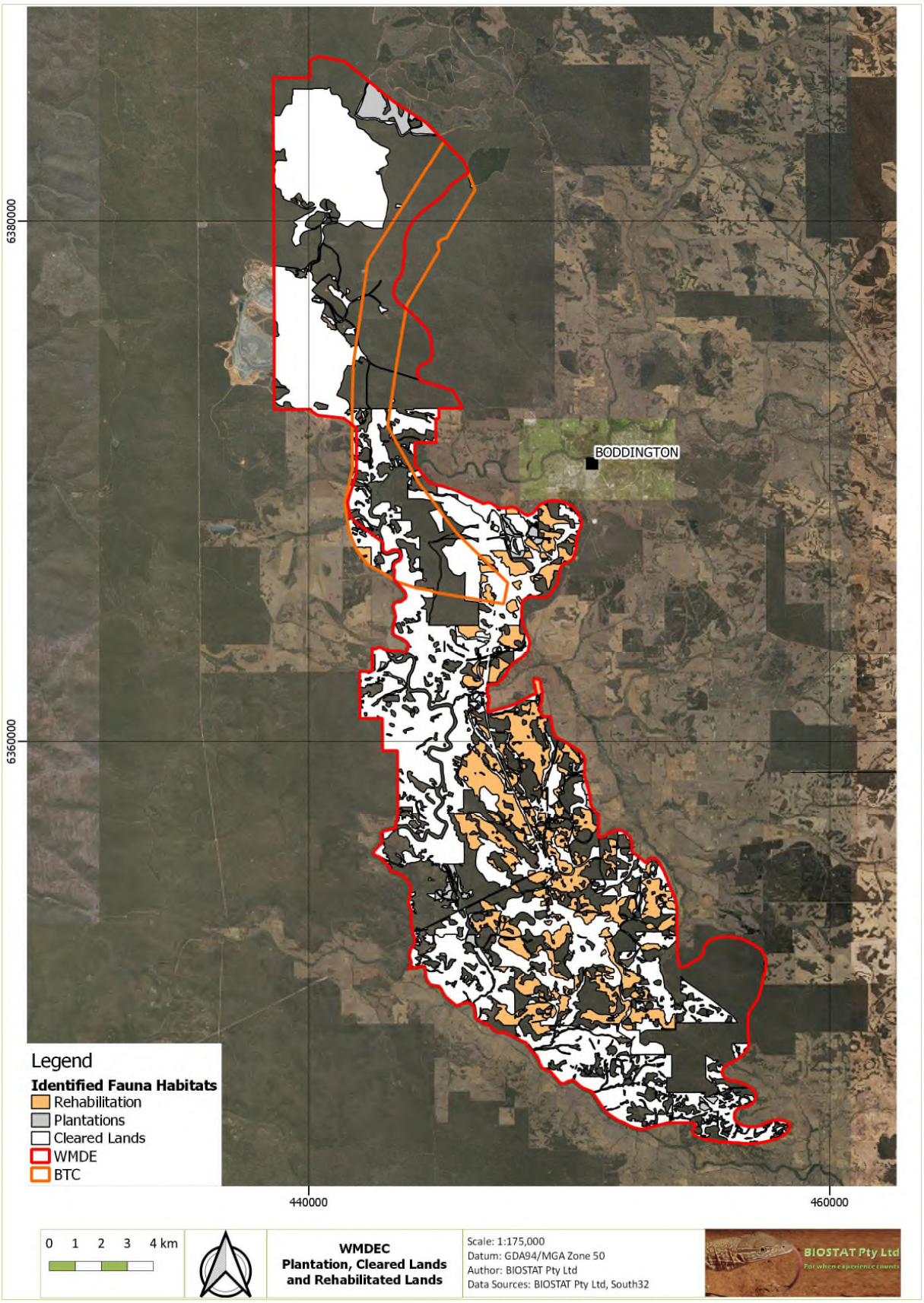

Figure 2 Map of cleared lands (CL), Plantations (PL), and rehabilitated areas (RE) in the WMDEC

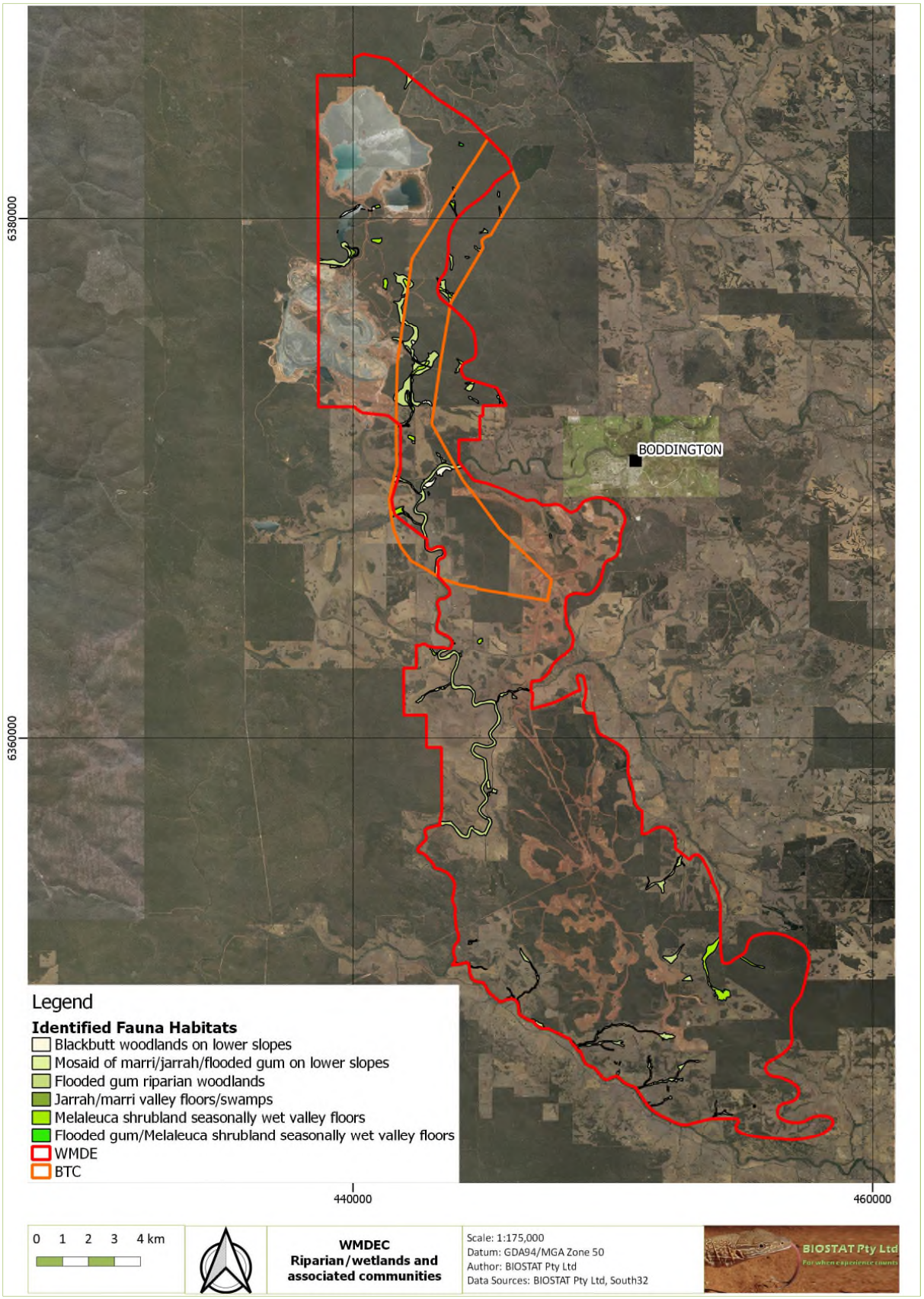

Figure 3 Riparian/Wetland and associated communities in the WMDEC.

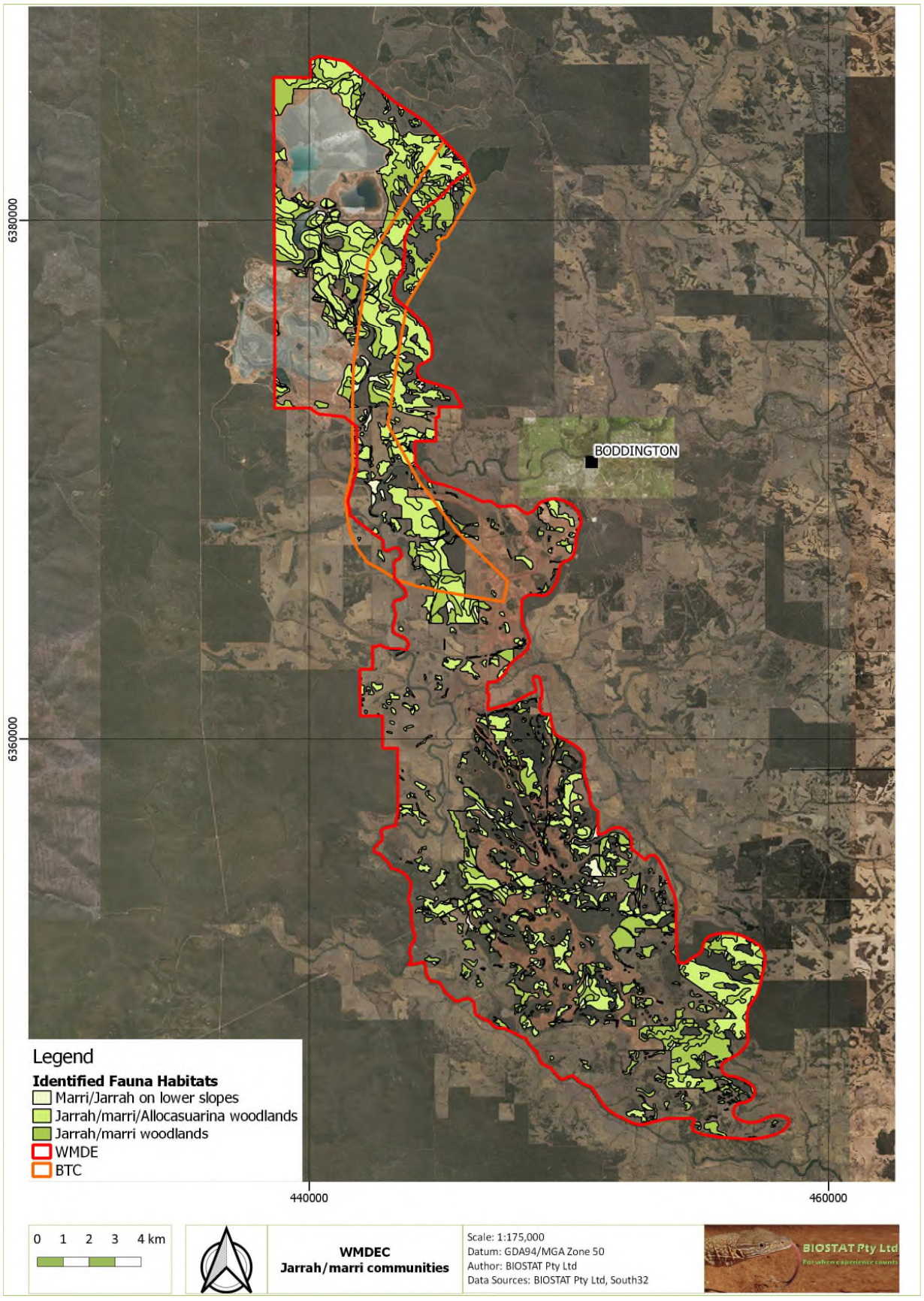

Figure 4 Jarrah/Marri Communities in the WMDEC.

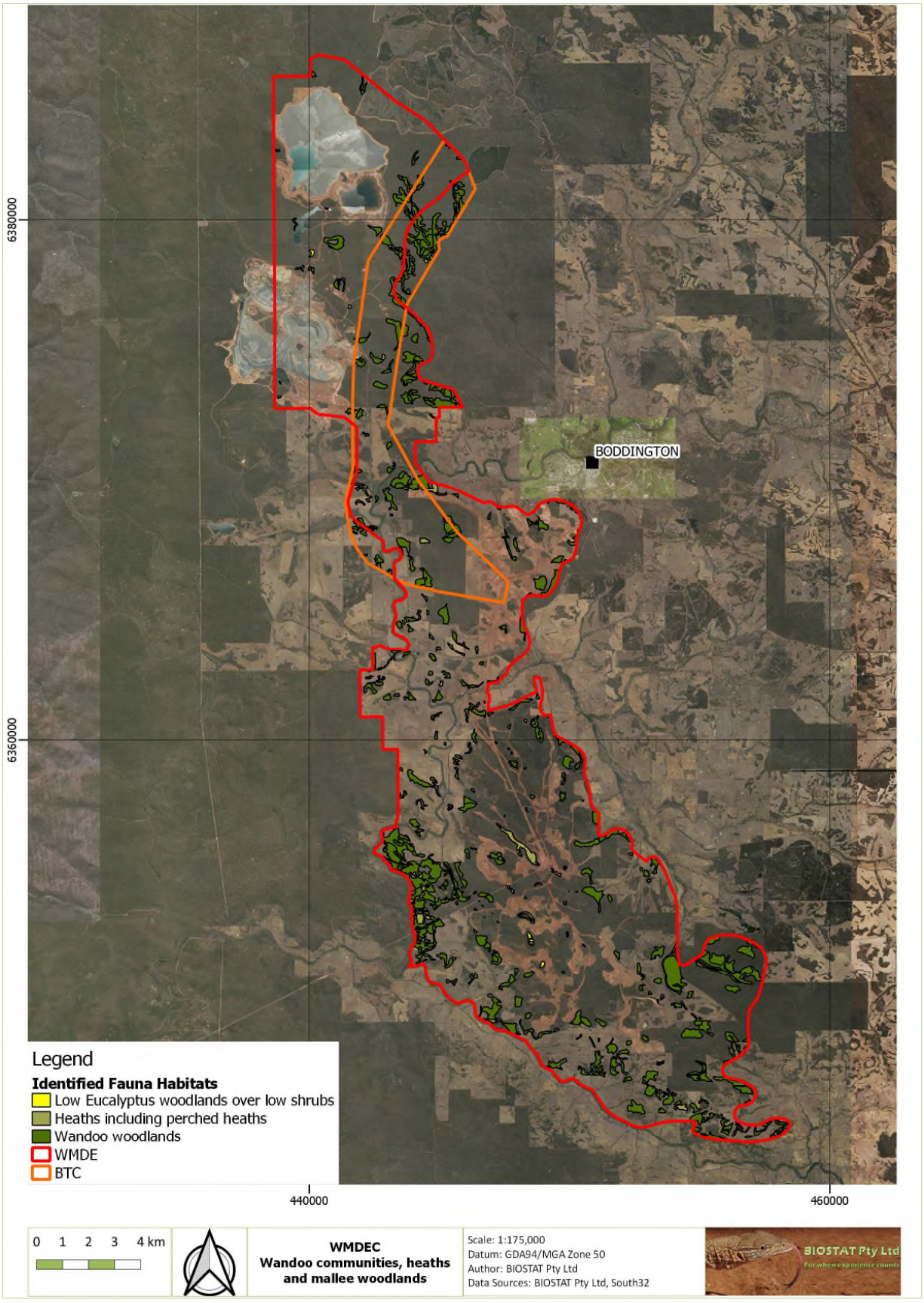

Figure 5 Mallee woodlands, Wandoo Communities and Heath Communities in the WMDEC.

5.2.2 Overview of CBME Habitats

The CBME is part of the Mornington Mill Block, a State Forest area that was logged prior to the development of the Bauxite Refinery in the early 1980s. The landscape consists of hills overlooking a valley at its southern boundary (Figure 6). The area is relatively small and supports four general fauna habitats. The valley has been dammed for a constructed freshwater source covering approximately 73 ha (approximately 10%) of the CBME (Table 7). The eastern and southern edges of the block have been cleared for mine expansion (CL). The cleared areas make up over 22% of the CBME and contain some very small highly disturbed fragments of native vegetation.

The native vegetation associated with the lower landscapes in the area, include minor drainage systems including the Augustus River at the north west of the freshwater dam, consists of the more mesic woodlands and forests (BB). These habitats comprise approximately 12% of the CBME and are characterised by the presence of blackbutt (*Eucalyptus patens*). The most abundant habitat type is a mosaic of jarrah/marri communities that cover nearly 56% of the CBME. The variations in this habitat include marri/jarrah forests on moister lower slopes (DL) although the more dominant habitat type are the jarrah/marri forests of the slopes and ridges with bull banksia and western sheoak (JC). Smaller stands dominated by jarrah/marri woodlands (JM) form the interface between BB/DL and JC.

The quality of remnant forest areas in the CBME is generally relatively high resulting primarily from the exclusion of logging within the area. Fire remains one of the more important threatening processes for the area in conjunction with the presence of introduced predators (fox and cat), herbivores (e.g. pig), and plant pathogens (e.g., *Phytophthora* sp and *Armillaria* sp.).

Table 7 Areas of fauna habitats identified in CBME.

Fauna Habitats	Fauna Code	General Fauna Habitat Type	Area (ha)*
Cleared Lands	**CL**	**May contain very small areas of remnant native vegetation**	168
Blackbutt woodlands on lower slopes	**BB**	**Riparian/Mesic communities**	91
Marri/jarrah on lower slopes	**DL**	**Jarrah/marri communities**	18
Jarrah/marri/sheoak woodlands on slopes/ridges	**JC**		315
Jarrah/marri woodlands on slopes	**JM**		83
Dam	**Dam**	**Others**	73
		Grand Total	748

** figures should be used as approximation for relative comparisons.*

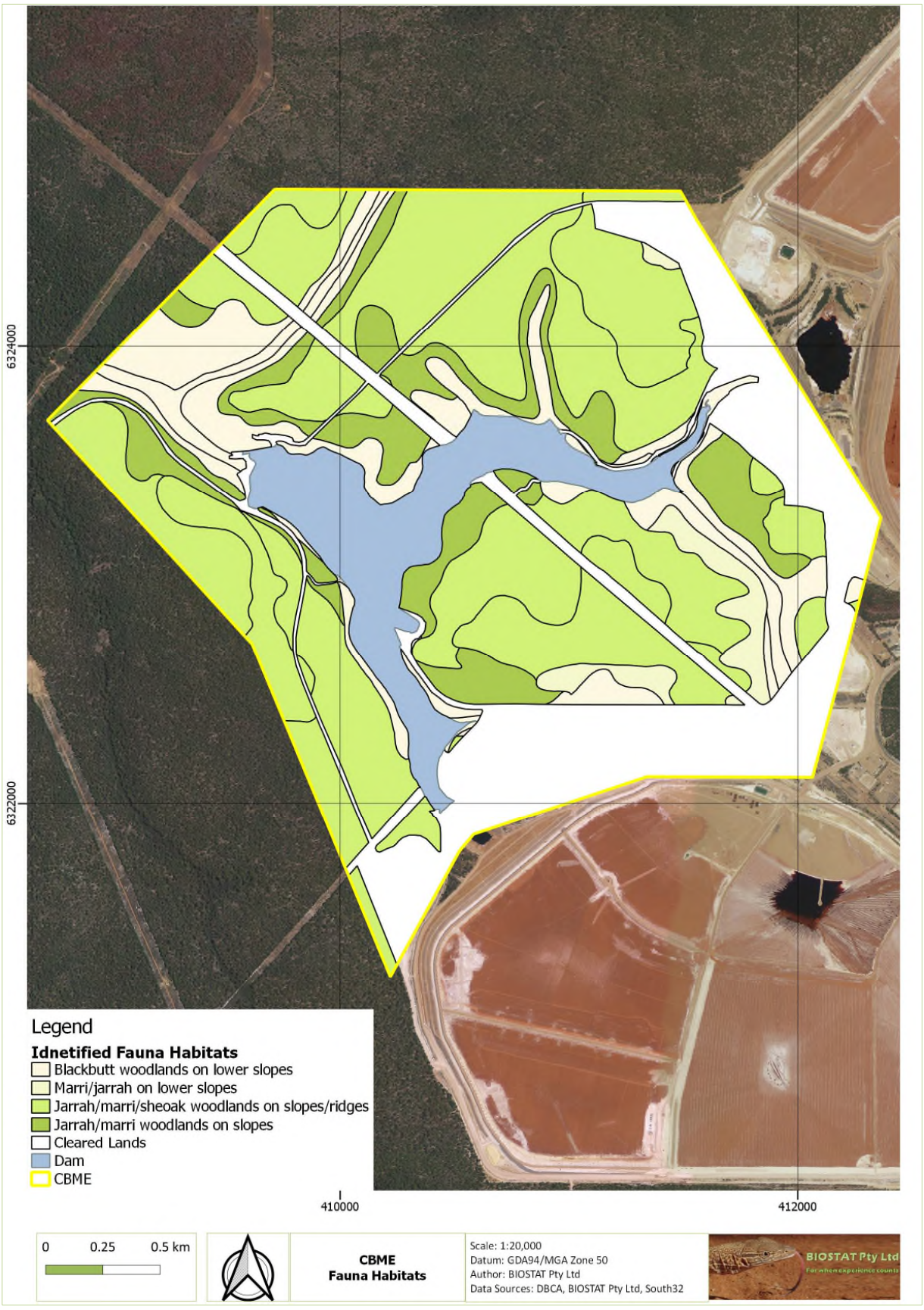

Figure 6 General fauna habitats in the CBME.

5.3 Potential Habitat Trees

The 2015-2016 fauna assessment of the mine expansion area (MEA) that eventually was integrated into the much larger WME study area of this current assessment also included a study of Potential Habitat Trees (PHT) (BIOSTAT Pty Ltd 2017). The PHT survey was undertaken in the area referred to as WMDEC in this document.

The logistical task of attempting to assess every tree within the WMDEC and the CBME is not viable, nor justifiable as black-cockatoo are known to use the areas for roosting, breeding and feeding. The focus is required in determining the quality of habitats for these three black-cockatoo species.

The standard PHT survey is designed to determine the quality of potential habitat for hollow nesting species, especially threatened or listed species such as black-cockatoo. However, it is known that observers assessing hollows from the ground tend to under-estimate the number of hollows, diameter and quality hollows (Harper et al. 2004; Rayner, Ellis & Taylor 2011).

The original study incorporated the limitations of surveying such a large area by designing a representative random sampling model for assessing the presence of PHT and to provide additional information in relation to the relative density of PHT and the "future" potential of the area for producing PHT. This methodology allows for the collection of a higher level of information for large areas. Details of the methodology are provided in Appendix 4 and a detailed analysis can be found in the original report (BIOSTAT Pty Ltd 2017).

In summary, a total of 776 trees were assessed over 28 ha of plots (N=28). Generally, most were live single stemmed trees (81%). The most common tree species encountered were jarrah (45%) with wandoo (26%) and marri (24%) making up most of the remainder (Table 8). Three western sheoak were recorded with hollows which is interesting as this species is known more for nests and drays than for denning/nesting hollows. Dead trees comprised 4.5% of the trees surveyed.

Table 8 Descriptions of tree species recorded during PHT survey in the WMDEC.

Tree species	Tree Height	DBH (cm) Category >100	>30 and <50	>50
Western sheoak	0-10		1	2
	10-15			
	15-20			
	20+			
Dead Tree	0-10		4	14
	10-15		1	9
	15-20	1	2	4
	20+			
Jarrah	0-10	3	33	28
	10-15	5	63	117
	15-20	11	6	55
	20+	6	1	22
Marri	0-10		26	14
	10-15		39	44
	15-20	2	7	38
	20+	6		10
Wandoo	0-10		13	8
	10-15	1	39	49
	15-20	2	15	41
	20+	4	3	27

Most trees fell into the 10 m – 15 m height/50 cm – 100cm DBH categories. There is a noticeable lack of trees beyond on either side of these measures, which could reflect the outcome of selective removal of trees through logging.

Tree hollows were recorded in 22% of the trees surveyed, at a density of 6.1 hollow bearing trees per hectare in mapped habitat areas. A total of 254 hollows were recorded. Hollows were more likely to be recorded in wandoo (29.7%), marri (19.4%) and jarrah (14.6%) had relatively high recording rates for hollows.

Tree hollows were most often recorded in trees in the 10 m – 15 m height category. The data also suggests that single stemmed taller trees of greater DBH (i.e., older trees) have the higher likelihood of recording hollows. Most of the recorded hollows were estimated at <15cm in diameter (79%), while it was more likely for larger hollows to be found in jarrah and wandoo trees (Figure 7).

A comparison of density of trees and hollows between fauna habitat sites indicates that the highest tree densities occur in the jarrah/marri fauna habitats (Figure 8). However, the ratio of hollows density to tree density suggests there is a higher occurrence of hollows in wandoo (WO) and disturbed remnants[8] (RM) (Table 9). A dominant explanation for this result is likely to be associated with the improved visibility in these much more open canopy areas, making identification of hollows more likely than in the more closed canopies of forests.

Table 9 Density of trees and hollows within each fauna habitat type.

	Density (No./ha)		
	<15cm Diam.	**>15cm Diam.**	**N (transects)**
Riparian	50		2
Blackbutt	20		1
Interzone between Riparian and Forest	10		1
Jarrah/marri on lower slopes	59	13	8
Jarrah/marri woodlands on slopes	35	20	2
Jarrah/marri/Allocasuarina woodlands on slopes and ridges	35	15	2
Wandoo woodlands	50	20	3
Disturbed remnants	63	9	8
Rehabilitation/Plantation	10	10	1

Pre-clearance surveys as part of mine operations have also resulted in the identification of 627 PHT as of November 2018 (Figure 9). Not all these trees are retained as part of mine operations. However, trees are assessed under a mitigation hierarchy for action (retention or removal) prior to clearing and mine operations. Retention of trees is applicable if they area:

- Identified as a confirmed black-cockatoo breeding tree;
- Offer extremely high potential without confirmation of black-cockatoo breeding; and
- Identified as a confirmed night roosting tree (regular or intermittently used night roost).

The existence of PHT increase the ecological values of the landscape for numerous volant and non-volant fauna species. The presence of larger hollows (>15cm diameter) is dictated by higher densities of larger and, therefore, older, trees and these are considered an essential resource for the three threatened black-cockatoo species recorded in the area.

Of interest are remnant habitats which have the highest density of smaller hollows (<15cm diameter) and a relatively low density of larger hollows relative to other fauna habitats identified in the WMDEC. This could provide a useful resource for arboreal and volant hollow nesting species if improved and managed for such purposes.

The importance of the availability of hollows is a critical aspect of ecological values in the landscape. The existence of hollows of any size makes these trees essential for maintaining the biodiversity of

[8] Disturbed remnants are the equivalent of the remnant stands discussed in Section 5.2.1.

species within the area. Hollow bearing trees are not easily replaced and should be considered as an important resource in the management of fauna.

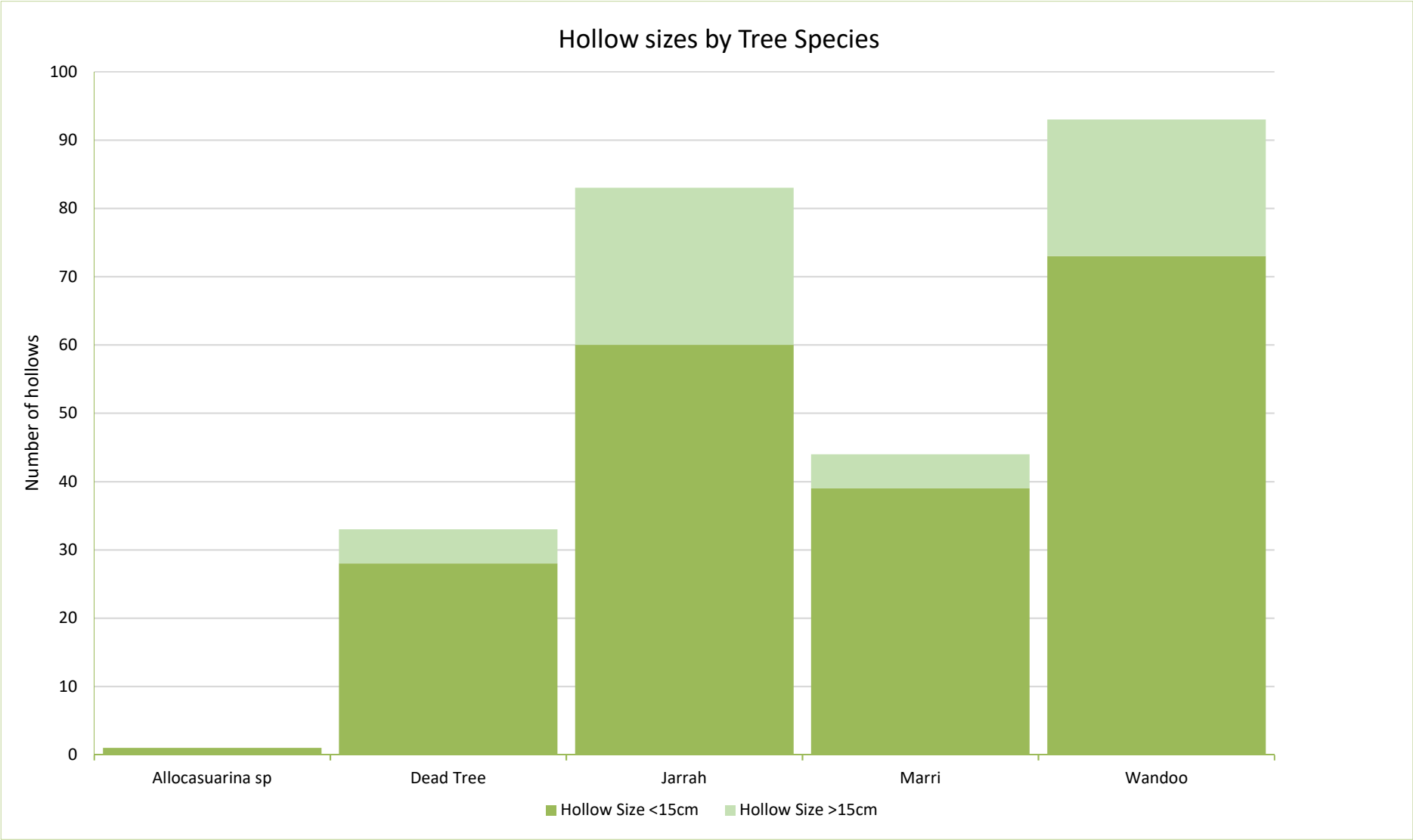

Figure 7 Hollow size for each species of tree recorded during the PHT survey.

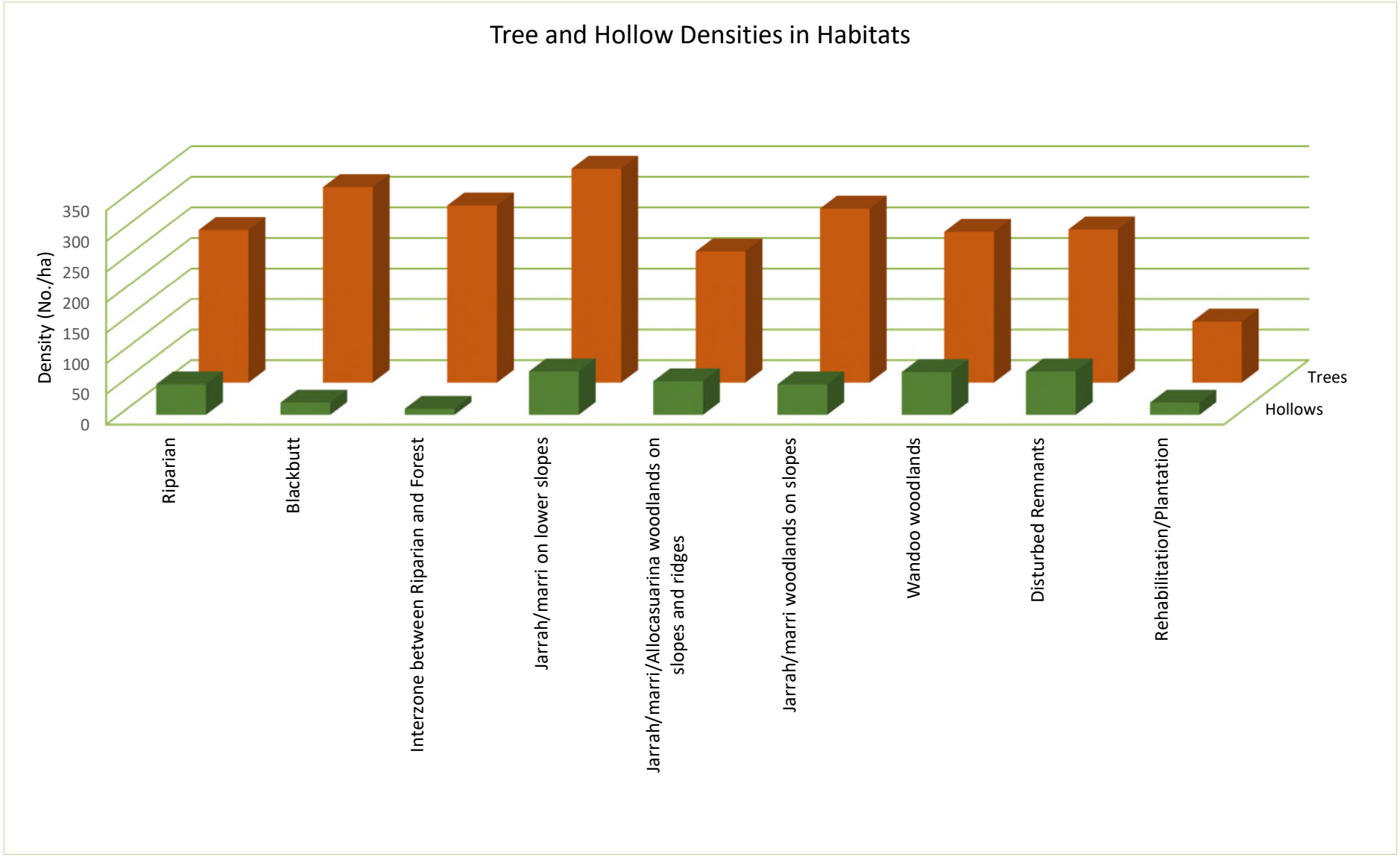

Figure 8 ***Density of trees and hollows for each fauna habitat type.***

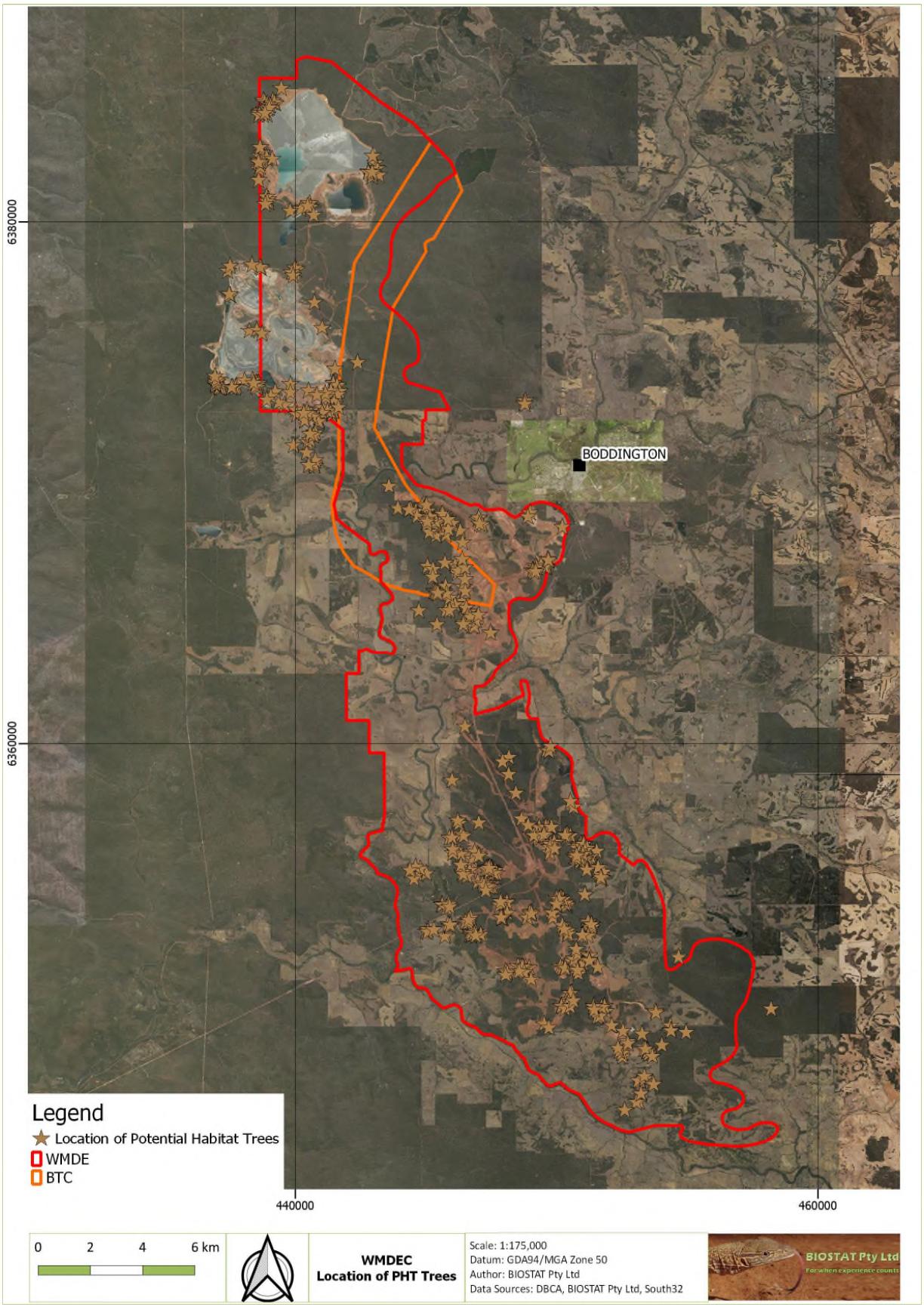

Figure 9 Location of PHT identified during pre-clearing assessments and targeted searches.

6 MATTERS OF NATIONAL ENVIRONMENTAL SIGNIFICANCE - TERRESTRIAL VERTEBRATE FAUNA

The search of species of conservation significance resulted in ten bird species and seven native mammal species listed under both the Commonwealth (EPBC Act) and Western Australian (WC Act) legislations. In addition, one bird species, five mammal species and three reptile species are listed under DBCA priority species categories.

The likelihood of occurrence is a subjective assessment reliant on an understanding of available habitat, quality of habitat, and historical and current records (Table 10). The quantification of occurrence for most species would require longer term monitoring which, in many cases, has been carried out for much of the area being assessed. Although, due to changes in species distributions brought on by climatic and habitat changes there is future possibility of species, which currently may exist on the fringes of the areas, becoming more common. In addition, the high mobility of many species of fauna, particularly migratory and nomadic birds, may require a combination of two or more categories.

Table 10 Likelihood assessment categories.

Likelihood	Description
Extremely Unlikely	no suitable habitat appears to be present, the species is known to be locally extinct.
Unlikely	preferred habitat does not appear to be present, the species may be vagrant in the area.
Low	has not been recorded in the general area (i.e., within the regional search area) in the recent past but suitable habitats are present.
Moderate	has been recorded in the general area (i.e., within the regional search area) in the past and/or preferred habitat is present.
High	has been recorded near or in the project area interest and/or preferred habitat is present.
Seasonally high **moderate** **low**	a seasonal migrant or nomadic species that has a widespread distribution and little specific habitat requirements.
Recorded	Observed during the assessment or in other surveys.

The Conservation Status of the listed species are indicated as described in Section 2. The codes used in the following species description are listed in Table 11. Species listed as Migratory but not under the main threatened species categories under the EPBC act, and priority species as listed by DBCA, are listed in Appendix 4.

This section will describe attributes of each of the species of conservation significance listed under the Federal and State government acts. The information that is provided will summarise what is currently understood of the species within the WMDEC and CBME areas. Species falling within the priority listings will be discussed in more general context. Some species will be categorised into functional groups that may display similar habitat requirements.

Table 11 Conservation status codes used in text.

Status – Australian Government (EPBC Act 1999)	
CR	Critically Endangered
EN	Endangered
VU	Vulnerable
MI	Migratory species
IA	JAMBA, CAMBA, ROKAMBA international agreements
Status – Western Australia (WC Act 1950 and DPaW Priority Species)	
S1	Schedule 1 of the WC Act 1950 (Critically Endangered fauna)
S2	Schedule 2 of the WC Act 1950 (Endangered fauna)
S3	Schedule 3 of the WC Act 1950 (Vulnerable fauna)
S5	Schedule 5 of the WC Act 1950 (Protected under international agreements)
S6	Schedule 6 of the WC Act 1950 (Special conservation needs fauna)
S7	Schedule 7 of the WC Act 1950 (Other fauna in need of special protection)
P1	DPaW Priority 1 – Poorly known species
P3	DPaW Priority 3 – Poorly-known species
P4	DPaW Priority 4 – Rare, near threatened and other taxa in need of monitoring

Species: *Leipoa ocellata*, malleefowl

Status: VU, S3

Description: Malleefowl distributions have been generally restricted to the lower rainfall areas (<600mm isohyet) and predominantly absent from the higher rainfall areas (Saunders & Ingram 1995). This species historically was not known from the Jarrah forests but from areas to the south and east of the south-west forest belt (Serventy & Whittell 1948). Populations of this species are known from reserves in the wheatbelt region including Dryandra Woodland Nature Reserve to the east of WMDEC. Records of this species in the Northern Jarrah Forest bioregion suggest it is present in low densities and may be patchily and sporadically distributed in suitable habitats.

The species has been recorded opportunistically in several locations to the north and east of the WMDEC area (Figure 10). There is a cluster of observations to the west in the Huntly mine area. A single record is located to the north of Lake Ballingal (Harris River) approximately 14km from CBME. Most of the records for this species obtained from the database are from the last 18 years which may reflect specific general survey effort, as opposed to survey effort targeting this species. There is no record of this species in the database held by South32 or NBGM. Although, these records were obtained primarily from lands under modification resulting from mining activities but “greenfields” biodiversity surveys (i.e., pre-mining) in areas such as MTR, QTR and in the Saddleback area of BBM did not record this species in 764 hours of general searches since 1998. It should be noted that additional opportunities to record this species existed in the effort placed in targeted surveys, passive surveys and the systematic bird surveys (an additional 1, 779 hours across WME).

Malleefowl have been impacted by loss of habitat and introduced predators, specifically fox, *Vulpes vulpes* (Bode & Brennan 2011; Priddel, Wheeler & Copley 2007). The loss of habitats, as with all fauna species under review here, is the major impact. Malleefowl also show a preference for long unburnt habitats with current agroforestry and fire protection practices impacting on the viability of habitats for this species (Parsons & Gosper 2011). It is likely that this species will utilise remnant vegetation corridors to allow them to move in highly modified landscapes such as agricultural areas. However, the persistence of this species in modified environments and in habitats not previously associated with their biology suggests a level of resilience.

The species will utilise broad habitats including shrublands, forests and woodland systems. All these habitats are found within WME. It is a long-lived (~20 years) species with a relatively large home range. The likelihood of encounter with this species over time could be considered high due to the level of effort, especially in the WMDEC area. However, records for this species within 30km of the WMDEC and within 15km of the CBME suggests this species has some potential to exist within these areas, albeit in low numbers.

Likely Habitat Use: Open woodland and open forest systems.

Threatening Processes: Loss of habitat. Habitat fragmentation. Predation by fox, wild dog, feral pig.

Likelihood of Occurrence: Low to Unlikely (WMDEC and CBME).

Data Adequacy: Limited.

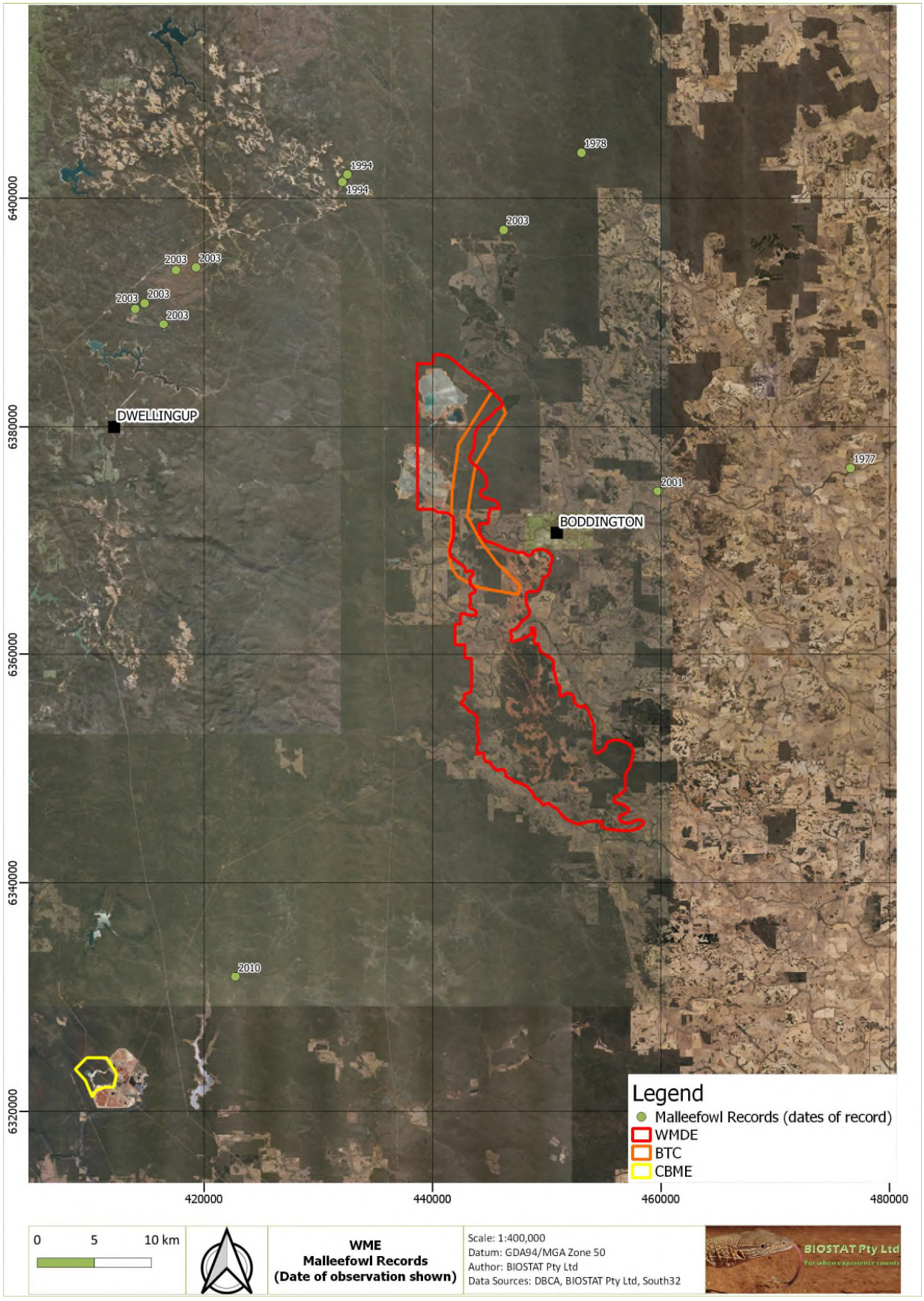

Figure 10 Records of Malleefowl with dates of records.

Species: *Botaurus poiciloptilus*, Australasian bittern

Status: EN, S2

Description: This species has suffered a contraction of its distribution to the south coast of Western Australia with much of their habitat disappearing from the Swan Coastal Plain (Garnett, Szabo & Dutson 2011). It is associated with shallow permanent or ephemeral wetlands with substantial fringing dense reed vegetation (Garnett, Szabo & Dutson 2011). Many of these systems have been cleared for urbanisation or agriculture.

Farm dams and smaller water bodies are generally managed, and fringing vegetation is often absent. Older dams and abandoned dams may provide some level of temporary habitat when free water and dense fringing vegetation is present. There are several large waterbodies within the vicinity of CBME, such as Wellington and Harris Dam, that could support this species. The large water body at CBME may provide suitable habitat for this species if water levels are high enough to inundate some of the shoreline vegetation.

The various vegetated riparian systems within the WMDEC area can provide suitable habitat for this species. Other wetland/heath systems do occur at BBM in the Tunnel Road area, and at NBGM with ephemeral swamps and large freshwater lakes on their leases. As part of the management process, a buffer has been incorporated in the early designs to be established along major waterways (i.e., Hotham River and tributaries) that will protect suitable habitat for this species within the WME area. However, the value of these buffers will be determined by upstream actions.

The Australasian Bittern has not been recorded in any of the surveys undertaken within the WMDEC or CBME. This potentially reflects the limited effort in surveying suitable habitat for this species. The focus of surveys has been primarily in areas likely to be impacted by infrastructure and mining operations which almost always excludes wetlands or other suitable habitat for this species.

The available records from the DBCA threatened species search are sparse. There is a single record from Nanga Brook in 2017, the only other two sightings were pre-1980's (Figure 11).

Likely Habitat Use: Shallow ephemeral densely vegetated water sources including riparian systems.

Threatening Processes: Loss of habitat. Habitat fragmentation. Predation by fox, cat.

Likelihood of Occurrence: Low to Unlikely (WMDEC and CBME).

Data Adequacy: Low.

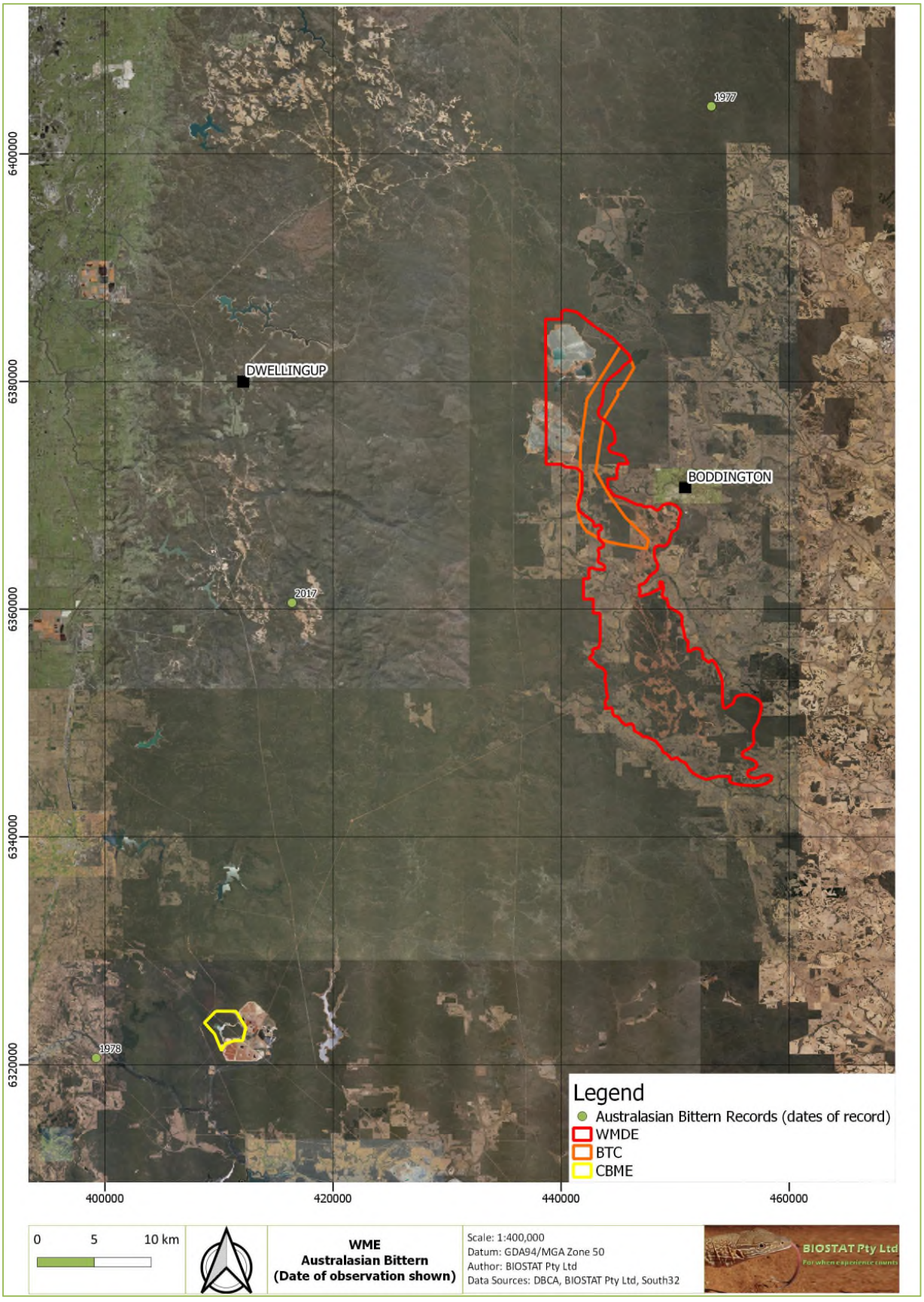

Figure 11 Location of Australasian Bittern Records with dates.

Species: *Falco peregrinus*, peregrine falcon

Status: S7

Description: The peregrine falcon is a wide-ranging species with large home ranges and diverse habitat use. They are often found in hilly or mountainous landscapes but are recorded over much of the Australian mainland and offshore islands (Johnstone & Storr 1998). Due to their eclectic habitat use, this species is likely to exist in most areas but could not be regarded as common in any.

There have been 11 individual records of the peregrine falcon at WMDEC since 1982 (Table 12). A single record exists from the CBME area from the original systematic survey undertaken in 2000-2001.

The persistence of presence at the WMDEC site would suggest that there is sufficient suitable habitat for the peregrine falcon. This species, as with all higher order predators, have large home ranges and are often observed infrequently and opportunistically.

The peregrine falcon are known to nest on cliff faces or other lofty structures such as communication towers and tall buildings. Previous works have suggested that the nesting in hollows by this species was rare and limited (Pruett-Jones, White & Devine 1981). A breeding pair with fledglings were recorded in a Wandoo woodland area at BBM in 2017, nesting in a hollow approximately 8m above the ground in a Wandoo tree (BIOSTAT Pty Ltd 2018). Another nesting pair was located in a ledge in a tall Jarrah (South32 2017). This implies that the birds will utilise suitable hollows in forests if they cannot find any taller structures.

The major threat to this species is the loss of nesting areas within forest habitats, i.e., tall trees. An emerging threat is the secondary poisoning from the use of rodenticides and insecticides (Lohr & Davis 2018).

Table 12 Observations of Peregrine Falcon at WMDEC and CBME locations.

	1982	1984	1987	2000	2001	2002	2003	2017	2018
WMDEC	1	1	2	2	1	1	2	3*	1
CBME				1					

* Nesting pair with fledglings recorded in 2017 close to systematic survey site

Likely Habitat Use: Eclectic. Will utilise woodlands, heath, forests. Tends to nest where tall structures exist, including tall trees, cliff faces, radio towers, etc.

Threatening Processes: Loss of habitat, especially suitable breeding habitat. Habitat fragmentation. Secondary poisoning.

Likelihood: High, Recorded (WMDEC and CBME).

Data Adequacy: High.

Figure 12 Location of Peregrine Falcon records from Survey Database.

Species: *Rostratula australis*, Australian painted snipe

Status: Australian Painted Snipe EN, S2

Description: The Australian Painted Snipe is a cryptic species with dispersive habits (Johnstone & Storr 1998). Has been recorded in diverse natural and built habitats (e.g., sewage farms, dams). This, as with other wetland species, are usually under-surveyed due to their scarcity and the associated high level of effort required to record them.

This species has been recorded in shallow ephemeral wetlands and on the margins of deeper permanent lake systems where there is fringing low dense vegetation. Older dams and abandoned dams with fringing vegetation may provide some level of temporary habitat when free water is available. There are several large waterbodies within the vicinity of CBME such as Wellington and Harris Dam that have potential to support this species. As with other waterbirds, this species may utilise the large water body at the CBME depending on water levels and the presence of fringing vegetation.

There is suitable habitat in the WMDEC especially along the riparian systems of the Hotham River and its tributaries and some swamps and ephemeral lands at NBGM. As part of the management process, a buffer has been incorporated in the early designs to be established along major waterways (i.e., Hotham River and tributaries) that will protect suitable habitat for this species.

No records of this species resulted from the database searches. Surveys at the WMDEC and CBME areas have focused on forest habitats and revegetation areas. Records of any fauna from wetland and riparian systems are only opportunistic and occasional.

Likely Habitat Use: Shallow ephemeral densely vegetated water sources including riparian systems.

Threatening Processes: Loss of habitat. Habitat fragmentation. Predation by cat, fox, dog, rat.

Likelihood: Low to Unlikely (WMDEC and CBME).

Data Adequacy: Low.

Species: *Numenius madagascariensis*, eastern curlew
Calidris ferruginea, curlew sandpiper

Status:

Eastern Curlew	VU IA, S3 MI
Curlew Sandpiper	VU IA, S3 MI

Description: These two shorebird species are discussed collectively due to the shared habitat preferences. The two species are common in coastal mudflat areas but can sometimes be observed at inland ephemeral lakes (fresh or saline).

The species are under threat resulting from impacts on their coastal inter-tidal habitats in both the southern and northern hemispheres. They are regarded as vagrant in the interior and will utilise water bodies as short-term roosting areas (Garnett, Szabo & Dutson 2011). However, these are transient species and unlikely to be resident and their potential use of the WMDEC and CBME habitats would be regarded as opportunistic.

No records of these species resulted from the database searches. Surveys at the WMDEC and CBME areas have been focused on forest habitats and revegetation areas. Records of any fauna from wetland and riparian systems are only opportunistic and occasional.

Likely Habitat Use: Large open water sources and riparian systems.

Threatening Processes: Loss of habitat. Habitat fragmentation. Predation by cat, fox, dog, rat.

Likelihood: Low to Unlikely (WMDEC and CBME).

Data Adequacy: Low.

Species: *Calyptorhynchus banksii naso*, forest red-tailed black-cockatoo
Calyptorhynchus latirostris, Carnaby's black-cockatoo
Calyptorhynchus baudinii, Baudin's black-cockatoo

Status:

forest red-tailed black-cockatoo	VU, S3
Carnaby's black-cockatoo	EN, S2
Baudin's black-cockatoo	EN, S2

Description: All three species have suffered a decline in their distribution and their population sizes in Western Australia due to a reduction in available foraging, roosting and breeding habitat. Viability of these three species is further exacerbated through poor fire management practices, illegal shootings, poaching, and climate change.

Data was obtained from DBCA search for threatened species and included an assessment of foraging and roosting habitats. Additional records were derived from the survey data set. The survey data set contains records for a "white-tailed black-cockatoo" to differentiate those individuals that could not be clearly identified as either of the two white-tailed black-cockatoo species.

For reasons indicated in Section 5.1.2, the data for the CBME area is not as extensive as that available for the WMDEC. Survey data used in the analysis for each of the areas is limited to records obtained in the period 1998-2018. Data from the OBC area was not included in the analysis.

All three species have been recorded within both WMDEC and CBME areas (Figure 13). The most common of the three species was found to be the forest red-tailed black-cockatoo, accounting for around half of all individuals observed (Table 13). Carnaby's black-cockatoo was the next most abundant at WMDEC although this was not reflected at CBME. The Baudin's black-cockatoo was more abundant at CBME although much of the information is derived from lower level survey effort in this area.

Table 13 Relative distribution of records for black-cockatoo species at WMDEC and CBME.

	Total Abundance	Proportion of observations
WMDEC		
Red-tailed Black-Cockatoo	1118	48.1%
Carnaby's Black-Cockatoo	753	32.4%
Baudin's Black-Cockatoo	362	15.6%
White-tailed Black-Cockatoo species	93	4.0%
CBME		
Red-tailed Black-Cockatoo	119	54.1%
Carnaby's Black-Cockatoo	41	18.6%
Baudin's Black-Cockatoo	60	27.3%

A substantial portion of the area within the WMDEC boundaries has been cleared for agricultural and mining activities. This has led to a fragmentation of habitat that is likely to have altered land use by these species. However, their occurrence throughout the WMDEC and CBME/RLA would suggest they are utilising remnant habitats for foraging, roosting and breeding, as well as adapting to new habitats such as mine rehabilitation.

Breeding Habitat: One of the threatening processes is the loss of potential breeding habitat in this area due to the removal of mature hollow bearing trees. The DBCA threatened species data indicates a confirmed breeding area for Carnaby's black-cockatoo encompassing much of the NBGM and MAR areas (Figure 14). This resulted from intensive studies of black-cockatoo undertaken at NBGM (e.g., Lee, Finn & Calver 2013). Similar studies have not been carried out in areas to the south to include SAD and QIN. However, in 2017, confirmed breeding by Carnaby's black cockatoo was identified during pre-clearance black-cockatoo surveys within the SAD area of the WMDEC (South32 2017).

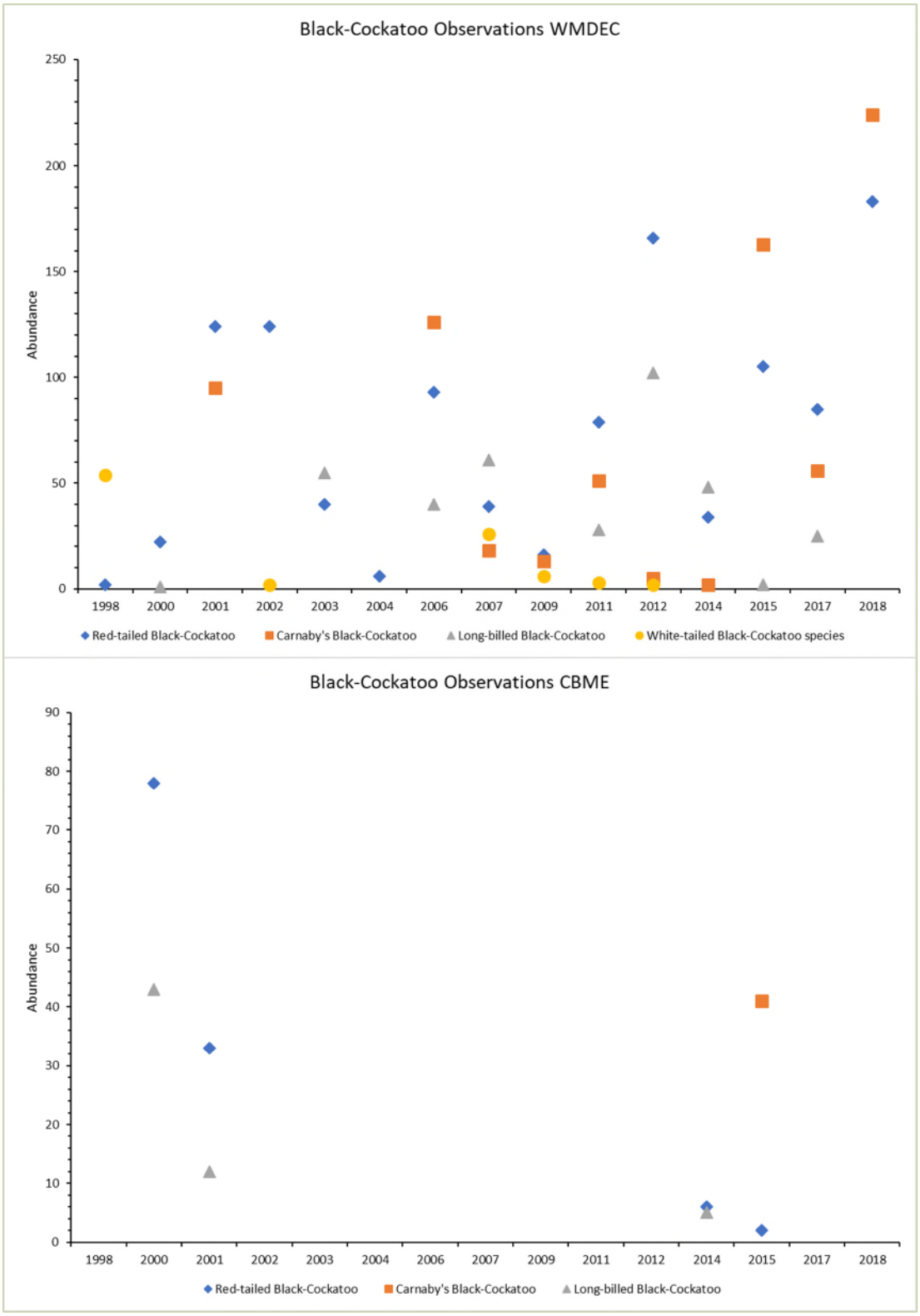

Figure 13 Abundance for the three species of black-cockatoo[9] at WMDEC and CBME since 1998[10].

[9] Individuals that could not be identified as either of the White-tailed Black-Cockatoo species are included in the general generic group, Calyptorhynchus sp.

[10] Data is shown as raw abundance and may only include the results of single season survey events which formed part of a longer 3 season survey program.

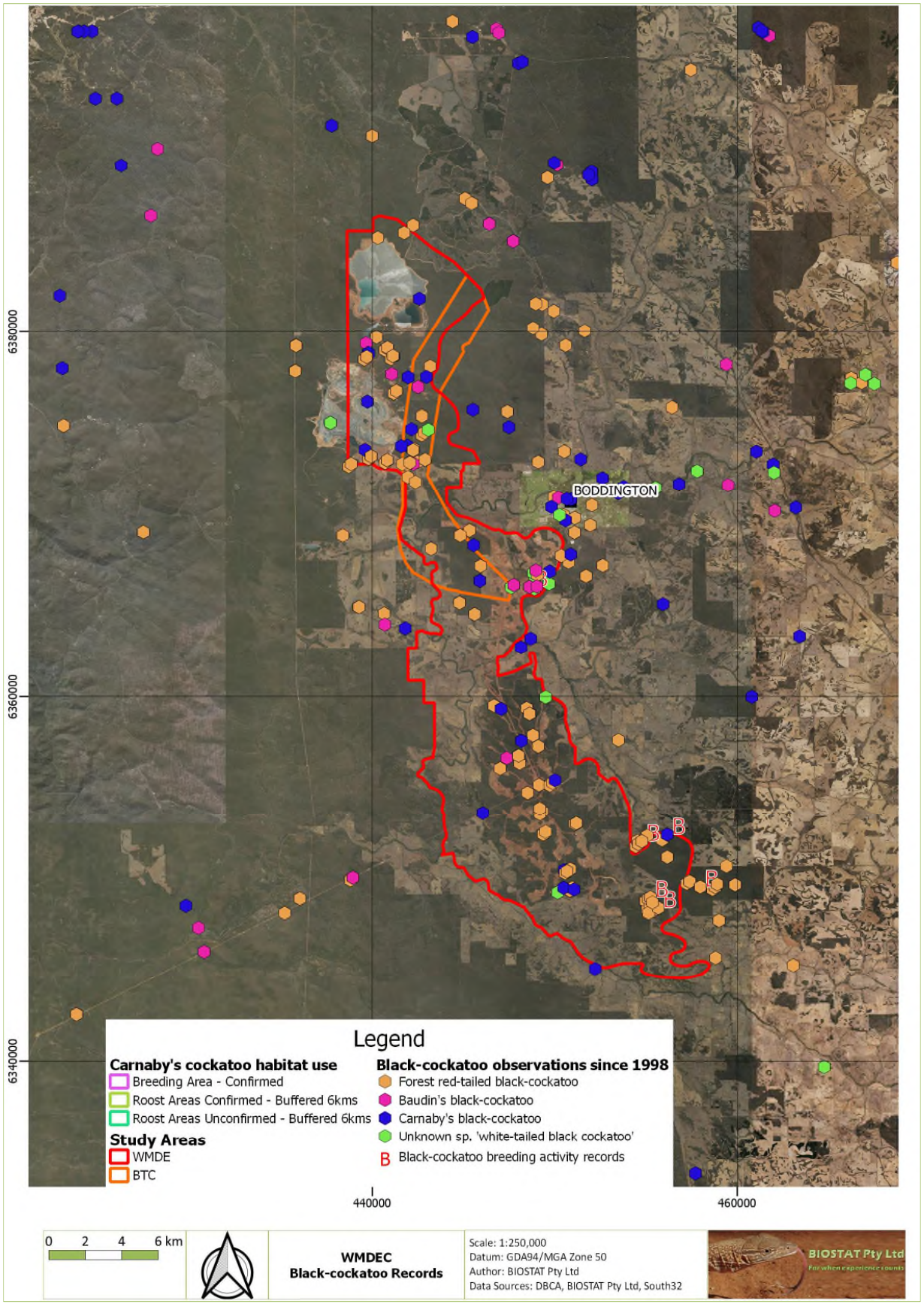

Figure 14 Observations of the three black-cockatoo species in the WMDEC area.

Additional confirmed breeding locations have been recorded in SAD, MAR and QIN, although most have been in QIN. The majority are breeding records of forest red-tailed black-cockatoo with an additional record of a nesting Baudin's black-cockatoo at MAR from 2007 and confirmed breeding of Carnaby's black-cockatoo at SAD. The surveys were undertaken during breeding times for all three species over the three survey events.

Black-cockatoo records from the CBME are dominated by forest red-tailed black-cockatoo although Baudin's black-cockatoo are common in nearby State forest (Figure 15). There is a single breeding record for Baudin's black-cockatoo[11] from a site assessment undertaken in 2014 located in an area within RLA boundaries but outside the CBME boundary (BIOSTAT Pty Ltd 2014).

PHT assessment carried out in 2015-2016 illustrated trees with hollows that will provide suitable nesting habitat for black-cockatoo are well distributed within the WMDEC (see Section 5.3). Interestingly, there is the potential for remnant tree stands in cleared paddocks to support suitable nesting hollows for black-cockatoo. This was highlighted during South32 pre-clearance surveys 2018 which located a breeding pair in hollows of remnant stands (South32 2018). These remnants are sometimes located close to or adjacent to forested areas to further increase their value as potential breeding habitats. This provides an opportunity for these areas to be surveyed and monitored to determine their value as potential breeding habitats for these species.

Unlike at the WMDEC, the CBME is covered almost entirely by old logged regrowth forest offering suitable feeding, foraging and roosting habitat for the three black-cockatoo species. The quality of the forest habitats will require assessment for black-cockatoo values with consideration of broader ecological values providing an assessment of local and regional sustainability of habitats in the landscape.

Roosting Habitat: Roosting areas are considered an important habitat value for black-cockatoo and there is evidence of roost fidelity in Carnaby's black-cockatoo (Shah 2006). This type of habitat can consist of a general location where flocks may congregate on a regular basis or more randomly located over-night roosts. A study of Carnaby's black-cockatoo roost site characteristics on the Swan Coastal Plain found the location of roost site was associated with several landscape scale environmental variables; including distance from water, distance from foraging habitat, forest and tree type surrounding roost (Le Roux 2017).

The data from the threatened species search defines roosting sites for Carnaby's black-cockatoo centred on Crossman to the east of the WMDEC. Given the evidence available, it is likely that there are roosting sites within the WMDEC, although they are yet to be defined. Pre-dusk bioacoustic recordings of fringing forest sites within the SAD mine lease, during 2014-2015 and 2017-2018 surveys, identified the distinctive multiple contact calls of red-tailed black-cockatoo and Carnaby's black-cockatoo normally associated with flocks settling for overnight roosting. The locations of the roosting flocks cannot be ascertained using the bioacoustic recordings other than they are within the sound catchment area of the recording device.

No roosting sites have been defined for RLA or any nearby areas. This may reflect a lack of adequate long-term assessment for the area rather than a lack of roosting sites in the area.

Foraging Habitat: Black-cockatoo feed on a diverse range of native and introduced plant material. They are considered primarily granivorous but their diets also consists of fruit, flowers, nectar and invertebrates (Johnstone & Kirkby 1999; Johnstone, Kirkby & Sarti 2017; Mawson 1995; Valentine & Stock 2008).

As wide-ranging species, food resources are an important factor for their movements along their migration paths. Water is also an important resource in conjunction with their foraging habitats. The WMDEC and CBME areas contain suitable native vegetation foraging habitat including jarrah/marri

[11] An adult pair attending to an on-wing young.

forests, wandoo woodlands, and native heaths. Additional highly modified habitats can also provide suitable foraging habitat including plantations, orchards, and remnant tree stands in agricultural landscapes.

Mine rehabilitation has been shown to provide suitable foraging habitat for black-cockatoo and can provide substantial diversity in food types (Lee, J, Finn & Calver 2013). Flocks of Carnaby's black-cockatoo have been recorded more often feeding in mine rehabilitation areas from SAD surveys although forest red-tailed black-cockatoo are more likely to be encountered in forested sites (BIOSTAT Pty Ltd 2018).

The successional process of rehabilitation results in revegetation going through distinct phases where community structures change from low open shrubland, dense tall heath, tall shrubland, low forest and forest. The changes in vegetation assemblage and the presence of different successional stages in the landscape will ensure long term foraging habitats are available for all three species of black-cockatoo (Doherty et al. 2016; Lee, Finn & Calver 2010a).

Natural and artificial water resources are available to all species of black-cockatoo at both WMDEC and CBME from a variety of sources including freshwater reservoirs, farm dams and drainage systems.

Guideline Assessment: The referral process requires compliance with guidelines for assessment of black-cockatoo. Two guidelines currently exist, the first has been in operation since 2012 (Department of Sustainability, Environment, Water, Populations and Communities 2012) and is to be replaced by revised guidelines in the near future (Department of Environment and Energy 2017). The more recent referral guideline implements a scoring system to determine the need to refer areas under the EPBC Act.

An assessment under the 2012 guidelines (Table 14) would result in referral for all three species in the WME. It is difficult to assess the CBME due to lack of a robust data set. It has been omitted from this assessment. Specifically, this is based on:

NBGM, MAR, SAD and QTR represent known breeding habitat (Figure 14).

- Clearing for mining will degrade vegetation community that may support breeding habitat (i.e., trees with suitable hollows).
- There are records of all three species foraging in the WMDEC area over several surveys indicating the existence of suitable foraging habitat, However, it such information is specific to those areas that have been surveyed and not the entire WMDEC area. It is likely such habitat would be cleared as part of mining operations or agricultural practices. However, rehabilitation does provide a substantial foraging resource for all three species of black-cockatoo (e.g., Doherty et al. 2016; Lee, Finn & Calver 2010b).
- The agricultural areas and mining operations have fragmented habitats with some gaps between forests or woodlands of around 4km already present. Gaps of this nature already exist but the three species of black-cockatoo persist in the area.

Unlike the remaining areas within the WMDEC, SAD has been heavily developed with cleared areas for mining operations and/or areas under rehabilitation. The combination of mining operations, agricultural activity and agroforestry in the WMDEC highlights the level of disturbance and fragmentation present in the area. However, the persistence of all three species would suggest there is suitable remnant habitat to support the populations. This is likely to be enhanced by the closeness of the area to the State Forest blocks to the western and southern borders of the WMDEC.

The application of the scoring system from the 2017 revised draft guideline on the general areas within the WMDEC would suggest referral of the project in most uncleared areas. The scores were calculated on the general state of remnant forest vegetation within those areas. More detailed environmental assessments would be required especially in QIN and in portions of NBGM to the east of the residue dams and mine pits.

There is potential for relatively high-quality black-cockatoo habitat at the CBME. Site assessments of a very small area on the eastern boundary of the CBME suggests that there is potential for potential habitat trees and foraging habitat (BIOSTAT Pty Ltd 2015a). Application of the precautionary principle would require referral of the CBME area under either of the referral guidelines.

It is important to note management and mitigation measures that are already in place as part of mining operations have not been incorporated into either of these two assessments. These include the protection of breeding hollows and the supplementation of hollows with the installation of nesting boxes. As previously discussed, rehabilitated areas mitigate habitat loss by providing a foraging resource used by all three species. Similarly, other measures such as investigations into the use of remnant tree stands in fields and pasture for breeding by the three species of black-cockatoo could provide further options for mitigation of habitat loss. Importantly, connectivity between fragmented remnants in these areas is regarded as a component of mitigation (Saunders 1990).

The use of offsets is not recommended for these species as the concept does not consider habitats used by these species as a finite resource. An offset will either draw from a smaller pool of that finite resource or attempt to use analogues that are unlikely to provide replacements for lost resources (Lindenmayer et al. 2017; Maron et al. 2010, 2012). The major loss will be in breeding areas that support old mature trees with hollows. Offsets will always result in a net loss of habitat and ecosystem functionality for these three species. However, there are opportunities for potential habitat enhancements that could provide relatively rapid replacement for lost habitats. For example, the rehabilitation of remnant stands in agricultural landscapes and the maturity of older rehabilitated areas.

Table 14 Adapted guidelines from the 2012 referral guidelines for Black-Cockatoo.

High risk of significant impacts: referral recommended
• Clearing of any known nesting tree.
• Clearing or degradation of any part of a vegetation community known to contain breeding habitat.
• Clearing of more than 1 ha of quality foraging habitat.
• Clearing or degradation (including pruning the top canopy) of a known night roosting site.
• Creating a gap of greater than 4 km between patches of black cockatoo habitat (breeding, foraging or roosting).
Uncertainty: referral recommended or contact the department
• Degradation of more than 1 ha of foraging habitat.
• Clearing or disturbance in areas surrounding black cockatoo breeding, foraging or roosting habitat that has potential to degrade habitat through introduction of invasive species, edge effects, hydrological changes, increased human visitation or fire.
• Actions that do not directly affect the listed species but that have the potential for indirect impacts.
• Actions with the potential to introduce known plant diseases to an area where the pathogen was not previously known.
Low risk of significant impacts: referral may not be required
• Actions that do not affect black cockatoo habitat or individuals.
• Actions whose impacts occur outside the modelled distribution of the three black cockatoos.

Likely Habitat Use: All woodland and forested areas, heath, and rehabilitation.

Threatening Processes: Loss of habitat. Habitat fragmentation. Illegal shooting. Disease.

Likelihood: Forest Red-tailed Black-Cockatoo - High, Recorded (WMDEC, CBME).
Carnaby's Black-Cockatoo - High, Recorded (WMDEC, CBME).
Baudin's Black-Cockatoo - High, Recorded (WMDEC, CBME).

Data Adequacy: High (WMDEC). Low (CBME).

Table 15 Scoring of WMDEC areas in accordance with revised referral guidelines.

NBGM	Carnaby's Black-Cockatoo	Baudin's Black-Cockatoo	Forest Red-tailed Black-Cockatoo
Foraging habitat	7	7	7
Context adjustor - attributes improving functionality of foraging habitat	+7 (Contains trees with suitable nest hollows. Primarily comprises marri. Contains trees with potential to be used for breeding.)	No known breeding records. Is at the north-eastern extreme of its range	+7 (Contains trees with suitable nest hollows. Primarily comprises marri. Contains trees with potential to be used for breeding.)
Context adjustor - attributes reducing functionality of foraging habitat	-1 Possible Presence of dieback		
Final Score Range	13	6	13
MAR			
Foraging habitat	7	7	7
Context adjustor - attributes improving functionality of foraging habitat	+5 (Contains trees with suitable nest hollows. Contains trees with potential to be used for breeding.)	No known breeding records. Is at the north-eastern extreme of its range	+5 (Contains trees with suitable nest hollows. Contains trees with potential to be used for breeding.)
Context adjustor - attributes reducing functionality of foraging habitat	To be determined on site by site basis.		
Final Score Range	12	7	12
SAD			
Foraging habitat	1-7	1-7	1-7
Context adjustor - attributes improving functionality of foraging habitat	+7 (Contains trees with suitable nest hollows. Primarily comprises marri. Contains trees with potential to be used for breeding.)	No known breeding records. Is at the north-eastern extreme of its range	+7 (Contains trees with suitable nest hollows. Primarily comprises marri. Contains trees with potential to be used for breeding.)
Context adjustor - attributes reducing functionality of foraging habitat	To be determined on site by site basis.		
Final Score Range	8-14	1-7	8-14
QIN			
Foraging habitat	7	7	7
Context adjustor - attributes improving functionality of foraging habitat	+7 (Contains trees with suitable nest hollows. Primarily comprises marri. Contains trees with potential to be used for breeding.)	No known breeding records. Is at the north-eastern extreme of its range	+7 (Contains trees with suitable nest hollows. Primarily comprises marri. Contains trees with potential to be used for breeding.)
Context adjustor - attributes reducing functionality of foraging habitat	To be determined on site by site basis.		
Final Score Range	14	7	14

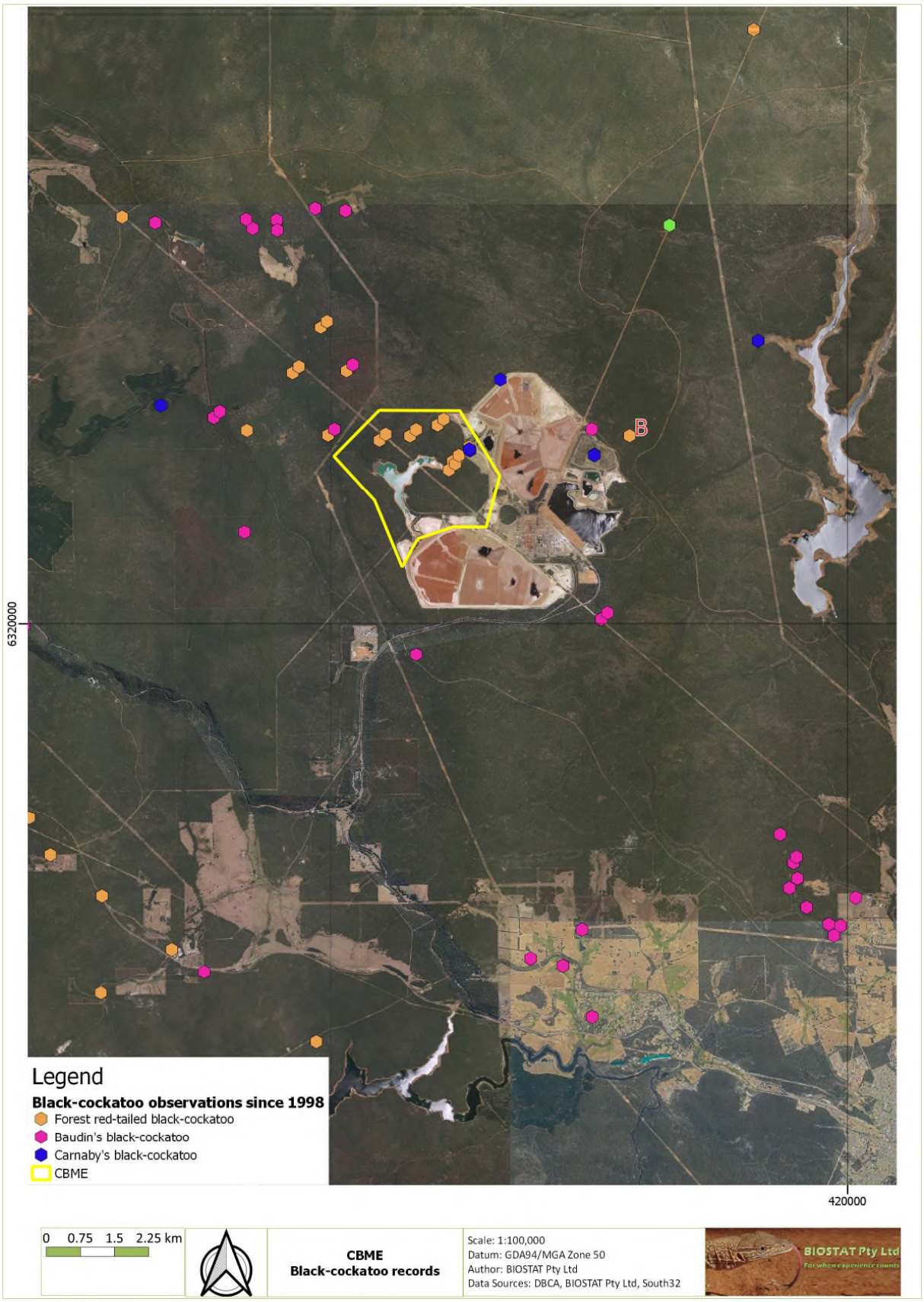

Figure 15 Observations of the three black-cockatoo species in the CBME area.

Table 16 Scoring system for foraging habitat from the revised referral guidelines.

Starting Score	Foraging habitat for Carnaby's Cockatoo	Foraging habitat for Baudin's 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.	Introduced eucalypts as well as the introduced Cape lilac (*Melia azedarach*).
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 map).	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 comprises 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 quality**
-2	No clear evidence of feeding debris.	No clear evidence of feeding debris.	No clear evidence of feeding debris.
-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 site.	Is > 12 km from a known roosting site.	Is > 12 km from a known roosting site.
-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 cinnamomi* or marri canker).	Disease present (e.g. *Phytophthora cinnamomi* or marri canker).	Disease present (e.g. *Phytophthora cinnamomi* or marri canker).

(*Table 3: Foraging habitat scoring tool, Page 21 of 32* in Department of Environment and Energy 2017)

Species: *Atrichornis clamosus*, noisy scrub-bird

Status: EN, S2

Description: This species was rediscovered in the 1960s at Two People Bay on the south coast of Western Australia. Conservation measures have involved the re-introduction of small populations into areas of its historical distribution including attempts in the Darling Range area in the late 1990s (Comer et al. 2010). After two years a small number of males were still heard calling at the site of the Upper-Harvey release area. However, subsequent surveys have not established the persistence of the population (Kemp et al. 2015).

The species prefers dense heath and thicket vegetation habitat types. This type of habitat is not present to any great degree at either WMDEC and CBME. The unlikely persistence of this species at its re-introduction points and the lack of suitable habitat make it unlikely that it would occur in the local area at the RLA.

Likely Habitat Use: Long unburnt dense heath or open woodland with dense understorey and ground cover.

Threatening Processes: Loss of habitat. Habitat fragmentation. Inappropriate fire regimes. Predation.

Likelihood: Extremely Unlikely (WMDEC and CBME).

Data Adequacy: Low (WMDEC and CBME). Potentially, passive long-term bioacoustic recording could be employed at CBME if, after discussion with the relevant experts in Noisy Scrub-birds, it could be justified.

Species: *Dasyurus geoffroii*, chuditch

Status: VU, S3

Description: The chuditch has suffered a substantial decline in its distribution across Western Australia. Its original distribution extended over much of Australia including arid and semi-arid zones but did not seem to extend east of the dividing range in eastern Australia. The decline resulted from the clearing and fragmentation of habitat, and the introduction of herbivores and predators.

One of the confounding factors in the conservation of this species is the impact of introduced predators in forests. The chuditch is a wide ranging species with relatively large home ranges and high dispersal rates (Serena & Soderquist 1989) The control of predators, specifically the fox (*Vulpes vulpes*), has proven beneficial to the chuditch (Marlow et al. 2015). However, cat (*Felis catus*) will depredate on chuditch (Glen et al. 2009) and control measures for this introduced predator are not as effective at this time. Pig (*Sus scrofa*) can alter habitats substantially through increased erosion, depredation, acting as disease vectors (Li et al. 2010; Mitchell et al. 2008; Taylor, Leung & Gordon 2011) and reduce the ability of these areas to support chuditch.

The species is relatively common in forests in the WMDEC and between the CBME and WMDEC (Figure 16). It has been recorded in NBGM, SAD, MAR, OBC and the QIN since surveys began in 1982. The fauna monitoring at SAD indicates a drop in the capture rate of chuditch at the mine possibly resulting from the continued loss and fragmentation of forested habitats and the lack of sufficiently mature rehabilitated areas to support this species (Table 17). The SAD mine site does undertake fox baiting to control predator populations, which would benefit the chuditch population. However, survey results confirm cat and pig persistence at SAD.

The chuditch appears to be most abundant at NBGM, likely due to the larger area of contiguous forest habitats present in that section of the WMDEC. The translocation project undertaken in 2016 on the southern boundary of the NBGM resulted in eight individuals captured and translocated to the George Block State Forest (Ninox Wildlife Consulting 2016). One of these individuals was re-captured 14 days after release and very near to its original point of capture which had since been cleared of vegetation (Cannella & Henry 2017). This would suggest a tendency to home range fidelity and an ability to navigate long distances.

A single individual was captured at QIN in 2000-2001 survey but no signs of the chuditch were recorded in the 2017-2018 survey of the same area. Records for areas around the CBME would suggest that the chuditch is not as common although this may also reflect the relatively low level of survey effort. A single individual was recorded at the CBME in 1982 but not in the following survey of the area in 2000-2001 (Figure 17). Monitoring for this species is recommended within the WMDEC and CBME areas.

Table 17 Captures of Chuditch since 1998 by area of capture

	1998	2001	2002	2003	2004	2006	2007	2009	2010	2011	2012	2014	2015	2016	2018
NBGM		15	33							4	15			8[1]	
SAD	3		4	3			1		2			1	2		SC[2]
MAR						1	5				1				
QIN		1													
OBC	13			4	9			5	2						

[1] All Chuditch caught in this survey were translocated to George Block to the south of WMDEC.
[2] A Chuditch scat was identified at one site but no other signs or captures were made.

Likely Habitat Use: All forested and woodland blocks and rehabilitation, especially areas supporting suitable denning resources.

Threatening Processes: Loss of habitat. Habitat fragmentation. Inappropriate fire regimes. Predation.

Likelihood: High, Recorded.

Data Adequacy: High (WMDEC), Low (CBME). Continued monitoring for this species at both sites is recommended.

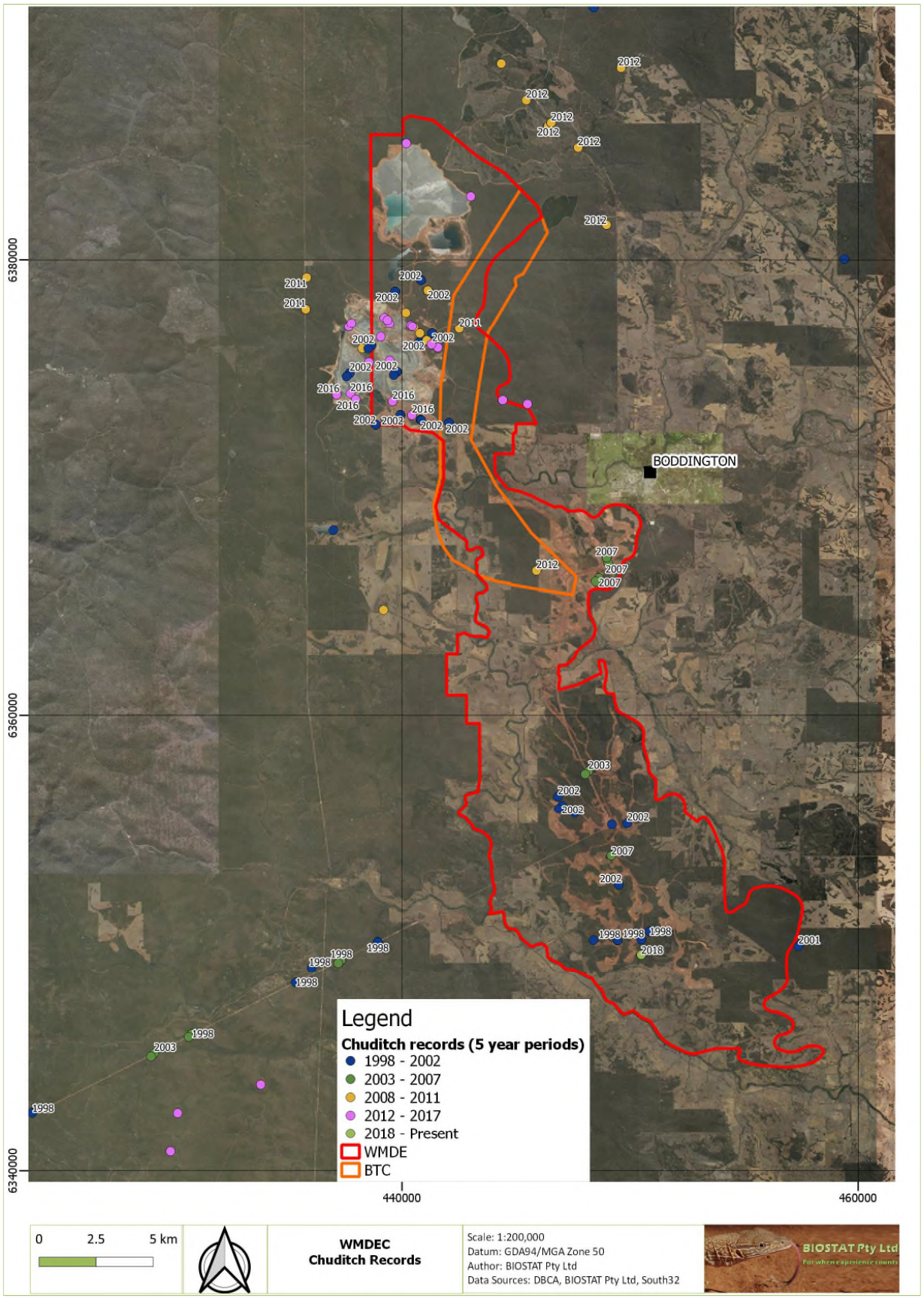

Figure 16 Location of Chuditch observation at WMDEC and OBC in each 5 year period since 1998.

Figure 17 Location of Chuditch observation at CBME in each 5 year period since 1998.

Species: *Phascogale calura*, red-tailed phascogale (kenngoor)

Status: VU, S6

Description: The kenngoor or red-tailed phascogale (*Phascogale calura*) is a small carnivorous/insectivorous Dasyurid marsupial originally found across much of southern Australia. It has declined dramatically and is regarded as vulnerable or threatened for most of its range (Short & Hide 2012). The western population has contracted to less than 1% of its original range and is found in fragmented populations in drier remnant woodlands in the Avon Wheatbelt bioregion but is also known from the Jarrah Forest and extends into the margins of the Mallee and Esperance Plains bioregions.

In Western Australia, this species is often associated with the drier wandoo woodlands with rock sheoak (*Allocasuarina huegeliana*) but is known from a wider range of habitats. It will readily utilise hollows in wandoo as denning and nesting sites but has also been known to inhabit the grass skirts of balga (*Xanthorrhoea* spp.) and hollows in dead stumps and logs (Short, Hide & Stone 2011).

This species was not known from any of the areas surveyed within the WMDEC boundaries until recently. During a biodiversity survey of QIN, 13 kenngoor individuals were captured (Cannella et al. 2018). This represented the first capture of this species on South32 leases since surveys began in 1982. The area in which these individuals were captured were atypical for this species consisting of mosaic of Jarrah/Marri creating a relatively open canopy cover with the occasional Wandoo and stands of Western Sheoak.

The kenngoor appears to be adapted to small remnants which has allowed it to exist throughout its range (Short & Hide 2012; Short, Hide & Stone 2011). It is thought to be an eruptive species, that is, populations quickly growing during periods of high resource availability. Its occurrence in QIN in atypical habitat requires further research to determine the demographics of this species in this interface zone between the wheatbelt region and the northern jarrah forests. Such investigations can identify a greater range of potential habitats suitable for this species that can be incorporated in conservation management. It is highly unlikely that the kenngoor would occur in the more mesic areas of the CBME.

Likely Habitat Use: Likely to be restricted to the eastern portions of WMDEC in mosaic of jarrah/marri, wandoo with western sheoak, also in wandoo dominated woodlands with western sheoak.

Threatening Processes: Loss of habitat. Habitat fragmentation. Inappropriate (frequent) fire regimes. Predation.

Likelihood: High, Recorded (WMDEC), Unlikely (CBME)

Data Adequacy: Further investigations at QIN is highly recommended due to the eruptive nature of this species (WMDEC), Low (CBME)

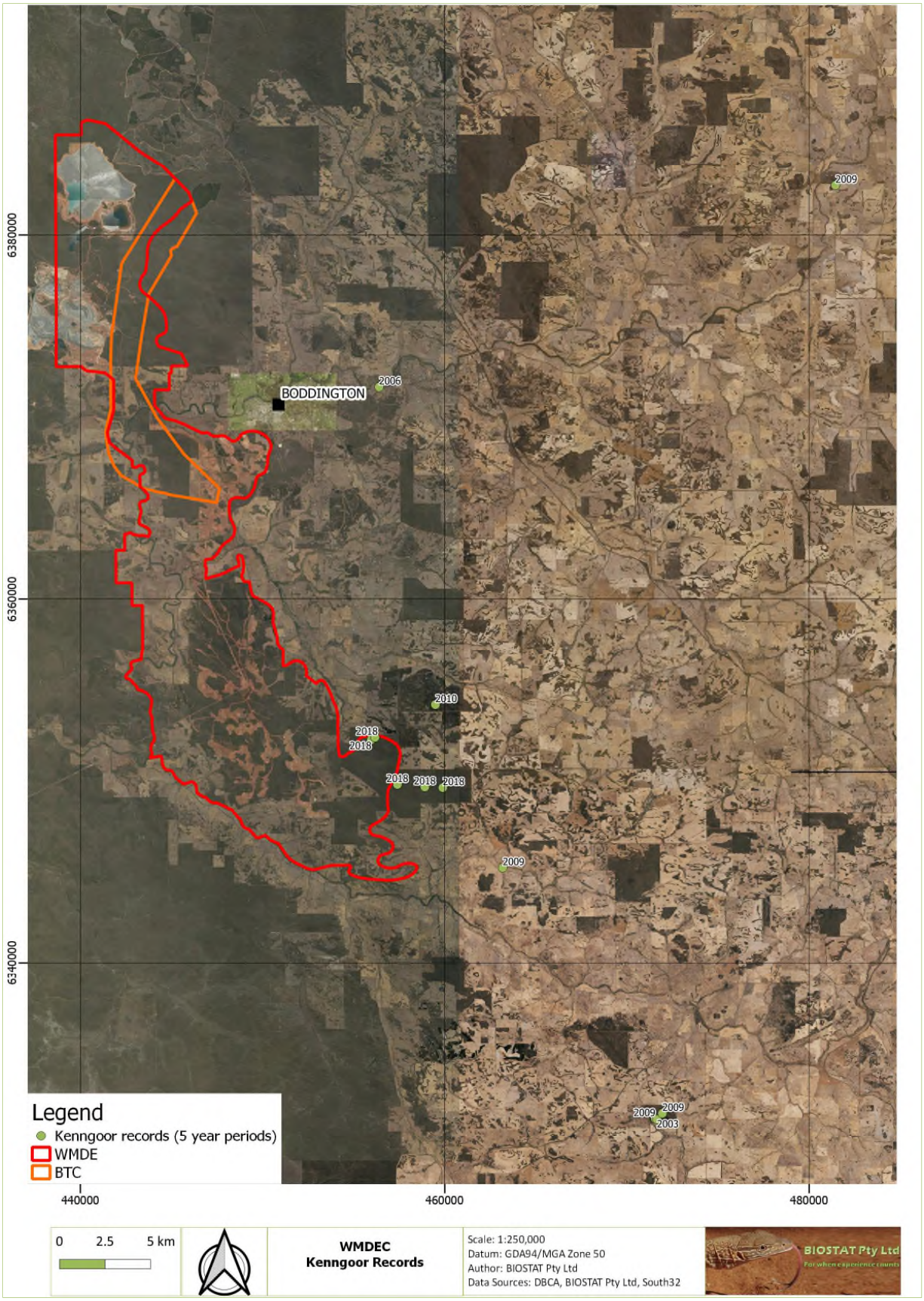

Figure 18 Location of Kenngoor records since 1998.

Species: *Myrmecobius fasciatus*, numbat (walpurti)

Status: EN, S2

Description: The numbat has suffered a high degree of displacement and reduction in population numbers through loss of habitat and the introduction of predators (Woinarski, Burbidge & Harrison 2014).

There are several natural and translocated populations distributed in the south west and wheatbelt region of Western Australia (Western Australian Department of Parks and Wildlife 2017) including Battaling Forest Block (approximately 40km from CBME) and Dryandra (approximately 50m from WMDEC). There have been no records within the WMDEC and CBME boundaries (Figure 19). Records of this species in the Muja State Forest (Batalling Forest Bloc) are the most recent observations date 2015 from a translocated population. The State Forest Block, QIN, supports suitable habitat for this species, however, it has not been recorded in either the 2000-2001 and 2017-2018 surveys. The QIN forest block has not been burned in at least two decades that is likely to benefit this species.

Areas within NBGM, to the east of the residue ponds and east of the open-cut mine, also support suitable habitat for the numbat including habitat of open woodland mosaics of jarrah/marri/wandoo. As with QIN, surveys carried out in these areas in 2003 and 2012, did not record numbats. The presence of suitable habitat within WMDEC tempers the likelihood assessment although this species has not been recorded.

Likely Habitat Use: Will utilise most open woodland and forest habitats with a variety of understory.

Threatening Processes: Loss of habitat. Habitat fragmentation. Inappropriate (frequent) fire regimes. Predation.

Likelihood: Unlikely to Low (WMDEC) in selected areas. Unlikely (CBME).

Data Adequacy: Only historical data available from DBCA records.

Species: *Macrotis lagotis*, bilby (dalgyte)

Status: VU, S3

Description: The range of the bilby has been greatly reduced since the onset of European Settlement. It is historically known primarily from the eastern Darling Range areas, but disappeared soon after European settlement, with its range contracting to most arid and semi-arid interior of Australia. A record of an individual date exists from just east of Shotts in 1910, east of Collie. There are a small number of Bilby sighting around WMDEC with the last record from 1947 (Figure 19). Its historical distribution suggests it was absent from the wetter jarrah and karri (*Eucalyptus diversicolor*) forests with heavy soils, but more prevalent in the coastal plain habitats (Burbidge 2004).

Likely Habitat Use: Will utilise most woodland and forest habitats with a variety of understory and soil types.

Threatening Processes: Loss of habitat. Habitat fragmentation. Inappropriate (frequent) fire regimes. Predation.

Likelihood: Highly Unlikely (WMDEC and CBME).

Data Adequacy: Only historical data available from DBCA records.

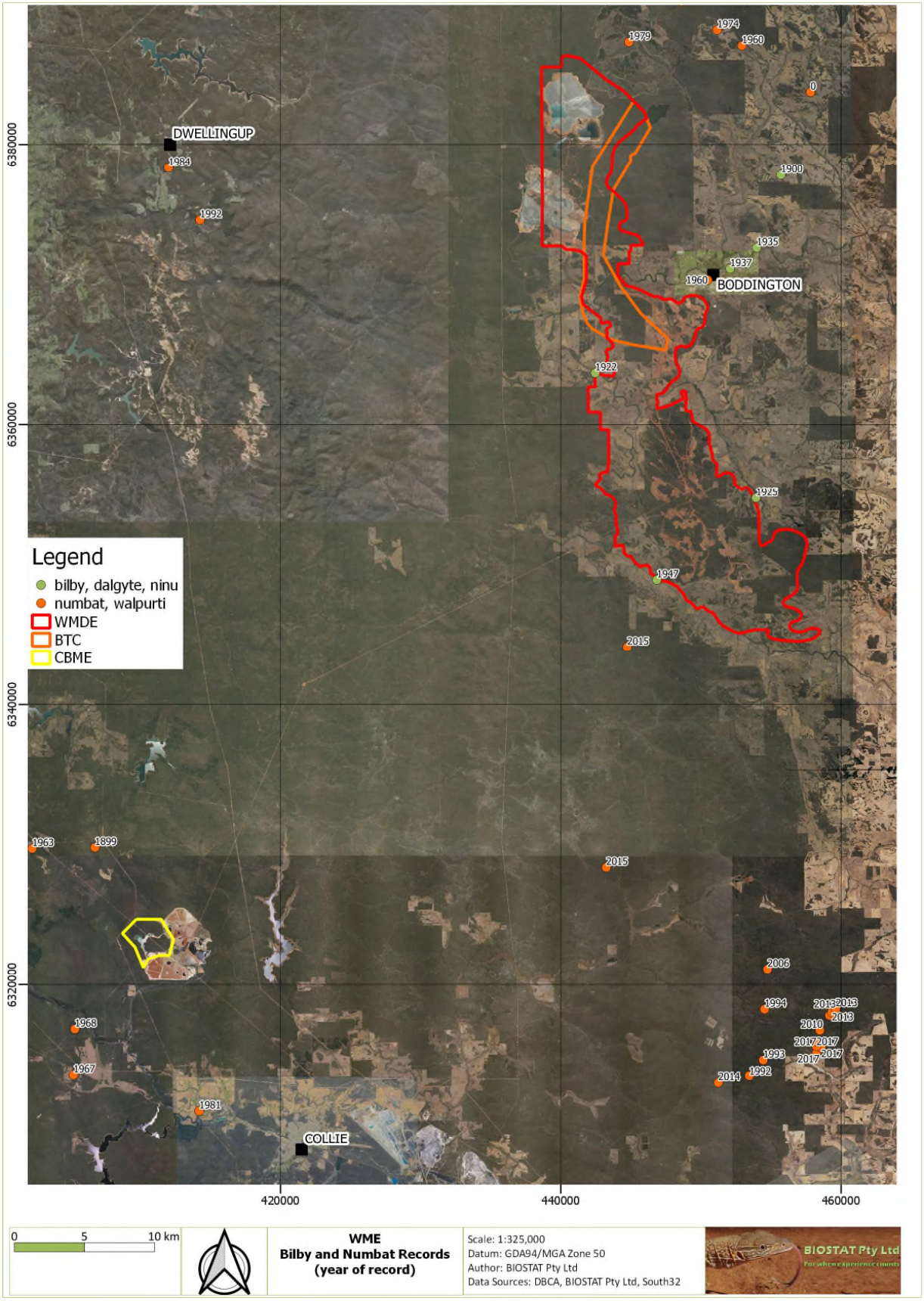

Figure 19 Location and dates of observation for Numbat and Bilby in WME area.

Species: *Pseudocheirus occidentalis*, western ringtail possum (ngwayir)

Status: CR, S1

Description: The western ringtail possum is common in long unburnt remnant of peppermint (*Agonis flexuosa*) and tuart (*Eucalyptus gomphocephala*) woodlands on the coastal plains of the south-west of Western Australia. It has also been recorded in jarrah/marri forests and woodlands, coastal heath, bullich (*Eucalyptus megacarpa*) dominated riparian zones and karri forests (Department of Parks and Wildlife 2014).

The drier forest areas of the eastern section of the Northern Jarrah Forest bioregion is not considered typical habitat for this species. One juvenile was recorded from the NBGM/Boddington area in 1998. Its origins were unclear, and it is thought it may have been unintentionally transported into the Boddington from another area. This species has not been recorded in any of the surveys undertaken in NBGM, SAD, MAR and Quindanning areas from 1982. It is known from the OBC but from areas closer to the RLA (Ninox Wildlife Consulting 2004, 2007a). Some of the valley landforms present along the conveyor may provide more of the mesic habitats preferred by this species although this has not been investigated to any great degree.

There are no records of the western ringtail possum from the survey carried out in the CBME in 2000-2001. There is one record of an individual within the RLA lease boundary. However, the availability of suitable habitat for western ringtail possum in the CBME and surrounding landscape is reflected in the numerous records collected for this species in that area (Figure 20). The most recent records for this species are from 2018 in the Wellington National Park approximately 10km to the south-west of the CBME.

Likely Habitat Use: Will utilise the more mesic woodland and forests especially in the CBME and surrounding area. Specifically, the most likely habitat to be utilised by this species is the blackbutt habitats (BB), mesic and riparian woodland surrounding the freshwater lake at the CBME.

Threatening Processes: Loss of habitat. Habitat fragmentation. Inappropriate (frequent) fire regimes. Predation.

Likelihood: Unlikely (WMDEC). Moderate to High (CBME).

Data Adequacy: Low data adequacy for the CBME, OCL and RLA areas.

Figure 20 Western Ringtail Possum records from CBME.

Species: *Bettongia penicillata ogilbyi*, woylie

Status: EN, S1

Description: This species was once abundant in the south-west region of Western Australia but has declined dramatically since European settlement (Abbott 2008). Its decline has been attributed to the introduction of the fox and disease, but fox control measures have resulted in a slowdown in its decline (Woinarski, Burbidge & Harrison 2014). The woylie is found in a variety of habitats, but long-unburnt tall *Eucalyptus* sp forest and woodland are regarded as one of the key habitats for this species (Yeatman & Groom 2012). It feeds on tubers, bulbs and fungi, often creating rabbit-like diggings in search of its food.

The species is widely distributed in the Jarrah forests but occurs patchily. It is known from the WMDEC and surrounding areas and records for woylie extend to the foothills west of the CBME (Figure 21).

The woylie is a cryptic species that are often difficult to detect effectively. Individuals were trapped from NGBM areas in a general biodiversity survey in 2012 (Ninox Wildlife Consulting 2012d). This species had not been recorded in previous occasions in surveys of similar habitats nor was it recorded in the subsequent translocation trapping project in 2016.

Woylies were recorded in both wandoo woodlands and jarrah/marri habitats to the east of the NBGM residue ponds and mine void. It has not been recorded in the extensive trapping survey effort carried out at SAD, or in surveys at MAR, QIN and OBC. Although suitable habitats exist across the WMDEC, it is likely that only the larger stands of contiguous native forest communities would support this species.

Likely Habitat Use: Known from long-unburnt wandoo dominated woodlands with well-developed understorey at NBGM. Similar long-unburnt woodland occurs at QIN.

Threatening Processes: Loss of habitat. Habitat fragmentation. Inappropriate (frequent) fire regimes. Predation.

Likelihood: High, Recorded (WMDEC). Moderate to High (CBME).

Data Adequacy: Moderate data adequacy for WMDEC area. Low data adequacy for CBME.

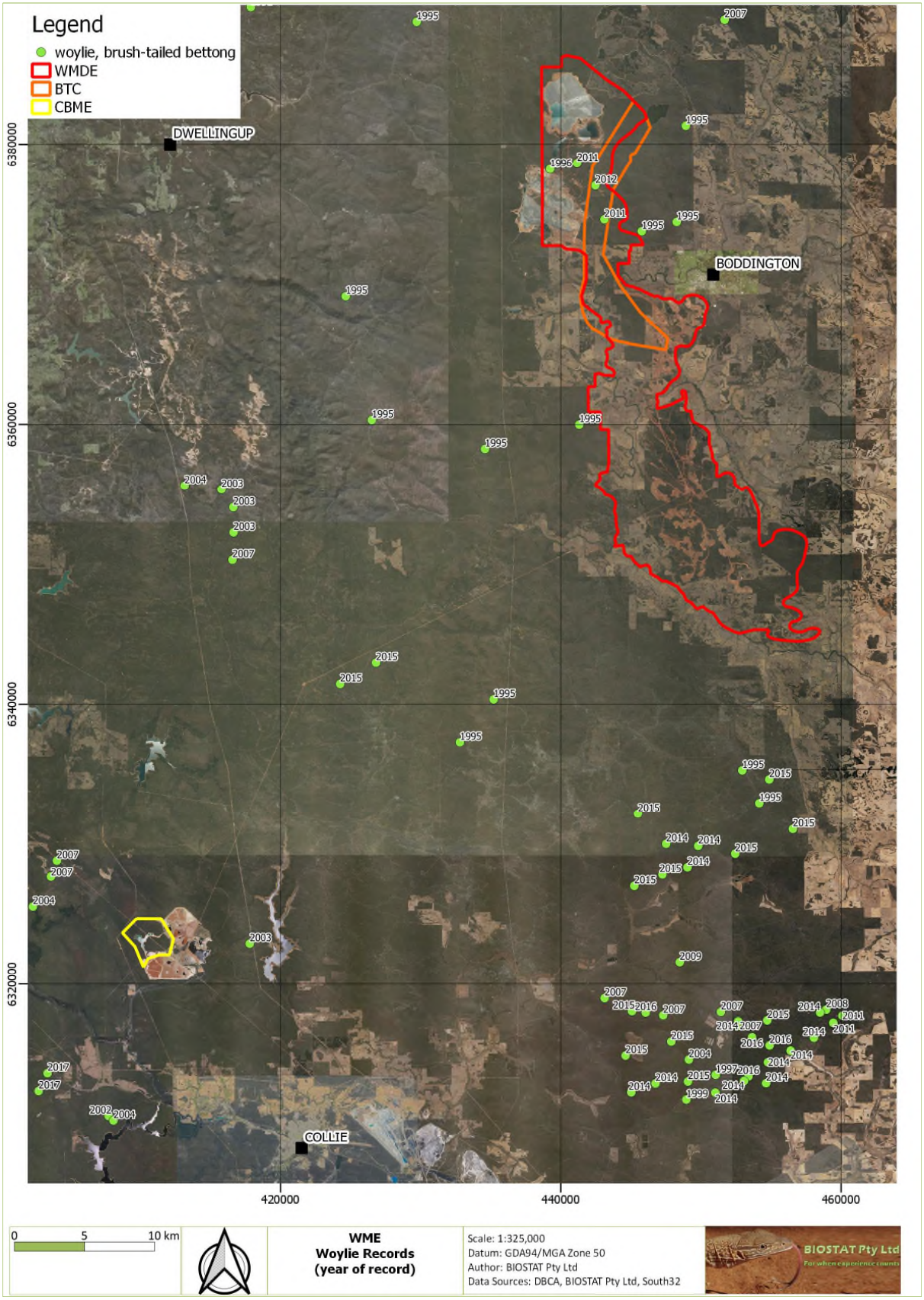

Figure 21 Woylie records in WME.

Species: *Setonix brachyurus*, quokka

Status: VU, S1

Description: The quokka was once very common in the south-west of Western Australia until the arrival of the European settlers. A combination of habitat clearing, hunting and the introduction of predators and stock have decimated its populations on the mainland (Abbott 2008; Burbidge 2004). It prefers swampy habitats within jarrah forests (Hayward et al. 2007; Hayward, de Tores & Banks 2005).

All records for quokka obtained for the WME search are from the more mesic jarrah forest areas along the western Darling Range (Figure 22). As with woylie, quokka are a cryptic species and difficult to survey (Bain, Wayne & Bencini 2014). They have not been recorded at CBME, however road-kill individuals have been recorded along Gastaldo Road, the main access into the RLA.

Likely Habitat Use: Known from long-unburnt mesic forest systems with relatively dense understorey.

Threatening Processes: Loss of habitat. Habitat fragmentation. Inappropriate (frequent) fire regimes. Predation.

Likelihood: Unlikely (WMDEC), High (CBME).

Data Adequacy: Moderate data adequacy for WMDEC area. Low data availability for CBME.

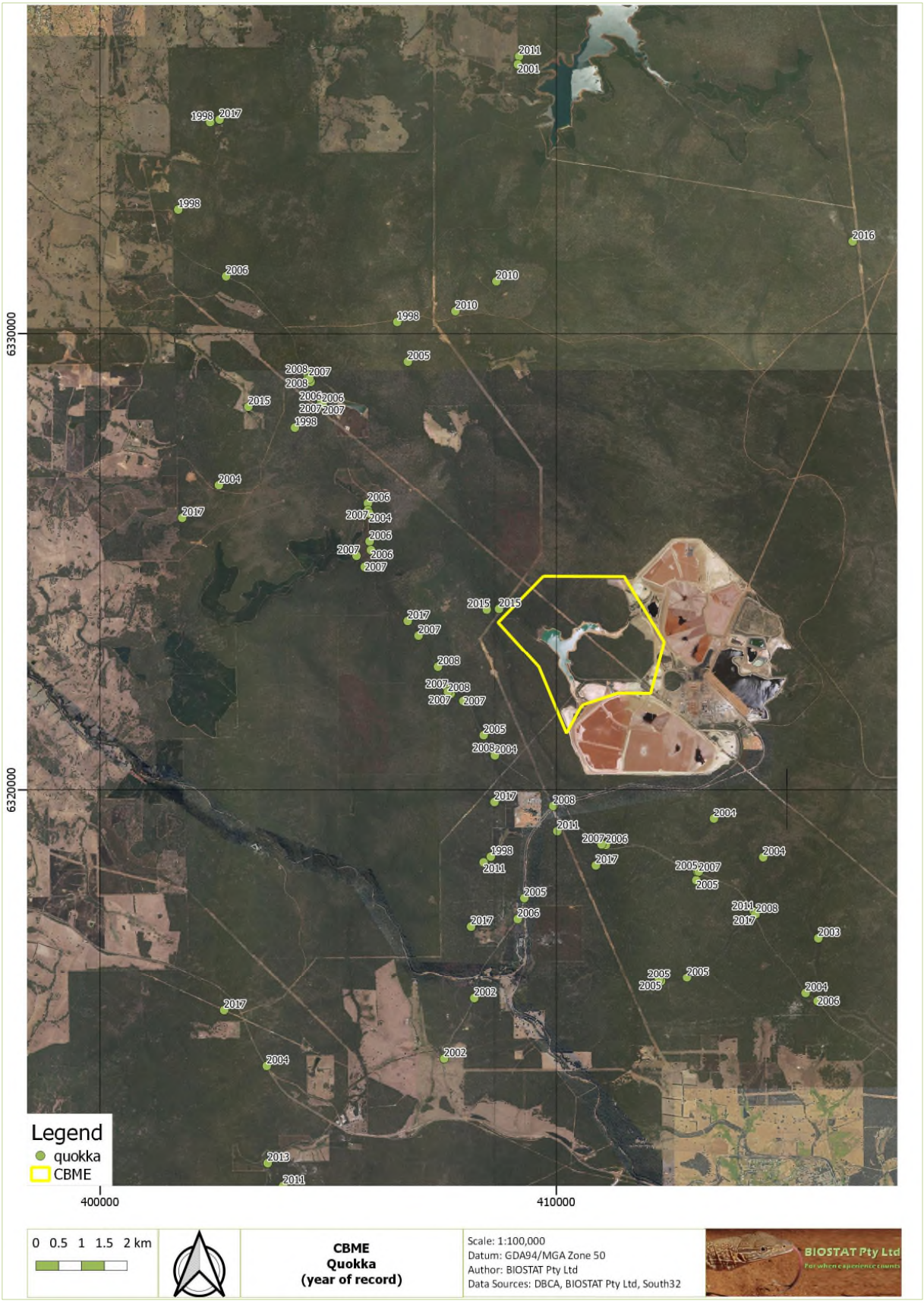

Figure 22 Quokka records in the area surrounding CBME.

7 GENERAL CONCLUSIONS AND RECOMMENDATIONS

This assessment considered a substantial volume of data to cover a very large area for assessment of the proposed WME. The two areas represent different components of the northern jarrah forest biogeographical sub region with the proposed CBME located in the more mesic south-western portion in State forest, and proposed WMDEC to the central east of the subregion in the drier zone within the highly disturbed agricultural region.

There is a large robust data set for fauna and flora for much of the area contained within the proposed WMDEC and relating to mining operations. Much of this data has been collected from the pre-mining planning stages in 1982, through to monitoring programs and biodiversity surveys carried out over time and into the present. The substantial survey effort in the WMDEC has provided significant information on most threatened species that may exist in the area. The data for the CBME is much less, with only the one systematic fauna survey undertaken in the area in 2000-2001. This is recognised as a gap in data that will require further attention.

Much of the data obtained for the proposed WMDEC and CBME is derived from multi-seasonal systematically designed surveys. This high-level data is generally more than is often available for consideration in environmental impact assessment determinations. This level of scientific robustness can provide a relatively higher level of certainty in the impact risk assessment process although this should be tempered with the knowledge that natural systems are both stochastic and dynamic (i.e., pseudo-random and constantly changing).

This assessment has highlighted that there are several species of national environmental significance that occur at the proposed WMDEC and CBME or in proximity to these areas. Their persistence in highly modified environments suggest a level of adaptability to these conditions and landscapes. The scarcity of records for some of these species, quokka and woylie in particular, reflect their cryptic nature but also a need to undertake further investigations to attempt to determine their distribution and biology across the landscapes. Because of their scarcity in the landscape, surveying for these species is inherently difficult, long-term and logistically costly. However, an attempt has been made to determine if further investigations are required for the threatened species of national environmental significance and, where this is appropriate, it has been indicated under the profile for the species. The undertaking could include:

- For such a large area as WMDEC it is difficult to determine habitat values without on-ground assessments. Such an undertaking would have to be planned over a medium-term period with section of the WMDEC surveyed over time focused on habitat values. This habitat quality assessment, carried out in a standardised systematic manner, is useful in developing habitat quality scales for species and thus provide another management tool. This could be extended to areas not yet surveyed i.e., northern NBGM.
- Similarly, certain areas within WMDEC have not been assessed systematically for biodiversity assemblages. These areas could be surveyed as part of information gathering over time as areas within WMDEC are allocated for development.
- Continued monitoring of fauna is also very important aspect of impact management and assessment. Monitoring of rehabilitation has provided insights into fauna recolonization and habitat use. Standardised monitoring can also be a useful tool in assessing impacts of climate change over the long-term.
- The CBME area, although small is part of a larger contiguous block of native forests. However, there is a gap in the data for the area since 2000-2001 survey. This needs to be remedied by a replicate systematic survey of the area prior to development.

The impact of habitat disturbance is almost always immediate and cumulative on any species. The management of such impacts is reliant on the ability to maintain some level of connectivity in the

landscape to retain the fauna assemblages locally. The connectivity in the landscape must be considered in assessing the quality or value of habitats.

Loss of habitat in the proposed WME is not confined to mine expansion and mine operations, as potential future clearing for agricultural or agroforestry purposes would also contribute to the loss. In a highly fragmented environment, a case can be made that any loss of habitat will have a disproportionate impact on the ecological viability of the area. Therefore, it is not so much a matter of the specific area of habitats lost but the context of the habitats within the landscape. For example, the loss of a few hectares of native remnant habitat may normally not be of concern, but if those few hectares provide a high level of linkage in the fragmented landscape, their ecological value and therefore their loss would be much greater. Within a highly fragmented landscape such as assessed in this report, a major imperative is habitat enhancement as a means of replacement or addition to the existing resource pool of habitats.

Another issue to be incorporated in assessments is the impact of climate change on the ecological processes at the local and regional scale. The exact nature of these changes is difficult to determine, but the changes are likely to manifest themselves over a relatively long period, that may parallel and will exceed the life of the mine. These changes have the potential to alter the long-term viability and sustainability of remnant habitats within the areas and will require a heightened level of adaptability in the management of landscapes.

Fauna species are not constrained by the artificial boundaries such as administrative boundaries or lease boundaries. They will be, however, impacted by “hard” boundaries that are often associated with clearing (either for mining, development or agricultural purposes). The assessment of impacts on the fauna assemblages requires attention, not only to the level of clearing of fauna habitat within the land parcel, but also to the cumulative impact resulting from changes that will or are likely to occur in adjacent areas.

The greater landscape provides suitable habitat for a large variety of volant and non-volant vertebrate fauna. Most have adapted to the fragmented environment and have been recorded in systematic surveys and opportunistically. Breeding records for threatened or listed species within the area include: Carnaby’s black-cockatoo, Baudin’s black-cockatoo, forest red-tailed black-cockatoo, kenngoor and chuditch. The reason many of these species have become conservation significant is because of habitat loss. Future loss would be expected to exacerbate overall ecological viability of these areas.

There are strategies which may be implemented which would mitigate and alleviate the pressures of future developments, and still allow for functional and sustainable diversity of native fauna and fauna habitats within the area. For example, this can include designating permanent refuge areas, progressive and overlapping enhancements of rehabilitation to encourage the return of fauna, management of introduced predators and herbivores, and the enhancement of remnants within agricultural lands to act as refuge and corridors for fauna.

The number of stakeholders covered by the proposed WME complicates the potential to avoid, mitigate and manage impacts and future conservation and rehabilitation strategies. The management of the conservation resources within the WME will require the collaboration of all stakeholders to ensure the sustainability of any plans and actions. Some of the strategies presented here will fall outside the direct scope of South32 control. Some of these measures would require a collaborative approach by South32, the community, NGO’s, local and State governments to achieve them. The benefits of such actions could result, not only in positive ecological outcomes, but also in greater cooperation between stakeholders.

Efforts in mitigation and management will need to incorporate a monitoring program to determine the quality and efficacy of progress. This is a critical component as the monitoring can highlight positive aspects of the landscape management plan but also determine if there are issues with the effective delivery of outcomes that need rectification or modification. Such monitoring programs can be

designed effectively by experienced ecologists and be implemented in the field by community science groups and NGOs as well as professional ecologists. The key to the monitoring program will be coordination with a focus on design, collection, and outcomes.

Rehabilitation can restore some habitat but not within 30 years or more as has been illustrated in studies on mine rehabilitation programs (BIOSTAT Pty Ltd 2015b; Nichols & Grant 2007; Nichols & Nichols 2003; Nichols & Watkins 1984). This lag period will result in a fall in biodiversity with some species locally extirpated if loss of habitat occurs too rapidly. To measure changes in biodiversity, it is important to establish a long-term monitoring program that can assess impacts not only on fauna of conservation significance but other fauna. The focus on biodiversity rather than just specific species is mandatory as all native flora and fauna species make up the habitat and its qualities that support the species of conservation significance.

In conclusion, the overriding issues in the fauna assessment of the proposed WME are:

1. There is adequate robust information to allow more certainty in assessing risk to threatened fauna at the proposed WMDEC.
2. Biodiversity information from CBME will need to be updated. It is recommended that a trapping survey, like the 2000-2001 general biodiversity survey, covering all terrestrial vertebrate fauna groups be undertaken, possibly using the same site locations. Targeted surveys are not designed to determine spatial and seasonal variation in species and would prove inadequate to determine the ecosystem functions of the area. However, targeted searches as part of the biodiversity survey could be incorporated to provide additional information.
3. It is likely the project will be referred on the evidence of information on all three species of black-cockatoo.
4. Certain listed species will need continued monitoring including all three black-cockatoo species, chuditch, woylie, kenngoor, and western ringtail possum. These monitoring programs can be incorporated as part of longer-term management strategies. Targeted populations studies are also recommended as part of the monitoring.
5. Connectivity in a fragmented landscape is critical for the longer-term sustainability of ecosystems. This may require active establishment and maintenance of corridors or protection of existing corridor systems.
6. A broader approach is required to undertake management of landscapes at both sites in the proposed WME. Collaboration with all stakeholders would be required to ensure effective ecological management of the landscape.
7. For highest value outcomes enhancement of habitats should commence early in the planning phase to ensure that they are advanced enough to provide the ecological function of the areas they are to replace.
8. Fauna monitoring is a critical component for collating detailed ecological data that will allow for the avoidance, mitigation and management of impacts on threatened species, ecosystems and other fauna within both areas.
9. General systematic biodiversity surveys are recommended for areas of native forests that have not been surveyed previously to obtain a better understanding of the distribution of fauna in the landscape, e.g., areas in the northern section of NBGM.
10. Climate change is an important consideration in the maintenance and management of ecosystems for the conservation of threatened fauna.

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Appendix 1. Protected Matters Search Tool report

Australian Government
Department of the Environment and Energy

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

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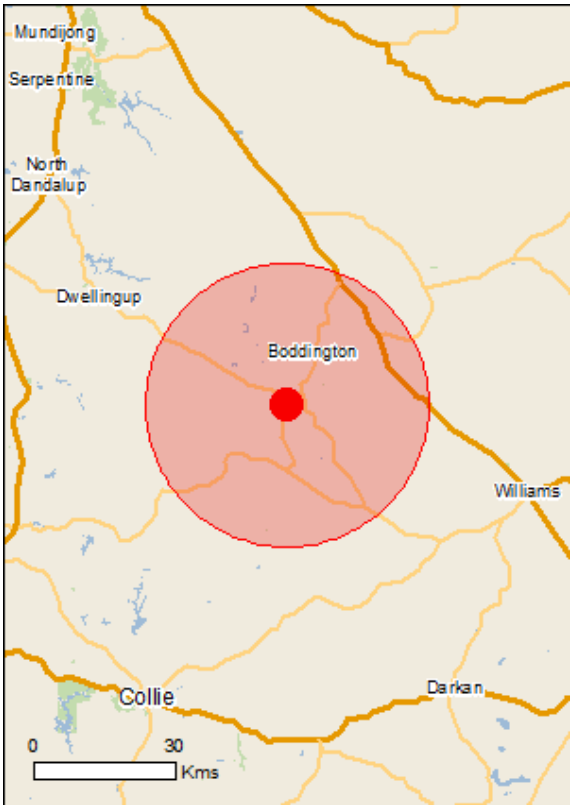

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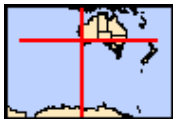

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	1
Listed Threatened Species:	24
Listed Migratory Species:	8

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	15
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	4
Regional Forest Agreements:	1
Invasive Species:	23
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Peel-yalgorup system	30 - 40km upstream

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Eucalypt Woodlands of the Western Australian Wheatbelt	Critically Endangered	Community may occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Atrichornis clamosus Noisy Scrub-bird, Tjimiluk [654]	Endangered	Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat known to occur within area
Calyptorhynchus baudinii Baudin's Cockatoo, Long-billed Black-Cockatoo [769]	Endangered	Roosting known to occur within area
Calyptorhynchus latirostris Carnaby's Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Species or species habitat known to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat known to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Mammals		
Bettongia penicillata ogilbyi Woylie [66844]	Endangered	Species or species habitat known to occur within area
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat known to occur within area

Name	Status	Type of Presence
Myrmecobius fasciatus Numbat [294]	Endangered	Translocated population known to occur within area
Phascogale calura Red-tailed Phascogale, Red-tailed Wambenger, Kenngoor [316]	Vulnerable	Species or species habitat known to occur within area
Pseudocheirus occidentalis Western Ringtail Possum, Ngwayir, Womp, Woder, Ngoor, Ngoolangit [25911]	Critically Endangered	Species or species habitat may occur within area
Setonix brachyurus Quokka [229]	Vulnerable	Species or species habitat likely to occur within area
Other		
Westralunio carteri Carter's Freshwater Mussel, Freshwater Mussel [86266]	Vulnerable	Species or species habitat known to occur within area
Plants		
Anthocercis gracilis Slender Tailflower [11103]	Vulnerable	Species or species habitat may occur within area
Caladenia hopperiana Quindanning Spider Orchid, Boddington Spider Orchid [88195]	Endangered	Species or species habitat known to occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat likely to occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat may occur within area
Eleocharis keigheryi Keighery's Eleocharis [64893]	Vulnerable	Species or species habitat may occur within area
Goodenia arthrotricha [12448]	Endangered	Species or species habitat known to occur within area
Lasiopetalum pterocarpum Wing-fruited Lasiopetalum [64922]	Endangered	Species or species habitat may occur within area
Pultenaea pauciflora Narrogin Pea [14013]	Vulnerable	Species or species habitat known to occur within area
Thelymitra dedmaniarum Cinnamon Sun Orchid [65105]	Endangered	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat likely to occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat likely to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area

Name	Threatened	Type of Presence
Chrysococcyx osculans Black-eared Cuckoo [705]		Species or species habitat likely to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat may occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat may occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Lane Poole Reserve	WA
Lane Poole Reserve	WA
Mooradung	WA
Unnamed WA04596	WA

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
South West WA RFA	Western Australia

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur

Name	Status	Type of Presence
		within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Mammals		
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Feral deer Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Pinus radiata Radiata Pine Monterey Pine, Insignis Pine, Wilding		Species or species

Name	Status	Type of Presence
Pine [20780]		habitat may occur within area
Rubus fruticosus aggregate Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Solanum elaeagnifolium Silver Nightshade, Silver-leaved Nightshade, White Horse Nettle, Silver-leaf Nightshade, Tomato Weed, White Nightshade, Bull-nettle, Prairie-berry, Satansbos, Silver-leaf Bitter-apple, Silverleaf-nettle, Trompillo [12323]		Species or species habitat likely to occur within area
Tamarix aphylla Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-32.88694 116.42205

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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EPBC Act Protected Matters Report

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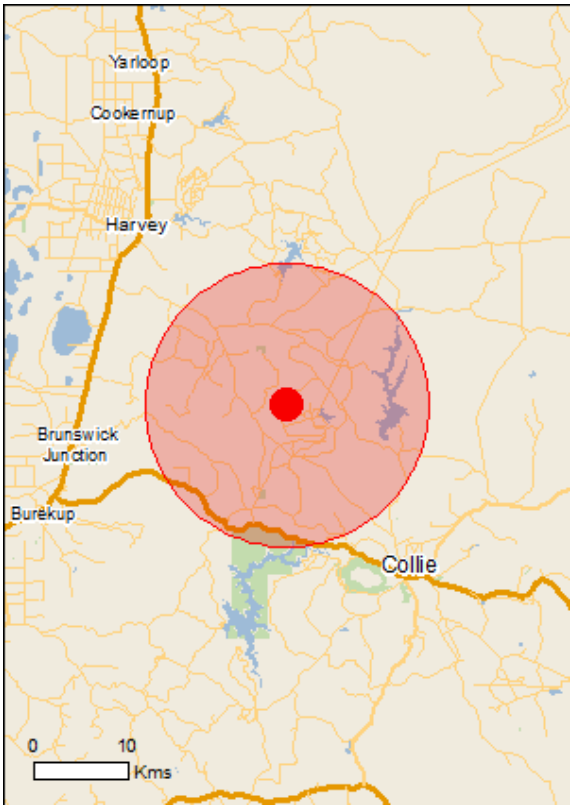

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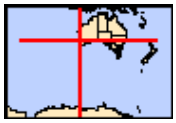
Coordinates
Buffer: 15.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	1
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	1
Listed Threatened Species:	17
Listed Migratory Species:	8

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	14
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	3
Regional Forest Agreements:	1
Invasive Species:	24
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Peel-yalgorup system	20 - 30km upstream

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Banksia Woodlands of the Swan Coastal Plain ecological community	Endangered	Community may occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat known to occur within area
Calyptorhynchus baudinii Baudin's Cockatoo, Long-billed Black-Cockatoo [769]	Endangered	Species or species habitat known to occur within area
Calyptorhynchus latirostris Carnaby's Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Species or species habitat known to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Fish		
Nannatherina balstoni Balston's Pygmy Perch [66698]	Vulnerable	Species or species habitat likely to occur within area
Mammals		
Bettongia penicillata ogilbyi Woylie [66844]	Endangered	Species or species

Name	Status	Type of Presence
		habitat known to occur within area
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat known to occur within area
Pseudocheirus occidentalis Western Ringtail Possum, Ngwayir, Womp, Woder, Ngoor, Ngoolangit [25911]	Critically Endangered	Species or species habitat known to occur within area
Setonix brachyurus Quokka [229]	Vulnerable	Species or species habitat known to occur within area
Other		
Westralunio carteri Carter's Freshwater Mussel, Freshwater Mussel [86266]	Vulnerable	Species or species habitat known to occur within area
Plants		
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat known to occur within area
Eleocharis keigheryi Keighery's Eleocharis [64893]	Vulnerable	Species or species habitat may occur within area
Grevillea rara Rare Grevillea [64911]	Endangered	Species or species habitat likely to occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Migratory Terrestrial Species		
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species		[Resource Information]
* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.		
Name	Threatened	Type of Presence
Birds		
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat may occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Breeding known to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat may occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Falls Brook	WA
Wellington	WA
Westralia	WA

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

Name	State
South West WA RFA	Western Australia

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Anas platyrhynchos Mallard [974]		Species or species habitat likely to occur within area
Columba livia Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia chinensis Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Mammals		
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Feral deer		
Feral deer species in Australia [85733]		Species or species habitat likely to occur within area
Mus musculus		
House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus		
Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus rattus		
Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Sus scrofa		
Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes		
Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Anredera cordifolia		
Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus asparagoides		
Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Chrysanthemoides monilifera		
Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Cytisus scoparius		
Broom, English Broom, Scotch Broom, Common Broom, Scottish Broom, Spanish Broom [5934]		Species or species habitat likely to occur within area
Genista linifolia		
Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana		
Broom [67538]		Species or species habitat may occur within area
Lycium ferocissimum		
African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area
Pinus radiata		
Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate		
Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii		
Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-33.22539 116.04066

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix 2. Vegetation Community and Fauna Habitat key.

Vegetation Community Code	Vegetation Community Code Description	Fauna Habitat Code	Fauna Habitat Description	General Fauna Type
CQ	Open Forest of *Eucalyptus marginata* - *Corymbia calophylla* - *Eucalyptus patens* to Open Woodland of *Melaleuca preissiana* on lower slopes with mixed understorey species, including *Trymalium odoratissimum*, *Taxandria linearifolia* and *Astartea scoparia* along the edges of the deeper incised valleys near creek-lines with moist loamy soils.	BB	Blackbutt woodlands on lower slopes	Riparian/Wetland and associated communities
CW	Woodland to Open Forest of *Eucalyptus patens* - *Corymbia calophylla* - *Banksia littoralis* with dense *Taxandria linearifolia* and *Astartea scoparia* in the understorey on creek-lines and water-courses with loamy soils.	BB		
L0	Open woodland of *Eucalyptus patens* with some *Eucalyptus wandoo* over *Xanthorrhoea preissii*, *Macrozamia riedlei*, *Trymalium ledifolium*, *Acacia saligna* and *Hakea prostrata* on clay and clay loam soils on lower slopes.	BB		
LG	Open woodland of *Eucalyptus patens* and *Eucalyptus wandoo* over *Hypocalymma angustifolium*, *Xanthorrhoea preissii*, *Grevillea bipinnatifida*, *Allocasuarina humilis* and *Babingtonia camphorosmae* over herbs and sedges on clay-loams on seasonally moister lower slopes underlain by outcrops.	BB		
Q0	Open Forest of *Eucalyptus marginata* - *Corymbia calophylla* - *Eucalyptus patens* with mixed understorey species, including *Trymalium floribundum*, *Acacia extensa* and *Phyllanthus calycinus* on loam soils on lower slopes.	BB		
W0	Open Forest of *Eucalyptus marginata* - *Eucalyptus patens* - *Corymbia calophylla* on lower slopes with mixed low understorey species, including *Acacia extensa* and *Hypocalymma angustifolium* on lower slopes with fertile loamy soils.	BB		
AY/D	Mosaic of AY and D	FD	Mosaic of marri/jarrah on lower slopes and Flooded Gum riparian communities	
AC	Open woodland of *Eucalyptus wandoo* and *Eucalyptus rudis* over *Juncus pallidus*, *Astartea scoparia*, *Taxandria linearifolia* and *Lepidosperma tetraquetrum* over herbs on clay loams in seasonally wet valley floors.	FG	Flooded gum woodlands riparian community	
AD	Low open woodland of *Eucalyptus rudis* and *Eucalyptus marginata* over *Banksia littoralis*, *Hakea prostrata* and *Pericalymma ellipticum* over low shrubs and herbs on leached sands over sandy-gravel on lower slopes.	FG		
AX	Open woodland of *Eucalyptus rudis* over *Acacia saligna*, *Melaleuca incana* subsp. *incana* and *Hypocalymma angustifolium* on clay-loams on valley floors.	FG		
AY	Open woodland of *Eucalyptus rudis* and *Eucalyptus wandoo* over *Acacia saligna*, *Hakea prostrata* and *Hypocalymma angustifolium* on clay-loams on valley floors.	FG		
B0	Open woodland of *Eucalyptus marginata* and *Corymbia calophylla* over *Mesomelaena tetragona*, *Adenanthos obovatus* and *Babingtonia camphorosmae* on lower sandier soils on fringes of swamps and valley floors.	JS	Jarrah/marri valley floors/swamps	

Vegetation Community Code	Vegetation Community Code Description	Fauna Habitat Code	Fauna Habitat Description	General Fauna Type
A0	Tall shrubland of *Melaleuca lateritia*, *Hakea varia*, *Melaleuca viminea* and *Melaleuca incana* subsp. *incana* on clay-loams in seasonally wet valley floors.	MS	Melaleuca shrublands on seasonally wet valley floors	
A1	Mixed tall shrubland of *Melaleuca viminea*, *Melaleuca lateritia*, *Taxandria linearifolia*, *Astartea scoparia* over *Baumea juncea* and *Lepidosperma tetraquetrum* with occasional patches of *Banksia littoralis* and *Melaleuca rhaphiophylla* over low herbs on seasonally water-logged clays and clay loams on valley floors.	MS		
A2	Low open woodland of *Melaleuca rhaphiophylla* over *Astartea scoparia* and low herbs on seasonally water-logged clays and clay loams in seasonally wet valley floors.	MW	Flooded gum/melaleuca shrublands on seasonally wet valley floors	
A3	Open woodland of *Eucalyptus rudis*, Eucalyptus patens and *Eucalyptus wandoo* over *Melaleuca lateritia*, *Hakea varia*, *Taxandria linearifolia* and *Hypocalymma angustifolium* over herbs and sedges on clay-loams in seasonally wetter valley floors.	MW		
D0	Open forest of *Corymbia calophylla* and *Eucalyptus marginata* over *Hakea lissocarpha*, *Macrozamia riedlei*, *Acacia alata*, *Babingtonia camphorosmae*, *Hypocalymma angustifolium* and *Phyllanthus calycinus* on clay-loams on lower slopes.	DL	Marri/jarrah on lower slopes	Jarrah/marri communities
DG	Open forest of *Corymbia calophylla* and *Eucalyptus marginata* over *Hakea lissocarpha*, Macrozamia riedlei, *Pericalymma ellipticum*, *Grevillea bipinnatifida*, *Allocasuarina humilis*, *Acacia alata*, *Babingtonia camphorosmae*, *Hypocalymma angustifolium* and *Phyllanthus calycinus* on clay-loams on lower slopes with localized patches of outcropping.	DL		
SW	Open forest of *Eucalyptus marginata* and *Corymbia calophylla* over *Hypocalymma angustifolium*, *Babingtonia camphorosmae*, *Acacia celastrifolia*, *Hovea chorizemifolia*, *Daviesia preissii*, *Leucopogon capitellatus* and *Styphelia tenuiflora* on seasonally moister sandy-gravels on slopes.	DL		
Y0	Open woodland of *Eucalyptus wandoo* over Gompholobium marginatum, *Acacia nervosa*, *Babingtonia camphorosmae*, *Hypocalymma angustifolium*, Macrozamia riedlei, *Phyllanthus calycinus* and *Gastrolobium calycinum* on clay and clay-loam soils on lower slopes.	Dam		
P0	Open forest of *Eucalyptus marginata* and *Allocasuarina fraseriana* with admixtures of *Corymbia calophylla* and *Banksia grandis* over *Lasiopetalum cardiophyllum* (P4), *Lasiopetalum floribundum*, *Lechenaultia biloba* and *Ptilotus drummondii* var. *drummondii* on sandy gravels on slopes and ridges.	JC	Jarrah/marri/sheoak woodlands on slopes and ridges	
PS	Open forest of *Allocasuarina fraseriana*, *Eucalyptus marginata*, *Corymbia calophylla* and *Banksia grandis* over *Adenanthos barbiger*, *Leucopogon capitellatus* on gravels and sandy gravels on slopes and ridges.	JC		
PW	Open forest of *Allocasuarina fraseriana*, *Eucalyptus marginata*, *Corymbia calophylla*, *Banksia grandis* with scattered understorey, including *Adenanthos barbiger*, *Leucopogon capitellatus* and *Hypocalymma angustifolium* on seasonally moister and sandy gravels on slopes.	JC		
S0	Open forest of *Eucalyptus marginata* and *Corymbia calophylla* with admixtures of *Allocasuarina fraseriana*, *Banksia grandis* and *Persoonia longifolia* over *Acacia celastrifolia*, *Hovea chorizemifolia*, *Daviesia preissii*, *Leucopogon capitellatus* and *Styphelia tenuiflora* on sandy-gravels on slopes and ridges. Open Forest of *Eucalyptus marginata - Banksia grandis - Allocasuarina fraseriana* with scattered understorey, including	JC		

Vegetation Community Code	Vegetation Community Code Description	Fauna Habitat Code	Fauna Habitat Description	General Fauna Type
	Adenanthos barbiger, *Leucopogon capitellatus* and *Styphelia tenuiflora* on mid to upper slopes of undulating hills with gravelly soils.			
SP	Open forest of *Eucalyptus marginata*, *Corymbia calophylla* and *Allocasuarina fraseriana* with admixtures of *Banksia grandis* over *Lasiopetalum cardiophyllum*, *Acacia celastrifolia*, *Styphelia tenuiflora*, *Daviesia decurrens* and *Trymalium ledifolium* on sandy-gravel to gravel soils on slopes and ridges. Open Forest of *Allocasuarina fraseriana - Eucalyptus marginata - Banksia grandis* with scattered understorey, including *Adenanthos barbiger* and *Leucopogon capitellatus* on mid to upper slopes of undulating hills with sandy-gravelly soils.	JC		
ST	Open forest of *Eucalyptus marginata* and *Corymbia calophylla* with admixtures of *Allocasuarina fraseriana*, *Persoonia longifolia* and *Banksia grandis* over *Stylidium dichotomum*, *Acacia urophylla*, *Acacia celastrifolia*, *Leucopogon verticillatus*, *Clematis pubescens* and *Leucopogon capitellatus* on sandy-loam gravel soils on slopes and ridges.	JC		
H0	Open forest to woodland of *Eucalyptus marginata* and *Corymbia calophylla* over *Petrophile striata*, *Daviesia decurrens*, *Daviesia longifolia* and *Daviesia rhombifolia* on sandy loam to sandy gravels on slopes and ridges.	JM	Jarrah/marri woodlands on slopes	
H1	Open forest to woodland of *Eucalyptus marginata* and *Corymbia calophylla* over *Petrophile striata*, *Daviesia decurrens* and *Daviesia longifolia* on sandy-gravel soils of slopes and less undulating hills.	JM		
H2	Open forest to woodland of *Eucalyptus marginata* and *Corymbia calophylla* with occasional admixtures of *Banksia grandis* and *Persoonia longifolia* over *Acacia celastrifolia*, *Daviesia preissii*, *Leucopogon capitellatus* and *Styphelia tenuiflora* on gravel and sandy-gravel soils of slopes and less undulating hills.	JM		
HG	Open forest to woodland of *Eucalyptus marginata* and *Corymbia calophylla* over *Petrophile striata*, *Lepidosperma squamatum*, *Styphelia tenuiflora*, *Daviesia preissii*, *Daviesia decurrens*. *Grevillea bipinnatifida*, *Allocasuarina humilis* and *Hakea undulata* on shallower sandy-gravel soils over granites or secondary laterisation areas on slopes and less undulating hills.	JM		
J0	Open woodland of *Eucalyptus marginata* and *Corymbia calophylla* over *Conospermum stoechadis*, *Patersonia rudis* and *Babingtonia camphorosmae* on sandier soils on lower to mid slopes.	JM		
O0	Open forest to woodland of *Eucalyptus marginata* and *Corymbia calophylla* over *Daviesia decurrens*, *Daviesia preissii* and *Bossiaea ornata* on sandy-gravels on slopes.	JM		
R0	Open woodland of *Eucalyptus marginata* and *Corymbia calophylla* over *Trymalium ledifolium*, *Phyllanthus calycinus* and *Hypocalymma angustifolium* on sandy-gravels associated with nearby shallow outcropping.	JM		
T0	Open Forest of *Eucalyptus marginata* ? *Corymbia calophylla* with scattered understorey, including *Leucopogon verticillatus*, *Pteridium esculentum*, *Clematis pubescens* and *Bossiaea aquifolium* subsp. *aquifolium* on sandy-loam gravelly soils on slopes and ridges.	JM		
TS	Open Forest of *Eucalyptus marginata* ? *Corymbia calophylla* ? *Banksia grandis* with scattered understorey, including *Leucopogon verticillatus*, *Pteridium esculentum*, *Clematis pubescens* and *Bossiaea aquifolium* subsp. *aquifolium* on sandy-loam gravelly to gravelly soils.	JM		

Vegetation Community Code	Vegetation Community Code Description	Fauna Habitat Code	Fauna Habitat Description	General Fauna Type
Z0	Open forest of *Eucalyptus marginata* and *Corymbia calophylla* over *Macrozamia riedlei*, *Xanthorrhoea preissi*i, *Hakea lissocarpha* and *Phyllanthus calycinus* on sandy-loam to sandy-loam gravel soils on slopes.	JM		
G4	Open scrub and tall shrubland of *Hakea trifurcata* and *Hakea undulata* with admixtures of mallee species including *Eucalyptus latens* and *Eucalyptus aspera* on clay to clay-loam soils over outcrops on slopes.	ML	Low *Eucalyptus* woodland over low shrubs	Mallee woodlands
G5	Low woodland of Eucalypt mallee species including *Eucalyptus aspersa*, *Eucalyptus latens*, *Eucalyptus longicornis* and Eucalyptus *drummondii* with occasional *Eucalyptus wandoo* over low shrubs of *Allocasuarina humilis*, *Hakea incrassata*, *Synaphea damopsis* and herbs on clay loams and sandy-loams on slopes.	ML		
M0	Open woodland of *Eucalyptus wandoo* over *Trymalium ledifolium*, *Macrozamia riedlei* and *Hakea lissocarpha* on clay loams with some gravel on mid to upper slopes and ridges.	WO	Wandoo woodlands	Wandoo woodlands
M2	Woodland to open woodland of *Eucalyptus accedens*, *Eucalyptus wandoo*, *Eucalyptus marginata*, *Corymbia calophylla* over *Hakea lissocarpha*, *Macrozamia riedlei*, *Banksia squarrosa* subsp. *squarrosa*, *Hypocalymma angustifolium*, *Babingtonia camphorosmae*, *Grevillea bipinnatifida* and *Allocasuarina humilis* on clay-loams over shallow granites on mid to upper slopes.	WO		
MG	Open woodland of *Eucalyptus wandoo* over *Trymalium ledifolium*, *Macrozamia riedlei*, *Pericalymma ellipticum*, *Hypocalymma angustifolium*, *Grevillea bipinnatifida*, *Allocasuarina humilis* and *Hakea lissocarpha* on clay-loams over shallow granite on mid to upper slopes and ridges.	WO		
YG	Open woodland of *Eucalyptus wandoo* over *Gompholobium marginatum*, *Acacia nervosa*, *Babingtonia camphorosmae*, *Hypocalymma angustifolium*, *Macrozamia riedlei*, *Pericalymma ellipticum*, *Grevillea bipinnatifida*, *Allocasuarina humilis*, *Phyllanthus calycinus* and *Gastrolobium calycinum* on clay and clay-loam soils with localized outcropping on lower slopes.	WO		
G0	Open Heath of *Grevillea bipinnatifida*, *Hakea undulata*, *Banksia squarrosa* subsp. *squarrosa*, *Hakea incrassata*, *Hakea undulata* and *Petrophile serruriae* over *Borya sphaerocephala* on shallow soils and outcrops.	PH	Heaths including perched heaths	Heath communities
G1	Mosaic of open heath of Proteaceae - Myrtaceae spp. with emergent patches of *Eucalyptus drummondii* on shallow soils on slopes.	PH		
G2	Mosaic of open woodland of Allocasuarina huegeliana and closed heath of Proteaceae - Myrtaceae spp. to Lithic Complex on exposed or shallow granite outcrops.	PH		
G3	Open heath of *Banksia squarrosa* subsp. *squarrosa*, *Hakea incrassata*, *Hakea undulata*, *Petrophile heterophylla* and *Petrophile serruriae* on shallow soils over granite outcrops on slopes with occasional emergent mallee species including *Eucalyptus drummondii*.	PH		
CL	Cleared Land	CL	Cleared Land	Others
Dam	Dam	Dam	Dam/Open Water Body	
PL	Plantation and Planted Trees	PL	Plantations	
RE	Rehabilitation Areas	RE	Rehabilitation	

Fauna Habitat Key

- BB - Blackbutt woodlands on lower slopes
- FD - Mosaic of FG and DL
- FG - E. rudis woodlands which may include Jarrah, Marri, B. littoralis or Wandoo. Riparian community.
- JS - Jarrah/Marri valley floors/swamps
- MS - Melaleuca shrublands on seasonally wet valley floors
- MW - Melaleuca, E. rudis woodlands on seasonally wet valley floors
- DL - Marri/Jarrah on lower slopes
- JC - Jarrah/Marri/Allocasuarina
- JM - Jarrah/Marri on slopes
- ML - Mallee
- PH - Heath/perched heath
- WO - Wandoo woodlands
- RE - Rehabilitation
- PL - Plantations
- CL - Cleared Land
- DM - Dam/Open Water Body

WME
Fauna Habitat Key.
Please refer to previous table and in text for detailed descriptions

Map Key
Author: BIOSTAT Pty Ltd

Legend

WMDE

BTC

6385000

6380000

6375000

440000

445000

0 1 2 3 km

WMDEC Fauna Habitats
Map 1

Scale: 1:40,000
Datum: GDA94/MGA Zone 50
Author: BIOSTAT Pty Ltd
Data Sources: BIOSTAT Pty Ltd

BIOSTAT Pty Ltd
For when experience counts

Legend

WMDE

BTC

BODDINGTON

6370000

6365000

6360000

445000

450000

0 1 2 3 km

WMDEC Fauna Habitats
Map 2

Scale: 1:40,000
Datum: GDA94/MGA Zone 50
Author: BIOSTAT Pty Ltd
Data Sources: BIOSTAT Pty Ltd

BIOSTAT Pty Ltd
For when experience counts

Legend

WMDE

BTC

6355000

6350000

6345000

445000

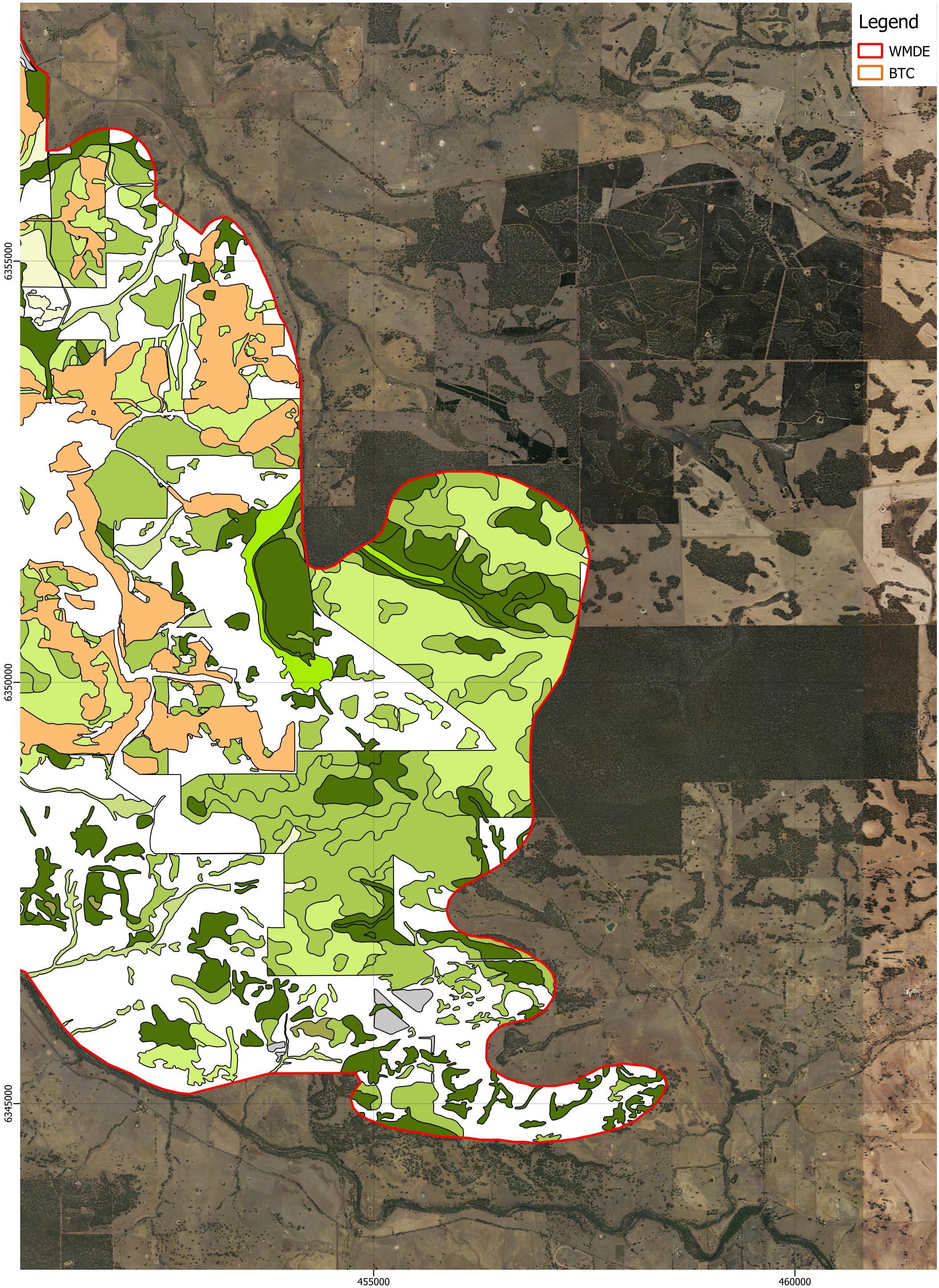
450000

0 1 2 3 km

WMDEC Fauna Habitats Map 3

Scale: 1:40,000
Datum: GDA94/MGA Zone 50
Author: BIOSTAT Pty Ltd
Data Sources: BIOSTAT Pty Ltd

BIOSTAT Pty Ltd
For when experience counts



0 1 2 3 km

WMDEC Fauna Habitats
Map 4

Scale: 1:40,000
Datum: GDA94/MGA Zone 50
Author: BIOSTAT Pty Ltd
Data Sources: BIOSTAT Pty Ltd

BIOSTAT Pty Ltd
For when experience counts

6325000

6320000

410000

0 0.5 1 km

CBME Fauna Habitats
Map 5

Scale: 1:15,000
Datum: GDA94/MGA Zone 50
Author: BIOSTAT Pty Ltd
Data Sources: BIOSTAT Pty Ltd

BIOSTAT Pty Ltd
For when experience counts

Appendix 3. Photographic examples of fauna habitats

Plate 1: Disturbed remnant community

Plate 2: Disturbed remnant community

Plate 3: Riparian community

Plate 4: Riparian community

Plate 5: Riparian community (Blackbutt merging into wandoo fringing river)

Plate 6: Jarrah/Marri Community (DL)

Plate 7: Jarrah/Marri Community (JC)

Plate 8: Jarrah/Marri Community (JM)

Plate 9: Wandoo woodland community

Plate 10: Wandoo woodland community

Appendix 4. Potential Habitat Tree Survey Methodology

The more common survey methodology for Potential Habitat Tree (PHT) is for all trees within the disturbance footprint that met DBH criteria are recorded and assessed. However, for very large areas this methodology is logistically unsustainable and impracticable. The value of PHT is in understanding their demographics, i.e., their density within a landscape and the distribution of hollows

The design consists of locating 100 metre x 10 metre (1000m^2) transects using hierarchical random selection methods to account for habitat and landform type. An experienced observer walks the transect and records and assesses trees with a DBH>50cm (DBH>30cm for Wandoo, *Eucalyptus wandoo*) and/or visible hollows (e.g., Department of Environment, Water, Heritage and the Arts 2010; Department of Sustainability, Environment, Water, Populations and Communities 2012; Gibbons & Lindenmayer 2002; Saunders 1979; Saunders, Mawson & Dawson 2014).

Data was recorded on the species of trees, number of stems, number and size of observable hollows, and the location of the hollow in the tree structure (see table below). Assessment of PHT, the number of hollows and the size of hollows is difficult from the ground and generally under-estimates the number of PHT and the number of hollows in trees (Harper et al. 2004; Rayner, Ellis & Taylor 2011; Stojanovic et al. 2012; Whitford 2001).

Field metadata

Field	Description
Tree Survey Date	Date of observation.
Tree Number	Transact Prefix + Consecutive numbering.
Tree Species	Species of tree.
Tree Height (m)	Estimated top of observable crown height.
No of Stems	Number of trunks.
DBH	Diameter at breast height.
No of Hollows	No of observed hollows.
Hollow Size	Size of hollows: <15cm diameter or >15cm diameter. Determined for a maximum of 5 hollows per tree.
Hollow Type	Location of hollow in tree structure (e.g., stag, ledge, trunk, etc). Determined for a maximum of 5 hollows per tree.
Marked	If tree is already marked as a habitat tree or if the tree is to be marked as a habitat tree – using day-glow paint marker.
Occupancy	Are there obvious signs of occupancy (scats, feathers, individuals)?
Chew Marks	Specifically, tree hollow nesting species (e.g., black-cockatoo) who tend to chew the outside of their nest entrances.
Potential for Black-cockatoo	Is the hollow of potential use to black-cockatoo?
Notes	Additional notes on observation
Tree location	Geographical coordinates of tree
Tree Photograph	A photographic record of the tree if determined to be PHT.

Appendix 5. Migratory/Priority Species.

Migratory Species

Species	EPBC Act	Potential Occurrence	
		WMDEC	CBME
Apus pacificus fork-tailed swift	Migratory (JAMBA, CAMBA, ROKAMBA)	Seasonally High	Seasonally High
*Ardea ibis** cattle egret	Listed Marine (JAMBA, CAMBA)	Moderate	Moderate
*Ardea modesta** eastern great egret	Listed Marine (JAMBA, CAMBA)	Moderate	Moderate
Pandion cristatus eastern osprey	Migratory (Bonn)	Low	Low
Actitis hypoleucos common sandpiper	Migratory (Bonn, JAMBA, CAMBA, ROKAMBA)	Low	Moderate
Calidris acuminata sharp-tailed sandpiper	Migratory (Bonn, CAMBA, JAMBA, ROKAMBA)	Low	Moderate
Calidris melanotos pectoral sandpiper	Migratory (Bonn, JAMBA, ROKAMBA	Low	Moderate
Motacilla cinerea grey wagtail	Migratory (JAMBA, CAMBA, ROKAMBA)	Unlikely	Unlikely

* listed as marine species only under EPBC but still listed under JAMBA and CAMBA international agreements

Priority Species

Species	DPaW Priority Listing	Potential Occurrence	
		WMDEC	CBME
Notamacropus irma western brush wallaby	Rare or near threatened (P4)	High Recorded	High
Notamacropus eugenii derbianus tammar wallaby		Low to Unlikely	Low to Unlikely
Falsistrellus mackenziei western false pipistrelle		High Recorded	High
Hydromys chrysogaster rakali		High Recorded	High Recorded
Isoodon fusciventer quenda		High Recorded	High Recorded
Aspidites ramsayi woma	Poorly known taxa (P1)	Unlikely	Unlikely
Acanthophis antarcticus common death adder	Poorly known species (P3)	High	High
Ctenotus delli Darling Range heath ctenotus	Rare or near threatened (P4)	High Recorded	High