Mt Holland Project:

- **Earl Grey**
- **Irish Breakfast**
- **Prince of Wales**
- **Van Uden**

Level 2 Vertebrate Fauna Survey and Targeted Chuditch Survey 2016 - 2017

Mallee woodland with Chuditch (left) and Salt Pan Dragon (right)

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Executive Summary

Introduction

Kidman Resources Limited (KRL) propose to mine lithium at their Mt Holland Project. The Mt Holland Project is situated 100 km south of Southern Cross in the Shire of Yilgarn. KRL commissioned Western Wildlife to carry out a a Level 1 fauna suvey at the Earl Grey study area, followed by a Level 2 fauna survey across the Earl Grey, Irish Breakfast, Prince of Wales and Van Uden study areas and a targeted Chuditch (*Dasyurus geoffroii*) across the 22,246 ha Regional study area.

The aims of the vertebrate fauna survey were to:

- Identify the fauna habitats present in the study area.
- List the vertebrate fauna that were recorded in the study area and/or have the potential to occur in the study area.
- Identify species of conservation significance, or habitats of particular importance for fauna, that potentially occur in the study area.
- Comment on the potential impacts that a mining development may have on fauna, particularly on fauna of conservation significance.

Methods

The fauna surveys were undertaken in accordance with Environmental Protection Authority (EPA) Statement of Environmental Principles, Factors and Objectives (EPA 2016a), Environmental Factor Guidelines – Terrestrial Fauna (EPA 2016b), Technical Guide – Terrestrial Fauna Surveys (EPA 2016c) and the Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment (EPA & DEC 2010). The field surveys were carried out between the following dates:

- 10 – 15 Oct 2016:

  A Level 1 fauna survey with targeted Malleefowl and Chuditch surveys in the Earl Grey study area.
- 21 Nov – 4 Dec 2016:

  A Level 2 single season fauna survey with targeted Malleefowl and Chuditch surveys in the Earl Grey, Irish Breakfast, Prince of Wales and Van Uden study areas, with some targeted Chuditch survey in the Regional area.
- 16 Jan – 25 Feb 2017:

  A targeted Chuditch survey across the Regional study area.

The field studies included:

- Identification of fauna habitats
- Trapping for terrestrial fauna
- Bird surveys
- Bat call survey
- Spotlighting
- Opportunistic record keeping and hand-searching
- Targeted searches for evidence of conservation significant species:
  - Malleefowl (*Leipoa ocellata*) – transects to search for mounds
  - Chuditch (*Dasyurus geoffroii*) – camera trap survey at 101 locations

Species of conservation significance were classified as: Conservation Significance 1 (CS1) if listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) or the *Western Australian Wildlife Conservation Act 1950* (WC Act); Conservation Significance 2 (CS2) if listed as a Priority species by the Department of Parks and Wildlife (DPAW); or Conservation Significance 3 (CS3) if a locally significant species.

Fauna Habitats

Three broad fauna habitats were identified across the Earl Grey, Irish Breakfast, Prince of Wales and Van Uden study areas:

- Mallee woodland (with patches of shrubland)
- Open woodland
- Shrubland

These habitats were also represented in the Regional study area, along with additional habitats such as sandplain. Habitats that are uncommon in the Bioregion, such as granite outcrops, salt lakes or freshwater wetlands, were absent from the study areas. The habitats identified in the study areas are regionally important, in that they form part of the Great Western Woodlands, a 16 million hectare area of woodlands of which a key feature is its relative intactness. On a local scale, unburnt habitats in the study area are important refuges for fauna in a landscape that has been subject to widespread fires.

Faunal Assemblage

The study area has the potential to support up to nine frog, 67 reptile, 108 bird and 32 mammal (27 native and five introduced) species. A significant proportion of these were recorded during the fauna surveys. A total of one frog, 38 reptiles, 70 birds and 23 mammals (18 native and five introduced) were recorded across all study areas.

Conservation Significant Fauna

Thirteen vertebrate fauna of conservation significance have the potential to occur in the study area, seven of CS1, five of CS2 and one of CS3. The seven species of Conservation Significance 1 are:

- **Malleefowl** (*Leipoa ocellata*) - EPBC Act (Vulnerable), WC Act (Schedule 3)
- **Peregrine Falcon** (*Falco peregrinus*) – WC Act (Schedule 7)
- **Carnaby's Black-Cockatoo** (*Calyptorhynchus latirostris)* - EPBC Act (Endangered), WC Act (Schedule 2)
- **Fork-tailed Swift** (*Apus pacificus*) – EPBC Act (Migratory), WC Act (Schedule 5)
- **Rainbow Bee-eater** *(Merops ornatus*) – WC Act (Schedule 5)
- **Chuditch** (*Dasyurus geoffroii*) - EPBC Act (Vulnerable), WC Act (Schedule 3)
- **Red-tailed Phascogale** (*Phascogale calura*) - EPBC Act (Endangered), WC Act (Schedule 6)

Of these, the Malleefowl, Peregrine Falcon, Rainbow Bee-eater and Chuditch were recorded in the study areas.

The Malleefowl was sighted and active mounds were recorded in the Earl Grey, Van Uden and Regional study areas. Inactive mounds were also recorded in the Earl Grey, Irish Breakfast, Prince of Wales and Regional study areas. Malleefowl have large overlapping home-ranges of one to many square kilometers. Malleefowl in the study areas are likely to range over all habitats, favouring patches of shrubland on gravelly sands for mound construction. Although birds may forage in recently burnt habitats, unburnt areas are required for mound construction.

Eighteen individual Chuditch were trapped (ten adult and eight dispersing young) and Chuditch were recorded on 44 of the 101 camera trap locations showing a preference for unburnt habitats. The Chuditch of the Mt Holland population appeared to occur in greater densities than those at Cosmic Boy Mine, 55 km south, despite being in the same bioregion. Factors that may have positively influenced Chuditch numbers at Mt Holland include low numbers of feral predators and the presence of long-unburnt habitats to provide shelter and denning sites. Individuals are likely to have a core home range of 2,125 ha (males) or 189 ha (females), though they are likely to range even more widely and the core home-ranges are likely to overlap. Chuditch are likely to occur in all habitats in the study areas, and may use hollow logs, burrows and old White-browed Babbler (*Pomatostomus superciliosus*) nests as den sites, as well as man-made structures such as rocky bund walls.

For both the Malleefowl and Chuditch, habitat loss, habitat fragmentation and feral predators are recognized as current threats. Large-scale fires are also likely to impact these species, resulting in loss of den sites and prey for Chuditch and loss of leaf-litter for Malleefowl to build their mounds.

The Peregrine Falcon is likely to forage in open habitats and nest on ledges in open pits. The Rainbow Bee-eater is likely to be a breeding summer visitor to the area. The populations of both these species are large and secure.

Of the species that remain unrecorded, Carnaby's Black-Cockatoo is on the eastern limit of it range in the area and its presence in the study area remains unconfirmed. If Carnaby's Black-Cockatoo is present, Salmon Gums (*Eucalyptus salmonophloia*) with large hollows are potential breeding habitat (in the Van Uden and Regional study areas only), and surrounding areas of woodlands and shrublands are potential foraging habitat.

The Fork-tailed Swift is a widespread migratory species, with a population that is large and secure. The Red-tailed Phascogale is relatively unlikely to be present due to lack of its favoured habitat, and most records of this species are to the west of the study areas.

The five species of Conservation Significance 2 that may occur are the:

- **Lake Cronin Snake** (*Paroplocephalus atriceps*) - Priority 3
- **Woma** (*Aspidites ramsayi*) – Priority 1
- **Inland Western Rosella** (*Platycercus icterotis xanthogenys*) - Priority 4
- **Western Brush Wallaby** (*Macropus irma*) - Priority 4
- **Central Long-eared Bat** (*Nyctophilus major tor*) - Priority 4

Of these, the Inland Western Rosella and Western Brush Wallaby were recorded in the study areas. The Inland Western Rosella is likely to forage in all habitats, nesting in tree hollows in open woodland. The Western Brush Wallaby is likely to occur throughout the mallee woodlands and shrublands.

Although not recorded, both the Central Long-eared Bat and Lake Cronin Snake are moderately likely to occur as the habitats in the study areas are suitable and the area is within the known range of these species. The Central Long-eared Bat is likely to occur in the mallee and open woodlands, where they may use hollows for roosting. The Lake Cronin Snake may occur in woodlands or shrublands in the study areas and is known from Jilbadji Nature Reserve. The Woma may occur in sandplains, but appears likely to be locally extinct.

The one species of Conservation Significance 3 that may occur is the:

- **Spotted Knob-tail Gecko** (*Nephrurus stellatus*)

This gecko has a very restricted range and was recorded in sandplain to the north of the Van Uden study area. This species may also occur in shrublands on sandy soils.

Potential impacts are some direct mortality of fauna, habitat loss, a small increase in habitat fragmentation, disturbance to fauna, increases in feral fauna populations and changed fire regimes. The potential impacts are likely to be small on a regional scale, as only a small area of fauna habitat is likely to be disturbed within a very large tract of intact habitat. On a local scale, impacts will be high within the mine footprint where most fauna habitat will be lost. Recommendations have been provided with the aim of minimising or mitigating these impacts on adjacent habitats during the planning phase of the mining development.

Recommendations:

- *Minimise habitat loss in the planning phase by using existing cleared or disturbed lands and minimising the mine footprint.*
- *Protect active Malleefowl mounds from disturbance.*
- *Where practicable, restrict vehicle speed limits on roads adjacent to active Malleefowl mounds.*
- *Protect mature eucalypt trees with hollows where practicable.*
- *Where possible, avoid clearing during late winter and spring, to avoid mortalities of young birds in nests.*
- *Appropriately dispose of food waste so it does not attract Chuditch or feral predators (foxes and cats). Where containers (e.g. skip bins) are used, ensure they are securely lidded to avoid Chuditch being fatally trapped.*
- *Prohibit feeding of any fauna on site.*
- *Ensure all drill holes are securely capped to prevent fauna becoming fatally trapped.*
- *Where appropriate, carry out re-vegetation once mining activities are complete, to restore fauna habitats.*
- *Ensure that site inductions include adequate environmental education for all personnel involved. This includes ensuring personnel can recognise and report species of conservation significance such as the Malleefowl.*
- *Where practicable, reduce disturbance to nocturnal fauna by minimising work at night.*
- *Prevent the introduction of weeds by washing down muddy vehicles and machinery prior to use on site.*
- *Consider control of foxes and feral cats in and around the study areas.*
- *Implement a fire management plan with the aim of protecting areas of long-unburnt habitat.*

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1. Introduction

Kidman Resources Limited (KRL) propose to mine lithium at their Mt Holland Project. KRL commissioned Western Wildlife to carry out a level 1 vertebrate fauna survey of the Earl Grey study area in October 2016. As the results of this survey indicated the presence of high quality fauna habitat and threatened fauna species, a further Level 2 vertebrate fauna survey of the Earl Grey, Irish Breakfast, Prince of Wales and Van Uden study areas was commissioned, commencing November 2016. To provide regional context for threatened species, a third survey was commissioned in early 2017.

The fauna survey involved a field study to inventory the fauna and fauna habitats present in the study area. To supplement the information gathered during the survey, a review of relevant fauna literature for the area was also undertaken.

The aims of the fauna survey were to:

- Identify the fauna habitats present in the study area.
- List the vertebrate fauna that were recorded in the study area and/or have the potential to occur in the study area.
- Identify species of conservation significance, or habitats of particular importance for fauna, that potentially occur in the study area.
- Comment on the potential impacts that a mining development may have on fauna, particularly on fauna of conservation significance.

This report details the findings of the fauna surveys conducted between October 2016 and February 2017.

2. The Study Areas

2.1 Context and Regional Location

The Mt Holland Project it is located in the Shire of Yilgarn in the Goldfields region of Western Australia, about 100km south of Southern Cross (Figure 1). The five study areas for this survey are as follows:

- Earl Grey – 233 ha
- Irish Breakfast – 121 ha
- Prince of Wales – 141 ha
- Van Uden – 121 ha
- Regional – 22,246 ha

These are shown in Figures 1 and 2. The Earl Grey study area was the focus of the initial Level 1 fauna survey. The Earl Grey, Irish Breakfast, Prince of Wales and Van Uden study areas were the focus of the Level 2 fauna survey. The Regional study area encompasses some of the study areas and was targeted for a further Chuditch survey.

The Earl Grey study area is on granted mining leases M77/1065 and M77/1080. The Irish Breakfast study area is on granted mining lease M77/1080 and granted exploration tenement E77/1400. The Prince of Wales study area is on granted mining lease M77/1080. The Van Uden study area is on granted mining leases M77/477 and M77/478.

The study areas are within the Great Western Woodlands (GWW) (Figure 1). The GWW are a 16 million hectare area extending from the wheatbelt to the edge of the deserts and is the largest intact area of Mediterranean Woodland on earth (DEC 2010). The GWW includes open eucalypt woodlands (63%), mallee eucalypt woodlands, shrublands and grasslands (Fox *et al*. 2016). Less common habitats in the GWW include granite outcrops, banded ironstone formations, salt lakes and freshwater wetlands (Fox *et al*. 2016). The relative intactness of the GWW is recognised as a key value by Fox *et al*. (2016), in that it provides connectivity for birds in a landscape that varies both spatially and temporally. The south-western half of the GWW provides habitat for many birds that are locally extinct or have reduced populations in the adjacent and substantially cleared wheatbelt (Fox *et al*. 2016).

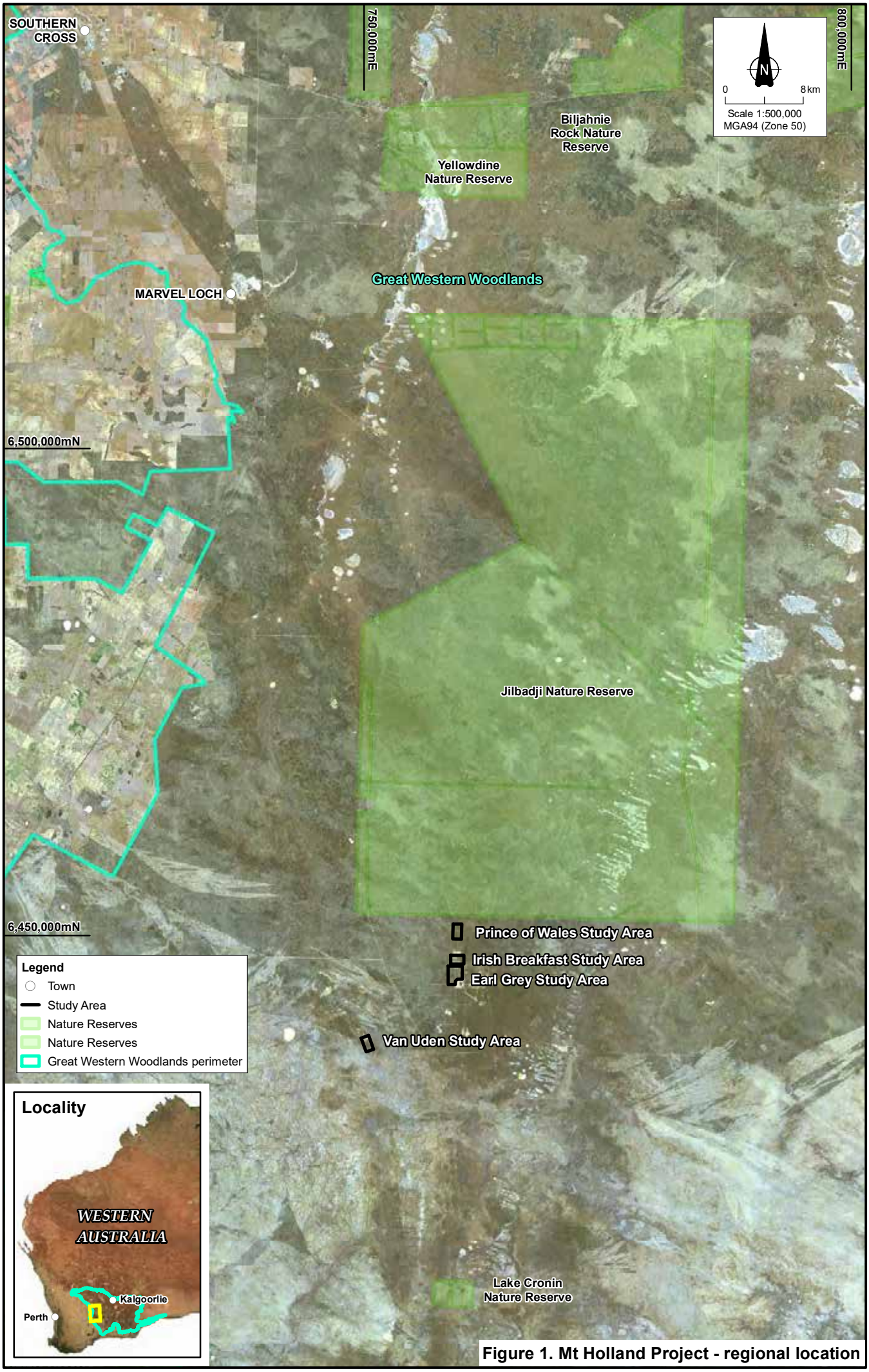
Jilbadji Nature Reserve is a large reserve of over 200,000 ha within the GWW (Plate 1), and part of the reserve is encompassed by the Regional study area (Figure 2). Jilbadji Nature Reserve is known to support a range of fauna, including conservation significant species such as the Malleefowl (*Leipoa ocellata*) (Keighery *et al*. 1995). A significant portion of the reserve was burnt in 2007, as well as more recently in 2015.

Lake Cronin Nature Reserve is a smaller reserve of around 1,000 ha and is also within the GWW, about 30 km south of the study area (Figure 1). Lake Cronin is the largest example of a semi-permanent freshwater lake in the region, and the areas in and around the reserve are recognized as including significant areas of sandplains, shrublands and woodlands (EPA 2009). Lake Cronin Nature Reserve supports a diverse faunal assemblage, including conservation significant species such as the Malleefowl, Lake Cronin Snake (*Paroplocephalus atriceps*) and Inland Western Rosella (*Platycercus icterotis xanthogenys*) (EPA 2009).

Plate 1. Jilbadji Nature Reserve.

The study areas are in the Southern Cross Subregion of the Coolgardie Bioregion of the Interim Biogeographic Regionalism for Australia (IBRA) classification system (DoEE 2017) (Figure 3). The dominant land-uses in this bioregion are Crown Reserves and Unallocated Crown Land (66.7%), grazing on native pastures (17%), conservation (11.5%) and dryland agriculture (2.3%) (Cowan *et al*. 2001). The greenstone hills, alluvial valleys and broad plains of calcareous earths support diverse eucalypt woodlands. The uplands support mallee woodlands and scrub-heaths on sandplains, gravelly sandplains and lateritic breakaways (Cowan *et al*. 2001). Chains of salt lakes with dwarf shrublands of samphire occur in the valleys.

The study area lies in the Southwest Interzone, the transitional area between the Southwest (Bassian) and Eremaen Provinces (Figure 3). These provinces are determined by vegetation mapping (Beard 1980) and broadly correspond to climactic regions, the Southwest Province experiencing warm dry summers and cool wet winters and the Eremaean Province experiencing low, irregular rainfall.



Author: Western Wildlife ~ Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ April 2017 ~ A4 ~ Rev: B ~ CAD Ref: a2441_F020

Figure 1. Mt Holland Project - regional location

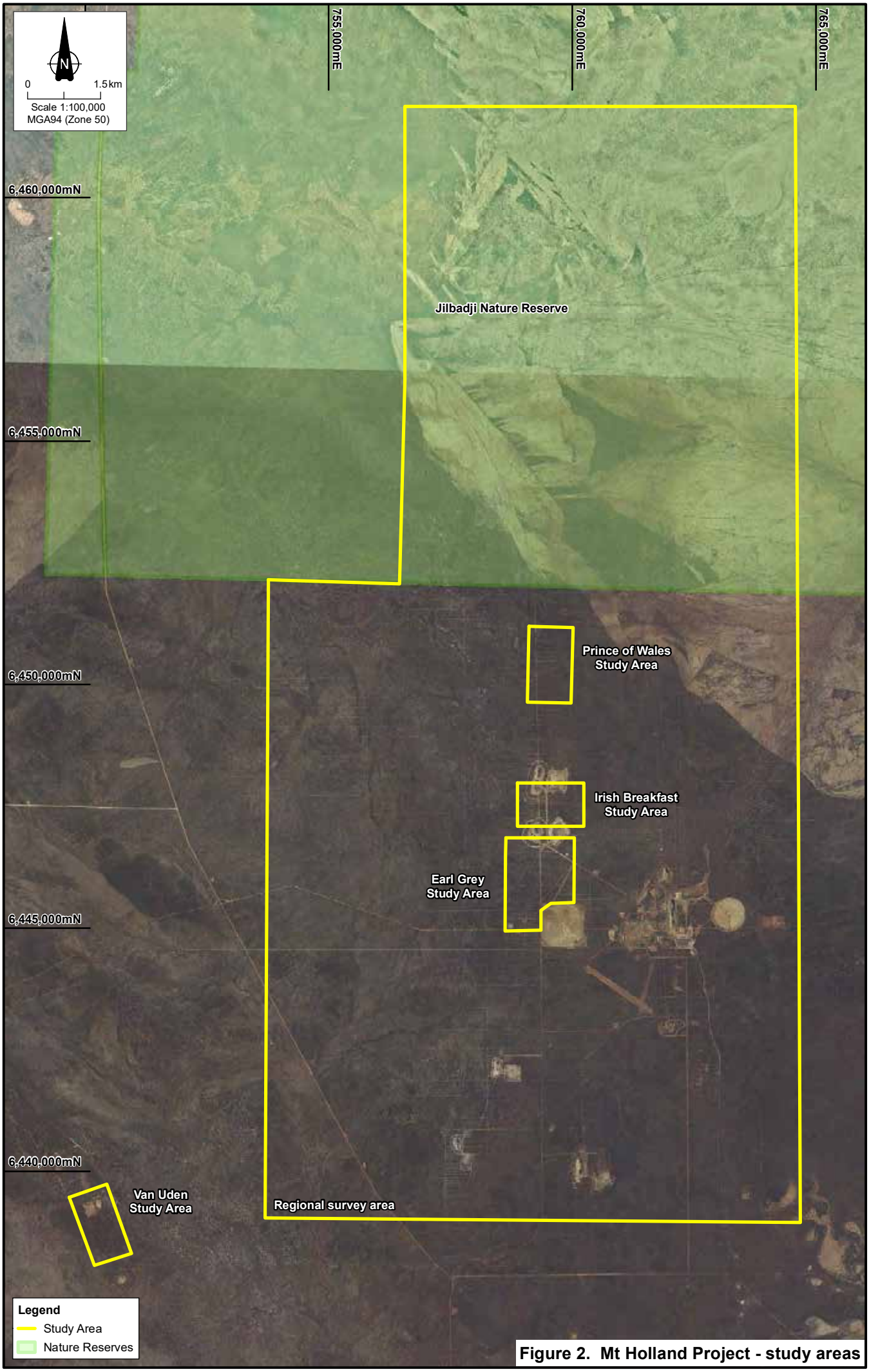


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Figure 2. Mt Holland Project - study areas

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Figure 3. IBRA bioregions and subregions (DoEE 2017) and Botanical Provinces (Beard 1980)

2.2 Climate and Weather

The study areas are situated midway between two Bureau of Meteorology weather stations; Southern Cross Airport and Hyden. The monthly mean temperatures are relatively similar between the stations, with December to February the hottest months and June to August the coolest (Figure 4). The rainfall recorded at Hyden shows a definite winter maximum with a mean annual rainfall of 340.5 mm. The variable rainfall recorded at Southern Cross Airport is indicative of the Eremaen region, and this weather station has a mean annual rainfall of 306 mm. It is likely that the rainfall patterns in the study area fall somewhere between the two.

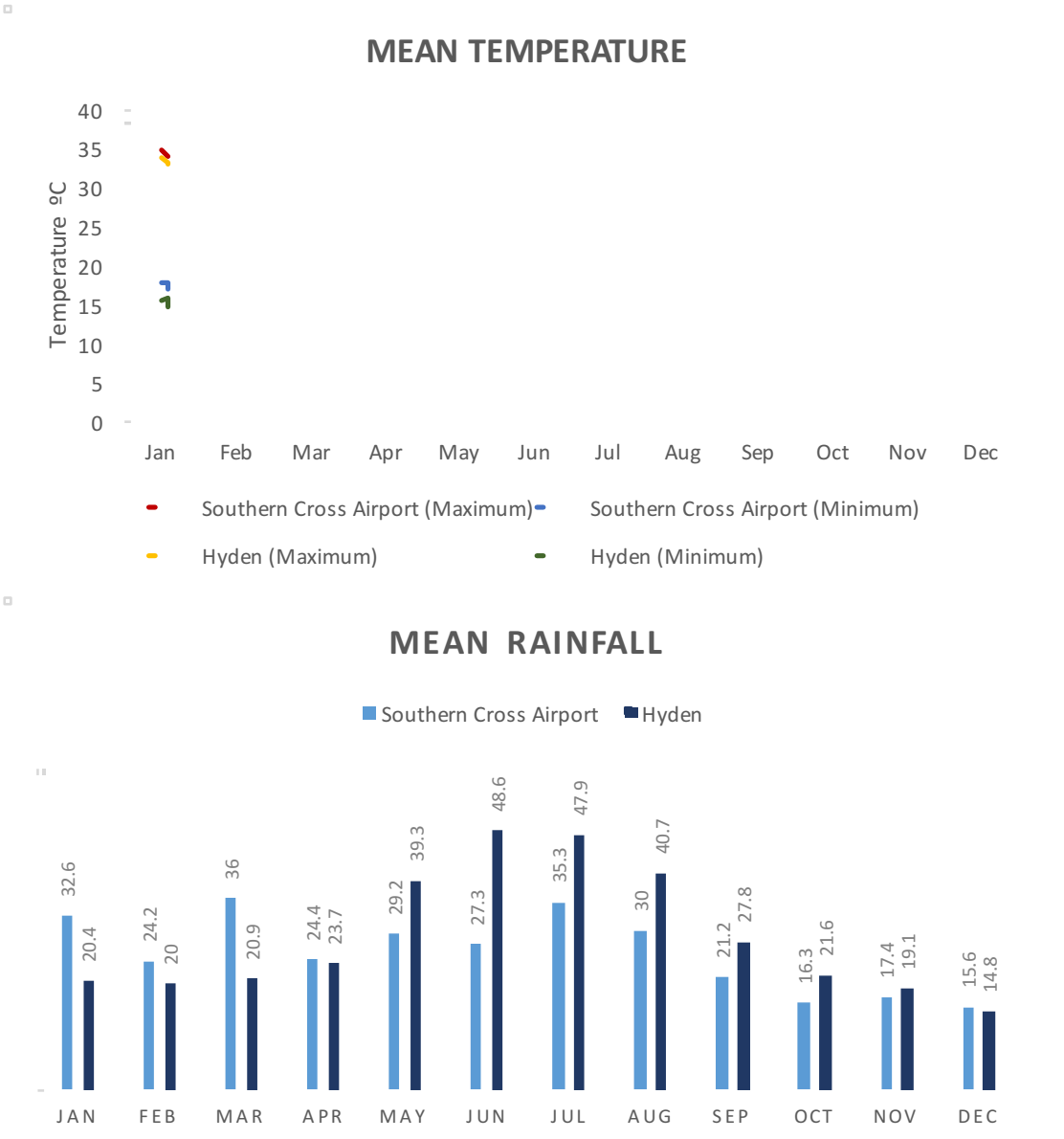

Figure 4. Mean monthly temperature and rainfall at Southern Cross Airport and Hyden (data from Bureau of Meteorology 2017).

The daily rainfall, maximum and minimum temperatures during the fieldwork are provided in Appendix 1.

3. Methods

Three fauna surveys were carried out at the Mt Holland Project (Table 1). The surveys were conducted with reference to the following documents:

- Statement of environmental principles, factors and objectives (Environmental Protection Authority (EPA) 2016a)
- Environmental factor guideline – terrestrial fauna (EPA 2016b)
- Technical guidance – terrestrial fauna surveys (EPA 2016c)
- Technical Guide: terrestrial vertebrate fauna surveys for environmental impact assessment (EPA and DEC 2010)
- Survey guidelines for Australia's threatened mammals (DSEWPaC 2011)
- Survey guidelines for Australia's threatened birds (DEWHA 2010)

The fauna surveys included a search of available literature and databases (a desk-top study), and three periods of fieldwork as described in Table 1. The data collected in the field serve to put the desk-top study into context, as well as allowing for the identification of fauna habitats and likely fauna assemblages of the site.

Table 1. Overview of fauna surveys carried out at the Mt Holland Project.

Survey	Level of survey	Extent of survey	Dates of fieldwork
1	Level 1 fauna survey with targeted Malleefowl & Chuditch surveys	Earl Grey (see Figure 2)	10 – 15 Oct 2016
2	Level 2 (single season) fauna survey with targeted Malleefowl & Chuditch surveys	Earl Grey, Irish Breakfast, Prince of Wales and Van Uden, with some targeted Chuditch survey in the Regional area (see Figure 2)	21 Nov – 4 Dec 2016
3	Targeted Chuditch survey	Regional area (see Figure 2)	16 Jan – 25 Feb 2017

3.1 Personnel

Eight zoologists from Western Wildlife carried out the fauna surveys, with bat call analysis provided by Kyle Armstrong of Specialised Zoological (Table 2) and additional field support provided by Dmitri Ivanov (KRL). This report was prepared by Jenny Wilcox.

3.2 Taxonomy and Nomenclature

Taxonomy and nomenclature for fauna species used in this report follow the Western Australian Museum checklists, last updated in August 2016.

Table 2. Personnel involved in the fauna survey.

Name	Role	Qualification	Experience	Survey*
Jenny Wilcox	Supervising Zoologist (plan and lead fieldwork, prepare report)	BSc.Biol./Env.Sci., Hons.Biol.	17 years	1, 2 & 3
Brenden Metcalf	Zoologist (fieldwork)	BSc. Env.Sci., Hons.Env.Sci.	17 years	1 & 2
Mike Brown	Zoologist (fieldwork)	BSc. Env.Sci.	11 years	1 & 2
Glen Murray	Zoologist (fieldwork)	BSc. Resource & Env.Sci.	9 years	2
Jeffrey Turpin	Zoologist (fieldwork)	BSc. Zool.	18 years	2
Cameron Everard	Zoologist (fieldwork)	BSc. Env.Sci., M.Sc.	9 years	2
Wes Bancroft	Zoologist (fieldwork)	PhD. Zoology	17 years	2
Genevieve Murray	Trainee Zoologist (fieldwork)	-	<1 year	1
Dmitri Ivanov	Field Assistant (fieldwork)	BSc. Env.Sci.	2 years	3
Kyle Armstrong	Bat call analysis	PhD. Zoology	20 years	2

* See Table 1

3.3 Literature Review

Lists of fauna expected to occur in the study area were produced using information from a number of sources. These included publications that provide information on general patterns of distribution of frogs (Tyler *et al*. 2000), reptiles (Storr *et al*. 1983, 1990, 1999 and 2002, Wilson and Swan 2010), birds (Barrett *et al*. 2003; Johnstone and Storr 1998; Johnstone and Storr 2004) and mammals (Churchill 1998, Menkhorst and Knight 2011; Van Dyck and Strahan 2008).

The databases in Table 3 were searched for fauna records in and around the study area. Some species may occur on database results that are not likely to be present in the study area, usually due either to lack of suitable habitat or the study area being outside the known range of the species. These species are not included in lists of expected fauna.

In addition, the results of the following fauna reports were used to compile the fauna lists:

- *The Biological survey of the Eastern Goldfields region of Western Australia. Part 11 Boorabbin - Southern Cross study area. Part 12, Barlee - Menzies study area* (Keighery *et al*. 1995). A comprehensive survey of Goldfields fauna was carried out by the Western Australian Museum. The Boorabbin - Southern Cross study area was surveyed in 1980 - 1981 across three surveys, sampling the amphibians, reptiles, birds and mammals at three main sites (Keighery *et al*. 1995). Only data from the Jilbadji Nature Reserve site (50H 767776 E, 6500951 N), located about 55km north of Earl Grey, was used while compiling lists of fauna present in the area.

- *Forrestania fauna survey: Fauna and faunal assemblages report* (Biota Environmental Sciences 2006). A fauna survey was undertaken for the Flying Fox Mine, about 35km south of the Earl Grey study area. The survey consisted of two surveys (February/March 2005 and November 2005), at ten sites in tall woodland, mallee woodlands and shrublands. Each site consisted of six pitfall traps (three PVC pipe and three buckets) on a single 30m flywire drift-fence, six Elliott traps and one cage trap. In addition, two sites of 15 Elliott traps and one site of 15 cage traps were also used. Bat calls were sampled in two locations using an Anabat detector, and bird surveys were undertaken at each of the ten trapping sites.

- *Spotted Quoll haul road single phase fauna survey* (Biota Environmental Sciences 2010). In November/December 2009, a single survey was carried out for the Spotted Quoll haul road, about 45km south of the Earl Grey study area. The survey consisted of nine sites, each consisting of six pitfall traps (three PVC pipe and three buckets) on a single 30m flywire drift-fence, six Elliott traps and one cage trap. In addition, two sites of 18 and 19 large Elliott traps and one site of 20 cage traps were also used. Bat calls were sampled in four locations using an Anabat detector and one location using a harp trap, and bird surveys were undertaken at each of the nine trapping sites.

Table 3. Databases used in the preparation of this report.

Database	Type of records held on database	Area searched
Western Australian Museum Specimen Database (DPAW 2007-)	Records of specimens held in the WA Museum. Includes historical data.	30km surrounding 32° 05' 37" S, 119° 44' 53" E.
Fauna Survey Returns Database (DPAW 2007-)	Records of fauna captured, observed or inferred from secondary evidence during fauna surveys.	30km surrounding 32° 05' 37" S, 119° 44' 53" E..
Birds Australia Atlas Database (DPAW 2007-)	Records of bird observations in Australia, 1998-current.	30km surrounding 32° 05' 37" S, 119° 44' 53" E.
DPAW's Threatened and Priority Fauna Database	Records of Threatened and Priority species in Western Australia, also drawing from the databases above.	90km surrounding 759300 E, 6448700 N (Zone 50)
EPBC Act Protected Matters Search Tool	Records on matters protected under the EPBC Act, including threatened species.	30km surrounding 32° 05' 37" S, 119° 44' 53" E.

The Department of Parks and Wildlife (DPAW) Threatened and Priority Ecological Community Database was searched by Mattiske Consulting (2017a). No Threatened Ecological Communities were present, and the one Priority Ecological Community present (Ironcap Hills Vegetation Complexes; Priority 3) is primarily defined by vegetation rather than fauna and has been discussed by Mattiske Consulting (2017a).

These sources of information were used to create lists of species that potentially occur in the study area. As far as possible, expected species are those that are likely to utilise the study area. The lists exclude species that have been recorded in the general region as vagrants, or for which suitable habitat is absent.

3.4 Field Studies

Three field studies were undertaken, as summarised in Table 1.

3.4.1 Licensing

All field studies were carried out under Regulation 17 License to Take Fauna for Scientific Purposes 08-000081-1, 08-000122-2 and 08-000186-1, as issued by the Department of Parks and Wildlife (DPAW).

3.4.2 Trapping for Terrestrial Fauna

Trapping for terrestrial fauna (frogs, reptiles and small mammals) was undertaken in a single survey in spring 2016, between 21 November and 4 December. Twelve trapping sites were installed across the Earl Grey, Irish Breakfast, Prince of Wales and Van Uden study areas (Figure 5, Table 4). The placement of sites in the study area aimed to sample the habitats present and provide geographic spread across the study areas. Site locations at Prince of Wales was constrained by the recent fire. A photograph of each site is given in Plates 2 and 3.

Site 1

Site 2

Site 3

Site 4

Site 5

Site 6

Plate 2. Site photographs for Sites 1 - 4 (Earl Grey) and Sites 5 - 6 (Irish Breakfast).

Site 7

Site 8

Site 9

Site 10

Site 11

Site 12

Plate 3. Site photographs for Sites 7 - 9 (Prince of Wales) and 10 - 12 (Van Uden).

Each trapping site consisted of ten pitfall traps, ten funnel traps, ten Elliott traps and two cage traps. The pitfall traps were placed in two transects with 25 m between each pitfall trap and 50 m between the two transects. Each pitfall trap was a 40 cm deep, white 20 L bucket with a 25 cm high flywire drift-fence extending 3m to either side of the pitfall. A piece of egg carton was used as shelter for any fauna in the trap.

Funnel traps were 15 cm wide and 60 cm long, with a funnel entrance of 5 cm. Funnel traps were set up midway along a pitfall trap drift-fence, with the funnel entrances bisected by the fence (Plate 4). Funnel traps were covered with shade cloth in order to keep the temperature inside the funnel cool. Elliott traps were placed near each pitfall and the cage traps were placed at pitfalls 1 and 6. All cage and Elliott traps were placed under vegetation to shade any captured animals and cage traps were covered with a hessian sack. All Elliott traps were baited with a mixture of rolled oats, sardines, peanut butter and vanilla essence. Cages were baited with the same mixture with the addition of tuna oil, with the purpose of targeting Chuditch.

Plate 4. Examples of pitfall and funnel trap setup.

The sampling at the trapping sites was undertaken for eight nights at each site, to given a total of 80 pitfall trap-nights, 80 funnel trap-nights, 80 Elliott trap-nights and 16 cage trap-nights per site. Across the 12 sites, this resulted in a total of 960 trap-nights each for pitfalls, funnels and Elliott traps, and 192 trap-nights for cages. All animals caught were identified and recorded, and generally released immediately at the site of capture.

3.4.3 Bird Surveys

Birds surveys were carried out at each of the 12 trapping sites in the early morning while bird activity was high. A total of seven 20 minute surveys were undertaken for each trapping site. Birds were recorded whether seen or heard. As birds were often difficult to observe or count in dense habitats, each species was recorded as present only, and the frequency of occurrence calculated for each site.

3.4.4 Bat Surveys

Bats were surveyed using SM2 ultrasonic bat detectors at each of the trapping sites for one night, plus one night at the camp (see Figure 5 for site locations). Analysis of the recordings was undertaken by Dr Kyle Armstrong of Specialised Zoological.

Table 4. Trapping site locations and descriptions.

Site	Dates opened & closed	Location	Habitat
1	22/11/16 - 30/11/16	Earl Grey 50H 759909 E 6446533 N	**Shrubland.** Shrubland of *Acacia*, *Melaleuca*, *Santalum* sp. with scattered Mallee eucalypts on pale gravelly sand. Drill pad in middle of site.
2	22/11/16 - 30/11/16	Earl Grey 50H 759420 E 6445948 N	**Mallee Woodland**. Mallee eucalypts over tall mixed *Melaleuca* spp. on gravelly red clay-loam.
3	22/11/16 - 30/11/16	Earl Grey 50H 759052 E 6445503 N	**Shrubland**. Sparse mallee eucalypt canopy over tall shrubland of *Allocasuarina*, *Acacia*, *Hakea* and *Melaleuca* spp., on pale gravelly sand.
4	23/11/16 - 1/12/16	Earl Grey 50H 758866 E 6446681 N	**Shrubland.** Mixed shrubland including *Acacia* and *Hakea* spp. with patches of *Allocasurina* sp. over on pale gravelly sand overlying pale clay.
5	23/11/16 - 1/12/16	Irish Breakfast 50H 759690 E 6447287 N	**Mallee woodland/Shrubland**. Mallee woodland over mixed *Melaleuca spp*. grading into tall shrubland of (*Allocasuarina* sp., *Acacia* sp. and *Melaleuca* sp. on pale, gravelly sand.
6	23/11/16 - 1/12/16	Irish Breakfast 50H 758985 E 6447617 N	**Mallee Woodland**. Mallee over patchy *Melaleuca spp*. and occasional *Callitris* on laterite rise. Surrounded by tall shrubland to South and West.
7	24/11/16 - 2/12/16	Prince of Wales 50H 759233 E 6450754 N	**Mallee woodland/Shrubland**. Mallee eucalypts over mixed *Melaleuca* spp. shrubland on small laterite rise, grading into *Allocasuarina* and *Acacia* spp. tall shrubland on pale gravelly sand. Unburnt patch in a largely burnt area.
8	24/11/16 - 2/12/16	Prince of Wales 50H 759276 E 6449802 N	**Mallee Woodland**. Mallee over mixed *Melaleuca* spp. shrubland on gravelly red clay-loam.
9	25/11/16 - 3/12/16	Prince of Wales 50H 759730 E 6450361 N	**Mallee Woodland**. Mallee woodland over mixed *Melaleuca* spp. shrubland on pale sandy clay. Recently burnt in 2015.
10	25/11/16 - 3/12/16	Van Uden 50H 750567 E 6439052 N	**Open Woodland.** Tall Salmon Gum and Merrit woodland over patchy *Melaleuca pauciflora* and scattered *Eremophila* sp. low shrubs on red gravelly clay-loam. Tree hollows present.
11	25/11/16 - 3/12/16	Van Uden 50H 750469 E 6438277 N	**Mallee Woodland**. Mallee and scattered larger eucalypts over mixed *Melaleuca* spp. and other shrubs (e.g. *Daveisia* sp*., Acacia* sp.) on pale gravelly sand on low rise.
12	26/11/16 - 4/12/16	Van Uden 50H 749456 E 6439815 N	**Sandplain.** A dense mixed shrubland (e.g. *Hakea* spp., *Grevillea* spp., *Melaleuca* spp., *Verticordia* spp.) with sparse low Mallee eucalypts on yellow sandplain.

3.4.5 Spotlighting

Spotlighting was carried out on two nights, 27 November and 3 December 2016. Spotlighting was carried out by six people in three teams of two. A combination of road-spotting using car headlights and head-torching in suitable habitat (e.g. around water for frogs or on large eucalypts for arboreal geckoes). Owls and other nocturnal birds were recorded if seen or heard.

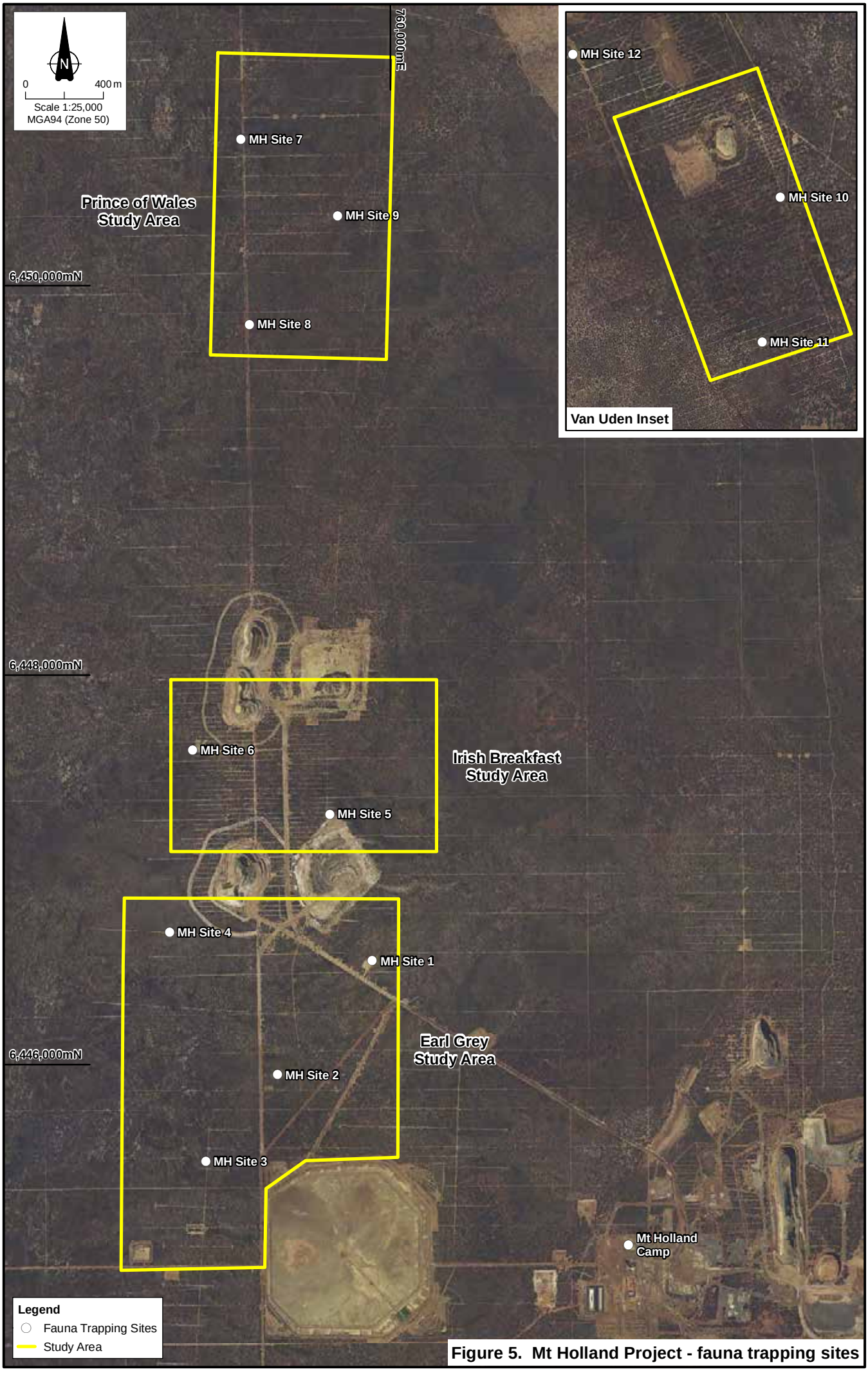

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Figure 5. Mt Holland Project - fauna trapping sites

3.4.6 Opportunistic and Hand-searching Records

At all times, observations of fauna were noted when they contributed to the accumulation of information on the fauna of the site. These included casual observations of reptiles, mammals and birds seen while travelling between sites or while undertaking other activities, such as Malleefowl transects. Hand-searching (raking under shrubs and in leaf litter, turning over logs) was carried out opportunistically with the aim of searching for reptile species not recorded in the trapping.

3.4.7 Targeted Malleefowl Survey

Malleefowl were targeted by walking transects across the entire study area at Earl Grey, Irish Breakfast and Prince of Wales, totaling approximately 583 km (Table 5, Figures 6 to 8). The transects were walked by four to six zoologists spaced about 10 m apart, using a handheld GPS for guidance (Plate 5). The close spacing was due to the low visibility in the dense shrublands. Any mounds identified were recorded with a GPS location, photograph, description of the habitat, estimated age of the mound and any evidence of shell fragments. Excavations that were not used for nesting (i.e. the mound attempt abandoned or site deemed unsuitable by the Malleefowl) were also recorded as evidence of Malleefowl activity in the area. Although transects were not undertaken for the Van Uden or Regional study areas, any mounds encountered were recorded. Two inactive mounds recorded in previous surveys (Western Wildlife 2014, 2016) were also included as they were within the Regional study area.

Table 5. Summary of Malleefowl mound survey effort.

Study area	Survey type	Dates of survey	Transect length (km)
Earl Grey	Transects, 4 people, 10m spacing	10 - 15 Oct 2016	269
Irish Breakfast	Transects, 6 people, 10m spacing	29 Nov – 3 Dec 2016	138
Prince of Wales	Transects, 6 people, 10m spacing	27 Nov – 1 Dec 2016	176
Van Uden	Opportunistic only	28 Nov - 4 Dec 2016	-
Regional area	Opportunistic only	Nov/Dec 2016, Jan/Feb 2017	-

Plate 5. Preparing to walk Malleefowl mound transects.

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Figure 6. Malleefowl transects - Earl Grey study area

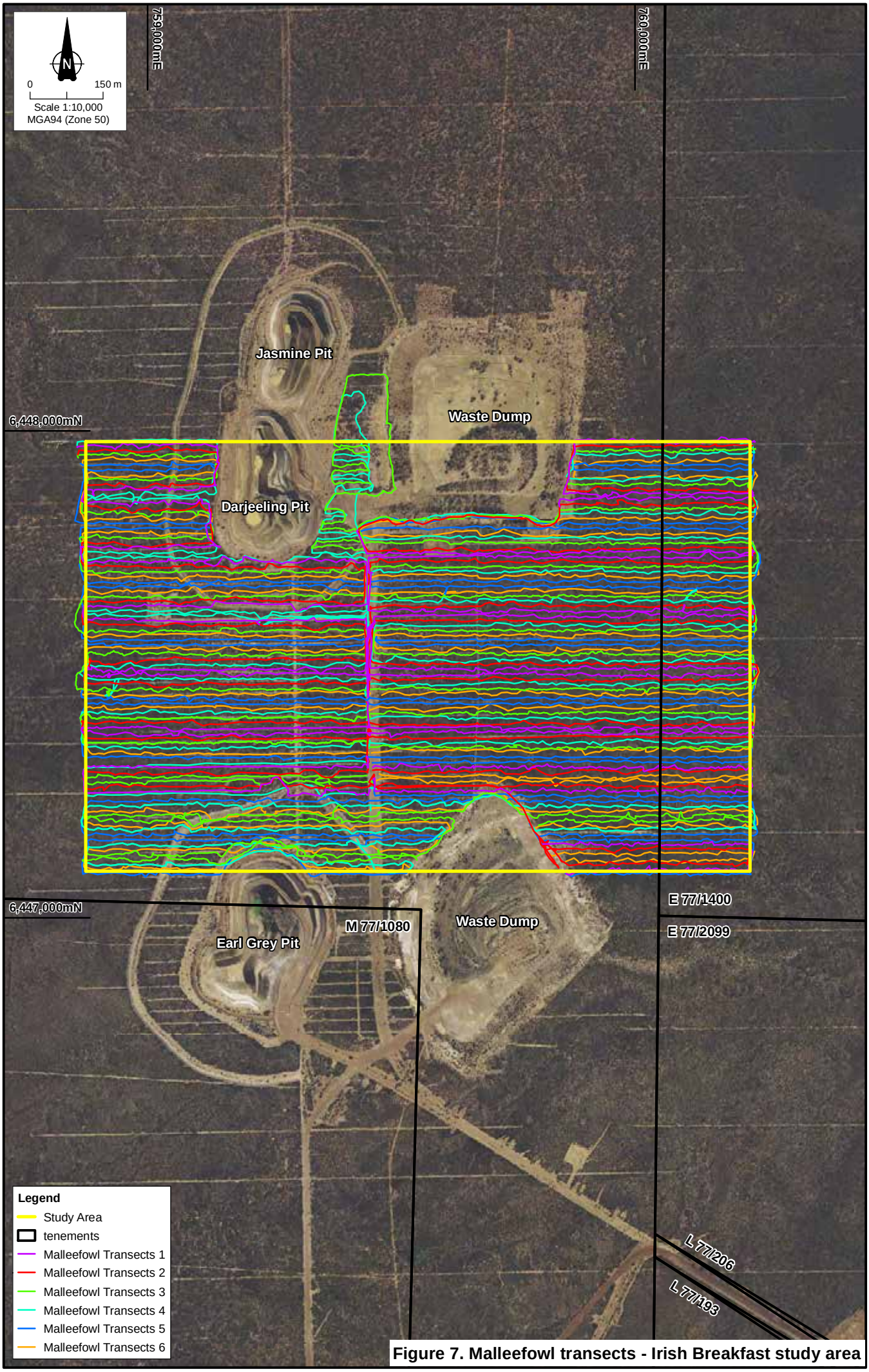

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Figure 7. Malleefowl transects - Irish Breakfast study area

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Figure 8. Malleefowl transects - Prince of Wales study area

3.4.8 Targeted Chuditch Survey

Chuditch were targeted using motion-sensitive camera traps. The camera traps were deployed on tracks and historic drill-lines across the study area, with the camera mounted on a dropper post (Plate 6). Cameras were set for between four nights and up to three weeks between October 2016 and February 2017. The location of each camera trap is shown in Figure 9, and the deployment dates and habitat are given in Appendix 2a. Additonal habitat data for cameras set in 2017 are given in Appendix 2b. The cameras used were branded either *Bushnell* or *Ltl Acorn*, which have similar settings and capabilities. Cameras were set to take three pictures when triggered. In 2016 cameras were set to take pictures day or night, in order to record all fauna as part of the Level 2 fauna survey. In 2017, cameras were set to only take pictures at night, when Chuditch are active, to avoid filling the memory cards during a longer-term deployment. In 2016, the bait used was a mixture of rolled oats, sardines, peanut butter and tuna oil. In 2017 bait tubes filled with sponge soaked in tuna oil were used, as these baits were intended to remain effective over a longer time period.

Table 6. Summary of camera trapping effort.

Study area	Number of camera trap sites	Overall dates of survey	Total camera trap-nights
Earl Grey	12	10 Oct – 15 Oct 2016	60
Irish Breakfast	6	22 – 26 Nov 2016	24
Prince of Wales	6	22 – 26 Nov 2016	24
Van Uden	6	26 – 30 Nov 2016	24
Regional area	71	26 Nov – 4 Dec 2016, 16 Jan – 24 Feb 2017	911

Plate 6. Camera trap set up.

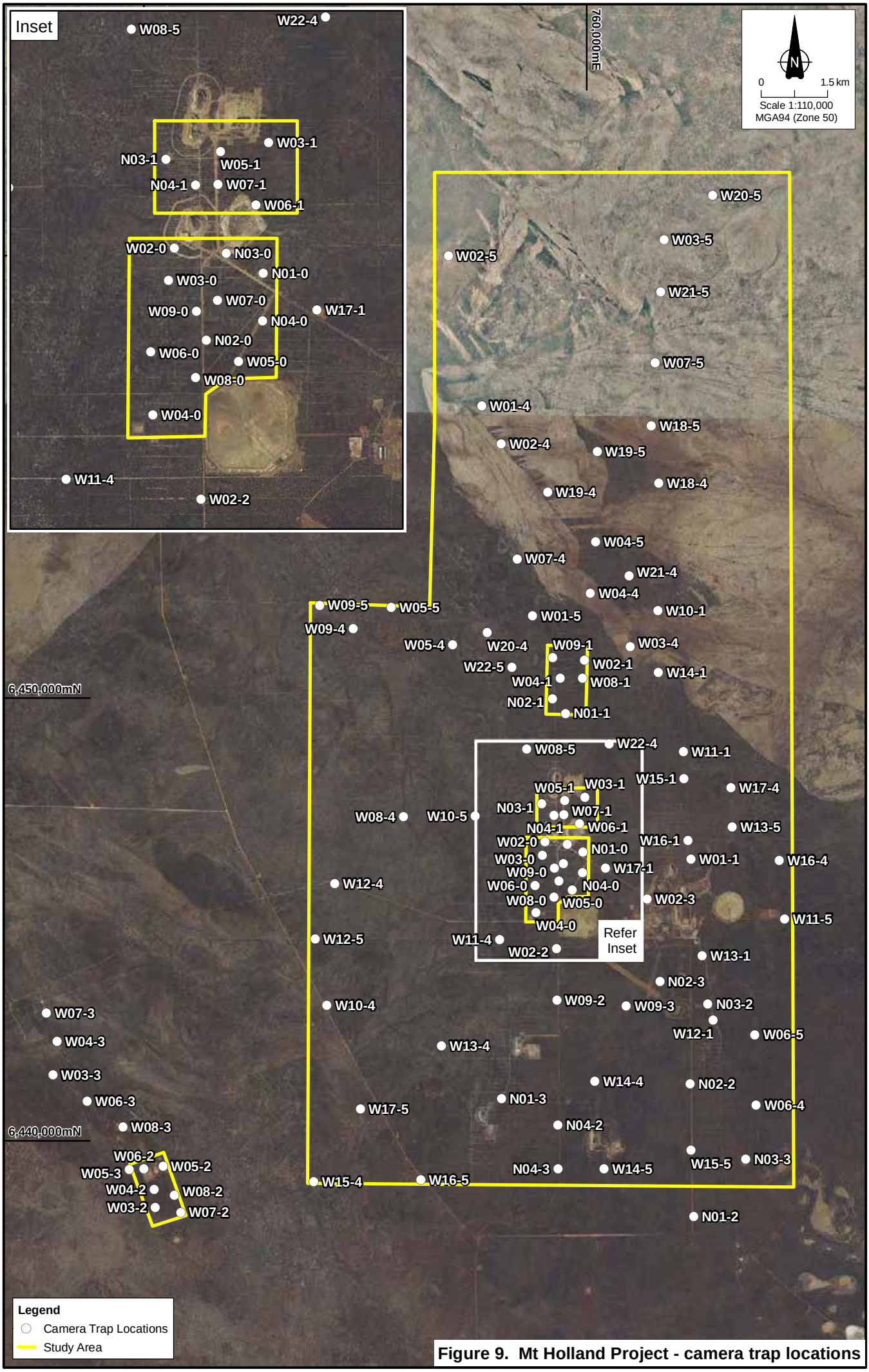

Figure 9. Mt Holland Project - camera trap locations

3.5 Habitat Mapping

Habitat mapping was undertaken using observations made by fauna personnel in the field, interpretation of aerial photography and interpretation of existing vegetation mapping produced by Mattiske Consulting (2017a, 2017b). CAD Resources produced the maps from information provided by Mattiske Consulting and Western Wildlife.

3.6 Survey Limitations

Various factors can limit the effectiveness of a fauna survey. Pursuant to EPA Guidance Statement 56 (EPA 2004), these factors have been identified and their potential to impact on the effectiveness of the surveys has been assessed in Table 7 below. All fauna surveys have limitations, and not all fauna species present on the site are likely to be sampled during a survey. Fauna may not be recorded because they are rare, they are difficult to trap or observe, or because they are only present on the site for part of the year.

Table 7. Fauna survey limitations.

Potential Limitation	Extent of limitation for the fauna survey	
Experience of fauna personnel	Not limiting:	The supervising zoologist has over 17 years' experience in fauna surveys, and team members have 1 to 20 years' experience.
Types of traps or other survey methods used	Not limiting:	All standard trap types were used (Pitfalls, funnels, Elliotts, cages) plus camera traps, bird surveys, spotlighting and observations by experienced zoologists.
Number of trapping sites	Not limiting:	Twelve trapping sites were established across the Earl Grey, Irish Breakfast, Prince of Wales and Van Uden study areas. This is a high number for the small size of the study areas.
Ability to survey all habitats present	Not limiting:	All habitats present in the Earl Grey, Irish Breakfast, Prince of Wales and Van Uden study areas were surveyed during the fauna survey. The Regional study area was not comprehensively surveyed for habitat.
Availability of fauna information for the area in literature and on databases	Not limiting:	Moderate amount of fauna information available on databases and in the literature.
Effects of weather during the survey	Not limiting:	Weather during the first two field surveys was cool to hot, ranging from clear and sunny to overcast, providing ideal conditions for trapping and observations of fauna. Although the rainy weather during the third survey (see Appendix 1) may have impacted on the bait-tubes used to attract Chuditch, the cameras all experienced a period of dry weather prior to the downpours.
Seasonal effects	Minor limitation:	Although only a single trapping survey was undertaken, it was scheduled for late spring to coincide with peak faunal activity.
Disturbance to site such as recent fires, cattle grazing	Minor limitation:	Much of the Prince of Wales and Regional study areas are recovering after extensive fire. This facilitated observation of Malleefowl mounds, but reduced the number of other fauna observations and is likely to have impacted the distribution of some species including Chuditch. Similar unburnt habitats were available nearby to survey.
Ease of access to site	Not limiting:	Site access to Earl Grey, Irish Breakfast, Prince of Wales and Van Uden was very good, with all areas accessible by vehicle or on foot. Access to the Regional study area was fair, with sufficient access to carry out the targeted camera trap survey.

Although only a single trapping survey was undertaken, it was scheduled in late spring to coincide with high levels of activity of most vertebrate fauna groups. The surveys undertaken either side (in October 2016 and Jan/Feb 2017) provided additional opportunities for opportunistic observations, particularly of birds. The only vertebrate group not targeted was frogs. This is a minor limitation only as no conservation significant frog species are present in the region, and the study areas lack wetland habitats likely to be significant for breeding frogs.

A significant portion of the study area has been impacted by large scale fire. This includes much of the Prince of Wales study area and a large portion of the Regional study area. These areas are recovering, and support some fauna, but the faunal assemblages of these areas are likely to differ in their species composition and abundance compared with unburnt sites. This is a minor limitation as most trapping sites were situated in unburnt habitats and the observations in these habitats can be used to infer the likely faunal assemblages across the study areas.

3.7 Assessing Conservation Significance of Fauna

Three levels of conservation significance are used within this report to indicate the level of significance of fauna species. These are described in the following sub-sections.

3.7.1 Conservation Significance 1

Conservation Significance 1 (CS1) is the highest level of conservation significance, describing species that are protected under State or Commonwealth legislation. These species are considered to be of state and/or national conservation significance, and some species (e.g. some migratory species) may be considered of international significance.

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Commonwealth Government's primary piece of environmental legislation. Listed under Part 3 of the EPBC Act are 'Matters of National Environmental Significance'. These include threatened species, threatened ecological communities and migratory species.

Fauna species are assessed against categories based on International Union for Conservation of Nature (IUCN) criteria. These criteria are as follows:

Extinct:	Taxa not definitely located in the wild during the past 50 years.
Extinct in the wild:	Taxa known to survive only in captivity.
Critically Endangered:	Taxa facing an extremely high risk of extinction in the wild in the immediate future.
Endangered:	Taxa facing a very high risk of extinction in the wild in the near future.
Vulnerable:	Taxa facing a very high risk of extinction in the wild in the medium-term future.
Conservation Dependent:	Taxa whose survival depends upon ongoing conservation measures. Without these measures, a conservation dependent taxon would be classed as Vulnerable or more severely threatened.

Of the above, only fauna classified as 'extinct in the wild' 'critically endangered', 'endangered' or 'vulnerable' are listed as Matters of National Environmental Significance.

The migratory species listed under the EPBC Act are those recognised under international agreements. These agreements are the China-Australia Migratory Bird Agreement (CAMBA), the Japan-Australia Migratory Bird Agreement (JAMBA), the Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA), or species listed under the Bonn Convention for which Australia is a range state.

Reports on the conservation status of most vertebrate fauna species have been produced by the Department of Environment and Energy (DoEE) in the form of Action Plans. An Action Plan is a review of the conservation status of a taxonomic group against IUCN categories. Action Plans have been prepared for amphibians (Tyler 1998), reptiles (Cogger *et al*. 1993), birds (Garnett *et al*. 2011) and mammals (Woinarski *et al*. 2014). These publications also use categories similar to those used by the EPBC Act. The information presented in some of the earlier Action Plans may be out of date due to changes since publication.

The *Western Australian Wildlife Conservation Act 1950* (WC Act) is State legislation for fauna protection administered by the Department of Parks and Wildlife (DPAW). The WC Act lists species under a set of Schedules, as listed below.

Schedule 1:	Fauna that is rare or likely to become extinct (critically endangered fauna)
Schedule 2:	Fauna that is rare or likely to become extinct (endangered fauna)
Schedule 3:	Fauna that is rare or likely to become extinct (vulnerable fauna)
Schedule 4:	Fauna presumed to be extinct
Schedule 5:	Migratory birds protected under an international agreement
Schedule 6:	Fauna that is of special conservation need (conservation dependent fauna)
Schedule 7:	Other specially protected fauna

3.7.2 Conservation Significance 2

Species of Conservation Significance 2 (CS2) are not listed under State or Commonwealth Acts, but are listed as Priority species by DPAW. These species may be considered to be regionally significant. In Western Australia, DPAW maintains a list of Priority Fauna made up of species that are not considered Threatened under the WC Act, but for which DPAW feels there is cause for concern. There are four levels of Priority as defined by DPAW, as listed below.

Priority 1:	Poorly known species (on threatened lands)
Priority 2:	Poorly known species in few locations (some on conservation lands)
Priority 3:	Poorly known species in several locations (some on conservation lands)
Priority 4:	Rare, near threatened and other species in need of monitoring

3.7.3 Conservation Significance 3

Conservation Significance 3 (CS3) species are not listed under State or Commonwealth Acts or in publications on threatened fauna or as Priority species by DPAW, but are considered by Western Wildlife to potentially be of local significance because they are at the limit of their distribution in the area, they have a very restricted range or they occur in breeding colonies (e.g. some waterbirds). This level of significance has no legislative recognition and is based on interpretation of information on the species patterns of distribution. For example, the Government of Western Australia (2000) used a similar sort of interpretation to identify significant bird species in the Perth metropolitan area as part of Bush Forever. Recognition of such species is consistent with the aim of preserving regional biodiversity.

4. Fauna Habitats

Three broad fauna habitats were identified in the Earl Grey, Irish Breakfast, Prince of Wales and Van Uden study areas. Habitats were identified during the fauna surveys and on the basis of vegetation mapping (Mattiske Consulting 2017a, 2017b), and are listed below:

- Mallee woodland
- Open woodland
- Shrublands

The habitats are described in the sections below and presented in Figures 10 to 12.

It is important to recognize that the fauna habitats are extremely variable on the local scale. For example, within the mallee woodland are small patches of shrubland that are too small to be separately mapped, but can provide Malleefowl breeding habitat within a matrix of less suitable habitat. This variability within the habitats contributes to the richness of the faunal assemblage.

Fauna habitats were not mapped for the Regional study area, though some habitat data were collected in conjunction with the camera trap survey (Appendices 2a and 2b). From opportunistic observations during the fauna survey, the Regional study area includes extensive areas of diverse mallee woodlands and shrublands, as well as smaller patches of open woodland (both Gimlet and Salmon Gum woodlands) and sandplain. The sandplain habitat was sampled during the fauna survey (Site 12, just north of Van Uden).

Mattiske Consulting (2017a) noted that the vegetation communities in the Earl Grey, Irish Breakfast and Prince of Wales study areas are typical of those reported in the Forrestiana region both historically (Beard 1972, 1990) and in recent flora and vegetation surveys. Similarly, none of the vegetation communites were considered to be restricted or unique in the region (Mattiske Consulting 2017). Although the fauna habitats identified are extensive in the region, they are regionally significant in that they are part of the relatively continuous area of habitat known as the Great Western Woodlands.

Uncommon habitat types, such as granite outcrops, salt lakes or freshwater wetlands, are absent from the study areas. Historically cleared areas, waste dumps and open pits are present in the study areas, and are only likely to support a small complement of native fauna. Cleared areas, including tracks, can provide access for feral predators.

Significant parts of the Prince of Wales and Regional study areas were recently burnt at the time of survey. The fire that intersects the Prince of Wales study area occurred in 2015. While these areas are recovering after fire they are likely to support a different faunal assemblage to that in long-unburnt habitats. Unburnt habitats are important, providing habitats for fauna that favour structurally dense habitats and a source from which fauna can recolonise burnt areas as they regenerate.

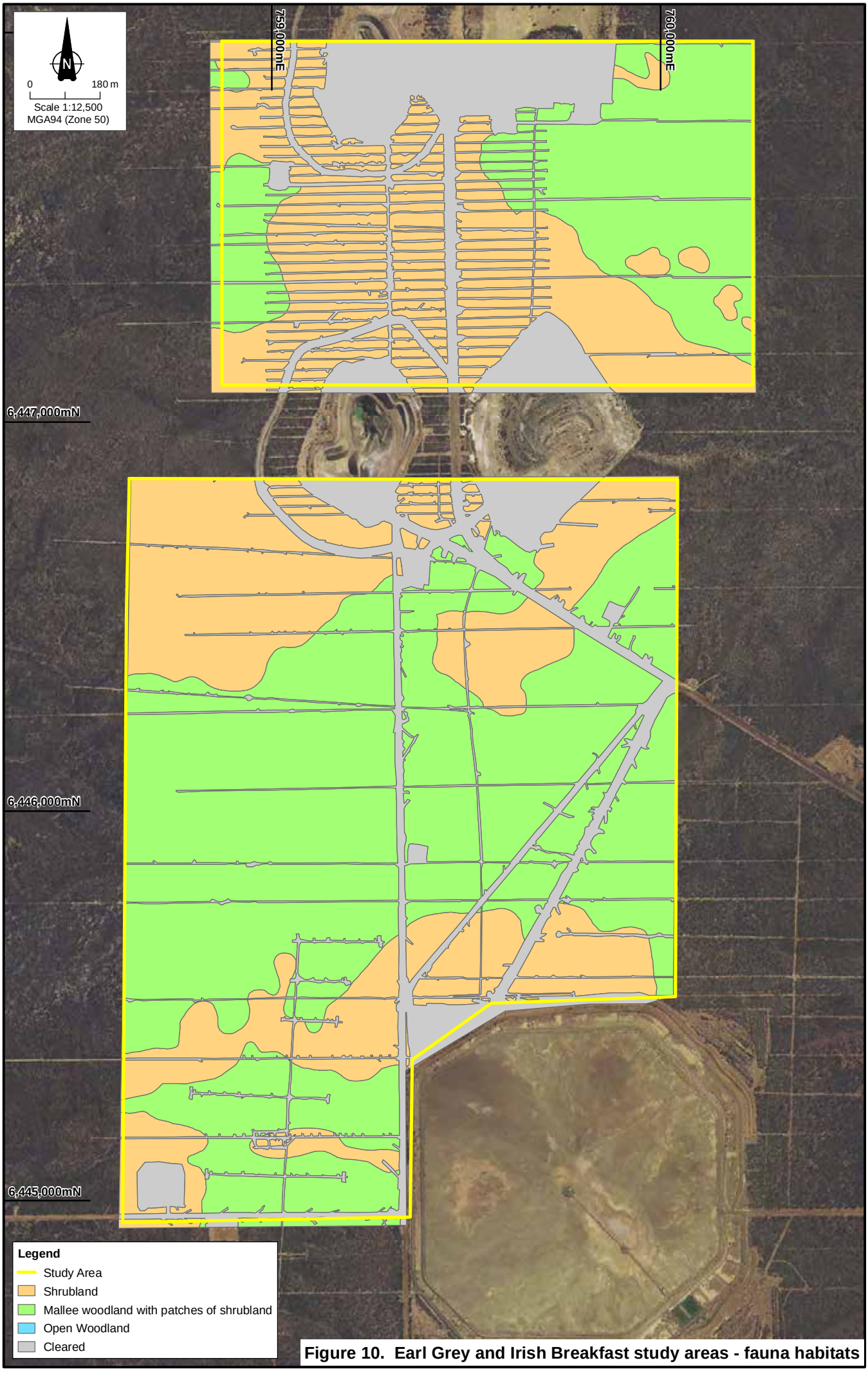

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Figure 10. Earl Grey and Irish Breakfast study areas - fauna habitats

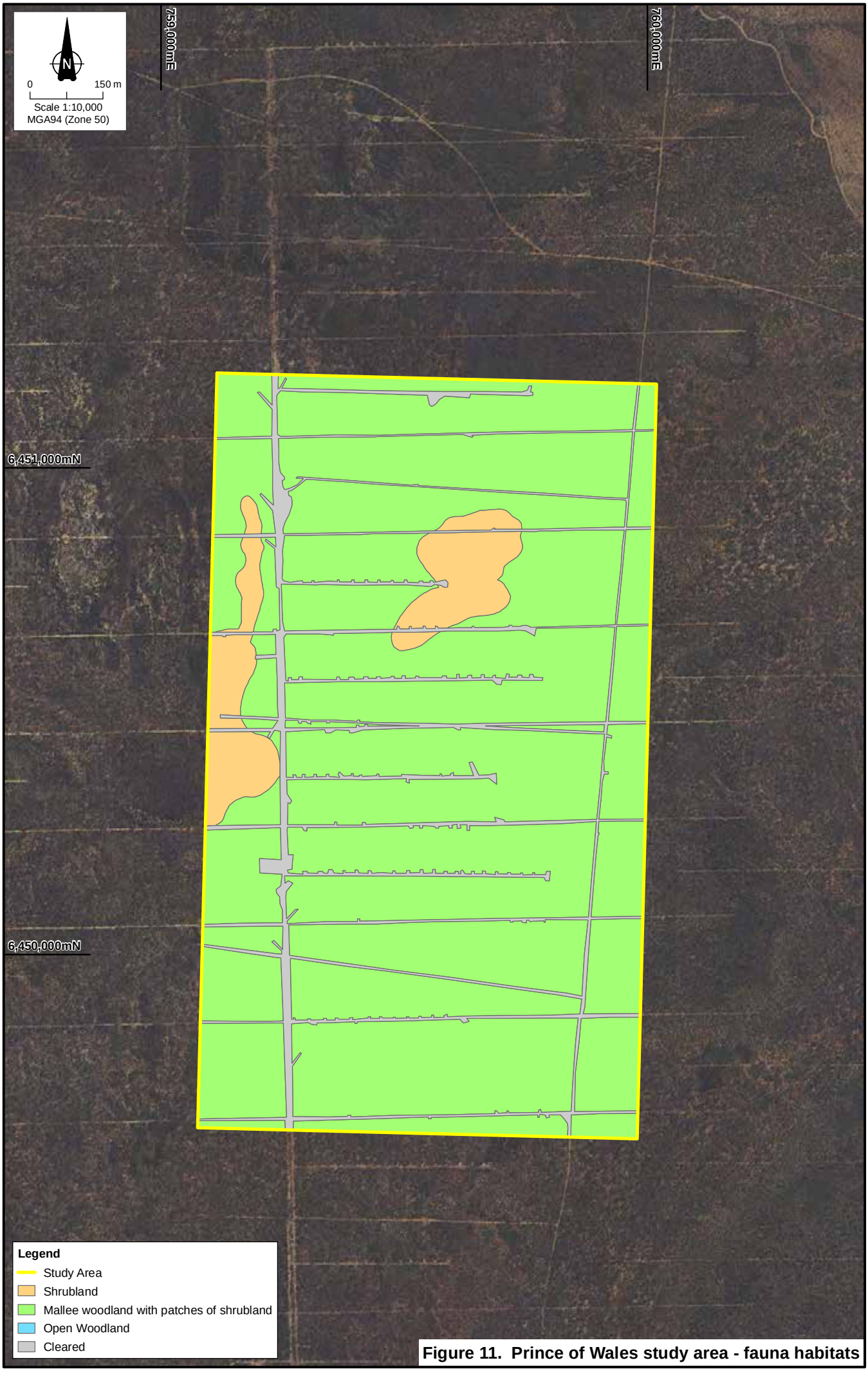

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Figure 11. Prince of Wales study area - fauna habitats

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Figure 12. Van Uden study area - fauna habitats

4.1 Mallee Woodland

Mallee woodland is a very common habitat, both within the study areas and in the bioregion. The 'mallee woodland' habitat describes a structural type, and within that the habitat there is much variability in plant species composition and the density and composition of the shrubland understory, ranging from minimal understory to dense shrubland (Plates 7 and 8).

In the Earl Grey, Irish Breakfast, Prince of Wales and Van Uden study areas, the mallee eucalypt canopy includes one or more of Tall Sand Mallee (*Eucalyptus eremophila*), Stiff-leaved Mallee (*Eucalyptus rigidula*), Wheatbelt Wandoo (*Eucalyptus capillosa*), Lerp Mallee (*Eucalyptus incrassata*), Square-fruited Mallee (*Eucalyptus prolixa*), Burracoppin Mallee (*Eucalyptus burracoppinensis*), Gimlet (*Eucalyptus salubris*) and Merrit (*Eucalyptus flocktoniae*). The understory includes a range of shrubs, particularly *Melaleuca* spp. In the Regional study area further Mallee eucalypts were identified, including White Mallee (*Eucalyptus cylindriflora*), Giant Mallee (*Eucalyptus oleosa*), Horn-capped Mallee (*Eucalyptus ceratocorys),* and Griffith's Grey Gum (*Eucalyptus griffithsii*), indicating the diversity inherent in this habitat.

Plate 7. Mallee woodland at Earl Grey.

Plate 8. Mallee woodland at Prince of Wales.

There are small patches of Gimlet woodland in the Earl Grey and Prince of Wales study areas, as well as in the Regional study area (Plate 9). These woodlands are dominated by a Gimlet (*Eucalyptus salubris*) canopy, sometimes with Merrit (*Eucalyptus flocktoniae*) over a shrubland of *Melaleuca* and other species. Gimlet woodlands have not been mapped as a separate habitat as the faunal assemblage is likely to be similar to that in Mallee woodlands.

As the mallee trees are relatively small in diameter, this habitat generally lacks tree hollows, though scattered hollow-bearing trees are present. Where the understory is dense, it provides nesting habitat for small birds. The reptile assemblage is likely to vary depending on the substrate (e.g. clay or gravelly sand). Mallee woodland potentially supports conservation significant fauna including the Malleefowl (*Leipoa ocellata*), Chuditch (*Dasyurus geoffroii*), Inland Western Rosella (*Platycercus icterotis*), Lake Cronin Snake (*Paroplocephalus atriceps*) and Central Long-eared Bat (*Nyctophilus major tor*).

Plate 9. Gimlet woodland in the Regional study area (left) and Earl Grey (right).

4.2 Open Woodland

Open woodland is less common in this mallee-dominated region. Open woodlands occur patchily, and in the study areas are characterised by a canopy of Salmon Gum (*Eucalyptus salmonophloia*) sometimes with Merrit (*Eucalyptus flocktoniae*) over a sparse shrub understorey. This habitat occurs on red to brown clay-loams, sometimes with ironstone pebbles. This habitat occurred in the Van Uden study area (Plate 10) but open woodlands, including Salmon Gum woodlands, were also noted to occur patchily in the Regional study area (Plate 11).

Open woodland is significant for the tall hollow-bearing trees and large fallen logs that provide shelter and nesting opportunities for a range of fauna. Open woodland potentially supports conservation significant fauna including the Chuditch (*Dasyurus geoffroii*), Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*), Inland Western Rosella (*Platycercus icterotis xanthogenys*), and Central Long-eared Bat (*Nyctophilus major tor*).

Plate 10. Open Woodland (Salmon Gum and Merrit) at Van Uden.

Plate 11. Open woodland (Salmon Gum) in the regional study area.

4.3 Shrubland

Shrublands are common but patchy in occurrence in the Earl Grey, Irish Breakfast and Prince of Wales study areas, as well as in the Regional study area (Plates 12 and 13). It occurs on gravelly sands and varies in composition, but is usually dominated by species of *Acacia*, *Allocasuarina*, *Hakea* and/or *Melaleuca*. This habitat lacks large trees, but the dense structure of the vegetation provides shelter and nesting habitat for ground-dwelling birds. When in flower, shrubland habitats are likely to attract a suite of nectar-feeding bird species.

Plate 12. Shrubland at Earl Grey.

Shrublands potentially support conservation significant fauna including the Malleefowl (*Leipoa ocellata*), Chuditch (*Dasyurus geoffroii*), Rainbow Bee-eater (*Merops ornatus*), Western Brush Wallaby (*Macropus irma*) and Lake Cronin Snake (*Paroplocephalus atriceps*).

Plate 13. Shrublands in the Regional study area.

5. Vertebrate Fauna of the Study Area

The numbers of vertebrate species potentially occurring in the study area are summarised in Table 8. The amphibians, reptiles, birds and mammals that have the potential to occur in the study area are listed in Appendices 3 to 6. Indicated in each Appendix are the species recorded in the study area by Western Wildlife during the October 2016 - February 2017 fauna surveys, as well as records from other sources (summarised in Table 3).

Table 8. Summary of vertebrate fauna potentially occurring in the study area.

Taxon	Total species	Introduced species	Recorded on this survey	Conservation significant species		
				CS1	CS2	CS3
Amphibians	9	0	1	-	-	-
Reptiles	67	0	38	-	2	1
Birds	108	0	70	5	1	-
Mammals	32	5	23	2	2	-
Totals:	**216**	**5**	**132**	**7**	**5**	**1**

The study areas are likely to support a relatively intact faunal assemblage, with only regionally extinct species likely to be missing from the area. The faunal assemblage is diverse as it contains elements from both the Eremaen (arid with irregular rainfall) and Bassian (southwest with regular winter rainfall) regions. The results of the fauna survey, supplemented with database records and published information, indicate that there are up to nine frogs, 67 reptiles, 108 birds and 32 mammals (27 native mammals) that have the potential to occur. A large proportion of these were recorded during the fauna surveys. Overall, one frog, 38 reptiles, 70 birds 18 native mammals and five introduced mammals were recorded.

The faunal assemblages recorded and fauna of conservation significance are discussed in the sections below. The results of the EPBC Act Protected Matters search are given in Appendix 7. The results of the DPAW Threatened and Priority Fauna Database search are given in Appendix 8 and records of species likely to occur in the study areas are shown in Figure 13.

5.1 Amphibians

Nine frog species have the potential to occur in the study area (Appendix 3). One species of frog, the Western Toadlet (*Pseudophryne occidentalis*) was recorded opportunistically during the October and November surveys (Appendix 9).

Most of the species expected to occur are burrowing frogs that use either seasonal or ephemeral wetlands for breeding. These species also breed opportunistically in depressions created by exploration and historical mining activities. The study area lacks natural wetlands, but pools around the base of the existing Earl Grey waste dump, Irish Breakfast pit bund wall and in an excavated depression at Earl Grey were noted to be holding water in October and November 2016. During the non-breeding season burrowing frogs use terrestrial habitats, so may forage throughout the study area.

5.1.1 Amphibians of Conservation Significance

No frog species of conservation significance or significant breeding habitat are likely to occur in the study area.

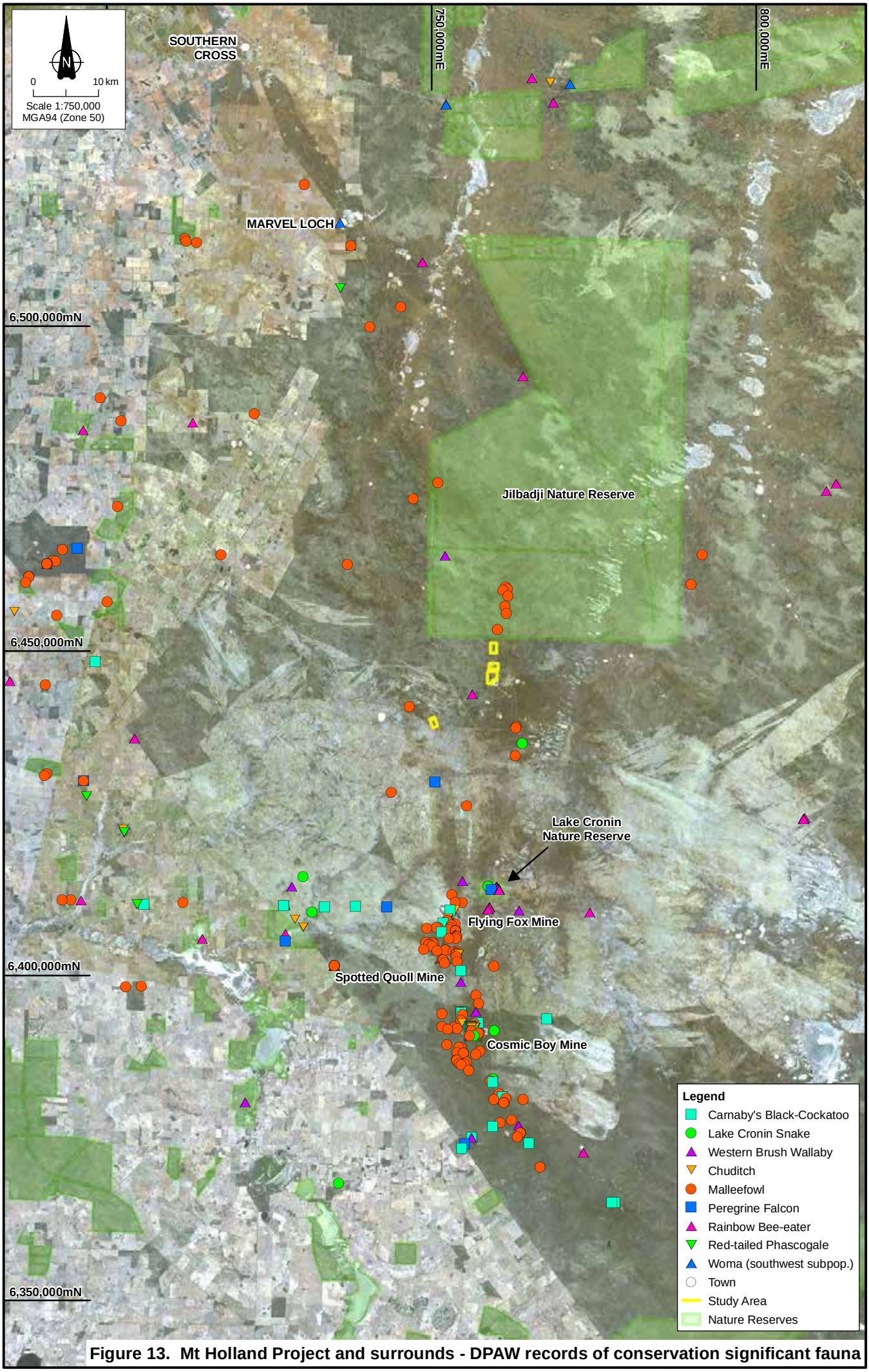

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Figure 13. Mt Holland Project and surrounds - DPAW records of conservation significant fauna

5.2 Reptiles

There are 67 species of reptile that potentially occur in the study area and a total of 38 species were recorded in the Mt Holland study areas (Appendix 4, Table 9). Given its setting in a large, continuous tract of native vegetation, the study area is likely to support a relatively intact reptile assemblage in each habitat. The expected reptile assemblage is both species rich and complex, as expected for the southwestern interzone where the Bassian and Eremaen regions overlap.

Most reptiles recorded in the fauna survey were represented by only a few records, and thus contribute to the species inventory for the study area as a whole, rather than provide data on habitat preferences. The observed reptile assemblage consisted of five dragons, nine geckoes, three legless lizards, 16 skinks, two goannas, one blind snake and two elapid snakes (Table 9). The most species rich sites were Site 10 (tall woodland at Van Uden) with 13 species, followed by Site 6 (Mallee woodland on laterite rise at Irish Breakfast) with eleven species. The lowest species richness was recorded at Site 2 (Mallee woodland at Earl Grey), with two species. At Site 9, despite being recently burnt, nine reptile species were recorded.

A suite of species have a Bassian distribution, generally occurring in the south-west and are at the north-eastern edge of their distribution in the study area. This includes species such as the Barking Gecko (*Underwoodisaurus milii*), Southern Blind Snake (*Anilios australis*) and Dusky Morethia (*Morethia obscura*). Species with an Eremean distribution occur across the heavier soils extending into the arid zone north and east of the study area.

Some reptiles favour sandy soils, and their distribution is likely to be centered around sandplain and shrubland habitats in the study areas. This includes species such as the Thorny Devil (*Moloch horridus*), Spotted Military Dragon (*Ctenophorus maculatus*), *Ctenotus atlas* and Spotted Knob-tail (*Nephrurus stellatus*). Species such as the Crested Dragon (*Ctenophorus cristatus*) (Plate 14), and *Egernia richardi* favour eucalypt woodlands, often sheltering in hollow logs. The Reticulated Velvet Gecko (*Hesperoedura reticulata*) inhabits smooth-barked eucalypts where it shelters in tree hollows or crevices and was only recorded at Site 10, the only site where suitable woodland was present (Table 9).

Other reptiles recorded or likely to be present are likely to occur across all the habitats present in the study area. Generalist species, such as the Dwarf Skink (*Menetia greyii*), Bobtail (*Tiliqua rugosa*) and Dugite (*Pseudonaja affinis*) have large distributions and occur in a range of vegetation and soil types.

Plate 14. The Crested Dragon (*Ctenophorus cristatus*) and South Coast Gecko (*Diplodactylus calcicolus*).

One species, the South Coast Gecko (Plate 14), was recorded unexpectedly. This species was recorded once at Site 10, and represents a modest range extension of about 30km. The next nearest records of this species to the study area on NatureMap are from around Lake Cronin (DPAW 2007-). The South Coast Gecko is common within its range.

Table 9. Reptile captures at each site and opportunistic records, Oct to Dec 2016.

Reptile species	Site												Opportunistic
	Earl Grey				Irish Break-fast		Prince of Wales			Van Uden			
	1	2	3	4	5	6	7	8	9	10	11	12	
Dragons													
Ctenophorus cristatus					1	1		x	1	1			
Ctenophorus maculatus	1		3	4								2	
Ctenophorus salinarum													x
Moloch horridus												x	
Pogona minor				1		1			1				
Geckoes													
Crenadactylus ocellatus			1			1		1	2				
Diplodactylus calcicolus											1		
Diplodactylus granariensis	1	2				2	2	1			2	1	
Gehyra variegata										4			
Hesperoedura reticulata										x			
Lucasium maini										1	2		
Nephrurus stellatus (CS3)												1	
Strophurus spinigerus							1						
Underwoodisaurus milli						1							
Legless lizards													
Delma australis			1				2						
Delma fraseri						3			1				
Pygopus lepidopodus										1			
Skinks													
Cryptoblepharus buchananii										2			
Ctenotus atlas					1								
Ctenotus impar				1									
Ctenotus mimetes					1								
Ctenotus schomburgkii	1			1	2	5		2	10	1			
Ctenotus uber				1	1	4	1	3	6				
Egernia richardi										4	1		
Hemiergis initialis			1										
Lerista distinguenda						3				2		1	
Lerista kingii													x
Liopholis multiscutata													x
Menetia greyii	3		2		2		1		3	3		1	
Morethia butleri	1					1		1	1	2			
Morethia obscura						3			1	12	4	2	
Tiliqua occipitalis	1				1						1		
Tiliqua rugosa													x
Monitors or goannas													
Varanus gouldii		1		1	2								
Varanus rosenbergi	1						1			1			

Table 9. (cont.)

Reptile species	Site												Opportunistic
	Earl Grey				Irish Break-fast		Prince of Wales			Van Uden			
	1	2	3	4	5	6	7	8	9	10	11	12	
Blind snakes													
Anilios australis			1										
Elapid snakes													
Pseudonaja affinis													x
Simosolaps bertholdi												1	
Total species:	7	2	6	6	8	11	6	6	9	13	6	8	5

X = observed opportunistically and numbers may include individuals captured more than once over successive days.

5.2.1 Reptiles of Conservation Significance

There are three reptiles of conservation significance that have the potential to occur in the area. Each species is listed and discussed below.

Conservation Significance 2

Woma (southwest sub-population) *Aspidites ramsayi*
This species is listed as Priority 1 by DPAW.

Lake Cronin Snake *Paroplocephalus atriceps*
This species is listed as Priority 3 by DPAW.

The **Woma** is a large ground-dwelling python that occurs widely across arid and semi-arid Australia. The disjunct southwest subpopulation is listed as Priority 1. This sub-population is not well-known and extremely rare, Bush et al. (2007) reporting that the last known wheatbelt sighting of this species was in 1989. While in other regions the Woma occurs in a variety of habitats, in the wheatbelt and goldfields this species occurs mainly on sandplains (Bush *et al*. 2007). Sandplain habitats are absent from the Earl Grey, Irish Breakfast, Prince of Wales and Van Uden study areas, but there are patches of sandplain in the Regional study area and on the road between Van Uden and the Forrestiana-Hyden road. The four records of this species on DPAW's Threatened and Priority Fauna Database are undated historical records (Figure 13, Appendix 8, and there are no recent sightings of this species reported from the region. The Woma appears likely to be locally exinct, but if present may occur in the sandplain habitats.

The **Lake Cronin Snake** is known from very few localities in the semi-arid southern interior of Western Australia (Storr *et al*. 2002). The Lake Cronin Snake has been recorded from areas of woodland (including Salmon Gum woodlands) and tall shrubland and, although not known to have declined, this species may be threatened by clearing for agriculture and mining (Cogger *et al*. 1993, Bush *et al*. 2007). Most of the records of this species on DPAW's Threatened and Priority Fauna Database are from Lake Cronin and around Cosmic Boy Mine, to the south of the study areas (Figure 13, Appendix 8). However, there is also a record from Jilbadji Nature Reserve to the north, so the distribution of this species is likely to overlap the study area. Although not recorded during the fauna survey, the Lake Cronin Snake potentially occurs in any of the woodland or shrubland habitats in the study areas.

Conservation Significance 3

Spotted Knob-tail Gecko *Nephrurus stellatus*
This gecko species has a restricted distribution.

The **Spotted Knob-tail Gecko** has a restricted distribution, occurring between Mt Holland and Bungalbin Hill (Bush *et al*. 2007). According to Bush *et al*. (2007), it favours mallee woodlands with hummock grass in sandplain habitats, and it has been recorded nearby in Jilbadji Nature Reserve by Keighery *et al*. (1995). This species was recorded once at Site 12, in sandplain shrubland habitat just north of the Van Uden study area (Table 9, Plate 15). The Spotted Knob-tail Gecko may also occur in shrubland habitats in the other study areas, but is likely to be absent from areas of heavier soils in mallee or open eucalypt woodlands.

Plate 15. The Spotted Knob-tail Gecko (*Nephrurus stellatus*) trapped at Site 12.

5.3 Birds

There are 108 species of bird that potentially occur in the study areas (Appendix 5). The study areas are in the south-western interzone, on the transition between the southwest (Bassian) and arid (Eremaean) regions, and the diverse bird assemblage reflects this. There is a suite of species present that have a south-western distribution and are on the north-eastern limit of their range in the study area, including Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*) and the Spotted Pardalote (*Pardalotus punctatus*). A second suite of species occurs mainly in arid regions and are at their south-western limit in the study area, such as the White-fronted Honeyeater (*Purnella albifrons*).

A total of 70 birds were observed in the Mt Holland study areas (Table 10, Appendix 5). The most species rich site was Site 9, despite being in a recently burnt area. The high species richness may be due to the mosaic of unburnt patches of understorey shrubland within the burnt area. The bird assemblage in Prince of Wales is likely to change over time, as the vegetation continues to recover after fire. Some species are more common in the open habitats created after fire, while others favour the dense vegetation of long-unburnt habitats (Fox *et al*. 2016).

The second most species rich sites were Sites 10 and 11 at Van Uden (26 species each). These sites at Van Uden were in or adjacent to eucalypt woodland with Salmon Gum and Merrit, unlike the remaining bird survey sites in Earl Grey, Irish Breakfast and Prince of Wales. Species such as the Yellow-plumed Honeyeater, Little Eagle, Dusky Woodswallow and Rufous Tree-creeper were only recorded at Van Uden.

Honeyeaters were very common with several species commonly occurring at all sites (Table 10). Honeyeaters and the Purple-crowned Lorikeet (*Parvipsitta porphyrocephala*) move to take advantage of seasonal flowering resources. These species are likely to fluctuate in abundance, both seasonally and between years, and are likely to be abundant in the study area when the shrublands or eucalypt canopy is flowering.

While many bird species occur across open woodlands, mallee woodlands and shrublands, others are more dependent on a single habitat. Some favour woodland habitats, such as the Rufous Treecreeper (*Climacteris rufus*) and Yellow-plumed Honeyeater (*Ptilotula ornata*). Where there are hollows in the eucalypts, birds such as owls, parrots, pardalotes and the Tree Martin (*Petrochelidon nigricans*) are likely to use these for nesting. Occasional hollow-bearing eucalypts are present in Earl Grey, Irish Breakfast and Prince of Wales, but the open woodland at Van Uden contains many potential nesting hollows.

The study areas, particularly Earl Grey, Irish Breakfast and Prince of Wales, support a suite of small insectivores that forage on the ground and mid-levels (Table 10). A few species, such as the Australian Pipit (*Anthus australis*), favour open areas and are relatively uncommon. Open patches in the woodlands are favoured by robins, which perch in the mid-storey and forage on the ground. A dense cover of shrubs is favoured by the Shy Heathwren (*Hylacola cauta*), Blue-breasted Fairy-wren (*Malurus pulcherrimus),* Southern Scrub-robin (*Drymodes brunneopygia*) and Copperback Quail-thrush (*Cinclosoma clarum*). These and other species nest in dense vegetation, some, such as the Southern Scrub-Robin, on the ground and many, such as the Inland Thornbill (*Acanthiza apicalis*), within a metre of the ground (Plate 16). These nests can be vulnerable to feral predators, (foxes and cats), when dense habitats are fragmented.

Plate 16. Inland Thornbill (left) and Southern Scrub-robin (right) nests in Earl Grey.

Water is present in a small excavation at Earl Grey and in pools around the base of the Earl Grey waste dump and the Irish Breakfast bund wall, which some waterbirds are likely to use on occasion. As this is not significant waterbird habitat, waterbirds were not included among the list of species in Appendix 5 unless observed in the study areas.

Table 10. Birds recorded at each site or opportunistically in the study areas.

Bird species	Frequency of occurrence (n = 7) at each site												Opportunistic
	Earl Grey				Irish B-fast		Prince of Wales			Van Uden			
	1	2	3	4	5	6	7	8	9	10	11	12	
Birds of Prey													
Brown Falcon				1							x		
Collared Sparrowhawk													x
Little Eagle										4			
Peregrine Falcon (CS1)												1	
Square-tailed Kite													x
Wedge-tailed Eagle													x
Whistling Kite													x
Waterbirds													
Grey Teal													x
Granivores													
Australian Ringneck							2			2			
Brush Bronzewing	4				1	3	1	2	2		1		
Common Bronzewing					x					2			
Elegant Parrot					1		2	1	3				
Painted Button-quail													x
Regent Parrot		1	1			1	1	2	3			1	
Inland Western Rosella (CS2)			1							4			
Insectivores – aerial foragers													
Dusky Woodswallow										6			
Rainbow Bee-eater										1			
Tree Martin			1	1						6			
Welcome Swallow													x
White-backed Swallow				1									
Insectivores – understorey to midstorey foragers													
Australian Pipit													x
Blue-breasted Fairy-wren	1		5	6	4	2	2	1	3		2	4	
Copperback Quail-thrush								1	1			1	
Hooded Robin													x
Inland Thornbill	4		4	4	2	3	5		4		6	4	
Jacky Winter													x
Painted Button-quail													x
Red-capped Robin		2	1								1		
Redthroat					2		1		2			1	
Shy Heathwren	2	2	5		2	x	2	1	1			1	
Southern Scrub-robin	5	4	4	5	5	6	5	5	3		5	6	
Western Yellow Robin		1				2	1	2	1	2	1		
White-browed Babbler		1	1			1		2		2	1		
White-browed Scrubwren					1				1			1	
Willie Wagtail									1	3			
Yellow-rumped Thornbill													x

Table 10. (cont.)

Bird species	Frequency of occurrence (n = 7) at each site												Opportunistic
	Earl Grey				Irish B-fast		Prince of Wales			Van Uden			
	1	2	3	4	5	6	7	8	9	10	11	12	
Insectivores – midstorey to canopy foragers													
Crested Bellbird	4	2	4		1		2	2	4		1	2	
Fan-tailed Cuckoo													x
Gilbert's Whistler													x
Golden Whistler	4	4	3	1	1		3	2	1		2		
Grey Shrike-thrush	1	4	5	1	2		3	4		6	4	1	
Horsfield's Bronze-cuckoo	3			2	2							1	
Restless Flycatcher													x
Rufous Treecreeper										6			
Varied Sittella													x
White-winged Triller													x
Mistletoebird													x
Insectivores – eucalypt canopy specialists													
Spotted Pardalote	2	2	1		2	2	1	4	3		1	2	
Striated Pardalote		1						2	2	1	6		
Weebill	1	3	2	4	2	6	4	6	5		5	4	
Nectarivores (honeyeaters & lorikeets)													
Brown Honeyeater	2							1			1	2	
Brown-headed Honeyeater	2	2	2		4	4	1	2			4	2	
Purple-crowned Lorikeet							1		2	6	4	2	
Purple-gaped Honeyeater	1	3	4	2	2	2	x	5	1			1	
Red Wattlebird		1		1		2	1	2	1	3	4	2	
Singing Honeyeater													x
Spiny-cheeked Honeyeater	2		1	1	1	2	1	2	4	1		4	
Tawny-crowned Honeyeater	2				2		1		1			1	
White-eared Honeyeater	4	3		2	2	4	2	1	3		4	2	
White-fronted Honeyeater	4	2	2	1	4	2	1	5	2		2	5	
Yellow-plumed Honeyeater										6	1		
Yellow-throated Miner													x
Large predator/insectivores													
Australian Raven											1		
Black-faced Cuckoo-shrike			1		1				2	1	2		
Grey Butcherbird				x			4		1	1	3	1	
Grey Currawong			1			2		1		1	1		
Nocturnal birds													
Spotted Nightjar							x						
Tawny Frogmouth													x
Large ground-dwelling birds													
Emu		x							x			x	
Malleefowl			x								x	x	
Total species:	**18**	**18**	**21**	**16**	**22**	**17**	**25**	**23**	**27**	**20**	**26**	**26**	**21**

5.3.1 Birds of Conservation Significance

There are six bird species of conservation significance that have the potential to occur in the study area, five of CS1 and 1 of CS2. Each is listed and discussed below. Records of conservation significant birds from this fauna survey are presented in Figure 14.

Several birds listed on database searches in the area (Appendices 7 and 8) have been omitted from Appendix 5 and the discussion below. Records of Baudin's Black-Cockatoo (*Calyptorhynchus baudinii*) are likely to be old records prior to taxonomic changes, that should be attributed to Carnaby's Black-Cockatoo, as Baudin's Black-Cockatoo is restricted to the deep southwest and does not occur in the area. The Hooded Plover (*Charadrius rubricollis*), Curlew Sandpiper (*Calidris ferruginea*) and Sharp-tailed Sandpiper (*Calidris acuminata*) are shorebirds that may occasionally occur on claypans and salt lakes in the region, a habitat that is absent from the study area. The Night Parrot (*Pezoporus occidentalis*) is an extremely rare species for which suitable habitat is absent in the study area.

Conservation Significance 1

Malleefowl *Leipoa ocellata*
This species is listed under Schedule 3 (Vulnerable) of the WC Act and as Vulnerable under the EPBC Act.

Carnaby's Black-Cockatoo *Calyptorhynchus latirostris*
This cockatoo is listed under Schedule 2 (Endangered) of the WC Act and as Endangered under the EPBC Act.

Peregrine Falcon *Falco peregrinus*
This falcon is listed under Schedule 7 (other specially protected fauna) of the WC Act.

Rainbow Bee-eater *Merops ornatus*
This species is listed under Schedule 5 (Migratory birds under international agreement) of the WC Act.

Fork-tailed Swift *Apus pacificus*
This species is listed under Schedule 5 (Migratory birds under international agreement) of the WC Act and as migratory under the EPBC Act.

The **Malleefowl** is a bird of dense shrublands, mulga woodlands and mallee woodlands, and used to be common in the southern arid and semi-arid areas of Western Australia (Johnstone and Storr 1998). In order to construct their nest mounds, the Malleefowl needs leaf litter on sandy substrates (Garnett and Crowley 2010). The mounds are usually constructed intermittently by a pair of birds between autumn and spring. Between early spring and mid to late summer, 15 - 25 eggs are laid in the mound by the female, while the male continues to tend the mound. The chicks emerge between November and January (sometimes as late as March), and as they receive no parental care, chick mortality can be high (Benshemesh 2007).

As Malleefowl nest on the ground, the eggs and flightless chicks are vulnerable to predation by feral predators. However, the main threat to Malleefowl is habitat loss and the fragmentation and degradation of remaining habitat, as well as the death of adults on roads (Benshemesh 2007, Garnett *et al*. 2011). Fire can have a significant impact on populations, by killing adult birds, causing local extinctions in fragmented habitats and causing a cessation in breeding activity for many years after a fire (Benshemesh 2007).

There are many records of Malleefowl within the 90km search area surrounding the study area on DPAW's Threatened and Priority Fauna Database, many of them recent (Figure 12, Appendix 8). Malleefowl are likely to occur throughout the woodlands and shrublands of the region. The Malleefowl was recorded in the study areas with two opportunistic sightings, three records of birds on camera traps and records of four active and 17 inactive mounds (Plate 17, Figures 14 and 15, Appendix 11).

Plate 17. Malleefowl recorded in Regional area.

Four active mounds were recorded, one in Earl Grey, one in Van Uden and two in the Regional area (Plate 18, Figure 15, Appendix 10). All active mounds found were in unburnt habitat, and three of the four were alongside tracks. Several old, inactive mounds were also recorded, indicating areas suitable for breeding, at least historically (Figure 15). Inactive mounds in burnt areas are unlikely to be used again until after the vegetation has regenerated sufficiently to provide leaf litter for use in nest construction. It should be noted that the distribution of mounds in Figure 15 is influenced by the level of survey carried out in various areas. Earl Grey, Irish Breakfast and Prince of Wales were intensively searched so it is likely that the inventory of mounds within these areas are near-complete. The remaining areas were sampled opportunistically only, so it is likely that many mounds remain unrecorded.

Plate 18. Active Malleefowl mound MM-03 in Earl Grey.

Malleefowl will often breed in the same general area year after year, and new mounds may be constructed or old mounds re-used. The adult birds have been found to range over one to many square kilometres, and these home ranges overlap (Benshemesh 2007). It is likely that all vegetation in the study areas is foraging habitat for Malleefowl, though open woodlands are less suitable compared to mallee woodland and shrublands (Parsons 2008). Breeding habitat in the study areas is widespread but patchy. Mounds were generally found in patches of tall shrubland in sparse mallee woodland, with a gravelly sand substrate (Appendix 10). Areas of long-unburnt mallee woodland and shrublands are likely to be regionally important for maintaining Malleefowl populations, particularly in the context of widespread fires in the region and the length of time it takes for burnt areas to return to conditions suitable for breeding.

Carnaby's Black-Cockatoo is endemic to the southwest of Western Australia, and has declined due to loss of breeding habitat in the wheatbelt and foraging habitat along the west coast (Johnstone and Storr 1998). Carnaby's Black-Cockatoo prefers to breed in smooth-barked eucalypts such as Salmon Gum (Johnstone and Storr 1998). This species feeds on the seeds of eucalypts and proteaceous vegetation, as well as a range of other seeding species including *Allocasuarina* spp. (Johnstone and Storr 1998). There are several records of this species on DPAW's Threatened and Priority Fauna Database, mostly from surveys around Cosmic Boy Mine, but also at Hatters Hill and Flying Fox Mine (Figure 13, Appendix 8). Although the study areas are on the very eastern limits of the known range of this species, Carnaby's Black-Cockatoo potentially breeds in Salmon Gum woodlands at Van Uden and the Regional study area, and surrounding areas of eucalypt woodlands and shrublands are potentially foraging habitat.

The **Peregrine Falcon** is a widespread bird of prey that globally has a very large range and a very large population that appears to be secure (BirdLife International 2016). In Western Australia the population is secure, though this species may experience reductions at a local level due to human disturbance at nesting sites (Debus 1998). The Peregrine Falcon nests mainly on ledges on cliffs or rocky outcrops, and it may also use tall trees (Johnstone and Storr 1998). This species often takes advantage of man-made structures such as abandoned open pits or quarries. The Peregrine Falcon was recorded during the fauna surveys (Figure 14), where it potentially nests in the existing open pits.

The **Rainbow Bee-eater** is a common species that migrates south in summer to breed. It is widespread in Western Australia and was recorded in the study areas during the fauna survey (Figure 14). The Rainbow Bee-eater may forage anywhere over the study areas, but is only likely to breed where there are lighter soils in which to burrow, potentially breeding alongside tracks or in open patches in shrublands or woodlands. As the Rainbow Bee-eater has an extremely large range and an extremely large population size that does not appear to be declining (BirdLife International 2016), it is unlikely that the study area is of particular significance for this species.

The **Fork-tailed Swift** is a non-breeding visitor to Australia between September and April (Boehm 1962). While it can be common further north, in southwest Australia this species is generally scarce (Johnstone and Storr 1998). The bird is primarily observed foraging for insects in proximity to cyclonic weather (Boehm 1962). This species has been recorded in the region on DPAW's Threatened and Priority Fauna Database (Appendix 8). Although a migratory species, the Fork-tailed Swift has a large range and a large population that appears to be stable (Birdlife International 2016). In Western Australia, the Fork-tailed Swift is a largely an aerial species and study area is not likely to be of particular significance for this species.

Conservation Significance 2

Inland Western Rosella *Platycercus icterotis xanthogenys*
This species is listed as Priority 4 by DPAW.

The **Inland Western Rosella** is endemic to southern Western Australia. The population of this species is thought to be declining in the western wheatbelt due to clearing, but stable in the western woodlands (Garnett and Crowley 2000). Although still a Priority species, the Inland Western Rosella was not listed in the 2010 Action Plan for Australian Birds as the population is considered too large and the decline too slow to be designated as Near Threatened (Garnett *et al*. 2011). This species occurs in eucalypt and Casuarina woodlands, nesting in tree hollows (Johnstone and Storr 1998). The Inland Western Rosella was recorded during the fauna surveys (Table 10, Figure 14), and is also known from records in the area (Figure 13, Appendix 8). The Earl Grey, Irish Breakfast and Prince of Wales study areas do not constitute significant breeding habitat as they generally lack large trees that may contain hollows. The Van Uden study area and parts of the Regional study area include habitats with tall, hollow-bearing eucalypts that are potential breeding habitat. The Inland Western Rosella is likely to forage in all the study areas in both woodlands and shrublands.

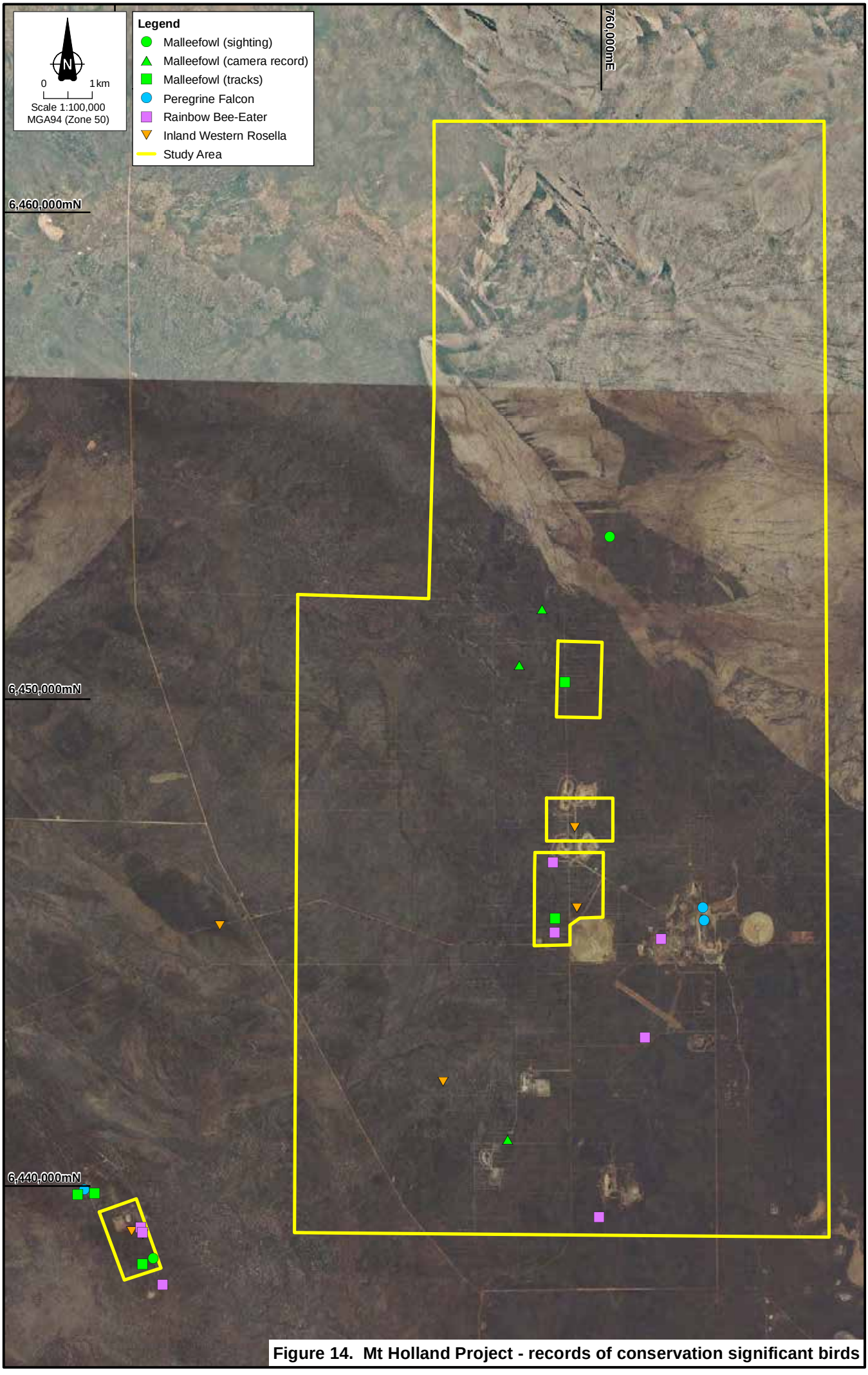

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Figure 14. Mt Holland Project - records of conservation significant birds

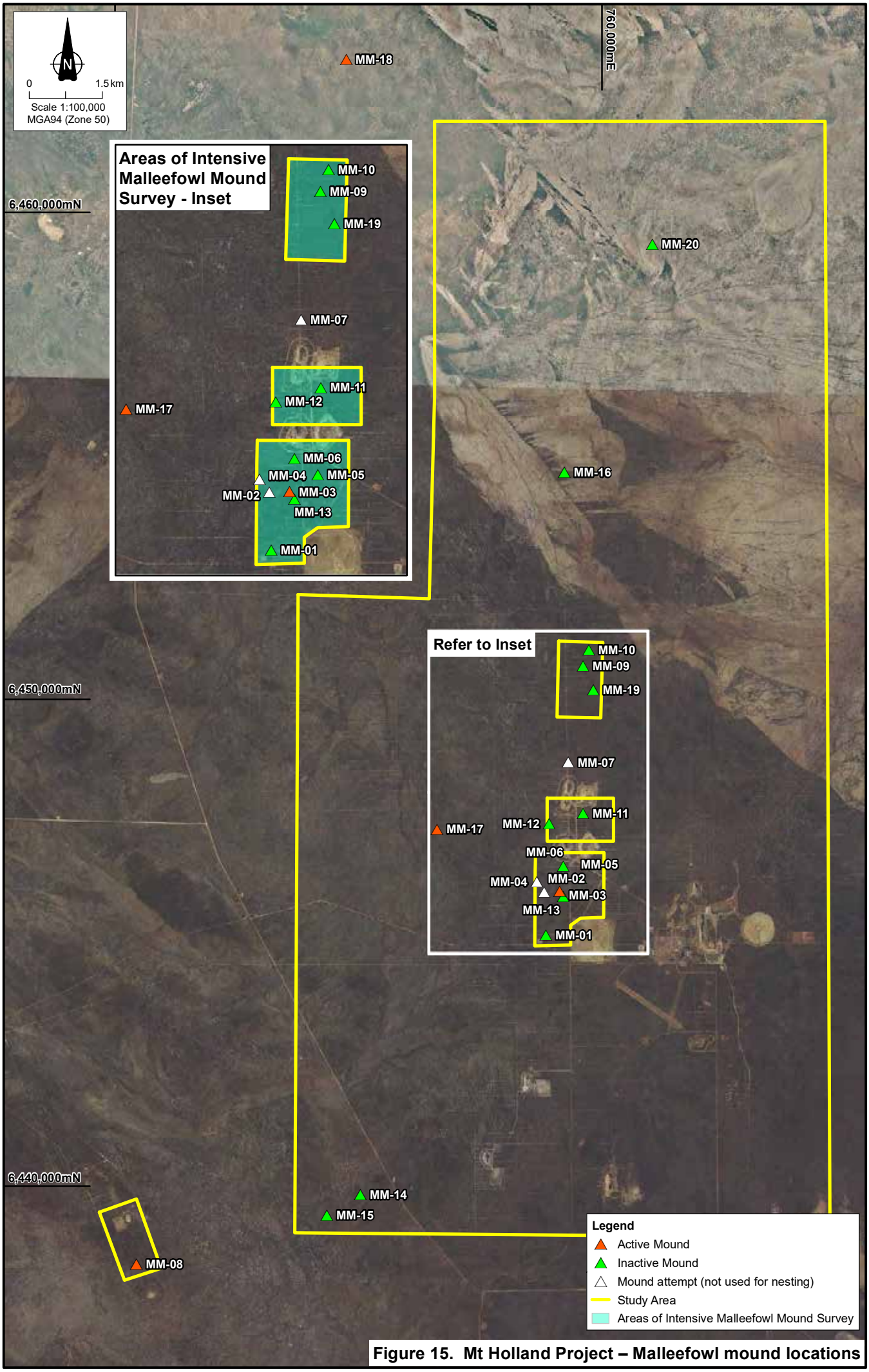

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Figure 15. Mt Holland Project – Malleefowl mound locations

5.4 Mammals

There are 32 mammals with the potential to occur in the study area, of which 27 are native and five are introduced (Appendix 6). A total of 23 mammals (18 native and five introduced) were recorded in the study area during the fauna survey (Table 11, Appendix 6). Unlike birds and reptiles, the mammal assemblage is primarily Bassian, with the distribution of most species extending into the southwest, rather than into the arid zone. Exceptions to this are some bat species and the Ooldea Dunnart (*Sminthopsis ooldea*), which have inland distributions.

Six dasyurid marsupials were recorded, with the Chuditch (*Dasyurus geoffroii*) particularly common at some sites, though it was absent from Van Uden (Table 11, Figure 16). This species is further discussed in section 5.4.1. Of the four dunnarts recorded, the Little Long-tailed Dunnart (*Sminthopsis dolichura*) and White-tailed Dunnart (*Sminthopsis granulipes*) were trapped in a both woodland and shrubland habitats (Plate 19). The remaining dunnart species were trapped only once each, but are also likely to occur in a range of habitats.

The Western Pygmy Possum (*Cercartetus concinnus*) was recorded at most sites, and is likely to be common in woodlands and shrublands (Plate 19). This small arboreal mammal is highly mobile, moving to take advantage of seasonal flowering resources. The Western Pygmy Possum feeds on pollen, nectar and insects, and hence favours habitats with a dense, floristically diverse understorey (Van Dyck and Strahan 2008).

Plate 19. Western Pygmy Possum (left) and White-tailed Dunnart (right).

Two native mice species were recorded in the study area. The Ash-grey Mouse (*Pseudomys albocinereus*) was recorded on a single occasion. This species favours heaths and mallee shrublands on sandy soils, and is likely to occur in these habitats across the study area. Mitchell's Hopping Mouse (*Notomys mitchelli*) was most commonly recorded at Site 12 in the sand-plain, but was also recorded in shrubland sites at Earl Grey and Irish Breakfast and on camera traps in the study areas (Table 11, Appendix 11).

Many of the native species likely to occur are bats. Six species of bat were positively identified from their calls (Table 11, Appendix 12). Some bat species, such as *Nyctophilus* spp., cannot be distinguished on call, so their presence could not be confirmed. Bats are likely to forage throughout the study areas, and during the day bats roost in tree hollows, crevices in mature trees and under loose bark.

Table 11. Mammal captures at each site and opportunistic records, Oct to Dec 2016.

Reptile species	Site												Opportunistic
	Earl Grey				Irish Break-fast		Prince of Wales			Van Uden			
	1	2	3	4	5	6	7	8	9	10	11	12	
Echidnas													
Tachyglossus aculeatus													x
Dasyurid marsupials													
Dasyurus geoffroii (CS1)	1	6	4	3	4	12	2		1				
Ningaui yvonneae												1	
Sminthopsis dolichura	1	1	1						1	3	2		
Sminthopsis gilberti										1			
Sminthopsis granulipes	5	1		8	2			1				7	
Sminthopsis ooldea												1	
Kangaroos and wallabies													
Macropus fuliginosus													x
Macropus irma (CS2)													x
Pygmy possums													
Cercartetus concinnus	1	2	2	2		1		2	1	3	5	1	
Bats													
Austronomus australis	x	x	x	x	x	x	x	x	x	x	x	x	
Chalinolobus gouldii	x		x	x		x		x	x	x	x	x	
Scotorepens balstoni										x	x		
Ozimops kitcheneri	x	x	x	x	x	x	x	x	x	x	x	x	
Vespadelus regulus				x	x	x	x	x	x	x	x	x	
Vespadelus baverstocki		x	x					x		x	x	x	
Native mice and rats													
Notomys mitchelli			5		6						1	11	
Pseudomys albocinereus					1								
Introduced Mammals													
Canis lupus / dingo										x			
Mus musculus	1												
Felis catus													x
Oryctolagus cuniculus									x				
Vulpes vulpes													x
Total species:	**8**	**7**	**8**	**7**	**7**	**6**	**4**	**7**	**8**	**10**	**9**	**10**	**5**

Note: X = observed opportunistically or a bat recorded on call and numbers may include individuals captured more than once over successive days.

A single House Mouse (*Mus musculus*) was trapped, and four other feral animals were recorded opportunistically or on camera traps (Table 11, Appendices 9 and 11). Of the feral predators, foxes and dogs appeared relatively uncommon, with most records from camera traps in Van Uden and burnt areas in Jilbadji Nature Reserve (Figure 17, Appendix 11), suggesting these species may prefer open habitats. Cats were more widely distributed and occurred in a range of habitats, including dense shrublands (Figure 17, Appendix 11).

5.4.1 Mammals of Conservation Significance

There are four mammal species of conservation significance that have the potential to occur in the study areas, two of CS1 and two of CS2. Each is listed and discussed below. Records of conservation significant mammals from this fauna survey are presented in Figure 16. There are three mammals listed on database searches in the area that have been omitted from Appendix 6 and the discussion below. The Bilby (*Macrotis lagotis*) and Numbat (*Myrmecobius fasciatus*) are locally extinct, represented only by historical records (Appendix 2). The Black-flanked Rock Wallaby (*Petrogale lateralis lateralis*) was recorded from South Yilgarn in 2007 (Appendix 8), but this species only inhabits rocky outcrops, a habitat absent from the study areas. The Western Mouse (*Pseudomys occidentalis*) has not been recorded further north than Hatters Hill and Dragon Rocks Nature Reserve (Appendix 8), about 90km south of the study area, and is not known to occur in the area.

Conservation Significance 1

Chuditch *Dasyurus geoffroii*
This species is listed under Schedule 3 (Vulnerable) of the WC Act and as Vulnerable under the EPBC Act.

Red-tailed Phascogale *Phascogale calura*
This species is listed under Schedule 6 (Conservation Dependent) of the WC Act and as Vulnerable under the EPBC Act.

The **Chuditch** used to occur across much of the continent, but is now restricted to the southwest of Western Australia. Although they used to occupy a range of habitats, the majority of Chuditch now occur in the Jarrah forest with some wheatbelt/goldfields populations in drier woodlands, heath and mallee shrublands (Van Dyck and Strahan 2008; Orrell and Morris 1994). In 1981, the Chuditch was not recorded in Jilbadji Nature Reserve during a comprehensive fauna survey and considered by Keighery *et al*. (1995) to be locally extinct or at least very rare in the region. Up until recently, there were only occasional records of the Chuditch from the wheatbelt and goldfields, with this population estimated at 2,000 mature individuals (Woinarski *et al*. 2014, DoEE 2016). However, Chuditch have been recorded recently in Forrestania on DPAW's Threatened and Priority Fauna Database, mostly in association with the Cosmic Boy Mine (Figure 13, Appendix 8).

In 2009, Chuditch at the Cosmic Boy Mine were subject to a study of their spatial and dietary requirements (Rayner *et al*. 2011). This included radio-tracking two females and four males to determine home range size and daytime refuge sites, trapping along transects with traps 200m apart to determine population density and scat analysis to determine diet. As the Cosmic Boy Mine is within the same bioregion, situated about 55km to the south, the results are likely to be relevant to the Mt Holland study areas.

During the initial survey at Earl Grey in October 2016, Chuditch were recorded at seven of the twelve camera trap locations (Appendix 11, Figure 17, Plate 20). This prompted further study to determine the distribution of Chuditch in the wider area, and in November 2016, Chuditch were recorded at four of the six locations in Prince of Wales and three of the six locations in Irish Breakfast. No Chuditch were recorded at Van Uden, despite apparently suitable habitat (open woodlands and mallee woodlands) being present. In the Regional study area, Chuditch were recorded in 12 of the 27 camera locations in November 2016, and 18 of the 44 camera locations in January/February 2017 (Figure 17, Appendix 11). Note that the distribution of Chuditch records in Figure 17 are influenced by sampling effort.

As Chuditch are highly mobile, it is likely that the same individual may be recorded across more than one camera trap. However, it does indicate that Chuditch are distributed across a large area, though notably unrecorded from the area around Van Uden and the north-east of Jilbadji Nature Reserve. It is difficult to ascertain why Chuditch remain unrecorded in some areas, though it may be the effects of fire, as there are large areas that are recovering after recent fires, or the presence of feral predators.

In the medium-term, fire is thought to act in a similar manner to clearing, in that it homogenises the habitat, destroys den logs, removes protective cover and reduces prey biomass, particularly large invertebrates (DEC 2012). Only three individuals were trapped at either Site 9 (recently burnt) or Site 7 (small unburnt patch surrounded by recently burnt area), and all three were young (Table 12). In addition, proportionally more Chuditch were recorded on camera traps in unburnt habitats than burnt ones (Table 13). It may be that while recently burnt areas are not generally suitable for adult Chuditch, young will disperse through them in search of their own home range.

Table 12. Chuditch caught at Mt Holland Project, Nov and Dec 2016.

Chuditch			Number of captures at each site												Distance moved between trap sites (m)
Individual	Age	Sex	1	2	3	4	5	6	7	8	9	10	11	12	
1	Adult	F		1											-
2	Adult	F		2											-
3	Adult	F	1				2	1							803 + 803 + 806 (S5 → S1 → S5 → S6)
4	Young	F						2							-
5	Young	F						2	1						3,170 (S6 → S7)
6	Young	F									1				-
7	Adult	M		1	1			1							685 + 2,160 (S2 → S3 → S6)
8	Young	M				2									-
9	Young	M				1		1							650 (S4 → S6)
10	Young	M						2							-
11	Adult	M						1							-
12	Adult	M			2										-
13	Adult	M						2							-
14	Adult	F					1								-
15	Young	M		1	1										685 (S3 → S2)
16	Adult	M					1								-
17	Adult	F		1											-
18	Young	F							1						-
Total captures:			**1**	**6**	**4**	**3**	**4**	**12**	**2**	**0**	**1**	**0**	**0**	**0**	
Total individuals:			**1**	**5**	**3**	**2**	**3**	**8**	**2**	**0**	**1**	**0**	**0**	**0**	

Table 13. Number of Chuditch recorded on camera traps in each habitat type.

Habitat		Number of camera traps and percentage with Chuditch recorded			
		Burnt	Unburnt	Unburnt, adjacent to burnt	Totals
Open woodland	Total number of traps:	5	7	.	12
	Traps with Chuditch:	1 (20%)	3 (43%)	-	4 (33%)
Mallee woodland	Total number of traps:	9	40	7	56
	Traps with Chuditch:	4 (44%)	19 (47%)	5 (71%)	28 (78%)
Shrubland	Total number of traps:	4	25	4	33
	Traps with Chuditch:	-	9 (36%)	3 (75%)	12 (36%)
All habitats	**Total number of traps:**	**18**	**72**	**11**	**101**
	Traps with Chuditch:	**5 (28%)**	**31 (43%)**	**8 (72%)**	**44 (44%)**

The Cosmic Boy Mine Chuditch population was found to have a density nearly three times lower than that in the Jarrah forest, of about 0.039 individuals/km^2 (Rayner *et al*. 2011, Woinarski *et al*. 2014). This equates to about one individual per 2,560 ha or 8.7 individuals across the entire 22,246 ha Regional study area. Although the cage trap layout was not designed to measure population density, the findings of Mt Holland fauna survey clearly demonstrate a higher population density than this, with 18 individuals (of which ten were mature adults) captured in a relatively small area across Earl Grey, Irish Breakfast and Prince of Wales (Table 12). Excluding captures in Elliott traps, the trap success in this study was 16% (31 captures in 192 cage trap-nights), much higher than the average trap success of 0.8% obtained at Cosmic Boy Mine.

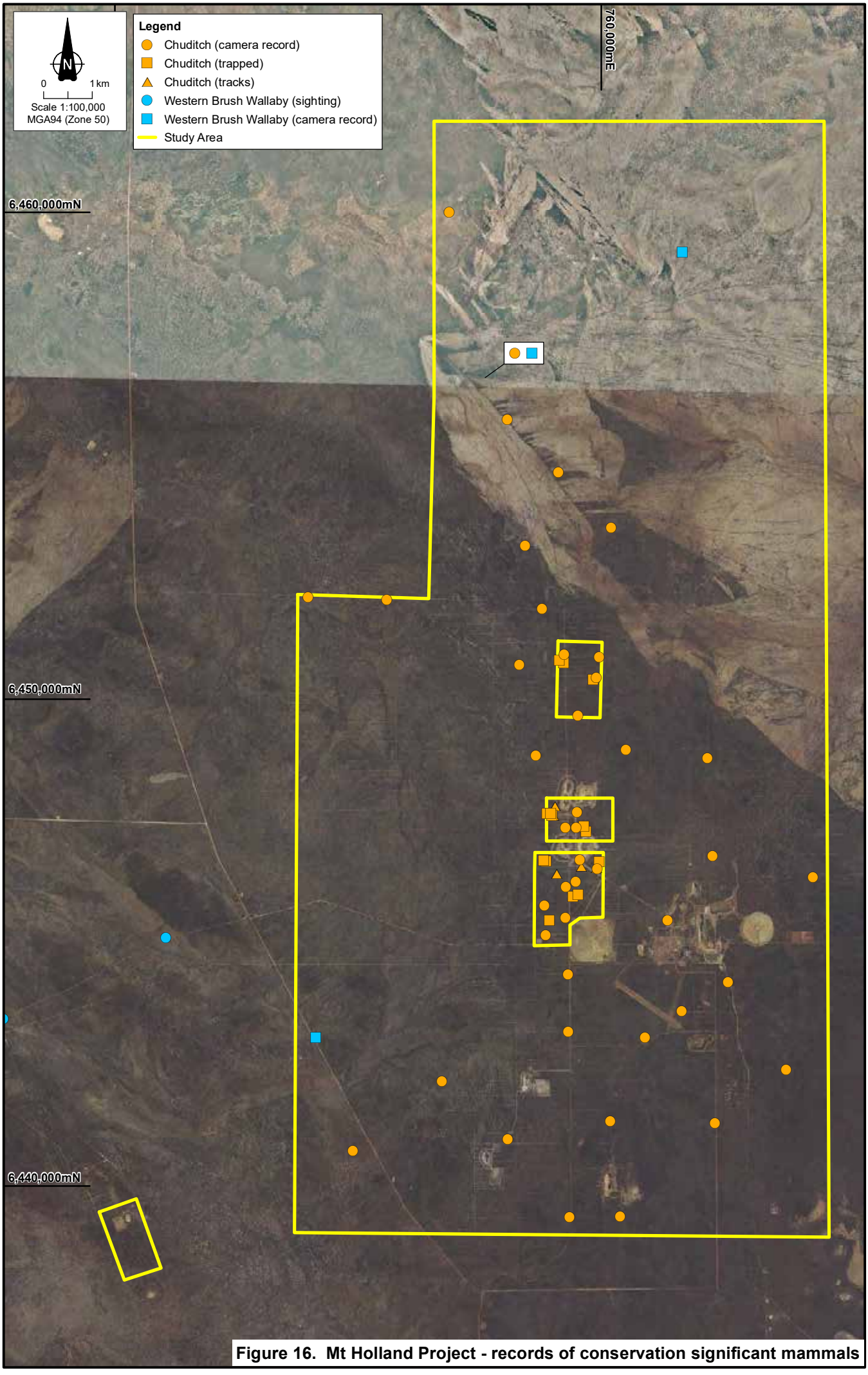
The low population density at the Cosmic Boy Mine was attributed to the lower rainfall (and therefore lower productivity) in the region compared to Jarrah forest, and to a lesser extent, the presence of feral predators. The rainfall at Mt Holland is likely to be similar, or even lower, than that at Cosmic Boy Mine, so it is uncertain why the population density of Chuditch at Mt Holland appears higher, even when considering only adult individuals and excluding dispersing young. However, at Mt Holland Chuditch appeared more common than feral predators, with the incidence of Chuditch on camera traps much higher at 43.5%, compared to feral predators such as foxes (7.9%), cats (4.9%) and dogs (2.0%), despite the fact that the bait used in front of the cameras should be attractive to feral predators. Chuditch populations are known to increase in response to fox control (Woinarski *et al*. 2014). It may be that a combination of low numbers of foxes and areas of dense unburnt habitat that provide cover from foxes and other feral predators, allows for higher density Chuditch populations. However, this hypothesis remains untested.

Plate 20. Chuditch recorded on camera traps W7-0 (top left), N3-0 (top right), W14-5 (bottom left) and N1-3 (bottom right).

Chuditch are highly mobile, and typically have large home-ranges (Woinarski *et al*. 2014). In the study at Cosmic Boy Mine, the average distance travelled between consecutive refuge sites was 500 m for females and 3.3km for males, with the maximum distance travelled 1.5 km for females and 4.5 - 12 km for males (Rayner *et al*. 2011). Males were found to occur across large core home ranges averaging 2,125 ha which overlapped with other males and females. Females inhabited a smaller core home range of 189 ha (Rayner *et al*. 2011). The core home range describes the area contained by den locations, and the actual area over which individuals can range is much higher (DEC 2012).

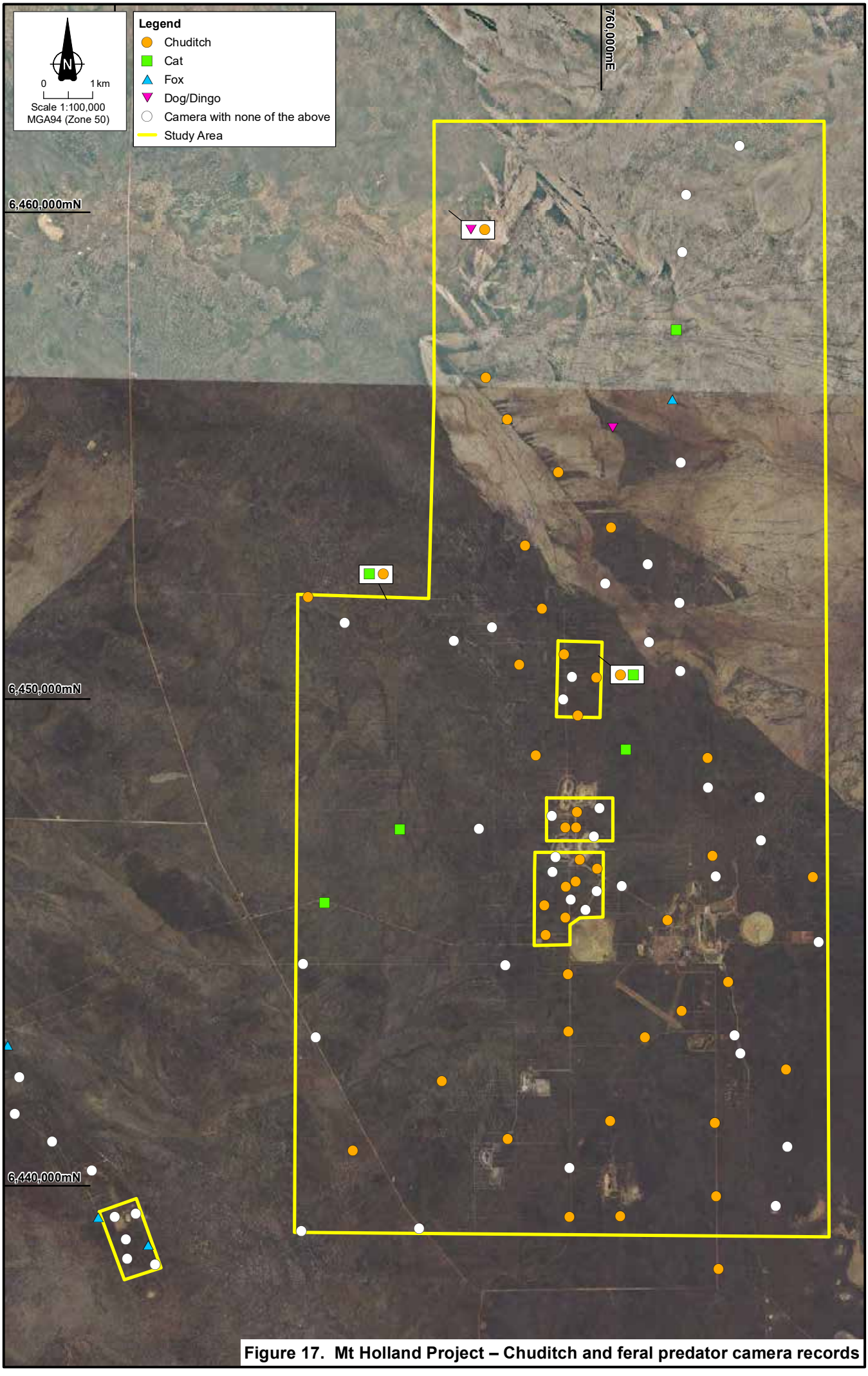
Although home range was not determined in the Mt Holland study, five of the Chuditch in this study were recorded at more than one site. Straight-line distances between traps ranged from 650 m to 3.17 km (Table 12), the latter being a young female who travelled the distance in a single night, indicative of dispersal. Adults caught across several sites indicate that these sites are within their home range, if not their core home range. It is possible, given the high population density recorded, that Chuditch at Mt Holland have smaller core home ranges, perhaps as low as those in Jarrah forest (410 ha for males and 90 ha for females) (Serena and Soderquist 1989).

The Chuditch was recorded in a range of habitats across the study areas, including mallee woodlands, open woodlands and shrublands (Table 13). At Cosmic Boy Mine, Chuditch mostly found daytime shelter in hollow logs, rock crevices and old White-browed Babbler (*Pomatostomus superciliosus*) nests, with some usage of burrows, timber/ concrete waste piles and pipes (Rayner *et al*. 2011). At Mt Holland, Chuditch are likely to use similar refuge sites. Though the availability of hollow logs is low in mallee woodland and shrublands compared to areas of open woodland, there are patches of open woodland in the region that are likely to provide shelter for this wide-ranging species. Mt Holland lacks rocky outcrops, but rock crevices are likely to be available in bund walls and other man-made structures. As Chuditch use up to 180 different dens sites within their core home range (Woinarski *et al*. 2014), no particular den site is likely to be significant.



Author: Western Wildlife ~ Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ April 2017 ~ A4 ~ Rev: A ~ CAD Ref: a2441_F030

Figure 16. Mt Holland Project - records of conservation significant mammals



Author: Western Wildlife ~ Drawn: CAD Resources ~ Tel 9246 3242 ~ URL www.cadresources.com.au ~ April 2017 ~ A4 ~ Rev: A ~ CAD Ref: a2441_F031

Figure 17. Mt Holland Project – Chuditch and feral predator camera records

The current major threats to Chuditch are land clearing (including fragmentation of continuous habitat), predation by and competition with feral predators (foxes and cats) and deliberate and accidental mortality from poisoning, trapping, illegal shooting or road kills (DEC 2012).

The **Red-tailed Phascogale** has declined in numbers and in range, and is generally restricted to woodlands. It favours Wandoo or York Gum woodlands with Rock Sheoak (*Allocasuarina huegeliana*), but it also is known to occur in shrublands and mosaics of woodlands and shrublands (Woinarski *et al*. 2014). There is a record of this species from 10km south of Marvel Loch in 1998 on DPAW's Threatened and Priority Fauna Database (Figure 13, Appendix 8), about 48 km north of the regional study areas, with the remaining records from granite outcrops. Most of records of the Red-tailed Phascogale on NatureMap (DPAW 2007-) are to the west of the study area. Though the Red-tailed Phascogale may potentially occur in the study areas, it is considered that the likelihood is low. Although there are shrublands with *Allocasuarina*, these generally do not occur in conjunction with the hollow-bearing trees that this species shelters in, and no phascogales were caught despite trapping with Elliott traps in this habitat.

Conservation Significance 2

Western Brush Wallaby *Macropus irma*
This species is listed as Priority 4 by DPAW.

Central Long-eared Bat *Nyctophilus major tor*
This species is listed as Priority 4 by DPAW.

The **Western Brush Wallaby** is endemic to the southwest of Western Australia and occurs in open forests or woodlands (Van Dyck and Strahan 2008). The home-range size of this species has been estimated at about 9.9 ha for males and 5.3 ha for females (Bamford and Bamford 1999), so the study areas potentially support many individuals. There are several records of the Western Brush Wallaby in Forrestania in 1998, 2005 and 2006, as well as a record from Jilbadji Nature Reserve in 1999 on DPAW's Threatened and Priority Fauna Database (Figure 13, Appendix 8). This species was observed in the study area on camera traps (Plate 21) and nearby in Jilbadji Nature Reserve (Figure 16, Appendices 9 and 11). The Western Brush Wallaby is likely to occur in shrubland and woodland habitats, including recently burnt habitats, in the study areas.

Plate 21. Western Brush Wallaby (*Macropus irma*) recorded at camera W01-4.

The **Central Long-eared Bat** is widespread across the arid south of Australia, and though thought to have a population of substantially more than 10,000 individuals, the reliability of this estimate is low (Woinarski *et al*. 2014). Although only known from 15 localities in Western Australia, it is considered locally common in some Bioregions (Duncan *et al*. 1999). It occurs in eucalypt woodlands with a tall shrub understorey and around granite outcrops, roosting beneath bark, in tree crevices or in the foliage of trees (Duncan *et al*. 1999, Van Dyck and Strahan 2008). Current threats to this species are inferred, and include habitat loss and fragmentation or inappropriate fire regimes leading to a loss of habitat and/or roost sites (Woinarski *et al*. 2014). The Central Long-eared Bat is known from Jilbadji Nature Reserve (Duncan *et al*. 1999) and may occur in the tall eucalypt woodlands and mallee woodlands of the study areas.

5.5 Summary of Conservation Significant Fauna

Thirteen species of conservation significance have the potential to occur in the study areas. These are summarised in Table 14.

According to database records and published information, the study area may support seven vertebrate species of Conservation Significance 1:

- Malleefowl (*Leipoa ocellata*)
- Peregrine Falcon (*Falco peregrinus*)
- Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris)*
- Fork-tailed Swift (*Apus pacificus*)
- Rainbow Bee-eater *(Merops ornatus*)
- Chuditch (*Dasyurus geoffroii*)
- Red-tailed Phascogale (*Phascogale calura*)

Of these, the Malleefowl, Peregrine Falcon, Rainbow Bee-eater and Chuditch were recorded during the fauna survey.

The Malleefowl was widely recorded (including active mounds and sightings of birds) and is likely to forage in most habitats but breed in shrublands or woodlands on gravelly sands. The Chuditch was also commonly recorded, occurring in most habitats and at high densities compared to Chuditch elsewhere in the bioregion. For both species habitat loss, habitat fragmentation and feral predators are recognized as current threats. Large-scale fires are also likely to impact these species, resulting in loss of den sites and prey for Chuditch, loss of leaf-litter for Malleefowl to build their mounds and invasion of feral predators into the open habitats created by fire.

As the Chuditch and Malleefowl have substantial populations in the study areas and are of high conservation significance (both listed as Vulnerable under the EPBC Act), they are key species to protect.

Both the Rainbow Bee-eater and Fork-tailed Swift are migratory species. However, their populations are large and stable, so changes to the study area are unlikely to have significant impacts on these species. The Peregrine Falcon is likely to nest in the open pits and forage in open areas. This species is only likely to be locally impacted if a nest site were disturbed, as its population is large and secure.

Carnaby's Black-Cockatoo is on the eastern limit of it range in the area. Although it may occur in the woodlands and shrublands of the study area, the presence of this species remains unconfirmed. If present, open woodlands (particularly of Salmon Gum) are potential breeding habitat and would be of high significance. Surrounding areas of woodlands and shrublands are potentially foraging habitat. The Red-tailed Phascogale is relatively unlikely to be present due to lack of its favoured habitat.

Database records and published information indicate that the study area may also support five species of Conservation Significance 2:

- Lake Cronin Snake (*Paroplocephalus atriceps*)
- Woma (*Aspidites ramsayi*)
- Inland Western Rosella (*Platycercus icterotis xanthogenys*)
- Western Brush Wallaby (*Macropus irma*)
- Central Long-eared Bat (*Nyctophilus major tor*)

Of these, the Inland Western Rosella and Western Brush Wallaby were recorded during the fauna survey. Although not recorded, both the Central Long-eared Bat and Lake Cronin Snake are moderately likely to occur as the habitats in the study areas are suitable and the area is within the known range of these species. The Woma is likely to be locally extinct in the region.

The one species of Conservation Significance 3 that may occur is the:

- Spotted Knob-tail Gecko (*Nephrurus stellatus*)

This species was recorded during the fauna survey.

Table 14. Summary of conservation significant (CS) fauna in the Earl Grey, Irish Breakfast, Prince of Wales and Van Uden study areas.

Key: Mig = Migratory, En = Endangered, Vu = Vulnerable, S = Schedule, P = Priority

Species	Status				Records	Habitat preferences	Likely habitat use in the study areas				Likelihood of occurrence
	Level of Conservation Significance	EPBC Act	WC Act	DPAW Priority			Mallee woodland	Open woodland	Shrubland	Sandplain*	
REPTILES											
Paroplocephalus atriceps **Lake Cronin Snake**	CS2			P3	Nearby at Lake Cronin & Jilbadji Nature Reserve (Appendix 8)	Woodlands & shrublands.	✓	✓	✓	✓	Moderate
Aspidites ramsayi **Woma (southwest population)**	CS2			P1	Historical records to the north at Marvel Loch and Yellowdine (Appendix 8)	Sandplains.				✓	Low
Nephrurus stellatus **Spotted Knob-tail Gecko**	CS3				Van Uden	Mallee woodlands on sandplains.			✓	✓	Known to occur
BIRDS											
Leipoa ocellata **Malleefowl**	CS1	Vu	S3		Active mounds recorded at Earl Grey, Van Uden & the Regional study area. Birds sighted at Van Uden & the Regional study area.	Acacia thickets, mallee woodlands and shrublands with leaf litter. Also forages in adjacent habitats.	✓	✓	✓	✓	Known to occur
Calyptorhynchus latirostris **Carnaby's Black-Cockatoo**	CS1	En	S2		Nearby at Cosmic Boy and Flying Fox Mines (Appendix 8).	Forages in eucalypt woodlands and proteaceous vegetation, breeds in large eucalypt hollows, particularly Salmon Gum.	✓	✓	✓	✓	Low

*Note: Sandplain habitat not present in the Earl Grey, Irish Breakfast Prince of Wales or Van Uden study areas, but present in Regional study area (unmapped) and north of Van Uden (unmapped).

Table 14. (cont.)

Species	Status				Records	Habitat preferences	Likely habitat use in the study areas				Likelihood of occurrence
	Level of Conservation Significance	EPBC Act	WC Act	DPAW Priority			Mallee woodland	Open woodland	Shrubland	Sandplain*	
Falco peregrinus **Peregrine Falcon**	CS1		S7		Recorded at Van Uden & the Regional study area.	Variety of habitats, nests in tall trees, cliffs, open pits.	✓	✓	✓	✓	Known to occur
Apus pacificus **Fork-tailed Swift**	CS1	Mig	S5		Recorded in Forrestiana (Appendix 8).	Overfly any habitat.	✓	✓	✓	✓	Moderate
Merops ornatus **Rainbow Bee-eater**	CS1		S5		Recorded at Earl Grey, Van Uden & the Regional study area.	Forages in a variety of habitats, breeds in sandy areas.	✓	✓	✓	✓	Known to occur
Platycercus icterotis xanthogenys **Inland Western Rosella**	CS2			P4	Recorded in Earl Grey, Irish Breakfast and Van Uden	Eucalypt woodlands. Nests in tree hollows.	✓	✓	✓	✓	Known to occur
MAMMALS											
Dasyurus geoffroyii **Chuditch**	CS1	Vu	S2		Recorded in Earl Grey, Irish Breakfast, Prince of Wales and the Regional area.	Forests, woodlands & shrublands, denning in hollow logs, babbler nests, burrows or rock crevices.	✓	✓	✓	✓	Known to occur
Phascogale calura **Red-tailed Phascogale**	CS1	En	S6		Nearby (Appendix 8).	Wandoo or York Gum woodlands with a Rock Sheoak understorey. Sometimes other shrublands or woodlands.	✓		✓		Low
Macropus irma **Western Brush Wallaby**	CS2			P4	Recorded in the Regional study area.	Woodlands & shrublands, sheltering in dense vegetation.	✓		✓	✓	Known to occur
Nyctophilus major tor **Central Long-eared Bat**	CS2			P4	Known from Jilbadji Nature Reserve (Duncan *et al*. 1999)	Woodlands, roosting in tree hollows and crevices.	✓	✓			Moderate

*Note: Sandplain habitat not present in the Earl Grey, Irish Breakfast Prince of Wales or Van Uden study areas, but present in Regional study area (unmapped) and north of Van Uden (unmapped

6. Potential Impacts on Fauna

6.1 Potential Impacts

Potential impacts may be on conservation significant fauna species, or on faunal assemblages in general. The following are a list of generic impacts that are associated with mining and mining infrastructure:

- Direct mortality of fauna
- Habitat loss
- Increased habitat fragmentation
- Increased disturbance to fauna (e.g. noise and light)
- Increased feral fauna
- Changed fire regimes

These are discussed in the sections below, along with potential impacts on conservation significant fauna. The potential impacts are likely to be small on a regional scale, as only a small area of fauna habitat is likely to be disturbed within a very large tract of intact habitat. On a local scale, impacts will be high within the mine footprint, as most fauna habitats will be cleared within this area. Impacts on adjacent habitats may be minimised by implementing mitigation strategies during the planning and operation of the mine. Recommendations on minimising potential impacts have been given below.

6.1.1 Direct Mortality of Fauna

Some direct mortality of fauna is unavoidable, particularly when clearing vegetation. Mortalities can be minimised by restricting vegetation disturbance to the minimum possible. Fauna most at risk of direct mortality are those with limited mobility, such as reptiles, frogs, small mammals, dependent young or nocturnal species. Avoiding clearing during late winter and spring (where possible), will aid in minimising mortality of young birds in nests. The Rainbow Bee-eater (CS1) may nest along tracks in the sandplain mallee heath, and young birds in burrows would be vulnerable to direct mortality.

When in operation, vehicles and heavy machinery may cause fauna mortalities, though many species are likely to avoid human activity. Road mortalities are undesirable both from a fauna welfare point of view as well as driver safety. Reptile species that bask on roads, larger mammals (such as kangaroos) and birds that forage on road edges are particularly at risk. In general, road mortalities are unlikely to negatively impact the conservation status of a fauna species, unless the fauna population was small or otherwise fragile. However, conservation significant species that are at risk of road mortalities include the Malleefowl (CS1), Chuditch (CS1), Lake Cronin Snake (CS2) and Western Brush Wallaby (CS2). The Malleefowl is at risk as it is a large bird that forages on the ground, and if the male is attending an active mound near a road, he may often be on or near the road. Chuditch may come into contact with vehicles when attracted to food waste in camps, foraging along roads or eating other road kill (DEC 2012). They may also become inadvertently trapped in steep-sided containers (e.g. skips or large bins) when in search of food, and these should be kept securely lidded to avoid mortalities. Many records of the Lake Cronin Snake are from inadvertent mortalities on mine sites in the area (Bush *et al*. 2007).

Uncapped drill holes are a source of direct mortality for reptiles and small mammals. These species may be attracted to the drill hole as shelter, but perish when they are unable to climb out. Conservation significant species that may be potentially affected are the Chuditch (CS1), Lake Cronin Snake (CS2) and Spotted Knob-tail (CS3).

6.1.2 Habitat Loss

Mining will result in habitat loss, though this can be minimised by situating infrastructure on existing cleared or disturbed areas. Any habitat loss in the study areas is likely to include loss of habitat for conservation significant fauna, as many species occur in all the habitats present.

Malleefowl (CS1) breeding habitat in the study areas is patchy, often occurring as small areas of dense shrubland on gravelly sands within a matrix of more open mallee woodlands. Active mounds were recorded in the Earl Grey, Van Uden and Regional study areas. It is likely that other active mounds are present in the Regional study area and that the habitats surrounding the mounds are used for foraging, as these birds range over a large area. It is unlikely that Malleefowl currently breed in recently burnt parts of the study areas, as they generally don't breed until at least six but more usually up to 17 years after extensive fires (Benshemesh 2007). However, these areas will return to breeding habitat in the future, at which time birds may return to inactive mounds or construct new mounds. Protecting active mounds and minimising clearing will minimise any long-term impact on Malleefowl breeding habitat.

Carnaby's Black-Cockatoo (Cs1) breeds in large hollows in eucalypts, which are generally absent from the mallee woodlands and shrublands in the study areas. Salmon Gum woodlands in the Regional study area and the open woodland at Van Uden are potential breeding habitat. However, Carnaby's Black-Cockatoo is on the far eastern limit of its range in the area and is uncertain whether it is present at all, let alone as a breeding species. The Inland Western Rosella (CS2) and Central Long-eared Bat (CS2) also breed in tree hollows, albeit smaller ones than cockatoos. Retaining large hollow-bearing eucalypts protects breeding and roosting habitat for many fauna species as well as conservation significant species. If Carnaby's Black-Cockatoo was found to be nesting, these areas would be highly significant. Areas of foraging habitat (eucalypt woodlands and proteaceous shrublands) in close proximity to breeding areas are also significant, though less so in a relatively continuous area of habitat compared with highly fragmented habitats (e.g. in the wheatbelt) where foraging resources are scarce.

Chuditch (CS1) are likely to occur throughout the study areas and in all habitats, though they may be temporarily absent in areas that have been recently and extensively burnt. Individual Chuditch use many denning sites, so are unlikely to be significantly impacted by the loss of a particular den site. All Chuditch breeding or foraging habitat in the area is considered 'critical habitat' for this species, and clearing, including the creation of new gaps in an otherwise homogenous habitat area, is regarded as a current threat to this species (DEC 2012).

6.1.3 Habitat Fragmentation

In an un-fragmented landscape fauna are free to move, allowing gene-flow between populations and the capacity to move to take advantage of dispersed or temporary resources such as food or nesting sites. Habitat fragmentation occurs when a large contiguous area of native vegetation is broken up into smaller patches. These patches can be large or small, and can exhibit varying degrees of linkage. Fauna are better able to persist in a modified landscape when vegetation patches are large and there are more links between patches. The study areas are within the Great Western Woodlands, a landscape of generally continuous woodlands and shrublands, and the relative intactness of these habitats is a key value of the area.

As the habitats in the region are continuous, rather than fragmented (as they are in the wheatbelt region), the potential impacts of habitat fragmentation are likely to be local, as the mining development is not likely to significantly increase habitat fragmentation in the region. Fauna will still be able to move through the landscape on all sides of the mining development. Locally, habitat fragmentation potentially impacts fauna by exacerbating other threats, particularly feral predators, by providing access into habitats that were previously dense and difficult to traverse. To some extent, these impacts are already present in the study areas due to the presence of roads and existing exploration tracks.

6.1.4 Increased Disturbance to Fauna and Fauna Habitats

Disturbance to fauna can be due to noise, movement or light, and includes examples such as the use of heavy machinery, workshop noises, road lighting, and the presence of people or vehicles. Disturbance to fauna may result in fauna avoiding an area, e.g. due to excessive noise, and therefore being unable to utilise an area of available habitat. Fauna may also experience increased stress and/or expend extra energy in avoidance behaviours. Opening new areas for exploration and mining also creates the potential for degradation of habitats adjacent to operations. Habitat degradation can occur when feral predators are allowed increased access due to the creation of open patches within the habitat (as discussed in the section below), or when weeds proliferate on habitat edges.

Some disturbance is inevitable, but can be reduced by minimising work at night that requires lights (where practicable) and preventing weed invasion.

6.1.5 Increased Feral Fauna

Feral fauna, particularly feral predators such as the fox, cat and wild dogs, can negatively impact native species. Predation by feral cats and foxes are both recognised as key threatening processes under the EPBC Act. An increase in human activity can lead to an increase in feral predators, as these species potentially thrive in modified landscapes with additional water sources, food from rubbish tips and increased access in the form of tracks and roads. Conservation significant species that are likely to be negatively impacted by increased feral predators include the Malleefowl (CS1), including chicks and eggs, and Chuditch (CS1).

6.1.6 Changed Fire Regimes

The impact of fire on many fauna species is not well understood, and some fire, particularly small, cool burns creating a mosaic of different fire ages, can be beneficial. However, it is generally accepted that large, unplanned hot bushfires are generally undesirable, as they substantially change fauna habitats on a large scale. Conservation significant fauna such as the Malleefowl (CS1) and Chuditch (CS1) are negatively impacted by fire. Mining activities potentially cause accidental fires, though this risk is generally low and unplanned fires can be caused by raod accidents, lightning or arson.

6.2 Recommendations

The following recommendations are general in nature. They are provided with the aim of minimising or mitigating impacts on native fauna during the planning phase, particularly any impacts on the Malleefowl and Chuditch. The Malleefowl and Chuditch are both listed as Vulnerable under the EPBC Act, and both species have been recorded in the study areas and are likely to occur in most habitats.

- *Minimise habitat loss in the planning phase by using existing cleared or disturbed lands and minimising the mine footprint.*
- *Protect active Malleefowl mounds from disturbance.*
- *Where practicable, restrict vehicle speed limits on roads adjacent to active Malleefowl mounds.*
- *Protect mature eucalypt trees with hollows where practicable.*
- *Where possible, avoid clearing during late winter and spring, to avoid mortalities of young birds in nests.*

- *Appropriately dispose of food waste so it does not attract Chuditch or feral predators (foxes and cats). Where containers (e.g. skip bins) are used, ensure they are securely lidded to avoid Chuditch being fatally trapped.*

- *Prohibit feeding of any fauna on site.*

- *Ensure all drill holes are securely capped to prevent fauna becoming fatally trapped.*

- *Where appropriate, carry out re-vegetation once mining activities are complete, to restore fauna habitats.*

- *Ensure that site inductions include adequate environmental education for all personnel involved. This includes ensuring personnel can recognise and report species of conservation significance such as the Malleefowl.*

- *Where practicable, reduce disturbance to nocturnal fauna by minimising work at night.*

- *Prevent the introduction of weeds by washing down muddy vehicles and machinery prior to use on site.*

- *Consider control of foxes and feral cats in and around the study areas.*

- *Implement a fire management plan with the aim of protecting areas of long-unburnt habitat.*

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